July 29, 2022 File No.: 303659-001

Ms. Lacy Bourdet
P.O. Box 1378
Hollister, CA 95024

PROJECT: LANDS OF BOURDET –STOCK PONDS
PACHECO PASS HIGHWAY, APN 898-19-005
SANTA CLARA COUNTY, CALIFORNIA

SUBJECT: Qualitative Evaluation of Past Performance of Stock Pond Stability

Dear Ms. Bourdet:

In accordance with your request, we have prepared this qualitative evaluation of past performance of three stock ponds (Ponds 1, 2, and 3) at your property located off Pacheco Pass Highway, in Santa Clara County, California. Earth Systems previously prepared a Landslide Compilation Report, dated April 12, 2020, for select portions of your ranch property in response to County of Santa Clara Department of Planning and Development (County) concerns that ranch roads, stock ponds, and other structures might lie on existing landslides. The County provided comments to your Grading Abatement Application in their response letter dated October 26, 2021 and referenced the Earth Systems report therein. Comment No. 56 of the letter, prepared by the County Geologist, Mr. Jim Baker, requires "additional site-specific geotechnical evaluations" to support legalizing Ponds 1 and 2. The County geologist acknowledged Earth Systems previous recommendation that Pond 3 be removed because of erosion and instability related to construction of that pond. Based on our discussion with Mr. Baker, the County is looking for a *qualitative* evaluation of stability for Ponds 1 and 2, and is not requiring subsurface investigation or quantitative stability analysis of the pond embankments. As both ponds are located on large-scale ancient deep-seated landslide deposits, the County may require that the landowner sign an acknowledgement that residual risk exists that is higher than normal due to natural conditions beyond the practical limit of being addressed.

SCOPE OF SERVICES

The scope of work for our evaluation included review of our previous landslide compilation report, available geologic maps, review of aerial images, and a site reconnaissance by an engineering geologist. A seismic analysis of the site was also performed to assess the presence of faults and earthquakes that could have an impact on the site, including a review of earthquake fault maps, a computer search of past earthquakes within a 65-mile radius of the site, and an evaluation of past earthquakes and the proximity of earthquake epicenters to the site. As part of our scope, we sub-contracted to a GIS specialist to generate a LiDAR hillshade image and contour map of the area of Ponds 1 and 2 with a recent (2020) LiDAR data set and 2020 orthophoto overlay. These maps form the basis for our evaluation of Ponds 1 and 2, included herein. We also performed a site reconnaissance of Pond 3 to look for any changes in site conditions since our April 2020 report was prepared. Our map of Pond 3 and other selected graphics are excerpted from our 2020 landslide compilation report for reference.

This evaluation provides a qualitative assessment of past performance of stock ponds based primarily on evaluation of aerial photographs, historical topographic maps, site reconnaissance observations, and seismic analysis. Subsurface investigation of pond embankments or foundations, stability analysis, drainage evaluation, hydrology, and geotechnical engineering evaluation are not included in this scope of work.

This letter report was prepared in parallel with a Technical Memorandum (Tech Memo) prepared by the project hydrologist, GeomorphDesign, in which the potential for downslope flooding impacts resulting from breaching of Ponds 1 and 2 was evaluated. The findings of the Tech Memo are briefly summarized herein, and the Tech Memo is attached to this report.

Subsurface geotechnical engineering investigation, analyses of the soil for infiltration rates, mold or other microbial content, lead, asbestos, corrosion potential, radioisotopes, hydrocarbons, or other chemical properties are beyond the scope of work discussed herein.

SITE DESCRIPTION

The subject property is the Bourdet Ranch, a family-owned/operated cattle ranch located on the south side of the Pacheco Creek drainage and State Highway 152 (Pacheco Pass Highway), approximately 12 miles due east of the City of Gilroy, in Santa Clara County, California (Figure 1). The large-acreage property is situated in mountainous terrain flanking both sides of Harper Canyon, a tributary drainage which flows north into the Pacheco Creek valley. Elevations at the site range from approximately 300 feet above mean sea level (MSL) on the Pacheco Creek valley floor to 2,770 feet above MSL at the top of Pacheco Peak on the eastern side of the property. A well-maintained dirt and gravel road traverses mountain slopes between the mouth of Harper Canyon and Pacheco Peak, providing access to antenna arrays on the summit of the peak. Ponds 1, 2, and 3 addressed in this study are accessed from this gravel road (Figures 1 and 2).

LITERATURE REVIEW

Geologic Setting

Based on Dibblee, et al (2007; Figure 2)[1], most of the site is underlain by graywacke sandstone (fs) of the Jurassic-Cretaceous Franciscan Assemblage. The graywacke sandstone is described as "gray, hard, massive to bedded, fine to medium grained, with thin layers of gray siltstone-claystone". Two smaller areas of Franciscan Assemblage mélange (fm) are mapped on west-facing slopes above Harper Canyon. The mélange is described as "fragments of sandstone, chert, and greenstone in a pervasively sheared matrix of dark-gray gougy claystone and graywacke". Tertiary marine sandstone (Tms) is mapped on the north and northwest flank of Pacheco Peak. Pacheco Peak is composed of Miocene andesite of the Quien Sabe Volcanics (Tva). Dibblee maps two large-scale Quaternary landslide complexes on west-facing slopes between Pacheco Peak and Harper Canyon. Ponds 1, 2, and 3 are located on these landslide complexes.

Landslide Setting

Nilsen[2] prepared a preliminary photointerpretation map of landslide deposits for the Pacheco Peak 7.5-minute map quadrangle covering the northern portion of the property, including the areas of the three ponds. The map was prepared by review and analysis of stereo-pairs of aerial photographs, which provides a 3-dimensional view of the ground surface via stereographic projection. Geomorphology associated with landslides, such as hummocky topography, arcuate scarps, and concave/convex landforms can be easily recognized using this method. The mapping by Nilsen shows large areas of mountain-scale, deep-seated landslides on west-facing slopes between Pacheco Peak and Harper Canyon (Figure 3). Ponds 1, 2, and 3 are located on these deep-seated landslide complexes. As noted in our landslide compilation report (ESP, 2020), the

[1] Dibblee, T.W., and Minch, J.A., 2007, Geologic map of the Pacheco Peak quadrangle, Santa Clara County, California: Dibblee Geological Foundation, Dibblee Foundation Map DF-337, scale 1:24,000.

[2] Nilsen, T.H., 1975, Preliminary photointerpretation map of landslide and other surficial deposits of the Pacheco Peak 7½ minute quadrangle, Santa Clara County, California: U.S. Geological Survey Open File Map 75-277-44, scale 1:24,000.

deep-seated landslides exhibit muted contours, such as rounded scarps and toes, suggesting that the landslides are old. None of the large-scale landslides showed evidence of recent activity. The deep-seated landslides likely occurred during the Pleistocene (more than 11,000 years ago) during wetter climes, as is widely recognized in the Coast Ranges province of Central California.

REVIEW OF AERIAL PHOTOGRAPHS AND HISTORICAL TOPOGRAPHIC MAPS

Earth Systems reviewed aerial photographs and historical topographic maps covering the site to establish the age of the ponds, and to the extent possible, evaluate the history, condition, and past performance of the ponds since their construction. We also reviewed the photographs for signs of instability not readily apparent at the ground surface. The results of our aerial photograph and map review are presented below in chronological order. Photo and map reference citations are included in brackets at the end of each description.

1939

Neither Pond 1 or Pond 2 are present in the photos. The access road to Pacheco Peak is present in generally the same configuration as present day. [Photos: 10-21-39; CIV 295-50,-51; 1:20,000; B&W]

1955

Pond 1 is not present; Pond 2 is portrayed on the map. [Map: USGS Pacheco Peak 7.5-minute quadrangle, 1955, photorevised 1971]

1956

Pond 1 has yet to be constructed. A dark tonal area is present in the swale axis, possibly a sign of green vegetation in contrast with dry grass of surrounding terrain. Pond 2 is present; the embankment appears narrower than present day. [Photos: 6-8-56; CIV-4R-90,-91; 1:20,000; B&W]

1963

Pond 1 has yet to be constructed. A dark tonal area in the swale axis may be a sign of green vegetation contrasting with dry grass of surrounding terrain. Pond 2 is present in the same configuration as 1956. [Photos: 7-15-63; SCL 2-59, -60; 1:20,000; B&W]

1965

Conditions are the same as in the 1963 photos above. The large scale photos provide a high resolution view of the terrain. No landslide features (such as scarps, toes, hummocky terrain, etc) are present in the swale occupied by Pond 1. Rather, a diffuse, radial network of small drainages converge from surrounding slopes in the wide, bowl-shaped swale. Pond 2 is unchanged. [Photos: 6-10-65; SCL 36-27,-28; 1:12,000, B&W]

1971

Pond 1 is not present; Pond 2 is portrayed on the map. [Map: USGS Pacheco Peak 7.5-minute quadrangle, 1955, photorevised 1971]

1978

Pond 1 is not present; Pond 2 is portrayed on the map. [Map: USGS Pacheco Peak 7.5-minute quadrangle, 1955, photorevised 1971, photoinspected 1978]

1984

Pond 1 is visible in very low-resolution, small-scale imagery, documenting the first appearance of Pond 1 in aerial imagery we reviewed. Pond 2 is also present. [Photo: 12/30/1984, Google Earth, color]

1998

Pond 1 is shown in good detail. The graded dirt road (ramp) ascending native slopes to the west end of the pond embankment has yet to be graded. Pond 2 is unchanged. [Photo: 8/16/1998, Google Earth, B&W]

2003

Pond 1 is unchanged from previous photos. Green grass is present in the broad swale between the embankment and the road in contrast with brown grass of surrounding hillsides. Pond 2 is unchanged. Both ponds appear to be at near full capacity [Photo: 6/3/2003, Google Earth, color]

2004

Conditions appear unchanged from 2003. [Photo: 6/30/2004, Google Earth, color]

2005

Pond 1 appears to be close to capacity in high-resolution photograph. Green grass is present in the broad swale between the embankment and the road in contrast with brown grass of surrounding hillsides. Pond 2 is unchanged and appears to be at near full capacity. No signs of erosion or instability are evident at either pond [Photo: 6/11/2005, Google Earth, color]

2008

Conditions appear unchanged from 2005 at both ponds [Photo: 5/11/2008, Google Earth, color]

2009

Conditions appear unchanged from 2008 at both ponds [Photo: 6/17/2009, Google Earth, B&W] Both ponds are dry later in the year [9/29/2009, Google Earth, color]

2010

Pond 1 appears to be at half capacity or less. A narrow path appears to ascend the west edge of the pond embankment at the native hillside. Conditions at Pond 1 are otherwise unchanged. Pond 2 is present in the same configuration as the present day and appears to be at ¾ capacity [4/24/2010, Google Earth, color]

2012

Conditions are generally unchanged from 2010 at both ponds. [5/5/2012, Google Earth, color]

2013

The pond embankments have been freshly graded at both ponds. At Pond 1, the embankment has been widened with what appears to be side cast fill, advancing the outboard toe of the embankment by as much as 10 feet to the south, as roughly measured in Google Earth. The crest of the embankment appears to be in the same location. It is unclear in the photo if the crest elevation was raised. The inboard slopes of the pond embankment and native slopes on the west, north, and east sides of the pond appear to have been bladed/dressed. Additional fill was added at the east end of the pond embankment, filling in the corner between the outboard side of the embankment and the adjacent native hillside. No signs of a local borrow area for the fill materials are present. A diversion ditch has been cut across the hillside between the eastern end of the S-curve in the main access road to the east end of the pond embankment, diverting runoff from the edge of the road into the pond. [3/20/2013, Google Earth, color]

At Pond 2, the embankment has been widened with additional fill materials, advancing the outboard toe of the embankment by as much as 45 feet to the southwest, as roughly measured in Google Earth. The crest of the embankment was also widened to the south but does not appear to have been raised. Inboard slopes of the embankment and native slopes on the west and east sides of the pond have been bladed. The pond outlet on the east side of the pond has also been bladed. No signs of a local borrow area for the fill material are present. [3/20/2013, Google Earth, color]

2015

At Pond 1, additional fresh grading is evident in the photograph. Additional side-cast fill has been added to the south face of the western third of the pond embankment, advancing the toe of the embankment southward by as much as 10 feet at the western end. The inboard slopes of the embankment and the pond outlet appear to have been bladed/dressed. A ramp has been graded into the native hillside at the west end of the embankment to access the top of the embankment. No additional grading is evident at Pond 2. Vegetation is present on the fill added in 2013. [4/12/2015, Google Earth, color]

2017

Pond 1 appears to be at full capacity, with the waterline at the outlet elevation. Extensive rilling (gullying) is present in the side-cast fills added to the front face of the pond embankment in 2013 and 2015. The rilling is restricted to these recent fills and does not encroach onto the crest of the embankment. Pond 2 also appears to be at full capacity, with the waterline at the outlet elevation. [3/13/2017, Google Earth, color]

2018

Conditions are generally unchanged from 2017 at both Ponds 1 and 2. Ponds are below full capacity, with the waterline below the outlet elevation. [3/28/2018, Google Earth, color]
Water levels have dropped in both ponds later in the year. [9/20/2018, Google Earth, color]

2020

Conditions are generally unchanged from 2018 at both Ponds 1 and 2. [9/25/2020, Google Earth, color]

Based on our review of aerial photographs and historical topographic maps, Pond 1 appears to have been constructed between 1978 and 1984. Based on personal communication with the property owner, Pond 1 was constructed in 1980. Pond 2 appears to have been constructed between 1939 and 1955. We did not observe any signs of instability at the Pond 1 or Pond 2 embankments in the aerial photographs we reviewed. The placement of additional fill material to the front face of each embankment in the 2013-2015 timeframe are the only major changes to the pond embankments noted in our review of the aerial photographs.

SITE RECONNAISSANCE

On July 22, 2022, an Earth Systems geologist performed a site reconnaissance of Ponds 1 and 2. We used a topographic map derived from a 2020 LiDAR data set with a 2020 aerial othophoto base to map our field findings. We also re-visited Pond 3 to look for any changes that have occurred since our previous visit in February 2020. A summary of our reconnaissance is presented below, and mapping of our field findings is presented on Figures 4 and 5.

<u>Pond 1</u>

The Pond 1 embankment spans approximately 380 feet across a broad swale with a relatively flat floor. The embankment is approximately 16 feet high at the western end and approximately 10 feet high at the eastern end based on the 2020 LiDAR elevations, measured from the outboard toe to the crest. The outboard (south) face of the embankment is inclined between 32 and 34 degrees. The crest elevation ranges from 736 to 740 feet. An outlet is graded into a pre-existing topographic saddle at the west end of the pond. The outlet elevation is approximately 733 feet (interpolated between the 732 and 734 elevation contours). The 732 elevation contour is traced in blue on Figure 4 to illustrate the approximate maximum impoundment elevation of the pond.

The pond embankment materials consist of clayey gravels composed of the same Franciscan Assemblage shale and sandstone lithologies observed in outcrops and road cut exposures across the greater ranch property. Rilling (erosion) observed in the 2017 photos is present along the front face of the embankment and is most pronounced in the western half. Rilling channels are up to 2 feet deep and 1-3 feet across. The rilling extends only a few feet northward into the crest of the embankment and appears to be restricted to the side-cast fills placed in 2013 and 2015. The top of the embankment in this area slopes gently to the south. As such, we interpret the rilling to be caused by precipitation runoff from the wide crest of the embankment flowing southward onto the front face during the wet winter of 2017. The rilling could not have been caused by overtopping of the embankment, as the outlet elevation (733 feet) is at least 3 feet lower than the crest (736 feet). No signs of leakage were observed on the front face of the pond embankment or on the native ground surface in front of it. The relatively flat to gently inclined floor of the swale to the south of the embankment shows not signs of erosion or channeling, and no established drainage channel was observed. No adverse signs of erosion were observed associated with the outlet.

Few outcrops are present on slopes adjacent to Pond 1. Smooth contoured slopes of adjacent terrain appear to be mantled by colluvial soils, with random large blocks of hard, resistant sandstone outcropping across the landscape, as is typical of Franciscan Assemblage mélange. As noted in our 2020 report, Pond 1 appears to have been constructed on ancient landslide debris composed of Franciscan Assemblage sandstone, shale, and mélange. We do not have any information regarding how the embankment was constructed.

The diversion channel identified in the 2013 photos that conveys runoff from the eastern end of the S-curve in the road into the pond is still present. The channel ranges from 2 feet deep near the road to 5 feet deep at the northern end and is approximately 3 to 5 feet wide. The channel is incised into highly variable Franciscan Assemblage mélange composed of sheared sandstone and shale with hard boulder size blocks of more competent rock, all of which is mapped as ancient landslide debris. Slope failures were observed in the east channel wall. The channel skirts the east end of the pond embankment, and embankment fill may be exposed in the west channel wall at this location.

Pond 2

The Pond 2 embankment spans approximately 300 feet, measured at the outboard toe of the embankment. The Pond 2 embankment appears to have been constructed across a broad, gently-inclined swale with a natural v-shaped channel incised in the middle. The embankment is approximately 14 feet high in the middle, and 6 to 10 feet high at either end based on the 2020 LiDAR elevations, measured from the outboard toe to the crest. The outboard (south) face of the embankment is inclined between 31 and 34 degrees. The crest elevation ranges from 1,244 to

1,246 feet. An outlet approximately 10 feet wide and 1 to 2 feet deep is graded across flat ground around the east end of the embankment. The outlet elevation is approximately 1,240 feet. The 1,240 foot elevation contour is traced in blue on Figure 5 to illustrate the approximate maximum impoundment elevation of the pond. The outlet conveys water into a pre-existing (natural) incised drainage parallel to the one that was dammed to form the pond. The drainage at this point is well armored with massive outcropping of hard rock, and no adverse signs of erosion were observed associated with the outlet.

The pond embankment materials consist of clayey gravels composed of the same Franciscan Assemblage shale and sandstone lithologies observed in outcrops and road cut exposures across the greater ranch property. Minor rilling (erosion) was observed on the front face of the side-cast fills placed in 2013 and does not encroach onto the wide crest of the embankment. Small, rounded mounds of soil at the base of the embankment suggest that minor slumping of the fills occurred, likely during the rainy winter of 2017. The top of the embankment is generally flat. No signs of leakage were observed on the front face of the pond embankment, on the native ground surface in front of it, or in the original v-shaped drainage channel. We did not observe any signs of instability on or adjacent to the Pond 2 embankment. Several mature oak trees are growing on the eastern portion of the embankment. Two of the trees, located on the outboard side of the embankment, have fallen. The downed trees to not appear to have adversely impacted the embankment.

As with Pond 1, few outcrops are present on surrounding slopes adjacent to Pond 2. Smooth, rounded, and hummocky slopes of adjacent terrain appear to be mantled by colluvial soils, with random large blocks of hard, resistant sandstone outcropping across the landscape, as is typical of Franciscan Assemblage mélange. As noted above, large blocks of hard bedrock up to tens of feet across are present within and adjacent to the natural drainage that now accepts overflow from the pond outlet. As noted in our 2020 report, Pond 2 appears to have been constructed on ancient landslide debris composed of Franciscan Assemblage mélange. We do not have any information regarding how the embankment was constructed.

Pond 3

On July 22, 2022 we also re-visited Pond 3 to look for any changes that have occurred since our previous visit in February 2020. Our 2020 mapping of the Pond 3 area is included for reference (Figure 6).

The erosional gully downslope of the outlet appears to have widened and deepened. The slope above the confluence of the gully with the original drainage shows signs of incipient landsliding. Likewise, the active landslide (Als) that developed upslope (north) of the pond outlet appears to have enlarged and advanced further north toward the access road. Part of the landslide mass was wet, and a section of orange 3-inch pipe was exposed within the landslide mass. The small active landslide (Als) on the north bank of the drainage at the toe of the pond embankment has enlarged and is seeping water. This landslide is beginning to undermine the pond embankment.

FAULTING

The subject site is located within the seismically active San Francisco Bay region. Several active and potentially active faults have been identified in this region. Until recently, faults were historically described by the California Geological Survey (CGS) as “active” and “potentially active”. As of 2018 (CGS, 2018), the CGS no longer uses the terms “Active” and “Potentially active” to describe faults. Faults are now described as “Holocene-active” for faults having activity within the last 11,700 years; “Pre-Holocene” for faults which have not been active within the last 11,700 years (Pre-Holocene faults may still have potential for rupture but are not regulated by the Alquist-Priolo Act); and “Age-undetermined” is used for faults where timing of last rupture is unknown. However, within Alquist-Priolo Earthquake Fault Zones age undetermined faults are considered active unless data can be obtained to demonstrate otherwise.

No faults are mapped passing through or nearby either of the ponds. The closest Holocene-active fault to Pond 1 is the Quien Sabe fault, located approximately 6.0 miles to the southwest. According to the Third California Earthquake Rupture Forecast (UCERF3, USGS 2013), the Quien Sabe fault is capable of generating a magnitude M6.5 earthquake. The next closest Holocene-active faults are the Calaveras (south) and Ortigalita (south) faults, located approximately 8.1 miles southwest, and 10.3 miles northeast, respectively. The Calaveras (south) fault is capable of generating a M6.0 earthquake and the Ortigalita (south) fault is capable of generating a M6.9

earthquake. The active San Andreas fault (Santa Cruz Mountains section) is located approximately 16.4 miles southwest of Pond 1 and is capable of generating a M7.6 earthquake. The locations of these and other faults of the San Andreas fault system relative to the site are shown on a Regional Faults and Earthquakes map (Figure 7). The earthquake locations are keyed to the Selected Earthquakes table (Figure 8).

EARTHQUAKE HISTORY

The historic earthquakes in the site region were researched using the Northern California Earthquake Data Center Catalogs (NCEDC 2014, accessed 2022). The parameters used for the search consisted of earthquake Richter magnitudes ranging from 5.0 to 9.0 that occurred within a 65-mile radius from Pond 1 from 1939 to 2020. Results are assumed to be the same for Pond 2, which is located only 2,900 feet east of Pond 1. The results of the search indicated that within the search parameters, 36 earthquakes have occurred. Of these earthquakes, 22 occurred during or after 1980, when Pond 2 is thought to have been constructed. Some of the nearby earthquakes are shown on the Regional Fault and Earthquakes Map (Figure 7). The largest earthquake had a 6.9 magnitude and occurred in 1989 (Loma Prieta earthquake). It was estimated to be located approximately 31 miles west of the site. The nearest large magnitude (M5.1) earthquake occurred in 1993 and was located approximately 7.6 miles to the west-northwest of the site in the foothills east of Gilroy. The Coyote Lake earthquake (M5.9, 1979) was located approximately 12 miles northwest of the site and is likely to have generated strong ground shaking at Pond 2 (Pond 1 was constructed the following year). The Morgan Hill earthquake (M6.2, 1984) was located approximately 28 miles northwest of the site and is likely to have generated strong ground shaking at both ponds. In general, both ponds have likely been subjected to strong ground shaking from multiple large earthquakes during their respective lifetimes.

DAM BREACH MODELING

This letter report was prepared in parallel with a Technical Memorandum (Tech Memo) prepared by the project hydrologist, GeomorphDesign, in which the potential for downslope flooding impacts resulting from breaching of Ponds 1 and 2 was evaluated. The memo was prepared to evaluate risk to downstream infrastructure should the ponds fail. The findings of the Tech Memo are briefly summarized below, and the Tech Memo is attached to this report.

GeomorphDesign modeled three scenarios in which the Pond 1 and Pond 2 dams were breached. The 1st scenario assumed only Pond 1 would breach. The 2nd scenario assumed only Pond 2 would breach. The 3rd scenario assumed that both Ponds 1 and 2 would breach simultaneously. Peak discharges were modeled at four points in the Harper Canyon drainage: Culvert #3, Culvert #6, the bridge, and the downstream property boundary. As shown in the Tech Memo, the two culverts convey water from tributary drainages hosting Ponds 1 and 2 beneath the main road in Harper Canyon before reaching the creek in Harper Canyon. The bridge spans the creek in Harper Canyon. Peak flows were compared to the "Rainfall Runoff 100 Year Flow". Inundation maps for each scenario are included in the Tech Memo.

GeomorphDesign concluded that breaching of Pond 1 or Pond 2 would cause peak flows exceeding normal 100-year runoff at Culverts #3 and #6, respectively. Individual or simultaneous combined pond dam breaching would not cause peak flows approaching the 100-year peak flow at the bridge or the downstream property line. Breaching of Pond 1 would overflow Culvert #3, likely significantly damaging the roadway. Breaching of Pond 2 would be likely to overflow the road at Culvert #6, and minor road damage could result. None of the dam breach scenarios would produce peak flows approaching more than about 50-60% of the normal rainfall-runoff 100-year peak flows at the bridge or downstream boundary, and potential dam breach flows would be fully contained in the channel at those locations. Simultaneous breaching of both ponds would not increase the peak discharges at the bridge or downstream boundary because the much larger flood peak from Pond 1 would arrive earlier than the much smaller flood peak from Pond #2 at those locations.

Based on the findings of the Tech Memo, impacts to downstream infrastructure would be limited to damage to the roadway and culverts at the Culvert #3 and Culvert #6 locations. While not noted in the Tech Memo, the inundation mapping included therein shows that breaching of either pond would inundate the gravel access road that ascends the eastern slopes of Harper Canyon.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our qualitative evaluation discussed above, we present the following conclusions and recommendations regarding Ponds 1, 2, and 3.

Pond 1

Based on review of aerial photographs and historical topographic maps, Pond 1 appears to have been constructed between 1978 and 1982. According to the property owner, it was constructed in 1980. No signs of instability of the pond embankment were observed in the aerial photographs we reviewed, or during our site reconnaissance. Likewise, no signs of leakage in the embankment, abutment, or foundation areas were observed. The pond embankment appears to have remained stable during multiple large magnitude earthquakes during its lifespan. As observed in aerial photographs, the embankment was enlarged southward by placement of side-cast fills on the front face of the embankment in 2013 and again in 2015. Rilling (erosion) of the new fills appears to have occurred during the wet winter of 2017. The rilling likely occurred due to runoff from the wide crest of the embankment onto the loose fills and was not caused by overtopping. The rilling appears to be restricted to the 2013/2015 fill materials and does not appear to encroach onto the main crest of the embankment. In our opinion, the addition of side-cast fills does not present an adverse condition to stability of the embankment. No adverse conditions associated with the pond outlet were observed.

The diversion channel that conveys runoff from the eastern end of the S-curve in the road into the pond appears to skirt the east end of the pond embankment, and embankment fill may be exposed in the west channel wall at this location. As such, it is our opinion that the diversion channel could erode the pond embankment and therefore presents a hazard to long-term stability of the pond. We recommend that the channel be removed and the hillside restored.

Pond 2

Based on review of aerial photographs and historical topographic maps, Pond 2 appears to have been constructed between 1939 and 1955. No signs of instability of the pond embankment were observed in the aerial photographs we reviewed, or during our site reconnaissance. Likewise, no signs of leakage in the embankment, abutment, or foundation areas were observed. The pond embankment appears to have remained stable during multiple large magnitude earthquakes during its lifespan. As observed in aerial photographs, the embankment was expanded to the southwest by placement of side-cast fills on the front face of the embankment in 2013. Minor rilling (erosion) was observed on the front face of the side-cast fills placed in 2013 and does not encroach onto the wide crest of the embankment. Small, rounded mounds of gravel and soil at the base of the embankment suggest that minor slumping of the fills occurred, likely during the rainy winter of 2017. The erosion appears to be restricted to the 2013 fill materials and does not appear to encroach onto the main crest of the embankment. In our opinion, the addition of side-cast fills does not present an adverse condition to stability of the embankment. No adverse conditions associated with the pond outlet were observed.

Pond 3

As noted during our July 22, 2022 reconnaissance, erosion and landsliding in the area of Pond 3 has continued to expand since our April 2020 report was prepared. Active landslides threaten the pond embankment and the access road. As such we maintain our previous recommendation that Pond 3 be removed.

Summary

Based solely on past performance of the Pond 1 and Pond 2 embankments in a seismically active region with a history of multiple large earthquakes, it is likely that the ponds will remain stable in their present condition under similar conditions in the future, provided the recommendations in this report are followed. As noted in the Tech Memo by GeomorphDesign, impacts to downstream infrastructure in the event of dam breaching at Ponds 1 and 2 would be limited to roadway and culvert damage.

It is important to note that our conclusions are based on a *qualitative* assessment, and our evaluation does not constitute a true measure of stability of the ponds. If a quantitative evaluation of long-term stability is required, we recommend that subsurface exploration and quantitative stability modeling of the pond embankment and foundation materials be performed.

Closure

This report is valid for conditions as they exist at this time for the type of project described herein. Our intent was to perform this qualitative evaluation in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in the locality of this project under similar conditions. No representation, warranty, or guarantee is either expressed or implied. This report is intended for the exclusive use by the client for the subject site. Application beyond the stated intent is strictly at the user's risk.

We appreciate the opportunity to have been of service. Please feel free to contact us at your convenience if you have any questions or require additional information.

Sincerely,

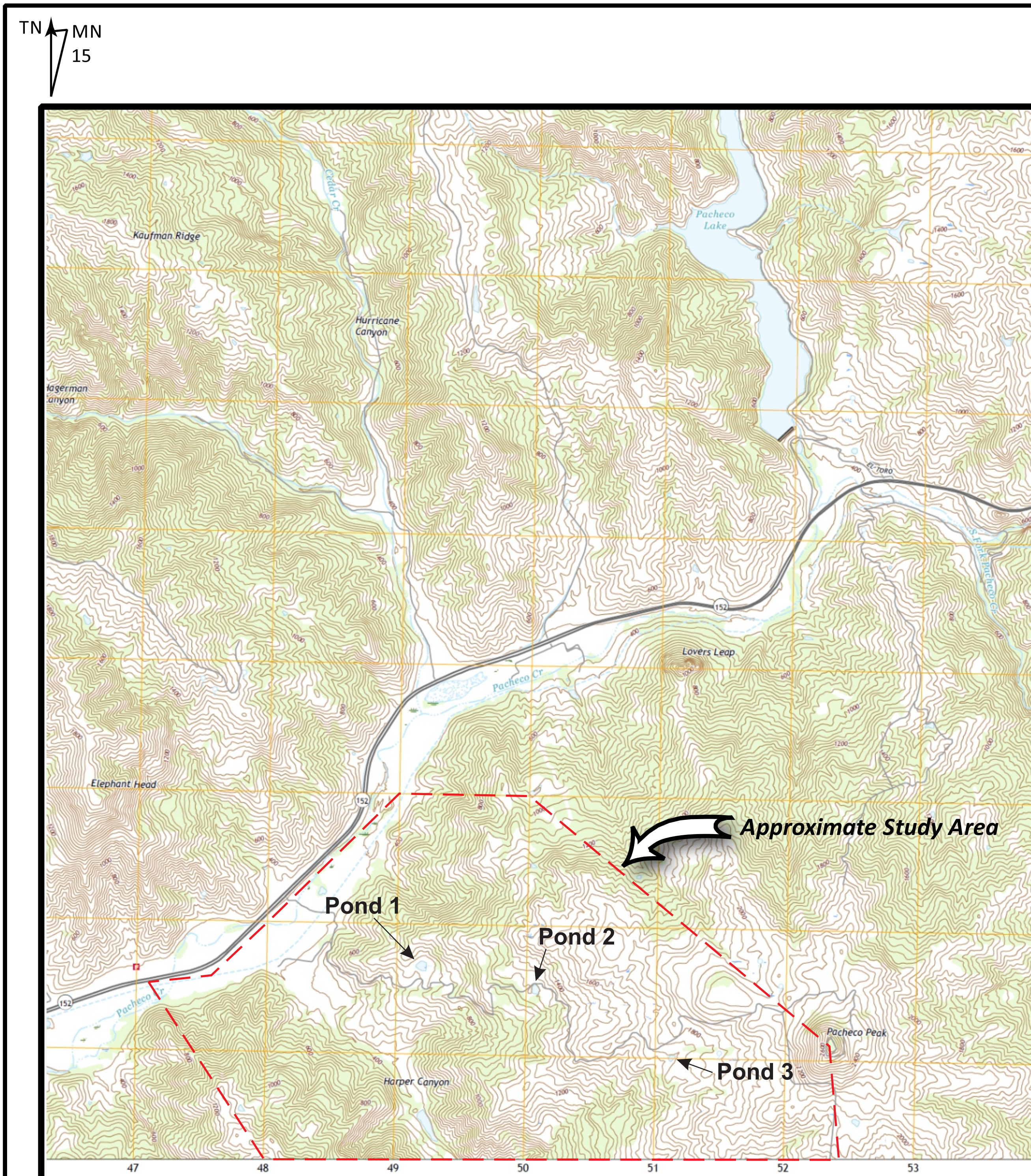
Earth Systems Pacific

PROFESSIONAL GEOLOGIST
JOHN A. FELTMAN
No. 2530
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

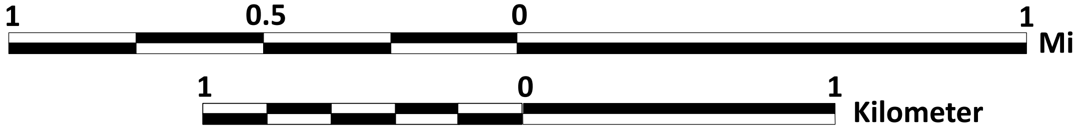
John Feltman, CEG 2530
Engineering Geologist

Attachments:
- Figure 1 – Site Location Map
- Figure 2 – Regional Geologic Map
- Figure 3 – Regional Landslide Map
- Figure 4 – Geologic Map – Pond 1
- Figure 5 – Geologic Map – Pond 2
- Figure 6 – Landslide Map – Pond 3
- Figure 7 – Regional Faults and Earthquakes
- Figure 8 – Selected Earthquakes
- GeomorphDesign Tech Memo #4 – Harper Canyon Watershed Pond Breach Modeling

Figure 1



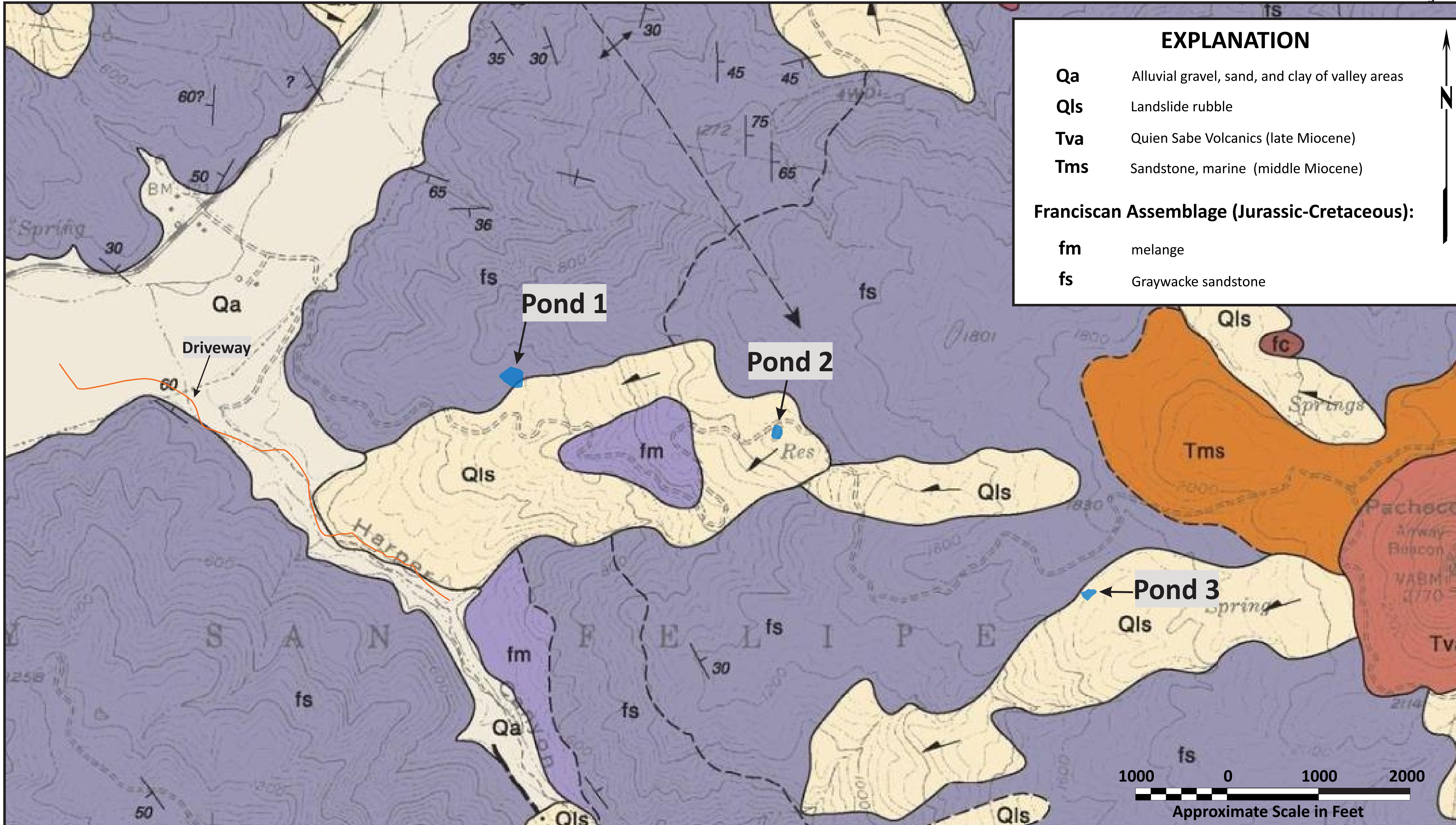
Approximate Scale 1: 24,000



Base: USGS 7.5 Minute Series, Pacheco Peak (2018)

Earth Systems Pacific	Lands of Bourdet Pacheco Pass Highway Santa Clara County, California	Site Location Map 303659-001

Figure 2



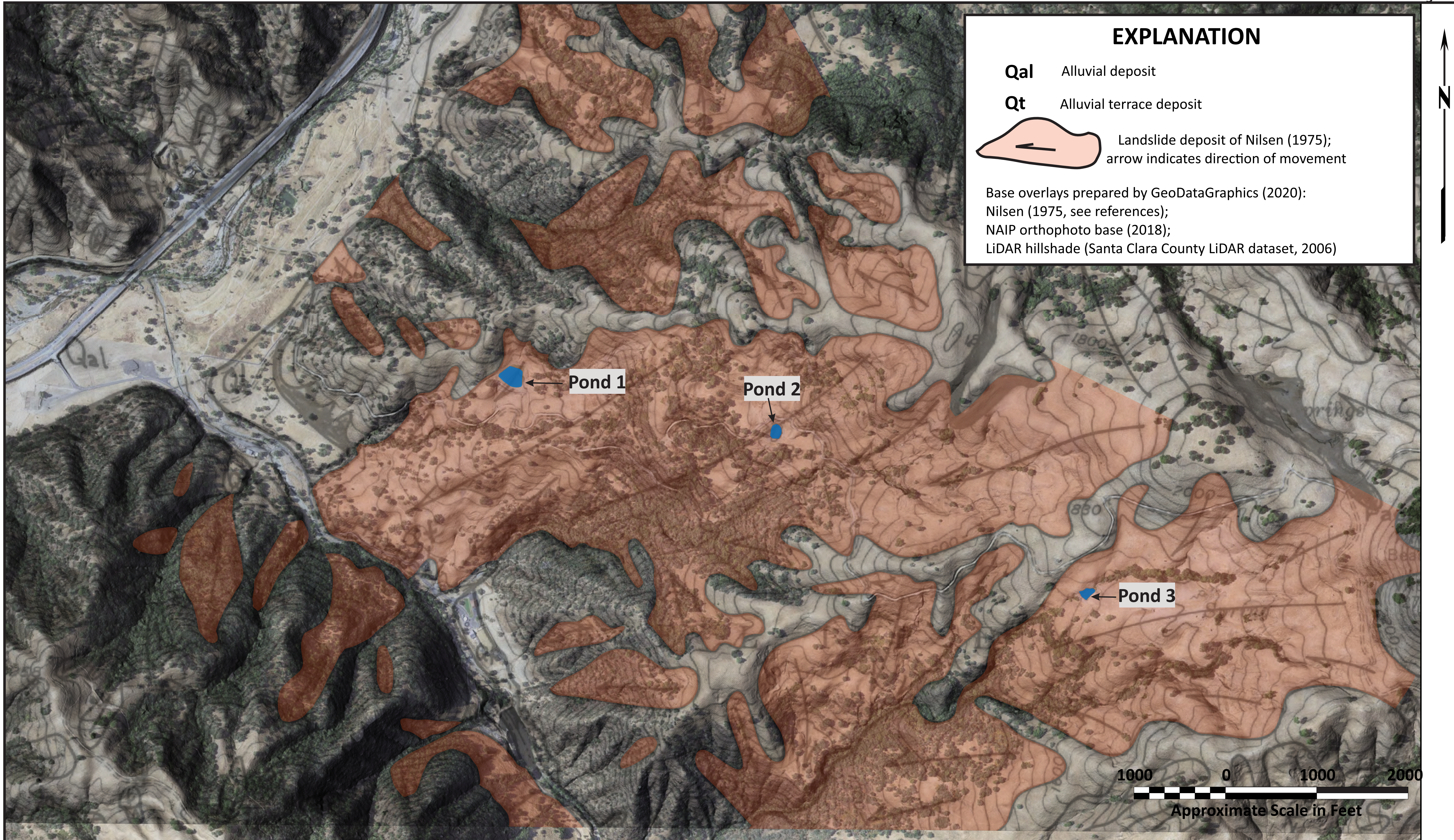
Earth Systems Pacific

Lands of Bourdet
Pacheco Pass Highway
Santa Clara County, California

Regional Geologic Map

303659-001

Figure 3

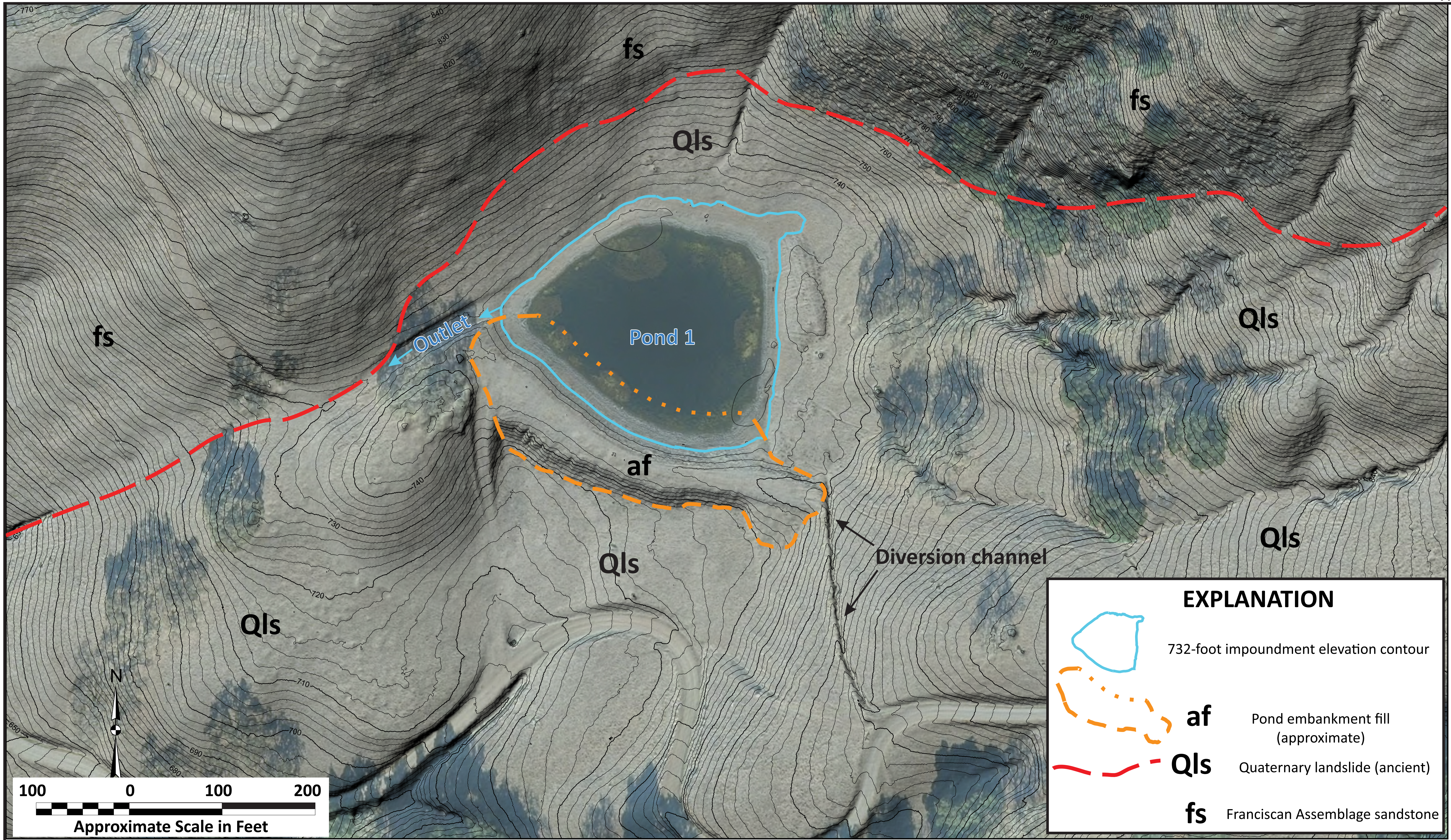


Earth Systems Pacific

Lands of Bourdet
Pacheco Pass Highway
Santa Clara County, California

Regional Landslide Map

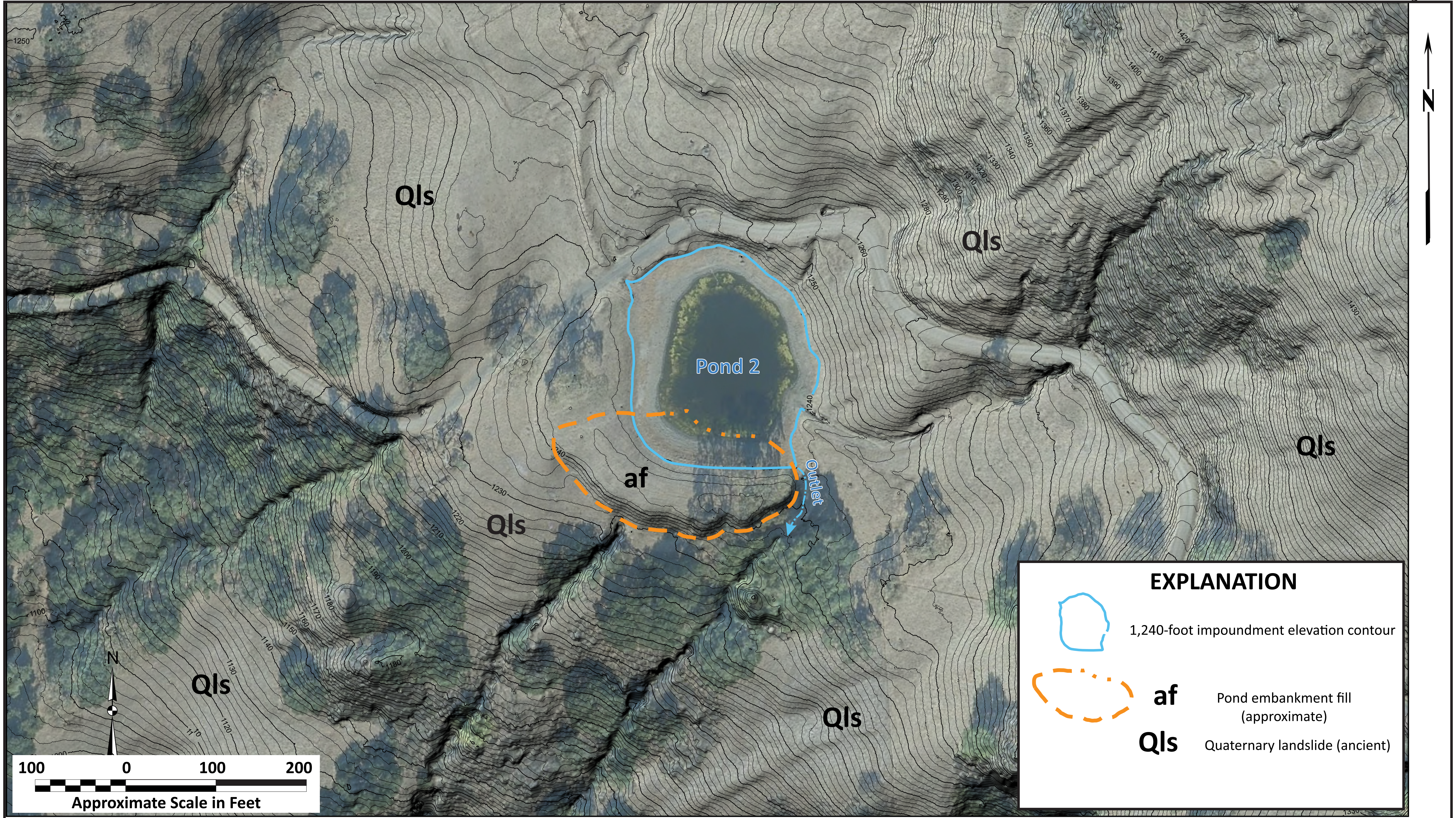
303659-001



Base Map: Lidar derived contours and hillshade from U.S. Geological Survey, USGS_LPC_CA_SantaClaraCounty_2020_A20_32008275 dated 4/3/2020 - 4/22/2020. Aerial photograph dated 12/2020

Earth Systems Pacific	Lands of Bourdet Pacheco Pass Highway Santa Clara County, California	Geologic Map - Pond 1 303659-001

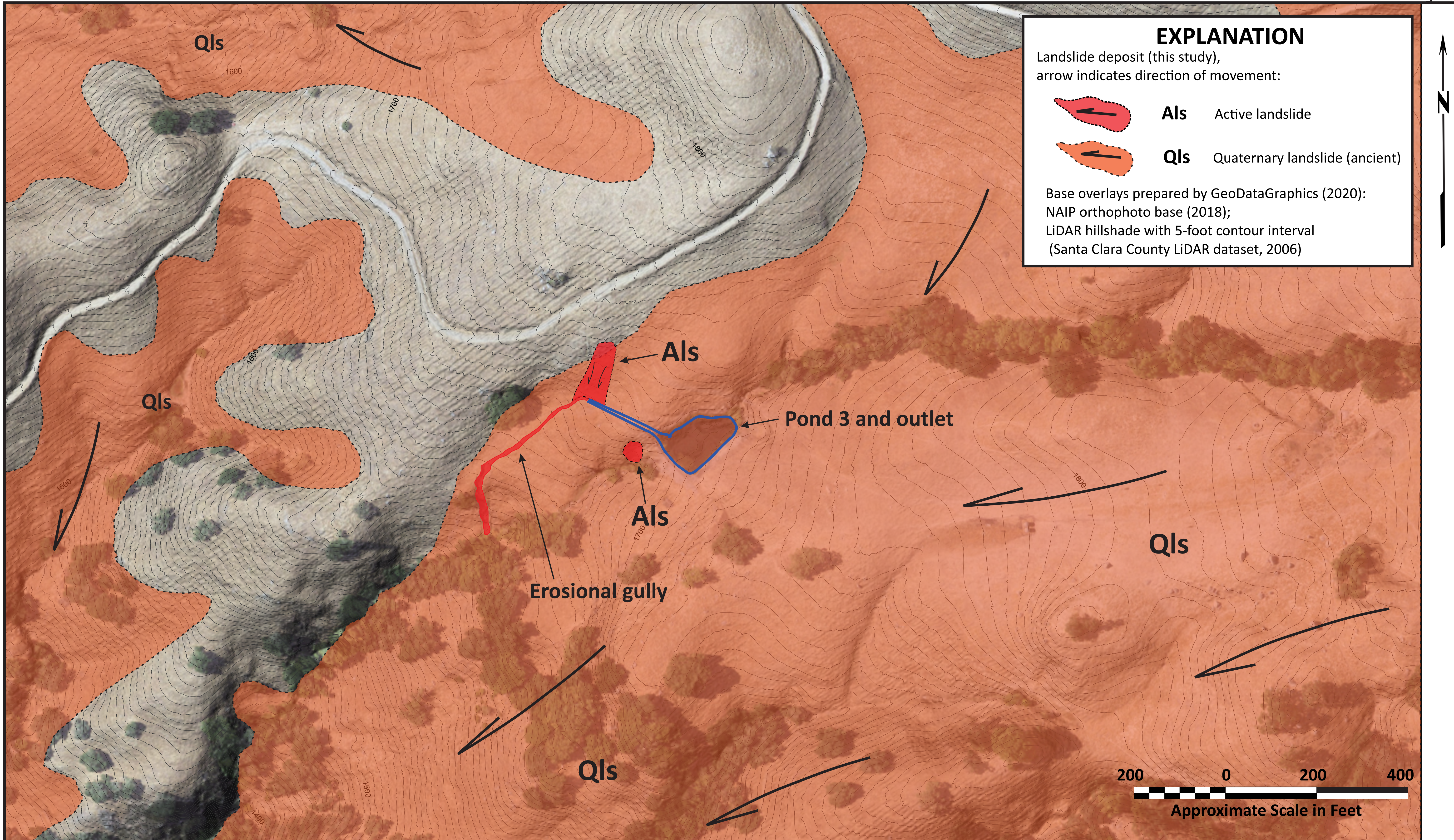
Figure 5



Base Map: Lidar derived contours and hillshade from U.S. Geological Survey, USGS Lidar Point Cloud CA_SantaClaraCounty_2020_A20 32258275 & CA_SantaClaraCounty_2020_A20_32258250 dated 4/3/2020 - 4/22/2020. Aerial photograph dated 12/2020

Earth Systems Pacific	Lands of Bourdet Pacheco Pass Highway Santa Clara County, California	Geologic Map - Pond 2 303659-001

Figure 6



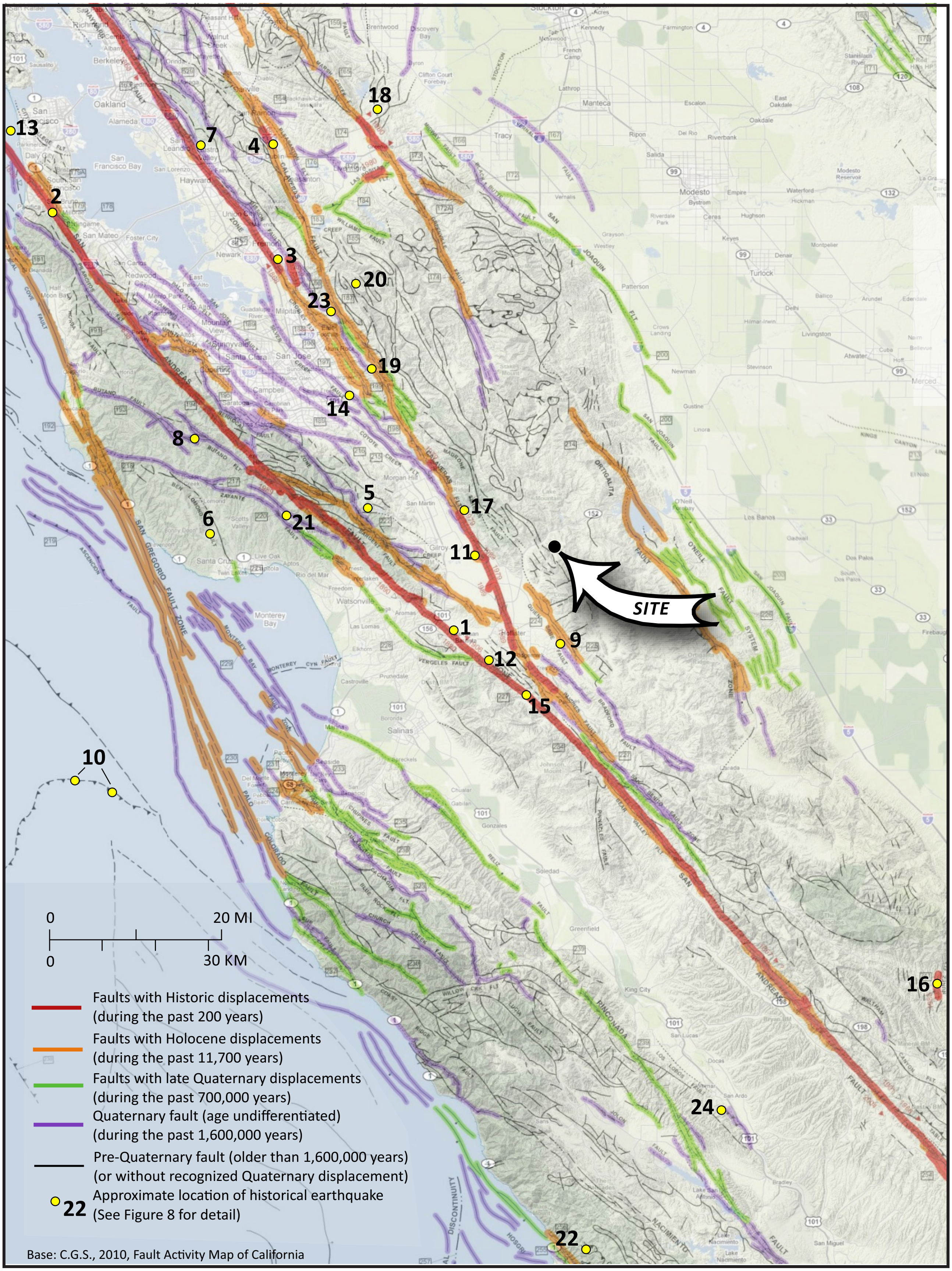
Earth Systems Pacific

Lands of Bourdet
Pacheco Pass Highway
Santa Clara County, California

Landslide Map - Pond 3

303659-001

Figure 7



Earth Systems Pacific	Lands of Bourdet Pacheco Pass Highway Santa Clara County, California	Regional Faults and Earthquakes 303659-001

Figure 8

Selected Bay Area Earthquakes

Location Number (See Regional Faults and Earthquakes map For Locations)	Earthquake and Year	Magnitude Reported	Reference
1	Monterey Bay Area, 1836	M 6.8	Toppozada, 1998
2	San Francisco, 1838	M 7.0	Toppozada, 1981
3	Hayward, 1858	M 6.1	Toppozada, 1981
4	Calaveras-Dublin, 1861	M 5.9	Toppozada, 1981
5	Santa Clara Valley, 1864	M 5.9	Toppozada, 1981
6	Santa Cruz, 1865	M 6.3	Toppozada, 1981
7	Hayward, 1868	M 6.8	Toppozada, 1981
8	San Andreas, 1870	M 5.8	Toppozada, 1981
9	Quien Sabe, 1986	M 5.5	NCEDC, 2010
10	Monterey Bay		
	1926	M 6.1	NCEDC, 2010
	1926	M 6.1	NCEDC, 2010
11	Calaveras, 1897	M 6.2	Toppozada, 1981
12	Hollister Area, 1939	M 5.5	NCEDC, 2010
13	San Francisco, 1906	M 7.8	U.S. Geological Survey, 2010
14	San Jose, 1911	M 6.5	Toppozada and Parke, 1982
15	San Andreas, 1961	M 5.6	NCEDC, 2010
16	Nunez Fault, 1982	M 5.4	NCEDC, 2010
17	Coyote Lake, 1979	M 5.9	Hart, 1988
18	Greenville, 1980	M 5.8	Oppenheimer, 1990
19	Morgan Hill, 1984	M 6.2	Oppenheimer, 1990
20	Mount Lewis, 1986	M 5.7	U.S. Geological Survey, 1989
21	Loma Prieta, 1989	M 7.1	U.S. Geological Survey, 1989
22	Central California		
	1983	M 5.2	NCEDC, 2010
	1991	M 5.2	NCEDC, 2010
23	Calaveras Reservoir, 2007	M 5.4	U.S. Geological Survey, 2009
24	San Ardo, 1955	M 5.2	NCEDC, 2010

NOTE: Modified After Geomatrix, (1992)
Updated, 2010

TECH MEMO

TO: Amanda Musy-Verdel, Hannah-Brunetti
John Feltman, Earth Systems

FROM: Matt Smeltzer, P.E.
Guoyuan Li, Ph.D., P.E., P.H.

DATE: July 28, 2022

SUBJECT: TM#4 - Harper Canyon Watershed Pond Breach Modeling

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1. Introduction

This tech memo #4 (TM#4) evaluates the potential for downslope flooding impacts to result from breaching of two stock pond dams in the upper hills of Harper Canyon. Though Pond #1 and Pond #2 are not within the jurisdiction of the California Division of Safety of Dams (DSOD), the analysis was conducted based on the same guidelines used by DSOD for jurisdictional dams. The guidelines are described in Title 23, Division 2, Chapter 1, Article 6 of the California Code of Regulations and the FEMA P-946. Peak flow discharges resulting from dam breaching were computed at four locations: culvert #3; culvert #6; the bridge; and the downstream property boundary. The computed peak flows were then compared to the 100-year peak flows (Q100) at each of these locations to evaluate the potential for damaging overbank flooding to result from dam breaching.

2. Elevation-Storage Curves

The flooding impact of a dam breach depends on the volume of water stored behind the dam. We used high-resolution 2018 LiDAR topographic elevation contour data to estimate the volume of water, or "storage", in each pond for several water surface elevations. These elevation-storage data points were used to develop elevation-storage (E-S) curves for each pond. E-S curves are input data for the HEC-RAS hydraulic model used to compute the peak dam breach flows.

The E-S curve points for the upper portion of the pond, above the pond water surface elevation, were calculated directly in AutoCAD using the LiDAR elevation contour data. Because there are no LiDAR elevation contour data below the pond water surface elevation, the E-S curve points for the lower portion of the pond below the pond water surface elevation were estimated in AutoCAD by projecting the upper pond slopes below the pond water surface to estimate pond bathymetry as follows:

First, the sloped pond bottom elevation was estimated by drawing a straight line from the downstream toe of the dam to the pond water surface elevation at the upstream pond limit. The minimum pond bottom elevation occurs where the sloped pond bottom intersects the projected upstream toe of the dam. The water depth equals the LiDAR pond water surface elevation minus the estimated minimum pond bottom elevation.

Second, according to the estimated bathymetric geometry, the volume of water below the LiDAR pond water surface elevation was estimated to be between one-half (½) and one-third (⅓), or 5/12 of the surface area times the water depth. Finally, the intermediate data points on the E-S curve from the pond bottom to the water surface were interpolated by fitting a polynomial line using the resulting volume and the upper portion of the E-S curve. The resulting E-S curves for both ponds are shown in Figures 1 and 2. The dam spillway crest elevation and corresponding storage are highlighted on each curve.

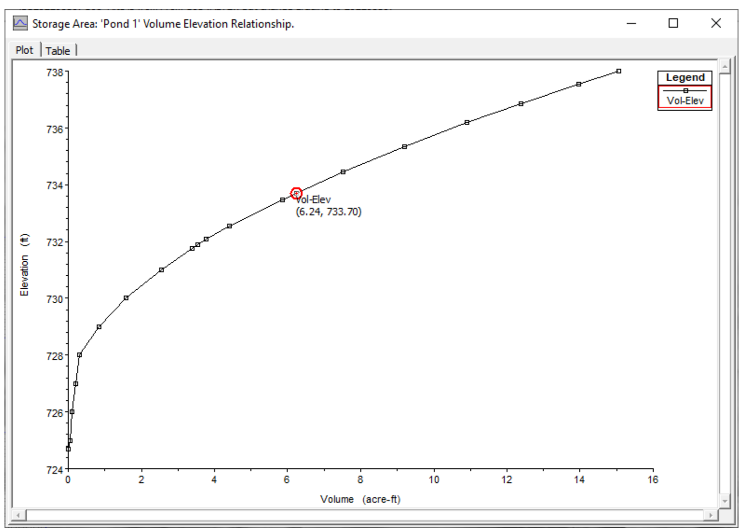

Figure 1
Estimated Pond 1 E-S Curve and Spillway Crest Elevation-Storage (red circle)

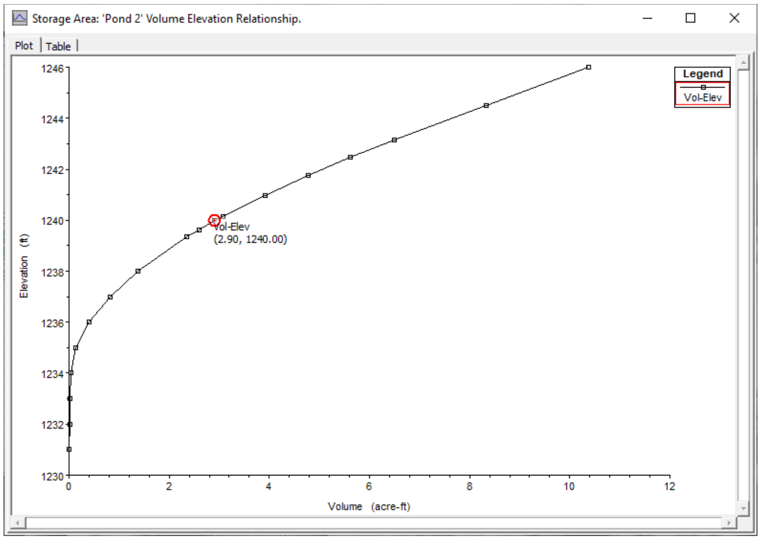

Figure 2
Estimated Pond 2 E-S Curve and Spillway Crest Elevation (red circle)

3. Breach Parameters

The hydraulic model requires input data describing the dam breach mechanics:

Does the breach occur when the downslope channels are dry ("sunny day") or during heavy rain when the downstream channels are conveying normal rainfall-runoff ("rainy day")?

- The DSOD guidelines require "sunny day" breach analysis.

What is the pond water surface elevation when the breach occurs?

- DSOD guidelines require that the initial pond surface elevation be set equal to the spillway crest elevation (the pond is "full").

Other dam breach parameters are: dam failure mode (piping vs overtopping); breach formation time; and, final breach dimensions (width, bottom elevation, and side slope).

The breach parameters selected for this analysis (Figures 3 &4) were according to DSOD guidelines.

Figure 3
Pond 1 Dam Breach Parameters

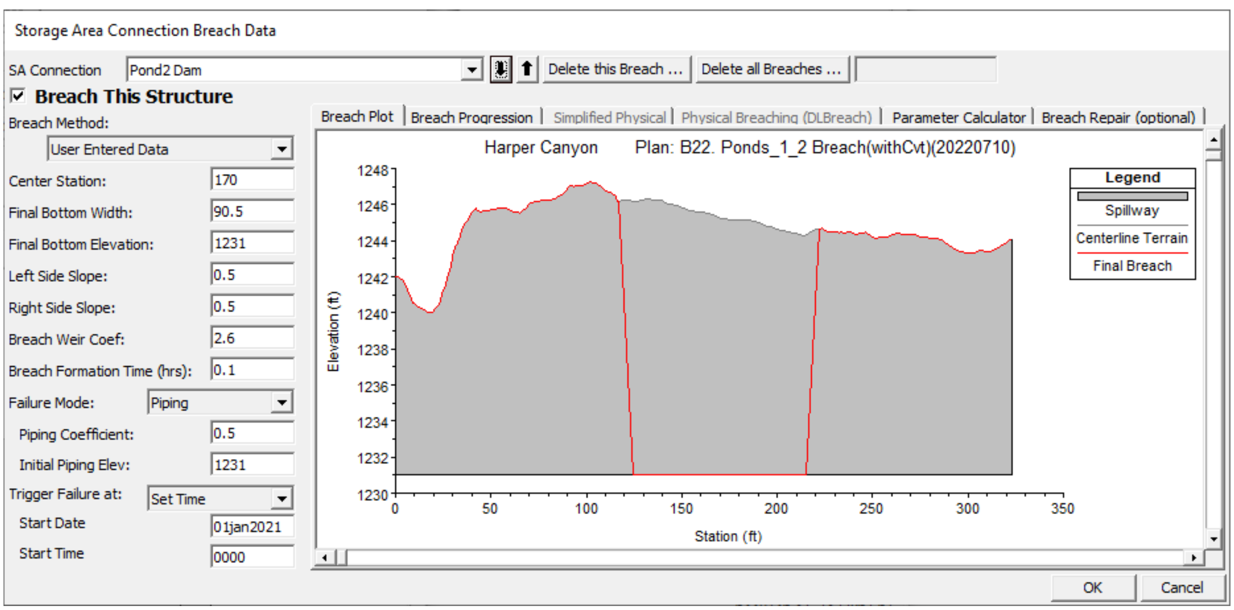

Figure 4
Pond 2 Dam Breach Parameters

4. Model Configuration

The pond breach hydraulic model was configured by expanding the previously developed HEC-RAS 2D model for the Harper Canyon watershed to include the entire area downslope from Pond #1 and Pond #2, with the same 10-ft square mesh size. The two ponds were represented in the model as storage areas. Connections were added between the ponds and the 2D flow area to represent the dams. The model configuration is shown in Figure 5.

Culverts 3 and 6 were added to the 2D model for more accurate representation of the flood wave flow path. Manning's n roughness coefficient for the flow paths below the two ponds was set to 0.045 based on HEC-RAS manual recommended literature values for watershed characteristics similar to Harper Canyon.

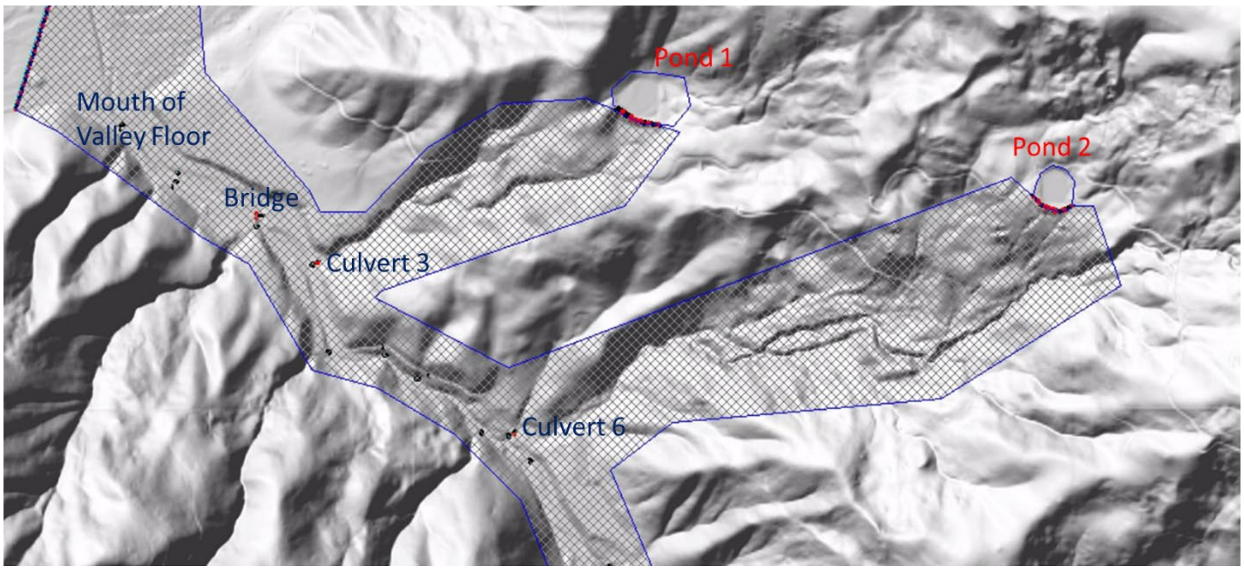

Figure 5
Model Configuration

5. Model Output

Three breach scenarios were modeled. The 1st scenario assumed only Pond #1 would breach. The 2nd scenario assumed only Pond #2 would breach. And the 3rd scenario assumed Pond #1 and #2 would breach simultaneously. The planed restored channel condition with replacement bridge was modeled as the likely future condition applicable for long-range risk forecasting.

The resulting model-computed dam breach peak discharges are shown in Table 1.

The corresponding resulting dam breach flow hydrographs are shown in Figures 6-9.

The peak flow inundation areas are mapped in Figures 10-12.

Table 1
Pond Breach Peak Discharges at Key Locations

Peak Flow at Location	Rainfall-Runoff Q100yr Flow (cfs)	Pond #1 Breach Peak Flow (cfs)	Pond #2 Breach Peak Flow (cfs)	Ponds #1 and #2 Simultaneously Breach Peak Flow (cfs)
Downstream from Pond		1,578	1,184	1,578 & 1,184
Culvert #3	128	1,486		1,486
Culvert #6	298		444	444
Bridge	1,976	1,274	208	1,274
Downstream Property Bdy	1,995	1,010	163	1,010

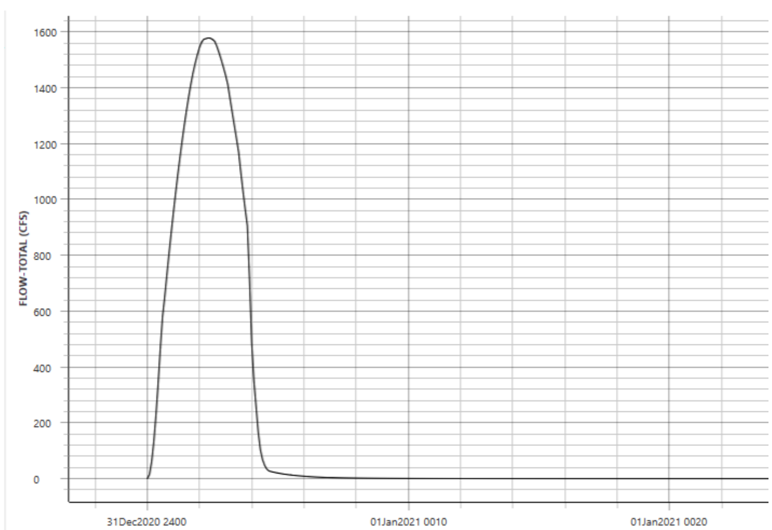

Figure 6
Pond #1 Breach Flow Hydrograph at D/S of Pond 1 Dam
(Peak Discharge = 1,578 cfs)

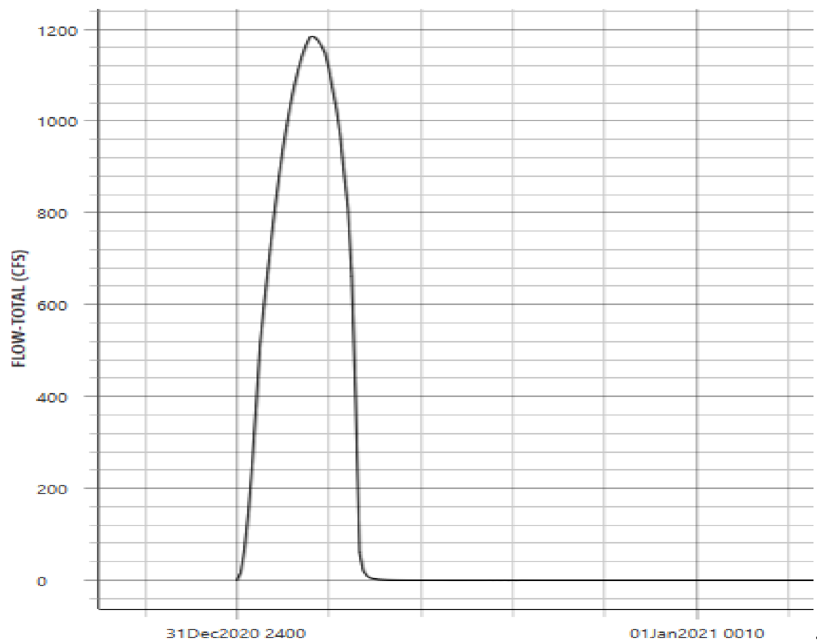

Figure 7
Pond #2 Breach Flow Hydrograph at D/S of Pond 2 Dam
(Peak Discharge = 1,184 cfs)

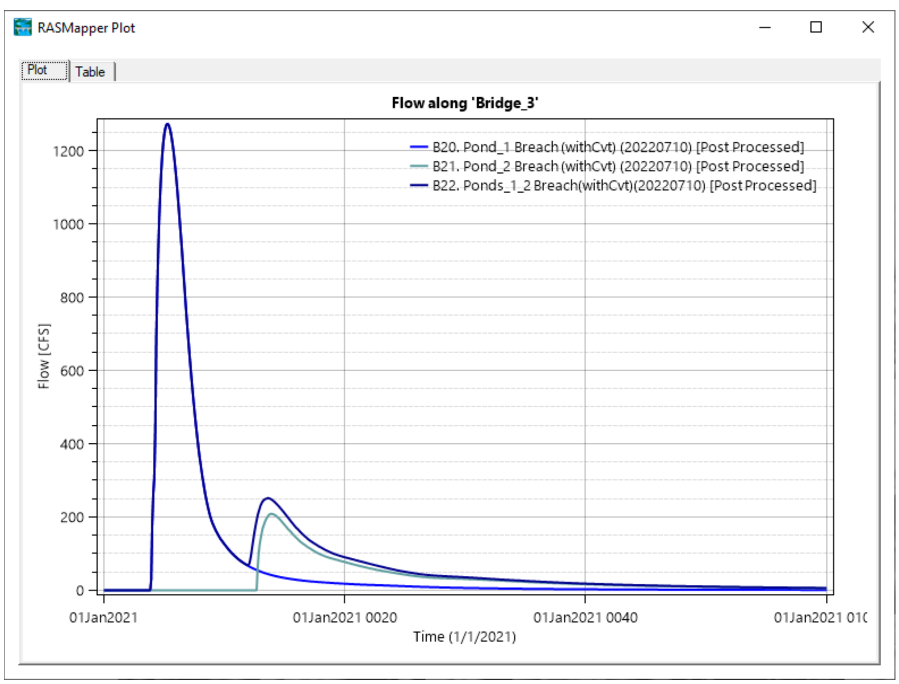

Figure 8
Ponds #1 & #2 Breach Flow Hydrographs at U/S of Bridge
(Peak Flow = 1,274 cfs)

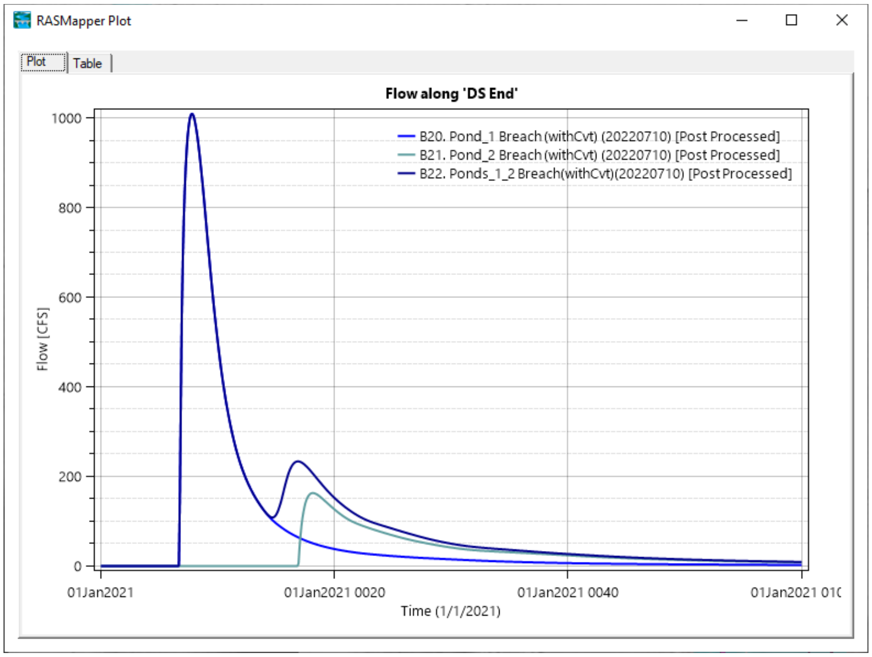

Figure 9
Ponds #1 & #2 Breach Flow Hydrographs at the D/S Mouth of Valley Floor
(Peak Flow = 1,010 cfs)

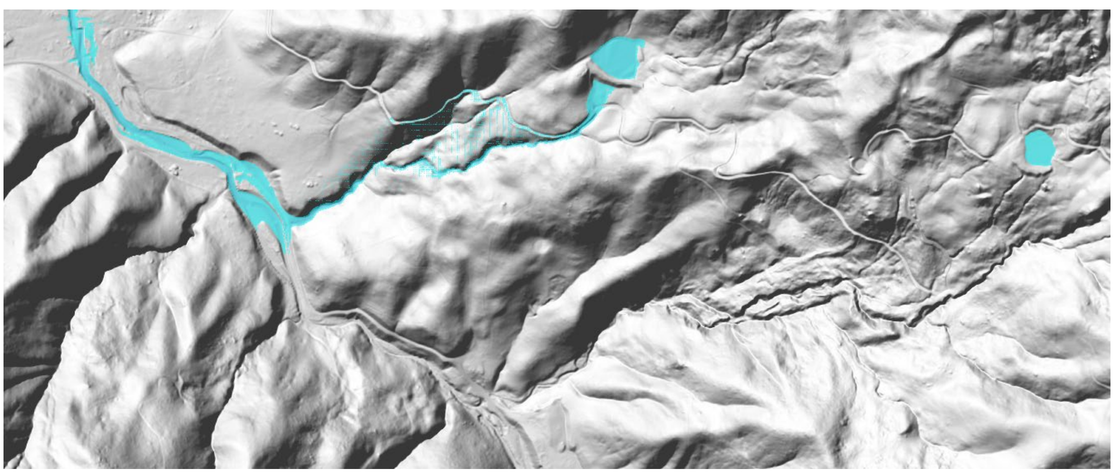

Figure 10 Pond #1 Breach Inundation Mapping

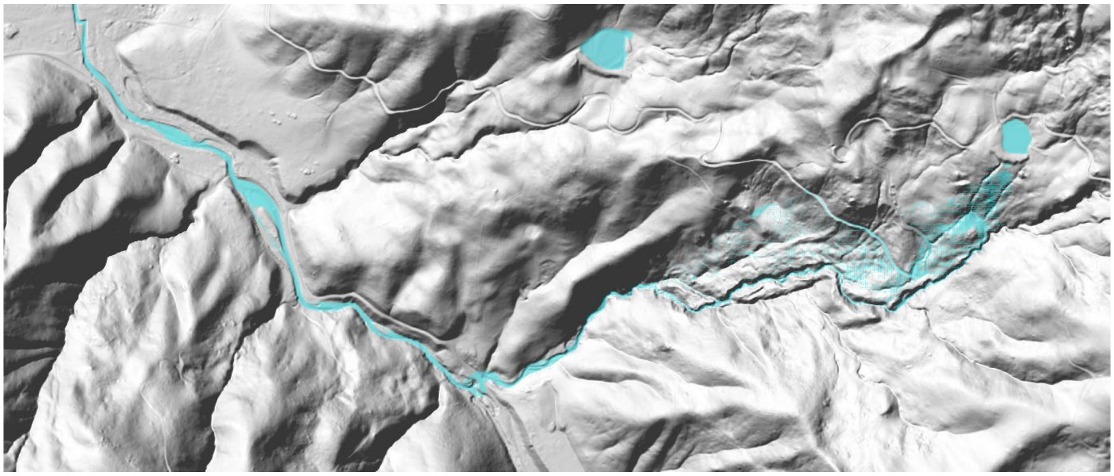

Figure 11 Pond #2 Breach Inundation Mapping

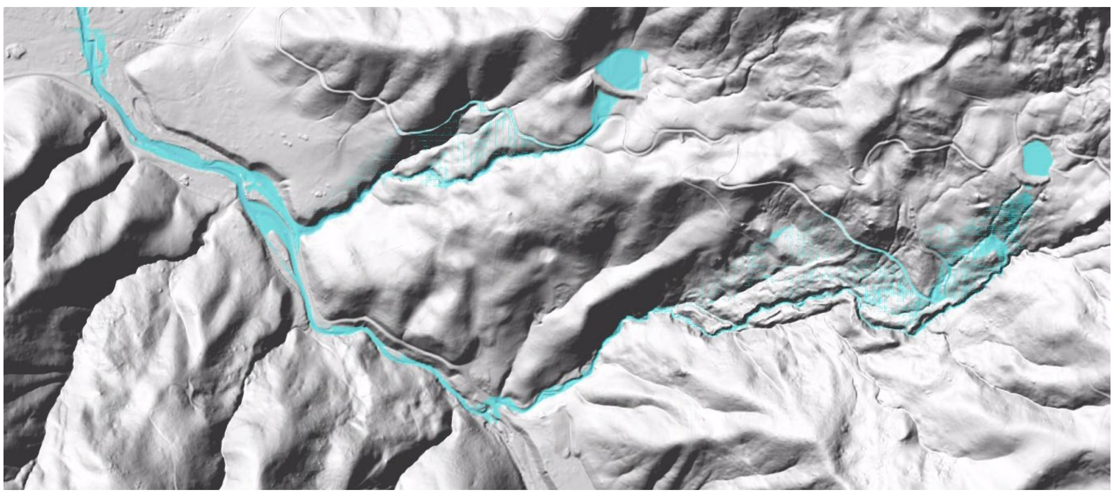

Figure 12 Ponds 1 & 2 Simultaneous Breach Inundation Mapping

6. Discussion and Conclusion

Breaching of Pond #1 and Pond #2 would cause peak flows exceeding the normal rainfall-runoff 100-year peak flows (Q100) at Culverts #3 and Culvert #6 (Table 1). Individual or simultaneous combined pond dam breaching would not cause peak flows approaching the Q100 at the bridge or the downstream property line.

Breaching of Pond #2 would produce a peak flow about 50% higher than the Q100 at Culvert #6, likely causing overflowing of the road and possible minor road damage.

Breaching of Pond #1 would produce a peak flow more than 10 times the Q100 at Culvert #3, overflowing and likely significantly damaging the roadway. Assuming the overflow does not cut a new channel through the roadway near Culvert #3, inundation mapping shows that flow exceeding the culvert capacity would steer along the roadway to re-enter the main channel downstream from the bridge. Substantial roadway and culvert repairs would likely be required.

None of the dam breach scenarios would produce peak flows approaching more than about 50-60% of the normal rainfall-runoff 100-year peak flows at the bridge or downstream property boundary (Table 1). Potential dam breach flows would be fully contained in the channel at the bridge and downstream property boundary. The peak pond dam breach flows would be similar to 5-10-year return interval flood flows.

Simultaneous breaching of both ponds would not increase the peak discharges at the bridge or at the downstream property boundary compared to individual Pond #1 dam breach because the much larger flood peak from Pond #1 would arrive at those locations about 8 - 10 minutes earlier, and dissipate before the arrival of the smaller flood peak from Pond #2 (Figures 8-9).