4.6 Geology and Soils

This section describes the existing geology and soils conditions in the vicinity of the Project sites, identifies associated regulatory requirements, evaluates potential Project and cumulative impacts, and identifies mitigation measures for any significant impacts related to implementation of the of the proposed Newell Creek Pipeline (NCP) Improvement Project (Proposed Project). The analysis is based on technical studies prepared to date for the Proposed Project (CE&G 2021a, 2021b, 2021c, HDR 2019.2020, Mott MacDonald 2021a) and in part on a vertebrate paleontological records check for paleontological resources from the Natural History Museum of Los Angeles County (LACM) conducted for the Proposed Project.

A summary of the comments received during the scoping period for this environmental impact report (EIR) is provided in Table 2-1 in Chapter 2, Introduction, and a complete list of comments is provided in Appendix A. There were no comments related to geology and soils.

4.6.1 Existing Conditions

4.6.1.1 Regional Geologic Setting

The existing NCP and Proposed Project alignment are located along the western side of the Santa Cruz Mountains, in the central portion of the Coast Ranges Physiographic Province of California. This province consists of a series of coastal mountain chains paralleling the pronounced northwest-southeast structural grain of central California geology between Point Arguello, in Santa Barbara County, and the California/Oregon border. The Proposed Project alignment and surrounding region are underlain by Miocene age sedimentary strata, which in turn is underlain by granitic and metamorphic rocks of the Salinian Block. This suite of basement rocks is separated from contrasting basement rock of the Franciscan Formation to the northeast by the San Andreas Fault System (Figure 4.6-1, Fault Map). While the core of the mountain range is dominated by gneiss, schist, limestone, quartzite, and granite, Cretaceous through Holocene sedimentary rocks and lesser amounts of Tertiary volcanic rocks overlie much of the region (AECOM 2018; USGS 1981, 1997).

4.6.1.2 Site Geology and Stratigraphy

The Proposed Project alignment is underlain primarily by Miocene sedimentary bedrock, Quaternary alluvium, and Quaternary terrace deposits.

Northern Segment

The hilly portions of the northern segment of the proposed alignment are underlain by the middle- to late-Miocene Monterey Formation (or Monterey Shale), middle Miocene Lompico Sandstone, upper Miocene Santa Margarita Sandstone, and Quaternary alluvium (Figure 4.6-2A). The Monterey Shale consists of medium- to thick-bedded and laminated, olive-gray to light gray mudstone and sandy siltstone, including a few thick dolomite interbeds. The Lompico Sandstone consists of pebble conglomerate, thick beds of light gray to yellowish gray, massive (i.e., non-bedded), fine- to medium-grained sandstone, with calcareous (hard, cemented), fossiliferous interbeds. The Santa Margarita Sandstone consists of white to yellowish gray, very thick-bedded to massive, fine- to medium-grained sandstone. This sandstone is generally friable (i.e., easily crumbled), but is locally calcareous and firm where fossiliferous. The relatively flat-lying, valley areas along the northern segment are underlain by Quaternary alluvium, which consists primarily of relatively unconsolidated silt, sand, and gravel deposits (USGS 1981, 1997).

Brackney Landslide Area

Landslides are widespread in the Santa Cruz Mountains. Although landslides occur in all rock units, landslides are most common in the northern and western parts of the Santa Cruz Mountains, where steeper slopes are underlain by one of the mudstone units. The highly fractured rocks of the Monterey Formation and Santa Cruz Mudstone have been most susceptible to landsliding (USGS 1981, 1997). The California Geological Survey (CGS) has completed Seismic Hazard Zone maps, which include seismically induced landslide zones for select U.S. Geological Survey (USGS) 7.5-minute quadrangle maps in California. The Proposed Project alignment is in the USGS Felton Quadrangle map. A Seismic Hazard Zone map has not been completed for this quadrangle (California Geological Survey [CGS] 2020).

A portion of the existing (and proposed) northern segment traverses the Brackney landslide area. Figures 4.6-3 and Figure 4.6-4 illustrate the location of these landslides with respect to the pipeline alignment, as well as the geologic units or geologic formations, in the vicinity of the Brackney landslide area. Dashed lines in Figure 4.6-4 define the approximate unit contacts, or boundaries, between individual geologic units. This e portion of the Brackney North section of the proposed pipeline alignment traverses an area that has included at least four historical landslides. During the January 1982 and January 2017 storm events, intense rainfall resulted in landslides in this area that blocked road access and damaged the pipeline. The northern-most slide was upslope of the pipeline alignment and terminated on the horizontal easement bench. Two other slides failed downslope of the easement, resulting in a steeper lower slope gradient. The landslides were relatively shallow, generally 5 feet deep, and generally failed along the soil-colluvium/bedrock contact, with possible involvement of the shallowest weathered bedrock. Boulders as large as 1.5 feet in diameter were observed in the landslide debris, and likely contains buried tree trunks (HDR 2019; Mott MacDonald 2021a; Cal Engineering & Geology [CE&G] 2021a, 2021b, 2021c).

Site visits have not detected any obvious bedrock structural failures; only small block failure pop-outs. Based on the high density of fracturing and jointing within the exposed bedrock, slab failure, oriented along joint surfaces (not dip slope), may play a partial role in slope failure of the bedrock exposed regions upslope of the pipeline alignment. The geomorphology of the ground surface, as well as the mature vegetation overlying the landslide surface, suggests this area has a long history of landsliding (i.e., thousands of years minimum). The two mapped 1982 slide areas below the pipeline alignment occur at an outer bend of the San Lorenzo River, where scour would be most aggressive (HDR 2019; Mott MacDonald 2021a; CE&G 2021a, 2021b, 2021c).

Based on exposed rock outcrops, geophysical surveys, five borings, and five test pits/potholes completed along the alignment, the Brackney landslide area is underlain by Monterey Formation deposits, with overlying topsoil, fill, and colluvium. The exposed bedrock in this area is variably weathered, heavily fractured, medium strong, silty fine-grained sandstone and sandy siltstone. Based on the geophysical survey and soil borings, the geologic subsurface conditions along the pipeline corridor and underlying the pipeline can be divided into two distinct zones as described below.

SOURCE: USGS 2020

DUDEK

0 1.5 3 Miles

FIGURE 4.6-1

Fault Map

Newell Creek Pipeline Improvement Project

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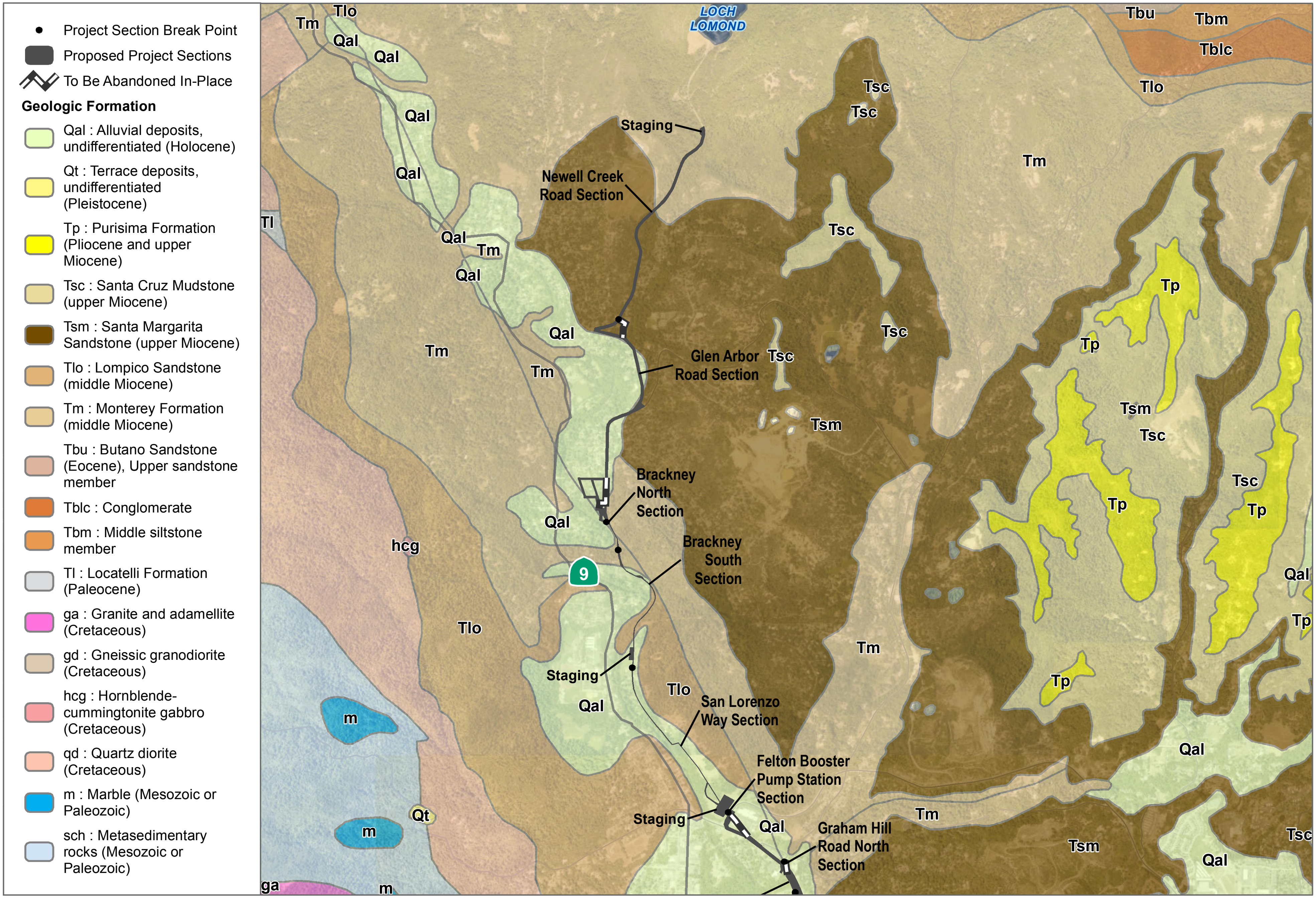

SOURCE: ESRI 2020, HDR 2019 County of Santa Cruz 2020, City of Santa Cruz Water Department 2020, USGS 2020

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FIGURE 4.6-2A

Geology Map - Northern Segment

Newell Creek Pipeline Improvement Project

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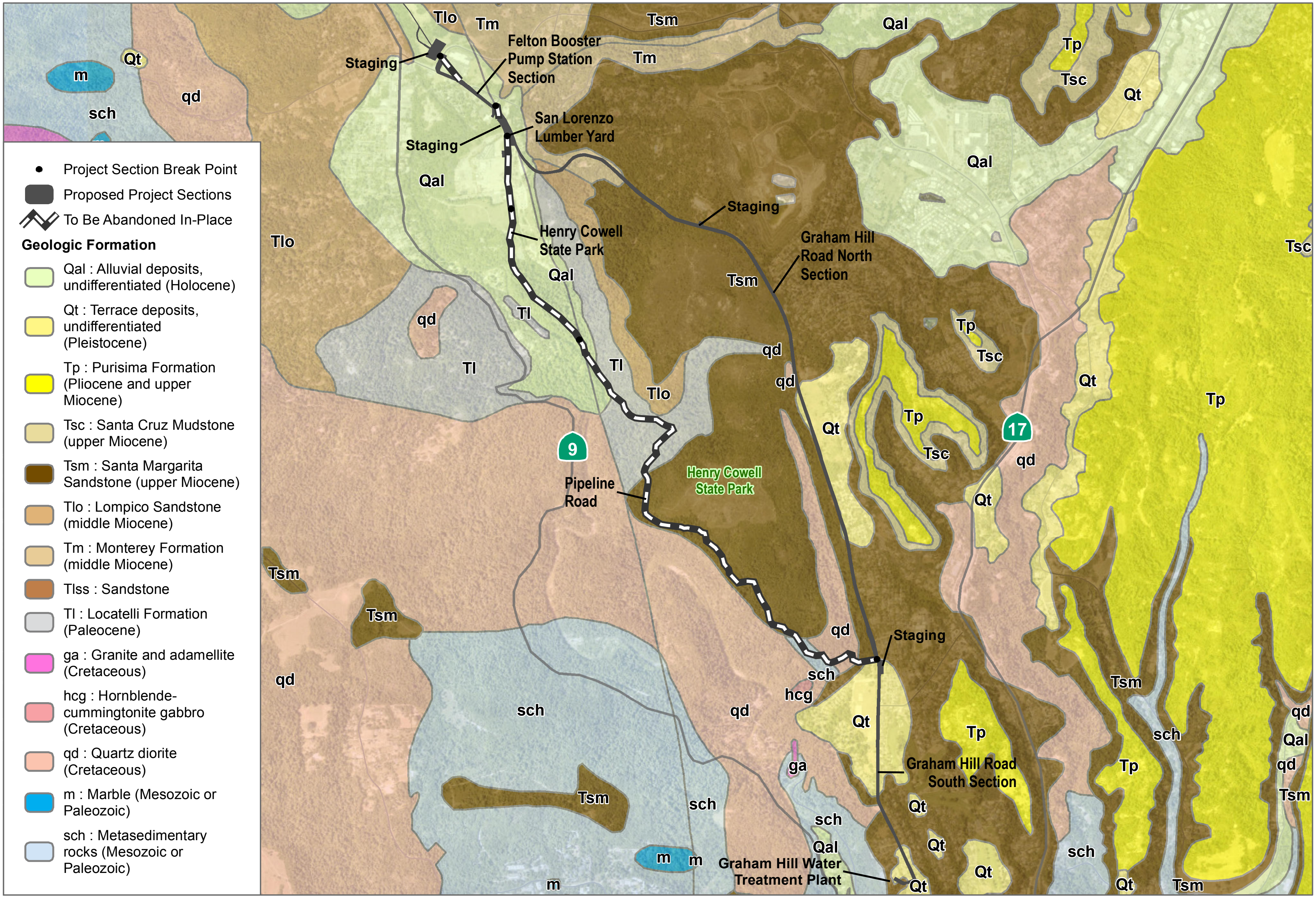

SOURCE: USGS National Map 2021, HDR 2019 County of Santa Cruz 2020, City of Santa Cruz Water Department 2020, USGS 2020

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FIGURE 4.6-2B

Geology Map - Southern Segment

Newell Creek Pipeline Improvement Project

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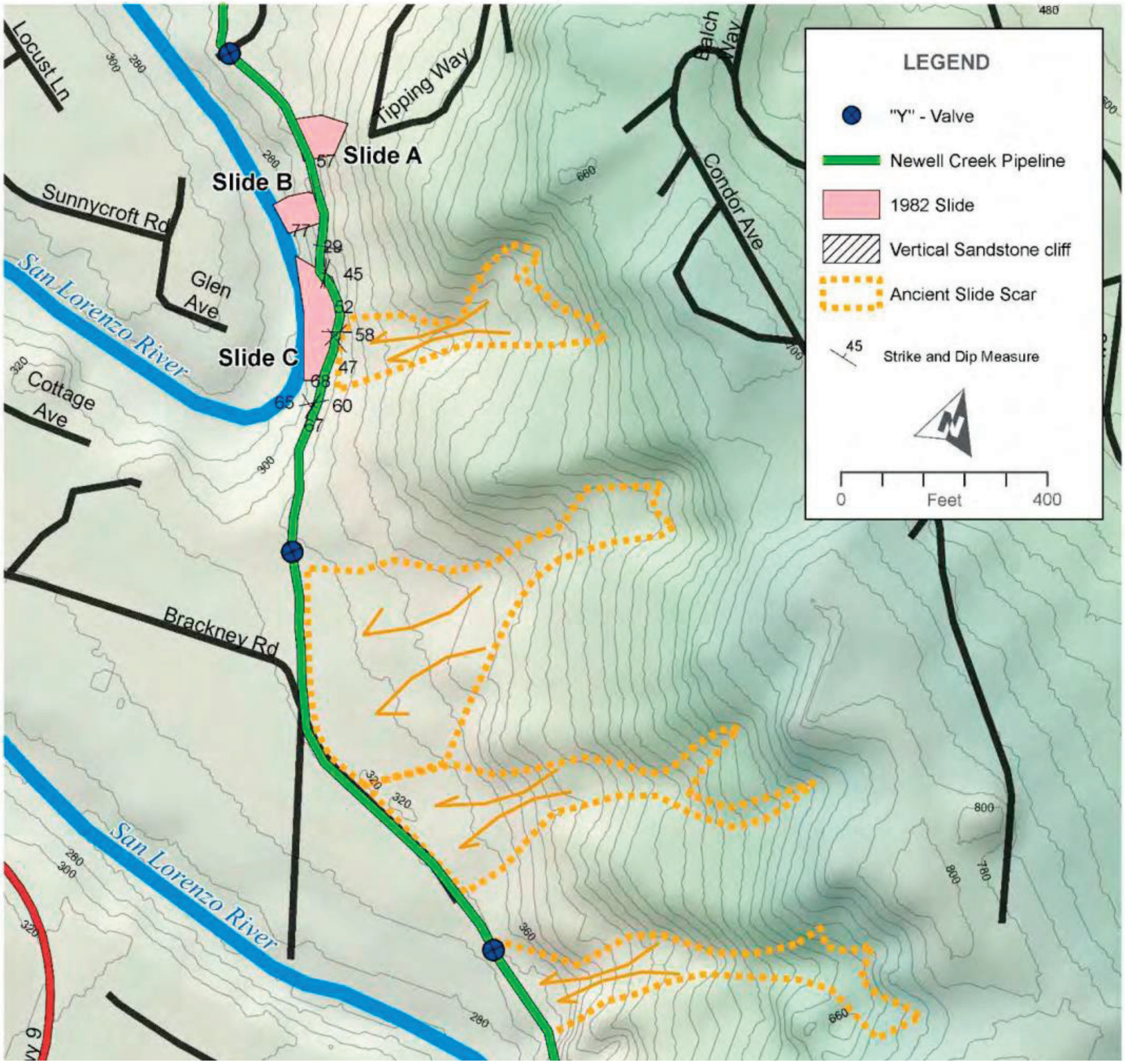

SOURCE: Mott MacDonald 2021

FIGURE 4.6-3

Brackney Landslide Area

Newell Creek Pipeline Improvement Project

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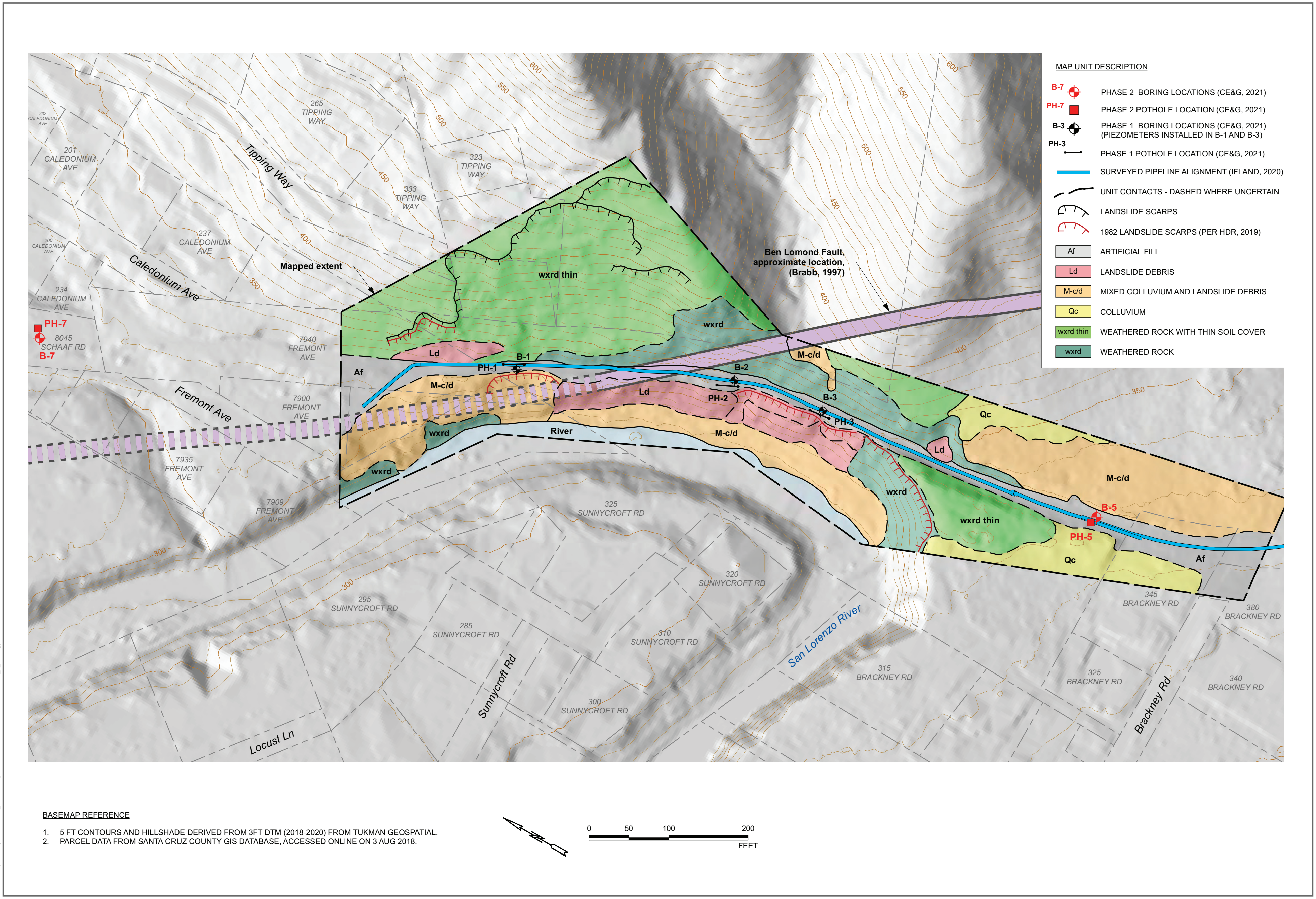

SOURCE: CE&G 2021

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FIGURE 4.6-4

Detail of Brackney Landslide Area

Newell Creek Pipeline Improvement Project

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The first zone is a broad colluvial and landslide debris fan at the southern end of the pipeline, bound to the north by the steepening hillslopes and extending south beyond the project area. The mixed colluvium and landslide debris unit consists of sandy silt with gravel and is interpreted as extending across a broad swale up to 25 feet below ground surface. The second zone is characterized by steep hillslopes cut by the old railroad grade, with exposed or thinly covered bedrock upslope of the road, and fill and landslide debris covered bedrock on the over-steepened slopes below the road and above the San Lorenzo River. The subsurface conditions for this zone can be characterized by 1 to 10 feet of colluvium and fill overlying an undulatory bedrock surface (Mott MacDonald 2021a; CE&G 2021a, 2021b, 2021c).

A transition zone of extremely weak to weak, highly- to slightly-weathered Monterey Formation silty sandstone occurs below the surficial fill, colluvial, and landslide deposits (described above), extending to depths of 13 to 20 feet below ground surface. The weathered bedrock is underlain by slightly weathered to fresh Monterey bedrock, to a depth of 80 feet (the depth of the borings). The top of the fresh bedrock, which is characterized as fine-grained, silty sandstone, varies from a depth of 13 to 25 feet below ground surface. The silty sandstone is friable (i.e., easily crumbled) and extremely weak to weak rock. Observed fractures, using a downhole acoustic televiewer, were generally parallel to bedding and were either partially or completely filled with clay. Although small block failure pop-outs were observed during site reconnaissance, no large-scale deep-seated bedrock failures were observed (HDR 2019; Mott MacDonald 2021a; CE&G 2021a, 2021b, 2021c).

The existing pipeline easement is approximately 10 to 15 feet wide, generally level longitudinally, but benched into a steep cross slope. The easement in this area consists of a narrow gravel and dirt road, which runs generally north-south. The pipeline is 4 to 8 feet below ground surface along this dirt road, which mostly slopes into the hillside, drained by four or five culverts, which divert water from the east side of the road to the west side of the road, but may be partially blocked (Mott MacDonald 2021a; CE&G 2021a, 2021b, 2021c).

The topography west of the easement slopes steeply downwards to the San Lorenzo River, at gradients generally greater than 0.5:1, horizontal to vertical. The river is approximately 60 vertical feet below the pipeline easement. Similarly, the topography east of the easement slopes steeply upward, at gradients generally exceeding 1:1, and locally exceeding 0.5:1. Fill underlies much of the dirt road. At various locations along the road, landslide and erosion debris cover the pipeline alignment by several feet to over 10 to 20 feet. Most of the slopes are somewhat densely vegetated, with legacy large redwood tree stumps locally present. Topographic contours and mature vegetation on the slide areas below ancient slide scars (Figure 4.6-3) suggests the area has a long history of landslides, perhaps thousands of years (Mott MacDonald 2021a; CE&G 2021a, 2021c).

Southern Segment

The hilly portions of the southern segment of the proposed pipeline alignment are similarly underlain by Monterey Shale, Lompico Sandstone, and Santa Margarita Sandstone, whereas the relatively flat-lying valley areas are underlain by Quaternary alluvium (Figure 4.6-2B). In addition, relatively flat-lying Quaternary Terrace deposits, consisting of weakly consolidated, sandy, pebble to cobble gravel and pebbly fine to medium sand, are locally present along the southern half of the southern segment (USGS 1981, 1997).

A geotechnical investigation report, completed by Crawford and Associates, was summarized in the Basis of Design Report (Carollo Engineers 2021a). Based on 20 new soil borings drilled along the southern segment, to a maximum depth of 46 feet, as well as a review of previous boring data collected by Pacific Geotechnical

Engineering, soils beneath the southern segment generally consist of poorly graded sand with silt and clayey/silty sand. The upper soils were loose, underlain by progressively denser soils.

Subsidence

Subsidence occurs when a large portion of land is vertically displaced, usually due to the withdrawal of groundwater, oil, or natural gas, or as a result of decomposition of natural organic materials. Soils that are particularly subject to subsidence include those with high silt or clay content and/or high organic content. The effects of subsidence include damage to buildings and infrastructure, increased flood risk in low-lying areas, and lasting damage to groundwater aquifers and aquatic systems. The Proposed Project alignment, including the both the northern and southern segments, is not in an area of historic or recent subsidence due to groundwater extraction (Luhdorff & Scalmanini Consulting Engineers, Inc., California Water Foundation 2020). These bedrock deposits are not high in silt, clay, or organic content and therefore would not be susceptible to subsidence due to high organic content.

Expansive Soils

Expansive soils are composed largely of clays, which greatly increase in volume when saturated with water and shrink when dried. Expansive soils can cause structural foundations to rise during the rainy season and fall during the dry season. If this expansive movement varies underneath different parts of the structure, foundations may crack and portions of the structure may be distorted. The potential for soil to undergo shrink and swell is greatly enhanced by the presence of a fluctuating, shallow groundwater table. Changes in the volume of expansive soils can result in the consolidation of soft clays after the lowering of the water table or the placement of fill. As previously discussed, the Proposed Project alignment, including the Northern and Southern segments, is underlain primarily by Monterey Shale, Lompico Sandstone, and Santa Margarita Sandstone with overlying surficial deposits of alluvium, colluvium, topsoil, and fill. The overlying surficial deposits may locally be clay-rich and susceptible to soil expansion.

4.6.1.3 Regional Seismicity and Seismic Hazards

The Proposed Project alignment is located in a seismically active region of California, between two major Holocene-active faults, including the San Andreas Fault, located approximately 7 miles to the northeast, and the San Gregorio Fault, located approximately 9 miles to the southwest, as shown on Figure 4.6-1. Historical earthquakes along the San Andreas Fault and its branches have caused substantial seismic shaking in Santa Cruz County in historical times. The two largest historical earthquakes to affect the area were the moment magnitude (Mw) 7.9 San Francisco earthquake of April 18, 1906, and the Mw 6.9 Loma Prieta earthquake of October 17, 1989 (corresponding to Richter magnitudes of 8.3 and 7.1, respectively) (City of Santa Cruz 2012).

The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Santa Cruz Mountains. The Loma Prieta earthquake may have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, although its regional effects were not as extensive. Based on a seismometer located at the University of California Santa Cruz (UCSC) campus, approximately 1.0 mile from the southern Proposed Project alignment, peak ground accelerations during the Loma Prieta earthquake were approximately 0.5 g (percent of gravity). There were also major earthquakes in northern California along or near the San Andreas Fault in 1838, 1865, and possibly 1890 (AECOM 2018; City of Santa Cruz 2012).

Regional Faulting

As previously discussed, Santa Cruz County is located in a portion of California that is crossed by a number of faults. The CGS classifies faults as:

- Holocene-active faults, which are faults that have moved during the past approximate 11,700 years. These faults are capable of surface rupture.
- Pre-Holocene faults, which are faults that have not moved in the past 11,700 years. This class of fault may be capable of surface rupture but is not regulated under the Alquist-Priolo Earthquake Fault Zoning Act of 1972.
- Age-undetermined faults, which are faults where the recency of fault movement has not been determined (CGS 2018).

This fault classification is consistent with criteria of the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (see Section 4.6.2, Regulatory Framework, for information about this act). Distances to regional faults, maximum probable earthquake magnitudes, and recurrence intervals are shown in Table 4.6-1.

Table 4.6-1. Distances to Local Faults

Fault	Distance from Proposed Project Site (miles)	Maximum Probable Earthquake Magnitude (moment magnitude)	Approximate Time Between Major Earthquakes (years)
San Gregorio	9	7.5	400
Zayante-Vergeles	1	7.5	8,821
Monterey Bay-Tularcitos	5	6.5	2,841
San Andreas	7	7.8	210
Ben Lomond	0	5.5	Not Holocene-Active

Sources: AECOM 2018; City of Santa Cruz 2012; USGS 1974, 2017a, 2017b, 2017c, 2017d, 2020.

The northern terminus of the Proposed Project alignment is located approximately 1 mile southwest of the Zayante-Vergeles Fault (see Figure 4.6-1) (USGS 2020), which is mapped by the USGS as a late Pleistocene to possibly Holocene fault, active within the past 15,000 years (i.e., Holocene-active to pre-Holocene fault). The Zayante-Vergeles Fault is marked by a zone of relatively parallel fault traces that extend from the vicinity of West Waddell Creek, southeast through the Santa Cruz Mountains, beneath Quaternary alluvium of the Pajaro River, and across the northern Gabilan Range, where the fault has a complex junction with the San Andreas Fault, approximately 5 miles southeast of Hollister (USGS 2000). For planning purposes, the maximum probable earthquake associated with the Zayante-Vergeles Fault is Mw 7.5 (USGS 2017a).

The Proposed Project alignment is approximately 7 miles southwest of the San Andreas Fault (see Figure 4.6-1) (USGS 2020), which is a 680-mile network of Holocene-active faults that collectively accommodate the majority of the north-south motion between the North American and Pacific tectonic plates. The San Andreas Fault Zone is considered to be a Holocene-active and historically active strike-slip fault that extends along most of coastal California, from its complex junction with the Mendocino Fault Zone on the north, southeast to the northern Transverse Range, and inland to the Salton Sea, where a well-defined zone of seismicity (i.e., the Brawley Seismic Zone) transfers slip to the Imperial Fault. Two major surface-rupturing earthquakes have occurred in historic time, including the 1857 Fort Tejon earthquake and the 1906 San Francisco earthquake

(USGS 2002). For planning purposes, the maximum probable earthquake associated with the San Andreas Fault is Mw 7.8 (USGS 2017b).

The Proposed Project alignment is approximately 9 miles east-northeast of the San Gregorio Fault (see Figure 4.6-1) (USGS 2020), which is a Holocene-active (past 11,700 years), structurally complex fault zone as much as 3 miles wide. The fault zone is primarily located offshore, west of San Francisco Bay and Monterey Bay, with onshore locations at promontories, such as Moss Beach, Pillar Point, Pescadero Point, and Point Año Nuevo. The San Gregorio Fault is a complex fault zone consisting of several named faults, including the Seal Cove, Frijoles, Coastways, Greyhound Rock, Carmel Canyon, Denniston Creek, and Año Nuevo Faults. This fault zone extends from Bolinas Lagoon south to the Point Sur region (USGS 1999). For planning purposes, the maximum probable earthquake associated with the San Gregorio Fault is Mw 7.5 (USGS 2017c).

The Proposed Project alignment is approximately 5 miles north of the Monterey Bay-Tularcitos Fault Zone (see Figure 4.6-1), which is generally considered late Quaternary (past 15,000 years) (USGS 2020); however, portions of this fault are considered Holocene-active (past 11,700 years). This offshore fault zone is a complex, generally northwest-trending zone up to 9 miles wide, consisting primarily of right-lateral, reverse/thrust faults, extending across Monterey Bay southeast to the Monterey Peninsula, to near the crest of the Sierra de Salinas (USGS 2001). For planning purposes, the maximum probable earthquake associated with the Monterey Bay-Tularcitos Fault Zone is Mw 7.3 (USGS 2017d).

In addition, the Ben Lomond Fault underlies the Brackney landslide area, in the southern portion of the northern pipeline segment (Figure 4.6-4) (Mott MacDonald 2021a, 2021b; CG&E 2021a, 2021b). This fault has been mapped generally along the San Lorenzo River from Boulder Creek to Felton, as well as within west Santa Cruz, traversing the coastline just east of Mitchell's Cove. Although well-defined in the Brackney landslide area, this late Quaternary fault (past 130,000 years) is not well-located throughout much of the area and is not Holocene-active (USGS 1981, 2020). The most recent movement on the Ben Lomond Fault occurred about 85,000 years ago (Mott MacDonald 2021b; Stanley and McCaffrey 1983).

Surface Rupture

Surface rupture involves the displacement and cracking of the ground surface along a fault trace. Surface ruptures are visible instances of horizontal or vertical displacement, or a combination of the two, typically confined to a narrow zone along the fault. Surface rupture is more likely to occur in conjunction with Holocene-active fault segments, where earthquakes are large, or where the location of the movement (earthquake hypocenter) is shallow.

As discussed in Section 4.6.2, Regulatory Framework, the Alquist-Priolo Earthquake Fault Zoning Act of 1972 regulates development near Holocene-active faults to mitigate the hazard of surface fault rupture. This Act requires the State Geologist to establish regulatory zones (known as Alquist-Priolo Earthquake Fault Zones) around the surface traces of Holocene-active faults and to issue appropriate maps. Local agencies must regulate most development Projects within the zones. The CGS has completed Seismic Hazard Zone maps, which include Alquist-Priolo Earthquake Fault Zones, for select USGS quadrangle maps in California. The Project alignment is located in the USGS 7.5-minute Felton Quadrangle map. As stated above, a Seismic Hazard Zone map has not been completed for this quadrangle (CGS 2020). The Alquist-Priolo Earthquake Fault Zone located closest to the Project is associated with the onshore portion of the San Gregorio Fault, located approximately 10.5 miles west of the Project alignment (CGS 2020; CDMG 1982). As previously discussed, although the Ben Lomond Fault traverses the northern segment, this fault is not Holocene-active. Therefore, the Project site is not expected to be subject to fault rupture.

Liquefaction and Lateral Spreading

Soil liquefaction occurs when ground shaking from an earthquake causes a sediment layer saturated with groundwater to lose strength and take on the characteristics of a fluid, thus becoming like quicksand. Factors determining the liquefaction potential are soil type, the level and duration of seismic ground motions, the type and consistency of soils, and the depth to groundwater. Liquefaction generally occurs at depths of less than 40 feet in soils that are young (Holocene-age), saturated, and loose (CGS 2004). Soils that are most susceptible to liquefaction are clay-free deposits of sands and silts, and unconsolidated alluvium.

The CGS has completed Seismic Hazard Zone maps, which include liquefaction zones, for select USGS quadrangle maps in California. As stated above, the Project alignment is located in the USGS Felton Quadrangle map. A Seismic Hazard Zone map has not been completed for this quadrangle (CGS 2020). However, the County of Santa Cruz has created Geologic Hazard maps that include areas of potential liquefaction in the County. As indicated in Figures 4.6-5A and 4.6-5B, portions of the northern and southern pipeline segments are in areas of moderate liquefaction potential.

Lateral spreading is the lateral movement of unsupported soils in association with liquefaction. Examples of areas/scenarios prone to lateral spreading include: 1) liquefaction-prone soils on slopes adjacent to creeks, rivers, canals, or lakes; and 2) liquefaction-prone soils during excavation and construction of subterranean parking garages. Lateral spreading may occur in areas where the Proposed pipeline alignment traverses slopes and is also within an area of liquefaction prone soils. For example, a geotechnical investigation completed for the Felton Booster Pump Station, at the northern end of the southern segment (Figure 4.6-2B), concluded that the slopes adjacent to Zayante Creek have a high potential for lateral spreading in the event of a strong earthquake (Pacific Geotechnical Engineering 2002).

4.6.1.4 Unique Geological Features

According to the County of San Diego (2007), which provides guidelines for determining significance of unique geological features throughout California, unique geological features include one or more of the following criteria:

- Is the best example of its kind locally or regionally;
- Embodies the distinctive characteristics of a geologic principle that is exclusive locally or regionally;
- Provides a key piece of geologic information important in geology or geologic history;
- Is a “type locality” of a geologic feature;
- Is a geologic formation that is exclusive locally or regionally;
- Contains a mineral that is not known to occur elsewhere in a County; or
- Is used repeatedly as a teaching tool.

Unique geological features do not include surficial geological expressions that are visually appealing. No unique geologic features are located along the Project alignment.

4.6.1.5 Paleontological Resources

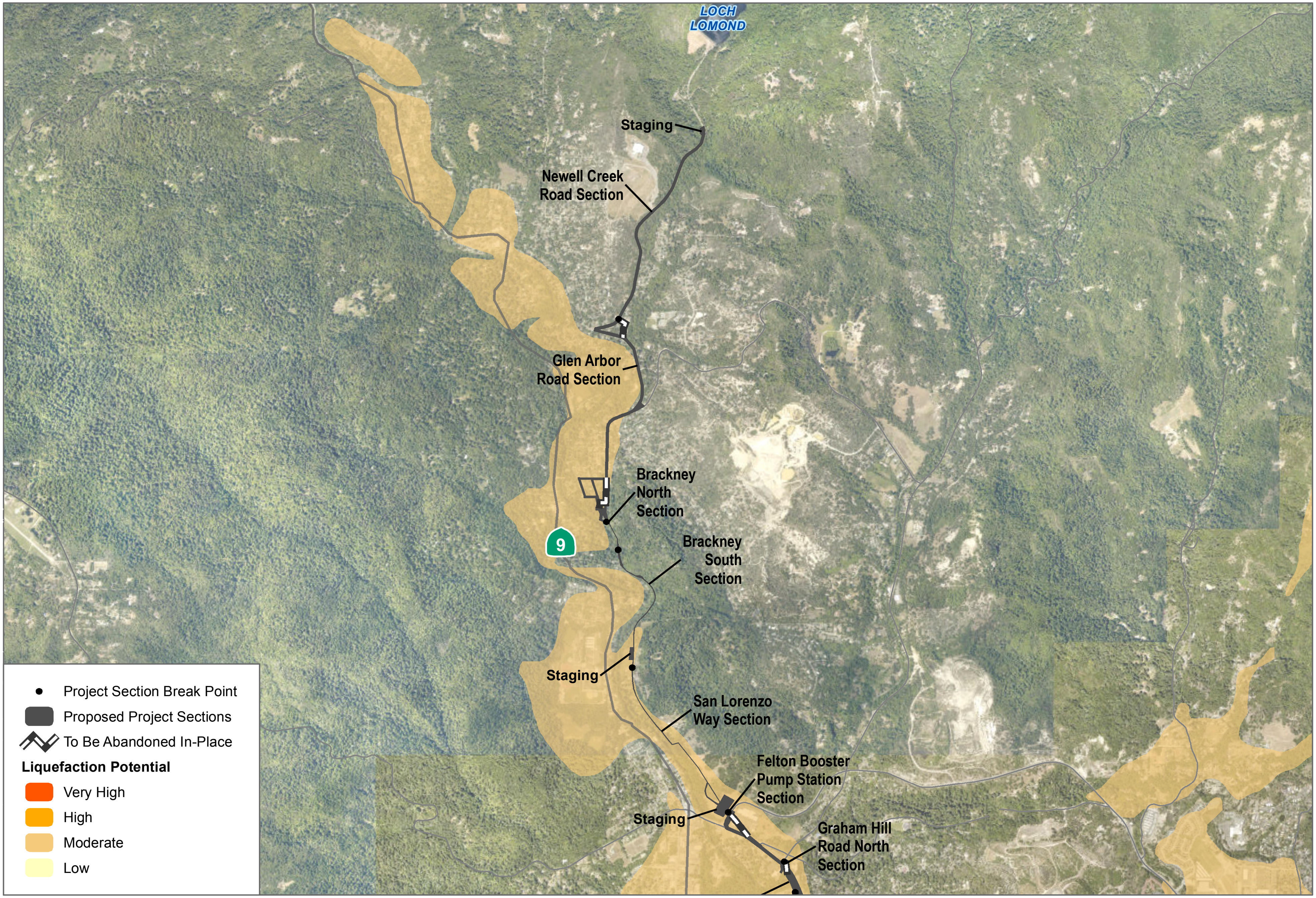
Paleontological resources are the fossilized remains, traces, and associated data of plants and animals, preserved in earth's crust, that are generally considered to be older than middle Holocene (approximately 5,000 radiocarbon years before present) (SVP 2010). Body fossils include bones, teeth, shells, leaves, and wood, while trace fossils include trails, trackways, footprints, and burrows. With the exception of fossils found in low-grade metasedimentary rocks, significant paleontological resources are found in sedimentary rock units that are old enough to preserve the remains or traces of plants and animals.

To determine paleontological sensitivity of individual rock units present along the Proposed Project alignment, a paleontological records search was requested from the LACM on April 23, 2021 and desktop geological and paleontological research was conducted. The LACM records search results indicated that they have no paleontological localities within the Proposed Project alignment boundaries, but they do have Miocene age fossil localities near the Proposed Project alignment. The fossiliferous geological units reported by the LACM include the Santa Margarita Formation, the Monterey Formation, and the Purisima Formation. Of these geological formations, only the Santa Margarita and Monterey Formations are mapped along the Proposed Project alignment.

The LACM reported five fossil localities from the Santa Margarita Formation near the Proposed Project alignment. Fossil locality LACM IP (Invertebrate Paleontology) 22182 produced a fossil sand dollar (*Astrodapsis spatiosus*) from an unknown depth beneath the ground surface (bgs), east of Felton (Mount Hermon) in an area mapped as the Santa Margarita Formation (LACM 2021). Fossil localities LACM VP (Vertebrate Paleontology) 1779 and LACM VP 3332, which are located near Glen Canyon Road and Redwood Drive, yielded a fossil dugong (*Metaxytherium*) and a member of the sea lion family (Otariidae) from an unknown depths bgs. Fossil locality LACM VP 3333 produced fossil marine mammals including *Paleoparadoxia*, *Desmostylus*, and the dolphin, *Liolithax*, recovered from a sand and gravel quarry within the Santa Margarita Formation, north of Camp Evers Junction in Scotts Valley (LACM 2021). Finally, the LACM reported a fossil marine mammal (*Paleoparadoxia tabatai*) from the Santa Margarita Formation several miles north of Santa Cruz.

The LACM did not report any localities from the Monterey Formation in the records search for the Proposed Project. Throughout its extent (from Orange County in the south to north of San Francisco Bay), the Monterey Formation has produced thousands of fossil traces, invertebrates, and vertebrates. Vertebrate taxa include sharks, bony fish, reptiles, and marine mammals (Koch et al. 2004). Dozens of bony fish species from multiple localities were reported from the Monterey Formation in a catalog of Neogene bony fishes from California (Fierstine et al. 2012). Furthermore, a new genus and species of eared seal was reported from the Monterey Formation of Los Angeles County (Downs 1956). In addition to vertebrate fossils recovered from the Monterey Formation, numerous Monterey Formation fossil invertebrates have been described in the scientific literature including two new stomatopod crustacean species (Hof and Schram 1998). Finally, a small, Monterey Formation invertebrate fauna was published in the literature, which consisted of bivalves, gastropods, and an echinoid that were collected during excavations for a housing development in south Orange County (Rugh 2018).

The LACM did not report any fossil localities from the Lompico Sandstone; however, this geological unit, which underlies the Monterey Formation, has produced scientifically significant invertebrate fossils. Clark (1981) reported foraminifers, echinoids, and bivalves from the Lompico Sandstone in Santa Cruz County.



SOURCE: ESRI 2020, HDR 2019 County of Santa Cruz 2020, City of Santa Cruz Water Department 2020, USGS 2020

DUDEK

0 1,500 3,000 Feet

FIGURE 4.6-5A

Liquefaction Map - Northern Segment

Newell Creek Pipeline Improvement Project

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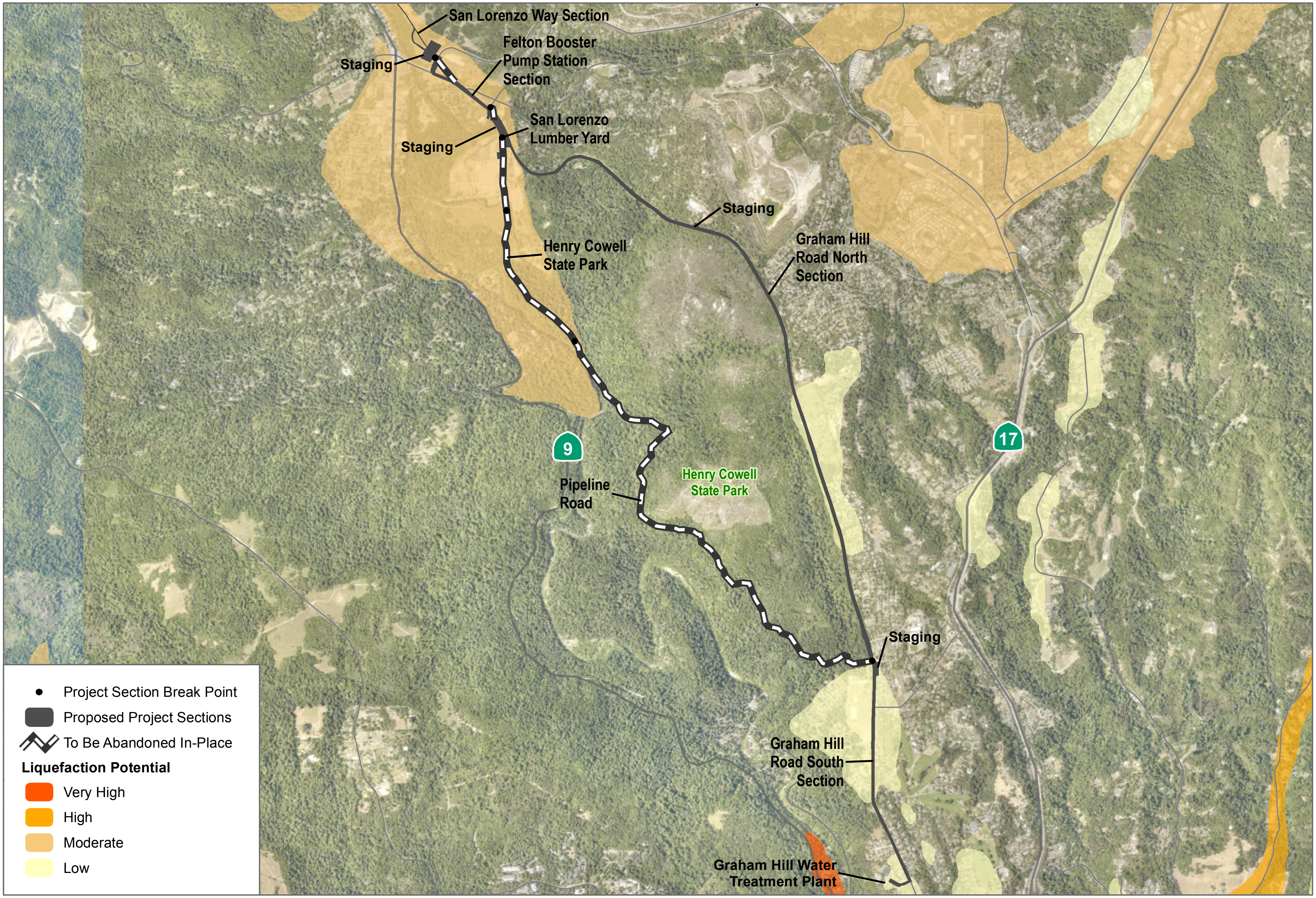

SOURCE: USGS National Map 2021, HDR 2019 County of Santa Cruz 2020, City of Santa Cruz Water Department 2020, USGS 2020

DUDEK

0 1,500 3,000 Feet

FIGURE 4.6-5B

Liquefaction Map - Southern Segment

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The Santa Margarita Formation has high paleontological sensitivity. Proposed Project pipe sections that are located within this formation include:

- Northern segment: Newell Creek Road section and portions of the Glen Arbor Road section
- Southern segment: Graham Hill Road North section

Overall, the Monterey Formation has produced scientifically significant fossils and is considered to have high paleontological resources sensitivity. Proposed Project pipe sections that are located within this formation include:

- Northern segment: portion of the Brackney North section
- Southern segment: portion of Graham Hill Road North section

The Lompico Sandstone is considered to have high paleontological resources sensitivity. Proposed Project pipe sections that are located within this formation include:

- Northern segment: portion of the Brackney South section
- Southern segment: portion of Graham Hill Road North section

4.6.2 Regulatory Framework

4.6.2.1 Federal

Earthquake Hazards Reduction Act

The Earthquake Hazards Reduction Act (42 U.S.C., Section 7701) is a statute formulation a national policy to diminish the perils of earthquakes in the United States. The National Earthquake Hazards Reduction Program, created under this act, mandated that four federal agencies maintain responsibility for long-term earthquake risk reduction. These agencies included the USGS, the National Science Foundation, the Federal Emergency Management Agency, and the National Institute of Standards and Technology. These agencies assess U.S. earthquake hazards, deliver notifications of seismic events, develop measures to reduce earthquake hazards, deliver notifications of seismic events, develop measures to reduce earthquake hazards, and conduct research to help reduce overall U.S. vulnerability to earthquakes. In November 2018, Congress passed the National Earthquake Hazards Reduction Program Reauthorization Act of 2018. This new act largely leaves the current four-agency National Earthquake Hazards Reduction Program intact, while providing some new areas of emphasis.

Paleontological Resources Protection Act

The Paleontological Resources Protection Act (PRPA) of 2009 directs the Secretaries of the Interior and Agriculture to manage and protect paleontological resources on federal land using "scientific principles and expertise." The PRPA incorporates most of the recommendations of the report of the Secretary of the Interior entitled "Assessment of Fossil Management on Federal and Indian Lands (USDI, 2000) in order to formulate a consistent paleontological resources management framework. In passing the PRPA, Congress officially recognized the scientific importance of paleontological resources on some federal lands by declaring that fossils from these lands are federal property that must be preserved and protected. The PRPA codifies existing policies of the Bureau of Land Management (BLM), National Park Service (NPS), United States Forest Service (USFS), Bureau of Reclamation, and United States Fish and Wildlife Service (USFWS) and provides the following:

a. criminal and civil penalties for illegal sale and transport, and theft and vandalism of fossils from federal lands;

b. minimum requirements for paleontological resource-use permit issuance (terms, conditions, and qualifications of applicants);

c. definitions for “paleontological resources” and “casual collecting”; and

d. requirements for curation of federal fossils in approved repositories.

The PRPA requires the Secretaries of the Interior and Agriculture to manage and protect paleontological resources on federal land. The PRPA furthers the protection of fossils on federal lands by criminalizing the unauthorized removal of fossils.

4.6.2.2 State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Act (Public Resources Code [PRC] Sections 2621 through 2630) was passed in 1972 to mitigate the hazard of surface faulting to structures designed for human occupancy. The main purpose of the law is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. A structure for human occupancy is defined as any structure used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year. The law addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. The Alquist-Priolo Act requires the State Geologist to establish regulatory zones known as Earthquake Fault Zones around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning efforts. Before a structure for human occupancy can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, the local agency must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act (PRC Sections 2690 through 2699.6 et seq.), passed by the California State Legislature in 1990, addresses earthquake hazards from non-surface fault rupture, including liquefaction and seismically induced landslides. The act established a mapping program for areas that have the potential for liquefaction, strong ground shaking, or other earthquake and geologic hazards.

California Building Standards Code

The state regulations protecting structures from geo-seismic hazards are contained in the California Building Standards Code (24 California Code of Regulations Part 2) (the California Building Code), which is updated every 3 years. These regulations apply to public and private buildings/structures in the state, including construction of utilities. Until January 1, 2008, the California Building Code was based on the then-current

Uniform Building Code and contained additions, amendments, and repeals specific to building conditions and structural requirements of the State of California. The 2019 California Building Code, effective January 1, 2020, is based on the current (2018) International Building Code and enhances the sections dealing with existing structures. Seismic-resistant construction design is required to meet more stringent technical standards than those set by previous versions of the California Building Code. Construction activities are also subject to Chapter 33 of the California Building Code.

California Division of Occupational Safety and Health

Construction activities are subject to occupational safety standards for excavation and trenching, as specified in California Division of Occupational Safety and Health (also known as Cal/OSHA) regulations (Title 8 of the California Code of Regulations). These regulations specify the measures to be used for excavation and trench work where workers could be exposed to unstable soil conditions. The Proposed Project would be required to employ these safety measures during excavation, trenching, and tunneling.

State Earthquake Protection Law

The State Earthquake Protection Law (Health and Safety Code Section 19100 et seq.) requires that structures be designed and constructed to resist stresses produced by lateral forces caused by wind and earthquakes, as provided in the California Building Code. Chapter 16 of the California Building Code sets forth specific minimum seismic safety and structural design requirements, requires a site-specific geotechnical study to address seismic issues, and identifies seismic factors that must be considered in structural design. Because the Project alignment is not located within an Alquist-Priolo Earthquake Fault Zone, as noted above, no special provisions would be required for the Proposed Project related to fault rupture.

California Environmental Quality Act

The California Environmental Quality Act (CEQA) Guidelines require that all private and public activities not specifically exempted be evaluated against the potential for environmental damage, including effects to paleontological resources. Paleontological resources, which are limited, nonrenewable resources of scientific, cultural, and educational value, are recognized as part of the environment under these state guidelines. This analysis satisfies Project requirements in accordance with CEQA (13 PRC Section 21000 et seq.) and PRC Section 5097.5 (Stats 1965, c. 1136, p. 2792). This analysis also complies with guidelines and significance criteria specified by the Society of Vertebrate Paleontology (SVP) (SVP 2010).

Paleontological resources are explicitly afforded protection by CEQA, specifically in Section VII(f) of CEQA Guidelines Appendix G, the “Environmental Checklist Form,” which addresses the potential for adverse impacts to “unique paleontological resource[s] or site[s] or … unique geological feature[s].” This provision covers fossils of signal importance—remains of species or genera new to science, for example, or fossils exhibiting features not previously recognized for a given animal group—as well as localities that yield fossils significant in their abundance, diversity, and preservation,. Further, CEQA provides that generally, a resource shall be considered “historically significant” if it has yielded or may be likely to yield information important in prehistory (PRC Section 15064.5[a][3][D]). Paleontological resources would fall within this category. Chapter 1.7, Sections 5097.5 and 30244 of the PRC defines unauthorized removal of fossil resources as a misdemeanor and requires mitigation of disturbed sites.

4.6.2.3 Local

The study area for the Proposed Project includes the unincorporated County of Santa Cruz and the City of Santa Cruz where the Graham Hill Water Treatment Plant (GHWTP) is located. The general plans and, where relevant, the local coastal programs of these jurisdictions include policies and programs related to geology, soils and paleontology.

County of Santa Cruz General Plan and Local Coastal Program

The Conservation and Open Space Chapter of the Santa Cruz County General Plan outlines policies and programs for the protection of hydrological, geological, and paleontological features (County of Santa Cruz 2020).

Chapter 16.44 (Paleontological Resource Protection) of the Santa Cruz County Code outline methods and regulations for the identification and treatment of paleontological resources within the County.

City of Santa Cruz General Plan

The Project alignment is in unincorporated Santa Cruz County, except for the southernmost pipe section that connects with the City's GHWTP. Therefore, the City of Santa Cruz General Plan only applies to the Proposed Project for a limited area. As such, the policies of these plans are not summarized or further evaluated in this section.

4.6.3 Impacts and Mitigation Measures

This section contains the evaluation of potential environmental impacts associated with the Proposed Project related to geology and soils. The section identifies the thresholds of significance used in evaluating the impacts, describes the methods used in conducting the analysis, and evaluates the Proposed Project's impacts and contribution to significant cumulative impacts, if any are identified. Mitigation measures are presented for identified significant or potentially significant impacts, and the level of significance with mitigation also is identified.

4.6.3.1 Thresholds of Significance

The thresholds of significance used to evaluate the impacts of the Proposed Project related to geology and soils are based on Appendix G of the CEQA Guidelines and the City of Santa Cruz CEQA Guidelines. A significant impact would occur if the Proposed Project would:

A. Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
    i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault.
    ii. Strong seismic ground shaking.
    iii. Seismic-related ground failure, including liquefaction.

iv. Landslides.

B. Result in substantial soil erosion or the loss of topsoil.

C. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse.

D. Be located on expansive soil, as defined in the 2019 California Building Code, creating substantial direct or indirect risks to life or property.

E. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

F. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

4.6.3.2 Analytical Methods

The following analysis considers whether the Proposed Project would directly or indirectly cause geologic and soils impacts, taking into account state-mandated construction methods, as specified in the California Safety and Health Administration regulations (Title 8 of the California Code of Regulations) and in Chapter 33 of the California Building Code. Moreover, the analysis considers whether a unique paleontological resource, site, or unique geologic feature would be directly or indirectly destroyed as a result of the Proposed Project.

Application of Relevant Standard Construction Practices

The City has adopted standard construction practices (see Section 3.6.6, Standard Construction Practices) that would be implemented by the City or its contractors during construction to avoid or minimize impacts. Standard Construction Practices #1-4 would reduce project-related erosion by requiring erosion control best management practices, soil stockpile containment, and runoff control.

Impacts have been evaluated with respect to the thresholds of significance, as described above. In the event adverse environmental impacts would occur even with consideration of applicable policies and regulations and Proposed Project Standard Construction Practices described in Chapter 3, Project Description, if applicable, impacts would be potentially significant, and mitigation measures are provided to reduce impacts to less-than-significant levels.

4.6.3.3 Project Impact Analysis

Areas of No Impact

The Proposed Project would not have impacts with respect to the following thresholds of significance for the following reasons:

- **Earthquake Fault Rupture (Significance Threshold A-i).** The Proposed Project would not have the potential to directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault because the Project alignment is not located within an Alquist-Priolo Earthquake Fault Zone or underlain by any Holocene-active faults.

- **Loss of Topsoil (Significance Threshold B).** The Proposed Project consists of installation of a new water pipeline primarily within developed roadways. Construction would not result in loss of topsoil as most of excavation would occur in previously disturbed areas. Soils removed during trenchless construction operations would be replaced on site or with engineered fill. Thus, the Proposed Project would not result in loss of topsoil. Potential erosion during construction is addressed in Section 4.9, Hydrology and Water Quality.

- **Septic Tanks/Alternative Wastewater Disposal (Significance Threshold E).** The Proposed Project would not entail wastewater disposal. During construction, temporary portable toilets would be installed for construction workers. Waste from the portable toilets would be transported off-site in vacuum trucks for disposal at the City's wastewater treatment facility. Therefore, the Proposed Project would have no impacts related to soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems.

Project Impacts

Impact GEO-1: Seismic Hazards (Significance Thresholds A-ii and A-iii). The Proposed Project would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death resulting from seismic ground shaking or seismic-related ground failure, including liquefaction. ***(Less than Significant)***

As discussed in Section 4.6-1, the Ben Lomond Fault underlies the Brackney landslide area, in the southern portion of the northern pipeline segment (Figure 4.6-4). This fault has been mapped generally along the San Lorenzo River from Boulder Creek to Felton, as well as within west Santa Cruz, traversing the coastline just east of Mitchell's Cove. Although well-defined in the Brackney landslide area, this late Quaternary fault (past 130,000 years) is not well-located throughout much of the area and is not Holocene-active. As a result, the pipeline is not anticipated to be damaged as a result of direct fault displacement across the pipeline alignment (CE&G 2021c).

However, the Project alignment is located in a seismically active region of California between two major Holocene-active faults: the San Andreas Fault, located approximately 7 miles to the northeast, and the San Gregorio Fault, located approximately 9 miles to the southwest (see Figure 4.6-1). In addition, the Project site is located approximately 1 mile southwest of the Zayante-Vergeles Fault, which is mapped by the USGS as a late Pleistocene to possibly Holocene fault (past 15,000 years), and 5 miles north of the Monterey Bay-Tularcitos Fault Zone, which is generally considered late Quaternary (past 15,000 years). However, portions of the latter fault are considered Holocene-active (past 11,700 years). The presence of these active to potentially active faults in the Project region indicate that the Project may be subject to strong seismically induced ground shaking and associated ground failure, including seismically induced slope failure, differential settlement, liquefaction, and lateral spreading. The intensity of ground shaking that is likely to occur would be dependent on the magnitude of the earthquake, the distance to the epicenter, and the local rock/soil type.

Seismically induced slope failure typically occurs on steep to very steep slopes, such as those that are present in the Brackney landslide area (Figure 4.6-4). Differential settlement typically occurs in flat-lying to gently sloping areas, where variable soil densities and other factors contribute to differing amounts of settlement over a given length of ground surface. As indicated in Figure 4.6-5A and Figure 4.6-5B, portions of the northern and southern pipeline segments are in areas of moderate liquefaction potential. Lateral spreading may occur in areas where the Proposed pipeline alignment traverses slopes and is also within an area of liquefaction prone soils. For example, a geotechnical investigation completed for the Felton Booster Pump Station, at the northern end of the southern segment (Figure 4.6-2B), concluded that the slopes adjacent to Zayante Creek have a high potential for lateral spreading in the event of a strong earthquake. Any of these types of seismically induced ground failure could damage the Proposed Project pipeline and associated appurtenances, such as air release valves.

The proposed pipeline alignment would consist of a northern segment and southern segment (Figures 4.6-2A and 4.6-2B). With the exception of the Brackney landslide area, the northern segment would be installed in open cut trenches within existing roadway, road ROWs, and/or City easements, primarily parallel to the existing pipeline. The pipeline would be installed on existing bridges across Newell Creek in two locations, replacing the existing pipeline in the same location. The structural design of the northern segment, included in the 30% Basis of Design report (Mott MacDonald 2021b), is based on an earthquake return period of 2,475 years (i.e., 2% exceedance in 50 years) and a peak ground acceleration of 0.751g (percent of gravity). The structural design includes earthquake design, based on the local geology and the maximum anticipated ground accelerations.

In the Brackney landslide area, the pipeline would be installed using horizontal directional drilling (HDD) technology. The pipeline would be installed to depths of 60 to 110 feet below ground surface, which is below the zone of incompetent rock (i.e., upper 13 to 25 feet) that is most susceptible to slope failure, including seismically induced failure. This portion of the pipeline is anticipated to withstand strong ground shaking if exposed to it during seismic events. Although the Ben Lomond Fault traverses the proposed HDD alignment, movement is not anticipated on this fault. The most recent movement on the Ben Lomond Fault occurred about 85,000 years ago. Therefore, the pipeline would not require fault offset design (Mott MacDonald 2021b).

The structural design of the southern segment, included in the 30% drawings (Appendix B) of the Basis of Design report (Carollo Engineers 2021a), is based on recommendations in a project-specific geotechnical investigation report (by Crawford and Associates). The geotechnical report included 20 new borings and a review of previous boring data by Pacific Geotechnical Engineering. The structural design includes earthquake design, based on the local geology and the maximum anticipated ground accelerations. Most of the southern segment of the pipeline would be buried in a 3- to 5-foot open cut trench. However, the pipeline would be placed on the existing bridge over Zayante Creek. The bridge has been evaluated to determine the structural adequacy in supporting the proposed pipeline. Two 30-inch diameter concrete piers would be installed at the southern abutment to provide structural support to the pipeline. In addition, the pipeline would be bored, to a depth of 10 feet over a 92-foot span, beneath a Santa Cruz Big Trees & Pacific Railway Company railroad easement, using pipe ramming or auger boring technology. Earthquake loads have been considered for each type of pipeline installation, including open cut, bridge attachment, and horizontal boring.

Proposed Project facilities would be constructed in accordance with provisions of the 2019 California Building Code, under the supervision of a California Geotechnical Engineer and/or California Certified Engineering Geologist, thus minimizing the potential for damage. In addition, construction and operation of Proposed Project facilities would not increase the potential for earthquakes or seismically induced ground failure to occur, including the risk of loss, injury, or death resulting from seismic ground shaking or seismic related ground failure. Therefore, the Proposed Project would have a less-than-significant impact related to seismic hazards.

Mitigation Measures

As described above, the Proposed Project would not result in significant impacts related to seismic hazards, and therefore, no mitigation measures are required.

Impact GEO-2:	**Unstable Geologic Unit or Soils (Significance Thresholds A-iv and C).** The Proposed Project could potentially cause adverse effects involving landslides or be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Proposed Project, and potentially result in on- or off-site landslide, slope failure/instability, subsidence, or collapse. ***(Less than Significant with Mitigation)***

Northern Segment

As described in Section 3.5.2, Description of Pipeline Segments, the pipeline would cross Newell Creek and an unnamed tributary to Newell Creek on bridge and culvert crossings. Construction activities would be staged on either side of the creek, and no construction is planned in the flowing channels. As a result, no geologic impacts would occur with respect to construction across Newell Creek and the tributary creek.

Trench excavation activities would result in temporary slopes that, if not constructed properly, could be prone to failure, which in turn could result in safety impacts to construction personnel and damage to adjacent infrastructure. However, in accordance with Cal/OSHA, temporary shoring would be required to maintain slope stability for trenches greater than 5 feet deep. An exception to this rule would be if the excavation is completed entirely in stable rock, a California Geotechnical Engineer and/or California Certified Engineering Geologist may determine that protective shoring is not required. In the event the trench is greater than 5 feet deep and shoring is not feasible (e.g., due to loose crumbly soils), the temporary slopes would be laid back to a lesser gradient, in accordance with engineered design plans of the 30% Design Drawings of the Basis of Design report (Mott MacDonald 2021b), and would be constructed in accordance with provisions of the California Building Code and Cal/OSHA, under the supervision of a California Geotechnical Engineer and/or California Certified Engineering Geologist, thereby minimizing the potential for slope failure.

Depending on the depth of the trench and the local depth to groundwater, groundwater may be encountered during trenching, which could potentially result in unstable soil conditions and associated slope failure within the trench. In the event groundwater is encountered, dewatering would be required to maintain dry working conditions. As described above, potentially unstable soils would be addressed in accordance with engineered design plans of the 30% Design Report and provisions of the California Building Code and Cal/OSHA, under the supervision of a California Geotechnical Engineer and/or California Certified Engineering Geologist, thereby minimizing the potential for unstable soils and associated slope failure.

The open cut trenching portions of the northern segment would be completed on relatively flat to moderately sloping topography. With the exception of the Brackney North and Brackney South sections (see below), the proposed alignment would not traverse any known landslides or steep slopes that might be susceptible to failure if undercut by the trench. As previously discussed, steep creek banks would not be traversed, as the pipeline would be attached to existing bridges and placed over or under existing culverts at creek crossings, thus eliminating the potential for creek bank failure. Following pipeline installation, the trench would be backfilled, and the soil compacted to prevent subsequent ground subsidence, collapse, or settlement. Controlled low-strength material (CLSM), consisting of a self-compacted cementitious material used primarily as a backfill in place of compacted fill, may be considered to reduce risk of long-term settlement (Mott MacDonald 2021b).

Brackney North Section

The proposed HDD method would avoid potential slope failure during construction, as opposed to the shallow open cut methods, which can create slope instability during construction. The pipeline would be installed 60 to 110 feet below ground surface, which is below the zone of incompetent rock (i.e., upper 20 to 35 feet) that is most susceptible to slope failure. As a result, the pipeline would have minimal exposure to future landslides during operations. Drilling would be completed near the intersection of Brackney Road and the existing pipeline easement, which is in a gently sloping private property, not susceptible to slope failure.

The length of existing pipeline at high risk to landslides in the Brackney Landslide area is about 1,200 linear feet. The proposed pipeline would be installed as a new 24 -inch carrier pipeline constructed by HDD technology, which would make it less susceptible to damage from landslides. No evidence of deep-seated landsliding was detected in the Brackney Landslide area. Relatively restricted shallow landsliding of colluvium and the uppermost, severely weathered bedrock appears to have been involved in the observed landslide features, which previously caused damage to the pipeline. The pipeline would be installed 60 to 110 feet below ground surface, which is below the zone of incompetent rock (i.e., upper 13 to 25 feet) that is most susceptible to slope failure. Slope stability analyses indicated that the potential for deep-seated landsliding (involving bedrock) to adversely affect the site improvements is low under static conditions (i.e., non-seismic) and low to moderate under seismic conditions. In addition, the potential for shallow-seated landsliding (under static and seismic conditions) to adversely affect the proposed site improvements is low (CE&G 2021c).

HDD can result in inadvertent drilling fluid return to the ground surface, which occurs when the fluid pressure is greater than the pressure of the surrounding ground. Topography with high relief, such as the steep slopes of the proposed alignment in the Brackney landslide area, carry higher risk of inadvertent fluid returns because there is less ground pressure resisting the fluid pressure in the horizontal direction. The closer the HDD borehole lies to the slope, the higher the risk of inadvertent returns on the slope face. For the proposed HDD option, the inadvertent fluid return risk is high, as the alignment is relatively close to the slope adjacent to the San Lorenzo River channel, considering the required drilling mud pressures and unknown underground flow paths that might be present. These flow paths could include permeable soils near the HDD exit location, highly fractured rock (e.g., the Ben Lomond Fault Zone), or open rock discontinuities (e.g., rock joints or bedding planes). Inadvertent fluid returns along the San Lorenzo River channel could erode soil and loose rock along the steep slopes. If erosion is substantial, slope destabilization could occur. While the risk of HDD operations triggering a landslide is not high, it may be possible (Mott MacDonald 2021a). As a result, impacts would be potentially significant. (See Section 4.9, Hydrology and Water Quality, Impact HYD-1 regarding HDD related water quality impacts.)

The Ben Lomond Fault traverses the pipeline alignment in the vicinity of the Brackney landslide (Figure 4.6-4). The rock in the vicinity of the fault may be fractured, potentially resulting in borehole instability. In addition, should the fault zone be clayey, it may act as an impermeable barrier that, when drilled through, produces larger groundwater flows into the borehole. Ground disturbance or loss around the pipeline could reach 10 to 30 feet radially from the pipeline alignment due to unstable ground conditions. The HDD alignment would be more than 30 feet from existing homes, at the closest point. A sinkhole could form at the ground surface where the HDD bore is not cased; primarily at relatively shallow pipeline locations at each end of the HDD borehole (Mott MacDonald 2021a). The HDD borehole jacking shaft, receiving shaft, and staging areas for the proposed HDD route would not be adjacent to an existing residence. Regardless, a sinkhole at either end of the HDD borehole, or at any point along the HDD route, would be considered a potentially significant impact due to unforeseen impacts to overlying roads, utilities, or private property.

Brackney South Section

South of Brackney Road in the Brackney South section, the depth to bedrock varies but is generally much greater than in the Brackney North section, estimated on the order of 30 feet, but may be greater in some locations. The potential exists for deeper-seated landslides through most or all the soil mass above the bedrock. These greater depths preclude the approach of installing a replacement pipeline in a deepened trench that extends into the bedrock or micro-tunneling that would require tunneling the pipeline on an order of 50 feet. through this area. For the area of potential landslides in the Brackney South section, incorporation of slope stability measures detailed in Section 3.6.2.3, Construction Methods in Brackney South section, would minimize the potential for slope failure. As a result, the Brackney South section of the northern segment would not result in potentially significant impacts related to unstable geologic units or soils. Impacts would be less than significant.

Southern Segment

The proposed trenchless construction method for installation of the pipeline under the Santa Cruz Big Trees & Pacific Railway Company railroad easement, as opposed to open cut methodology, would reduce the potential for long-term settlement beneath the railroad (Carollo Engineers 2021b). Several areas along the Graham Hill Road North section of the southern segment, including sections in the San Lorenzo Lumber Yard and Henry Cowell Redwoods State Park, are steeply sloped. There is a risk of leakage at segments that are steeply sloped due to high pressure from the injected material at the lowest end of the pipe segment. To reduce the risk of leakage during abandonment, the pipeline will be injected using specified design criteria (Carollo 2021a).

Potential slope stability impacts during trenching in the southern segment would be the same as that described for the northern segment. The structural design of the southern segment, included in the 30% drawings (Carollo Engineers 2021a), is based on recommendations in a project-specific geotechnical investigation report (by Crawford and Associates). The geotechnical report included 20 new borings and a review of previous boring data by Pacific Geotechnical Engineering. The southern segment would be constructed in accordance with provisions of the California Building Code and Cal/OSHA, under the supervision of a California Geotechnical Engineer and/or California Certified Engineering Geologist, thereby minimizing the potential for slope failure.

The open cut trenching portions of the southern segment would be completed on relatively flat to gently sloping topography. The proposed alignment would not traverse any known landslides or steep slopes that might be susceptible to failure if undercut by the trench. As previously discussed, steep creek banks would not be traversed, as the pipeline would be attached to an existing bridge and culvert crossing at creek crossings, thus eliminating the potential for creek bank failure. Following pipeline installation, the trench would be backfilled, and the soil compacted to prevent subsequent ground subsidence, collapse, or settlement.

As a result, construction and operation of the southern segment would not result in potentially significant impacts related to unstable geologic units or soils. Impacts would be less than significant.

Wildfire-Induced Debris Flows

Post-wildfire landslide hazards include fast-moving, highly destructive debris flows that can occur in the years immediately after wildfires in response to high intensity rainfall events accompanied by root decay and loss of soil strength. Post-fire debris flows are particularly hazardous because such flows can occur with little warning, can exert great impulsive loads on objects in their paths, and can strip vegetation, block drainages, damage structures, and endanger human life. Wildfires could also potentially result in the destabilization of pre-existing deep-seated landslides over long time periods (USGS 2021).

The 2020 C.Z.U. Lightning Complex Fire burned 86,000 acres, including large areas of Santa Cruz County. The burn areas are susceptible to debris flows in the event of an intense precipitation event. The County of Santa Cruz has prepared a debris flow map, delineating areas of potential debris flows in the burn areas. Based on this map, which covers the Proposed Project alignment, except for the southern approximate 0.5 mile of the southern segment, no debris flow hazards have been identified along the alignment (County of Santa Cruz 2021). Therefore, the NCP alignment would not be susceptible to impacts associated with debris flows. Impacts would be less than significant.

Mitigation Measures

Implementation of the Mitigation Measures GEO-1 and GEO-2 would reduce potentially significant impacts related to ground subsidence, soil collapse, erosion, and slope instability, as described above, to a less-than-significant level.

MM GEO-1: **HDD Geologic Monitoring (Applicable to Brackney North section).** A California Certified Engineering Geologist (CEG) or Registered Geotechnical Engineer (RGE) shall monitor horizontal directional drilling (HDD) operations for potential ground subsidence or soil collapse along the HDD alignment. In the event that ground subsidence or soil collapse is observed, HDD operations shall cease pending completion of remedial measures. Remedial measures shall include adjustments to drilling operations to preclude additional ground failure, as well as remedial measures to repair the area of ground failure.

MM GEO-2: **HDD Inadvertent Fluid Return Plan (Applicable to Brackney North section).** An inadvertent fluid return contingency plan shall be prepared and implemented, including measures for training, monitoring, worst-case scenario evaluation, equipment and materials, agency notification and prevention, containment, clean up, and disposal of released drilling mud. Site-specific contingency measures shall be developed for the proposed HDD alignment, taking into consideration terrain, access, resource sensitivities, and proximity of suitable areas for staging inadvertent fluid return equipment. Preventative measures would include incorporation of recommendations by a geotechnical engineer, based on geotechnical investigations, to determine the most appropriate drilling mud mixture and drilling pressures. Drilling pressures shall be closely monitored by a CEG or RGE such that those pressures do not exceed pressures required to penetrate the rock formation. Monitoring by a minimum of two monitors, which could include the CEG or RGE, shall occur throughout drilling operations to ensure swift response in the event of inadvertent fluid return. In the event of inadvertent fluid return and if containment becomes necessary, containment shall be accomplished through construction of temporary berms/dikes and use of silt fences, straw bales, absorbent pads, straw wattles, and plastic sheeting. Any required clean up shall be accomplished with plastic pales, shovels, and portable pumps. The inadvertent fluid return contingency plan shall be submitted to the City for review and approval.

Impact GEO-3: Expansive Soils (Significance Threshold D). The Proposed Project would potentially be located on expansive soil, as defined in the 2019 California Building Code, but would not create substantial direct or indirect risks to property. ***(Less than Significant)***

As previously discussed, the Project alignment is underlain primarily by Monterey Shale, Lompico Sandstone, and Santa Margarita Sandstone with overlying surficial deposits of alluvium, colluvium, topsoil, and fill. The overlying surficial deposits may locally be clay-rich and susceptible to soil expansion. Swelling and contracting of expansive soils within the proposed pipeline trench could result in damage to the pipeline. However, in accordance with provisions of the 2019 California Building Code, expansive soils would be identified either pre-construction or during construction, through standard geotechnical sampling and analysis. Remedial methods typically employed in areas of expansive soils includes placing the pipe on a bed of nonexpansive, granular sand; using chemical stabilization, such as a bed of lime; or stabilizing the soil with polymeric materials (i.e., geosynthetics). Utilizing these standard construction techniques would reduce the potential for expansive soils to damage the proposed pipeline. In addition, pipeline construction and operation would not cause or exacerbate the potential for soil expansion to occur. Therefore, the Proposed Project would have less-than-significant impacts related to expansive soils.

Mitigation Measures

As described above, the Proposed Project would not result in significant impacts related to expansive soils, and therefore, no mitigation measures are required.

Impact GEO-4: Paleontological Resources (Significance Threshold F). The Proposed Project could potentially directly or indirectly destroy a unique paleontological resource or site during construction. However, the Proposed Project would not directly or indirectly destroy a unique geological feature. ***(Less than Significant with Mitigation)***

As discussed above, the Proposed Project site is underlain by the middle Miocene Lompico Sandstone, middle to late Miocene Monterey Formation (or Monterey Shale), upper Miocene Santa Margarita Sandstone, and Quaternary alluvium and is not anticipated to be underlain by a unique geological feature. The Lompico Sandstone, Monterey Formation, and Santa Margarita Sandstone have produced scientifically significant fossils and are considered to have high paleontological resources sensitivity per the SVP (2010) mitigation guidelines. The LACM did not report any vertebrate fossil localities from within the Project site but did have nearby localities from the Santa Margarita Sandstone. In addition, a review of the paleontological literature indicated the Lompico Sandstone, Monterey Formation, and Santa Margarita Sandstone have yielded abundant invertebrate and vertebrate fossil remains in California.

Any significant grading, excavations, trenching, or augering that is below the depth of topsoil, if present, could potentially result in disturbance of paleontological resources. Such disturbance of paleontological resources during construction of the Proposed Project could result in significant impacts. Proposed Project pipe sections that are located within sensitive formations include:

- Northern segment: Newell Creek Road section, and portions of the Glen Arbor Road, Brackney North and Brackney South sections
- Southern segment: Graham Hill Road North section

The Proposed Project does not include grading, and the majority of the Proposed Project would not involve substantial excavation for installation of the new pipeline. The majority of the Proposed Project would be installed using conventional (open cut) trenching methods, except in the Brackney North and potentially Brackney South sections, as well as under the existing rail crossing in the Graham Hill Road North section, where trenchless methods would be used. Except as noted above, the Proposed Project generally would be constructed within existing road pavement, road right-of-way and/or existing City easements, primarily in areas that have been previously disturbed for road installation and maintenance. The standard pipeline construction trench would be approximately 4 to 5 feet wide with varying depths to avoid existing utilities under paved roadways, but generally would be a minimum of 5 feet deep.

Mitigation Measures

Implementation of the Mitigation Measures GEO-3 would reduce potentially significant impacts related to paleontological resources, as described above, to a less-than-significant level.

MM GEO-3: **Paleontological Resources Impact Mitigation Program and Paleontological Monitoring (Applicable to Newell Creek Road, Glen Arbor Road, Brackney North, Brackney South, and Graham Hill Road North sections).** Prior to commencement of any trenching activity on site, the City shall retain a qualified paleontologist per the Society of Vertebrate Paleontology (SVP) (2010) guidelines. The paleontologist shall prepare a Paleontological Resources Impact Mitigation Program (PRIMP) for the Proposed Project. The PRIMP shall be consistent with the SVP (2010 or most current version) guidelines and outline requirements for preconstruction meeting attendance and worker environmental awareness training; paleontological monitoring as required based on geological mapping, construction plans, and/or geotechnical reports; procedures for adequate paleontological monitoring and discoveries treatment; paleontological methods (including sediment sampling for microinvertebrate and microvertebrate fossils); reporting; and collections management. The qualified paleontologist shall attend the preconstruction meeting and a qualified paleontological monitor shall be on site during all trenching and other significant ground-disturbing activities (including augering) in previously undisturbed, Lompico Sandstone, Monterey Formation, and Santa Margarita Sandstone deposits, as defined by the PRIMP. In the event that paleontological resources (e.g., fossils) are unearthed during grading, the paleontological monitor will temporarily halt and/or divert grading activity to allow recovery of paleontological resources. The area of discovery will be roped off with a 50-foot radius buffer. Once documentation and collection of the find is completed, the monitor will allow grading to recommence in the area of the find.

4.6.3.4 Cumulative Impacts Analysis

This section provides an evaluation of cumulative geology and soils impacts associated with the Proposed Project and past, present, and reasonably foreseeable future Projects, as identified in Table 4.0-1 in Section

4.0, Introduction to Analysis, and as relevant to this topic. The geographic area considered in the cumulative analysis for geology, soils, and paleontological resources is generally the vicinity of the Project alignment.

The Proposed Project would not contribute to cumulative impacts related to earthquake fault rupture (Significance Threshold A-i) or septic tanks/alternative wastewater disposal (Significance Threshold E) because it would have no impacts related to these thresholds, as described above. Therefore, these significance thresholds are not further evaluated. Erosion-related cumulative impacts (Significance Threshold B) are addressed in Section 4.9, Hydrology and Water Quality.

Impact GEO-5: Cumulative Geologic Hazards (Significance Thresholds A-ii, A-iii, A-iv, C, and D). The Proposed Project, in combination with past, present, and reasonably foreseeable future development, would not result in a significant cumulative impact related to geology and soils. ***(Less than Significant)***

Known cumulative Projects planned within the vicinity of the Project alignment include the Santa Cruz Water Rights Project, Felton Diversion Pump Station Assessment, Newell Creek Dam Inlet/Outlet Replacement Project, GHWTP Tube Settlers Replacement Project, GHWTP Flocculator Rehab/Replacement Project, GHWTP Concrete Tanks Project, and GHWTP Facility Improvement Project. Projects that require discretionary approval are assumed to be designed or otherwise conditioned to avoid and minimize impacts to geology and soils. Furthermore, potential cumulative impacts on geological, seismic, and soil conditions would be reduced on a site-by-site basis by modern construction methods and compliance with California Building Code regulatory requirements that ensure building safety. Additionally, cumulative projects would be required to prepare and submit a site-specific geotechnical report for review and approval prior to the issuance of grading or building permits. Therefore, cumulative projects would not result in a significant cumulative impact related to geology and soils. Furthermore, as described in the analysis above, Proposed Project impacts would be localized and would not result in construction (including excavation or tunneling) or design features which could directly or indirectly contribute to an increase in a cumulative geological hazard. The Proposed Project would not cumulatively alter geological conditions or features.

Therefore, the Proposed Project, in combination with the past, present, and reasonably foreseeable future projects in the Project vicinity, would not result in significant cumulative impacts related to geological hazards.

Impact GEO-6: Cumulative Paleontological Resources Impacts (Significance Threshold F). The Proposed Project, in combination with past, present, and reasonably foreseeable future development, would not result in a significant cumulative impact related to paleontological resources. ***(Less than Significant)***

Potential cumulative impacts on paleontological resources could result from known or unknown Projects that combine to create an environment where fossils, exposed on the surface, are vulnerable to destruction by earthmoving equipment, looting by the public, and natural causes such as weathering and erosion. The majority of impacts to paleontological resources are site-specific and are therefore generally mitigated on a project-by-project basis. Additionally, as needed, projects would incorporate individual mitigation for site-specific geological units present on each individual Project site. Therefore, the Proposed Project, in combination with the past, present, and reasonably foreseeable future projects in the Project vicinity, would not result in a significant cumulative impacts to paleontological resources. Furthermore, the mitigation measures provided in this analysis are prescribed to preserve significant paleontological resources uncovered during Project excavations by proper analysis and salvaging by the on-site paleontological monitor.

4.6.4 References

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