MINDEGO RANCH
PONDS ENHANCEMENT PROJECT
BASIS OF DESIGN REPORT

Prepared for
Midpeninsula Regional Open Space District

Prepared by
cbec, inc.

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GLOSSARY OF ACRONYMS

Acronym	Meaning
BGE	Butano Geotechnical Engineering
BMP	Best Management Practice
CRF	California Red-Legged Frog
DBE	Design Build Entity
DEM	Digital Elevation Model
D50	50th percentile grain size diameter
Ifland	Ifland Survey
KEC	Kittleson Environmental Consulting
MROSD	Midpeninsula Regional Open Space District
NRCS	Natural Resource Conservation Service
SFGS	San Francisco Garter Snake
WPT	Western Pond Turtle

1 INTRODUCTION

This report details pond enhancement designs completed by the Design Build Entity (DBE) composed of Hanford ARC, cbec eco-engineering (cbec), Kittleson Environmental Consulting (KEC), Butano Geotechnical Engineering (BGE), and Ifland Survey (Ifland). The existing ponds, Upper Spring and Knuedler Lake, are located on Mindego Ranch, a property contained within the Russian Ridge Open Space Preserve and managed by the Midpeninsula Regional Open Space District (MROSD), Figure 1. The surrounding area is used for public recreation and cattle grazing. **The goal of the project is to increase the amount of open-water habitat in the two ponds to support the local populations of San Francisco garter snake (*Thamnophis sirtalis tetrataenia*; SFGS), California red-legged frog (*Rana draytonii*; CRF), and the Western pond turtle (*Actinemys marmorata*; WPT). The objectives of the project are to increase ponding depth and duration at the two ponds focusing on SFGS and CRF habitat needs, and improve the existing outlets to improve the long-term sustainability of the pond features.** Existing emergent vegetation will be removed, and the ponds will be excavated to remove accumulated sediment and increase water depth.

2 METHODOLOGY

A number of methodologies were employed to support the design process. These were used to develop a general design concept, and then to further refine the design details. The first stage of the design process was a careful review of the available information provided in the Request for Proposals submitted by MROSD on May 10, 2018. The information provided details on the desired design outcome and deliverables, site access, cattle grazing operations, species of interest, and current best management practices related to the project.

An initial site walk involving multiple members of the DBE was completed to gain a better understanding of site conditions. This initial field visit was supplemented with further field investigations to refine the existing topography within the ponds; gain a better understanding of the existing biota at each of the sites; determine existing soil conditions; and determine construction methods and limitations.

An initial concept design was developed at both Upper Spring and Knuedler Lake to accompany the proposal submitted on June 6, 2018. Concepts were developed in GIS using San Mateo County (County) LIDAR and were based on the design criteria provided in the Request for Proposals.

The initial concept was revisited after additional field investigations were completed. A composite digital elevation model (DEM) was developed by combining the County LIDAR with the cbec site survey. Detailed grading designs were created based on the updated pond topography and with consideration for habitat suitability, constructability, and slope stability. Proposed stability measures for the outlet of each pond were appropriately designed for the needs and constraints of each site. At Upper Spring, particular care was taken to stabilize the spillway in a way that does not threaten the project species.

The design was further informed by the creation of a water budget model and an estimation of the 100-yr flow event. This information helped inform the design so that it maintains sufficient water in the excavated ponds and the features are stable in large flow events.

3 ASSESSMENT OF EXISTING CONDITIONS

Access to the site is gained by a dirt ranch road off of Alpine Road with a MROSD gate at the Audrey C. Rust Commemorative Site (GPS Coordinates: 37.307437 ° N, -122.198046 ° W). Vehicles accessing the site must follow specific driving requirements including the requirement for an approved biological monitor to proceed all vehicles within designated areas.

Upper Spring (Figure 2) is a steep sedge seep with vegetation consisting of native tall flatsedge (*Cyperus eragrostis*), spreading rush (*Juncus patens*), iris-leafed rush (*Juncus xiphioides*), spike rush (*Eleocharis palustris*), cocklebur (*Xanthium strumarium*), and water cress (*Nasturtium officinale*). Non-native poison hemlock (*Conium maculatum*), purple star thistle (*Centaurea calcitrapa*), curly dock (*Rumex crispus*), rabbits-foot grass (*Polypogon monspeliensis*), prickly sow thistle (*Sonchus asper)*, and mint (*Mentha* sp.) are also present. The pond is surrounded by willow (*Salix* sp.) trees along the outer edge. The pond is surrounded by a berm which is densely vegetated with poison hemlock, coyote brush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobum*), stinging nettle (*Urtica dioica*), and California blackberry (*Rubus ursinus*). The pond serves as habitat for CRF and SFGS.

In addition to wildlife, Upper Spring supports grazing cattle by providing a water source. Cattle are excluded from the actual pond, but a concrete box and plastic pipeline convey water to a storage tank where it can be used to provide water for cattle.

The spillway at Upper Spring is steep and shows signs of erosion. Upper Spring is located entirely within the parcel described by APN 080-340-010, which is owned by MROSD.

Knuedler Lake (Figure 3) is comprised of three separate waterbody classifications. The main body of the pond is a bur-reed dominant marsh. A zone of seasonal wetland with soft rush (*Juncus effuses*), pennyroyal (*Mentha pulegium*), and dock surrounds the main body of the pond. On the north and west banks of the pond, there is a sedge and rush wetland. Knuedler Lake is known to support populations of CRF, SFGS, and WPT.

The pond outlet at Knuedler is fairly steep and also shows signs of erosion. Knuedler Lake is bisected by a property line running north to south. On the east side, the pond falls within the parcel described by APN 080-340-010. Again, this parcel is owned by the MROSD. On the west side, the pond is within the parcel described by APN 083-300-010, which is owned by the City and County of San Francisco.

Existing site conditions were observed by several representatives of the DBE to better understand the project sites and consider how best to complete the project goals. Figures 4 and 5 show the general setting at each of the ponds as seen on September 19, 2018.

Ifland visited the site separately to establish a network of control points at both project sites. This network was then utilized by cbec staff to collect supplemental survey data. It was suspected that the accuracy of the existing LiDAR data was reduced by the heavy vegetation present in the ponds. The site was surveyed by cbec using a Trimble S7 robotic total station under the supervision of a biological monitor. Additionally, geotechnical investigations were completed for the berms at both ponds by BGE.

KEC conducted three site visits to the project area to assess site conditions and biological resources in both the dry and wet seasons. Two fall visits (9/17/2018 and 10/26/2018) were made during initial site surveying tasks and were done in coordination with USFWS-authorized biologists Mark Allaback and Dave Laabs of Biosearch Associates. During the fall 2018 site visits, habitat conditions at both sites were noted and mapped. During both fall visits, CRF and WPT were observed in Knuedler Lake but were absent from Upper Spring. No San Francisco garter snakes were observed.

On 1/18/2019 KEC conducted a winter-season site visit to see pond inundation levels and to map ordinary high water at both sites. During the January visit, both ponds were found to be filled and spilling from recent rains. Western pond turtles were observed basking on vegetation in the center of Knuedler Lake. No CRF or SFGS were observed.

Hanford ARC visited the site to observe existing conditions and evaluate potential site access needed to facilitate construction activities. Site access routes and feasible staging areas were assessed and subsequently included on the drawings. Earthwork activities will be performed in such a way that would minimize any potentially adverse effects due to grading operations by implementing/maintaining applicable erosion and sediment control best management practices (BMPs) throughout the performance of the work. Upon completion, the spoil areas will be loosely graded to a smooth, uniform surface that will drain and create a non-compacted growth medium which will subsequently be seeded with a native mix consisting of plant species that are appropriate for the given location. These procedures are intended to prevent erosion and restore the spoil area to a pleasing aesthetic appearance and, possibly, make it available for future use.

4 DETERMINATION OF GENERAL RESTORATION DESIGN

The RFP outlined clear design goals which were incorporated in the general design. At Upper Spring, the RFP design goals were (1) to remove 80-90% of emergent vegetation and maintain 20-50% of perimeter vegetation and (2) remove 75 to 125 cubic yards of sediment so that 30-50% of the pond is at least 3 feet deep and 20-30% slopes on at least one side of the pond. Furthermore, repair or replace the existing outlet to support CRF development as well as withstand a 100-year flow. Figure 6 shows the existing concrete box at Upper Spring full of vegetation and debris.

At Knuedler Lake, the RFP design goals were (1) to remove 80-90% of pond vegetation from the pond basin and (2) remove approximately 600 cubic yards of sediment from the pond basin to create a 4 to 6 foot deep pond with 20-30% side slopes. Additionally, design the enhancements to accommodate a 100-year flow through the outlet.

The guidelines above were used to develop conceptual designs at the proposal stage (Appendix A). Aerial imagery and County LiDAR were used to estimate excavation locations, grading volumes, and spoils areas in GIS.

5 DEVELOPMENT OF DETAILED RESTORATION DESIGN

The initial concept design was refined based on additional field data collected by the DBE. Geotechnical explorations were completed to determine the underlying soil characteristics. Fine topography was collected in the ponds and combined with County LIDAR to create a composite DEM.

Both site designs are similar in execution. Prior to pond excavation, vegetation will be cleared from the excavation footprint. The pond will then be excavated to the design depth and the banks will be sloped to meet the existing ground. Excavated material will be placed nearby in a spoils area and protected to prevent erosion. Equipment to be used includes a Cat 321 Excavator and front-end Cat Wheel Loader. Cattle exclusion fencing will be placed around the excavated area to prevent cattle from disturbing the project area after construction at Knuedler Lake.

5.1 UPPER SPRING

Geotechnical investigations at Upper Spring revealed that the berm is unstable, both statically and seismically (Appendix B). There are no homes or valuable infrastructure below the berm, so the consequences of a possible berm failure are likely to be minimal. Since the cost of rebuilding or reconfiguring the berm would be substantial and not in line with the primary project objective of providing a low cost design for pond enhancements, it was determined that the best path forward for the project was to excavate material from the pond and to minimize any disturbance to the berm. The DBE and MROSD discussed this outcome and a change order detailing that MROSD agrees to hold the DBE harmless for any failure of the berm except as a result of the DBE's active negligence, or willful misconduct (Appendix C).

A hydrologic analysis was prepared and consisted of determining the 100-year inflow rates to Upper Spring. This inflow rate was subsequently used to determine design shear stresses over pond outlet and calculate appropriate turf reinforcement mat (TRM) suitability for slope stabilization. See Appendix D for a comprehensive technical memorandum detailing this topic.

Per the proposal (Appendix A), the desired depth of water at Upper Spring was 3.5'. The water surface elevation was surveyed at 1,681.1' in September 2018. Based on this information, the pond bottom was set to an elevation of 1,677.6'. The proposal also stated that and estimated 75 - 125 CY of material would need to be removed from the pond to provide the required depth, thus this range of values served as a limit to the extent of grading. The slopes of the pond were varied to provide different habitat functions. Steep slopes allow for animals to quickly dive and escape potential threats. Shallow slopes make it easier for aquatic creatures to climb up a bank to find food or sunlight. Side slopes

adjacent to the existing berm were set at 3:1 (horizontal:vertical) to avoid disrupting the berm feature. Opposite the berm, the side slopes were set at 1:1. The existing ground in Upper Spring is moderately sloped. By establishing a fairly steep excavation slope on this side of the pond, the design avoids chasing the grade uphill and needlessly disturbing the surrounding area. The soil in Upper Spring is composed chiefly of fat clay to a depth exceeding 5 ft , and a 1:1 slope is the steepest stable slope for this type of soil. Lastly, the equipment which will perform the pond excavation is assumed to have a reach of no more than 60' from the berm. These factors served to define the design and determined the shape and location of the pond excavation.

The spillway at Upper Spring exhibits signs of erosion. One of the project goals at Upper Spring was to stabilize the existing outlet. Installation of a TRM was determined to be the optimal solution as this method will stabilize the steep slope of the outlet but cause minimal disturbance to the Upper Spring berm, and limits the cost associated with importing rock to this remote site. Additionally, reducing soil disturbance on the berm face became an important consideration once the geotechnical investigation revealed that the berm is unstable. Since the primary goal of this project was to create additional habitat for California red-legged frogs and San Francisco garter snakes, the material selection for the pond outlet needs to consider the local fauna. The concern with a woven mat is that animals can become trapped in the fabric. MROSD recommended Landlok 300 turf reinforcement mat by Propex as a potential solution since the pyramidal pattern of the weaving makes it difficult to be penetrated by animals and has been previously approved by regulatory agencies and successfully installed at two ponds having CRF and garter snakes of similar sizes and habitat usage to the SFGS. . According to the hydrologic and hydraulic analysis (Appendix D), the 100-yr peak flow from Upper Spring is 15 cfs, resulting in a velocity of 4.5 ft/s and shear stress of 7.4 lb/sf. The specifications for Landlok 300 provided by Propex indicate that the permissible shear stress of the fabric with vegetation established is 12 lb/sf. Therefore, the material should be sufficient to protect the outlet from further erosion without threatening the project's target species.

Upper Spring serves as a water source for grazing cattle. The pond itself is completely fenced off with new fencing installed in the last 3-5 years, but a concrete box built into the berm collects water which is then piped into a nearby water tank to serve cattle when they are in the area. The continued exclusion of cattle from Upper Spring is recommended. This will reduce the likelihood of siltation and outlet clogging in the concrete box. Pond siltation reduces the pond volume available for California red-legged frogs and San Francisco garter snakes, and flow restrictions in the concrete box adversely affect water availability for cattle. Upper Spring may previously have functioned as a stock pond with direct cattle access, but it currently functions as a spring used as a livestock trough water source. Both cattle and local species of concern will be better served if Upper Spring remains fenced off, and cattle water demands are met via the existing concrete box diversion structure and water tank.

As part of the project, the concrete box will be cleaned out and fitted with a grate to limit the amount of sediment and debris that can enter the box. A lid will be added to the top of the box to shade the box interior and reduce plant growth. The pipes that connect the concrete box to the water tank will be replaced with larger 3-inch diameter galvanized steel pipe. The tank will be drained in order to drill, thread and seal in a new pipe, and cap the existing pipe. A water budget analysis (Appendix D)

concluded that construction of the project is not expected to substantially alter the volume of water in Upper Spring so cattle operations should continue without issue. One of the initial concerns with the feasibility of this project was the possibility that excavation might rupture a clay lens under the pond and allow water that previously perched in the pond to leak away downhill. However, soil borings in the pond revealed one of two things, depending on the location of the borings. Close to the berm, clay was found as far down as 5 ft, which was the maximum depth for a hand auger. Further up the slope away from the berm, a continuous layer of clay was found above a layer of bedrock. Both of these features represent limited potential porosity so the possibility of dewatering the pond as a byproduct of excavation is low. However, to mitigate the risk of puncturing the clay layer an alternative adaptive solution will be used. This includes excavating the pond only as deep as the top of the clay layer, and widening the excavation footprint to remove the 75 – 125 CY of material. Importing bentonite is cost prohibitive, so an adaptive field-fitting approach to maximize habitat and minimize risk of dewatering is recommended.

5.2 KNUEDLER LAKE

Geotechnical investigations at Knuedler Lake indicated that the earthen berm forming the pond is statically and seismically stable (Appendix B). Additionally, a hydrologic analysis was prepared to determine the 100-year inflow rates to Knuedler Lake and subsequently used to determine design shear stresses over the outlets and calculate appropriate rock sizing for grade control slope stabilization. See Appendix D for a comprehensive technical memorandum detailing this topic.

The design at Knuedler Lake was based on the initial concept developed for the proposal. The grading extents were set so as not to exceed the concept footprint. Per the proposal, the desired maximum depth of the pond was 4’ to 6’. A September 2018 survey measured the water surface elevation at 1,011.5’ so the pond bottom elevation was set to 1,007.5’. Similar to Upper Spring, it was desirable for the pond to have variable side slopes. Near the shore, the side slopes were set at 4:1 (horizontal:vertical). On the opposite side, slopes were set at 1:1. These design constraints resulted in an excavation volume of 525 CY, within the range estimated in the proposal (600 +/- 200 CY). The elevation information was updated with ground survey data after the proposal was submitted. A lower excavation volume is an acceptable outcome because it will result in a smaller spoils area, which will reduce the amount of disturbance caused by the project.

Equipment accessibility was also a consideration at Knuedler. The entire extent of grading was placed within the operating range of a long-reach excavator, assuming the equipment goes no lower than elevation 1,015’. There was concern that the ground below that elevation may be soft if the winter preceding construction is especially wet.

Similar to Upper Spring, there was concern about dewatering Knuedler Lake if a clay lens was ruptured in the process of excavating the pond. However, geologic investigations revealed a 5- to 9-foot thick clay layer at a minimum depth of 5.5 ft below the ground surface that is unlikely to be penetrated in the course of project implementation.

The outlet south of Knuedler Lake has a steep grade. There was concern that, given the proximity of a hillslope below the gentler sloping upper outlet area, future erosion could result in a head cut, which might reduce the capacity of the pond. Geotechnical investigations did not note active headcut but acknowledged that protection of this outlet would provide sufficient redundancy to protect the area.

To mitigate against the possibility of headcut, the design calls for the installation of a Propex ArmorMax 75 erosion control fabric in the pond outlet. According to ArmorMax product data (Appendix E), the fabric, once vegetated, can withstand velocities up to 25 ft/s and shear stress up to 16 lb/sf. The suitability of this material was determined by looking at hydraulic modeling results at the Knuedler Lake outlet (Appendix D). The peak of the predicted 100-yr flow event of 40 cfs produces a maximum velocity of 4.3 ft/s and a shear value of 4.1 lb/sf. To protect the Knuedler outlet berm, fabric will be installed 20' past the existing fence line. Doing so will provide protection at least 10' beyond the toe of the dam fill, but limit the amount of required vegetation removal.

Knuedler Lake currently has no effective fencing to prevent cattle from entering the pond. There is a fence that bisects the pond from north to south, but it is in a state of disrepair and does not effectively exclude cattle. Water accessibility is important for cattle as they winter in the nearby area, and cattle grazing operations require the water provided by Knuedler Lake. To accommodate this need, the proposed design calls for cattle exclusion fencing surrounding the excavated area only. The fence will closely follow the limits of excavation. This will serve two functions. First, it allows cattle to manage emergent vegetation near the excavated pond to better maintain open water, but still excludes them from the actual excavation. Second, it reduces the amount of fencing required for the project, which means more of the pond is available for cattle access and the cost of implementation is reduced since less material will need to be installed. As part of the design process, a water budget model (Appendix D) was created to compare the existing pond conditions to the proposed excavation. The analysis concluded that the project will not affect water storage in the wet, winter months. In the dry, summer months, there was a small drop in stage because water concentrates in the deeper, excavated area. However, the difference is minor and outweighed by the expected habitat benefits.

6 NRCS STANDARDS COMPLIANCE

The project provides natural resource conservation benefits in the Mindego Ranch property within the Russian Ridge Open Space Preserve. Mindego Ranch is operated under the Mindego Ranch Use and Management Plan guiding implementation of habitat restoration, conservation grazing, and road improvements (MROSD 2013). Mindego Ranch provides habitat for the only SFGS population at the crest of the Santa Cruz Mountains. MROSD manages SFGS habitat under the San Francisco Garter Snake Habitat Management Plan, specifically calling for creating habitat conditions that will increase the abundance of prey species, the CRF (MROSD 2012).

Compliance with the standards established by the Natural Resource Conservation Service (NRCS) is required to obtain a San Mateo County grading permit exemption for project construction via the San Mateo Resource Conservation District. The DBE determined that the standards for Grade Stabilization Structures, Integrated Pest Management, Land Clearing, Ponds, Spoil Spreading, and Woody Residue

Treatment are potentially applicable. These standards are listed below detailing how the project design complies with each standard.

Grade Stabilization Structures

- Comply by protecting Knuedler outlet with rock

IPM

- Comply by steam cleaning equipment prior to entering the site
- Comply by preserving existing vegetation to avoid making opportunities for invasive species

Land Clearing

- Comply by performing work during dry months
- Comply by minimizing soil disturbance outside of excavation areas. Contractor will treat disturbed areas on an as-needed basis
- Comply by promoting endangered species habitat
- Comply by producing minimal material, given small project area size
- Comply by steam cleaning equipment prior to entering the site
- Comply by preserving existing vegetation to avoid making opportunities for invasive species

Ponds

- Most standards not applicable as project maintains existing ponds, rather than creating a new pond
- Comply by protecting areas where erosion risk is present (pond outlets)
- Comply by requiring contractor to notify MROSD if any archeologically significant items are found
- Comply by maintaining use as a water resource for cattle
- Comply by enlisting geotechnical engineer to evaluate the site
- Comply by removing sediment from an existing pond
- Comply by installing corrosion and UV resistant pipe material at Upper Spring
- Comply by installing trash guard at Upper Spring
- Comply by uniformly spreading excavated material to a height not to exceed 3 ft and sloped away from the pond
- Comply by creating new habitat for endangered species
- Comply by stockpiling topsoil to be placed on top of spoils areas
- Comply by increasing water storage capacity in ponds to protect water quantity
- Comply by stabilizing pond features and installing fencing to protect water quality

Spoil Spreading

- Comply by minimizing haul distance, but placing spoils outside of pond drainage path
- Comply by keeping spoils area slopes to 4H:1V or less
- Comply by stripping vegetation from spoils area, then placing on top of completed spoils pile
- Comply by seeding spoils areas and applying fiber rolls to reduce erosion risk

Woody Residue Treatment

- Comply by piling wood to achieve landowner goal of wildlife habitat creation
- Comply by placing woody residue near its source to minimize disturbance to other vegetation
- Comply by performing work in expected dry conditions to minimize soil disturbance
- Comply by keeping pile small and placing in a generally damp environment
- Comply by not burning woody residue
- Comply by placing material away from where cattle access water
- Comply by retaining material on-site for habitat and nutrient retention
- Comply by having biological monitor on-site to observe any threatened wildlife.

7 REVEGETATION PLAN

Given the small amount of proposed excavation as well as the current well-vegetated state of Upper Spring, planting within the excavated pond is not recommended. Doing so may result in less open water in the five to ten years after construction. The berm and spillway will be seeded with MROSD provided native grass seed shade mix and covered with a 3 to 4 inch layer of certified weed free straw. The spoils area (total 0.31 acre for both sites, Table 1) and any disturbed soil along the access route will be seeded with MROSD's native grass seed sunny mix and covered with a 3 to 4 inch layer of certified weed free straw. Since the project area is relatively small (total 0.46 acre, Table 1) and remote, hand broadcasting is the preferred method of seed application. See Appendix F for seed mix and other revegetation details.

Table 1. Project footprint summary

Pond Feature	Area (acre)			
	Spoils	Grading	Erosion/Grade Control	Project Total
Upper Spring	0.06	0.02	0.01	0.46
Knuedler Lake	0.25	0.11	0.01	
Total	0.31	0.13	0.02	

At Knuedler Lake, a total of 30 spike rush and tall flatsedge clumps will be salvaged from the project area and planted in the pond after excavation is complete. Salvaged plants will be installed along the margin of the newly excavated area at elevations 1011' – 1012". The spoils area will be seeded with sunny seed mix. To limit soil disturbance, no grading will be performed along the access route, the hauling route, or in the staging area. In the event of any soil disturbance, the same sunny seed mix will be applied to the affected area. Again, the small, remote work site necessitates seed application via hand broadcasting. Seed mix and other revegetation details are presented in Appendix F.

8 INTEGRATED PEST MANAGEMENT PLAN

Revegetation maintenance is expected to be limited due to the small size of the project and the over-arching goal of the project to create open-water habitat at the two ponds. Maintenance may be

necessary at regular intervals for the first 3 years. Maintenance includes the removal of invasive, non-native vegetation and replacement of dead plants at Knuedler Lake. Natural recruitment of native emergent wetland species is anticipated. Maintenance may include vegetation thinning if the burreed, sedge, cattail, and knotweed aggressively re-colonize the newly created open water habitat.

Aquatic weeds within the Knuedler Lake revegetation site will be controlled throughout the plant establishment period by the District's field staff or contractors. Cal-IPC rated species noted in wetlands will be managed. Weed control methods in the aquatic habitat shall be by pulling by hand or mowing and will be consistent with the MROSD's Integrated Pest Management Program and shall be conducted with the oversight of a qualified biomonitor. Spoils areas to be seeded with sunny seed erosion control mix will be subject to grazing and will not be formally monitored for plant success.

Both spoils areas are to be located in upland habitats designated in the site grazing plan as winter pastures. Due to the high percentage of organic material in the proposed dredge spoils (i.e., sedges, tules, rushes, and broad-fruited burred (*Sparganium eurycarpum*)) it is not anticipated that erosion off the spread spoils will be significant. In addition, the wetland plant seed stock within the spoils material will sprout and grow during the first winter/spring season, thereby further stabilizing the spoils disposal sites.

Following Year 3, the conditions of the salvaged plants installed at Knuedler Lake will be evaluated and dead plants will be replaced if the average plant survival for all installed species combined falls below the 80% plant survival criterion outlined in the next section. An adaptive management approach towards plant replacement will be instituted and plant species chosen for replacement will be based upon the availability of similarly suitable native plant material on the MROSD's property.

Due to the presence of CRF, SFGS, and WPT in the project impact areas, no herbicides are proposed for use in the project, or during the 3-year proposed maintenance period. If invasive plants are documented in the seeded upland spoils areas:

• Prior to conducting non-native plant removal (e.g., invasive thistles) or treatments (e.g., spraying with herbicide, cutting, pulling, digging out), every reasonable attempt should be made to ensure that snakes and frogs are not hidden within the plant or the residual plant matter to be treated. Source: USFWS Biological Opinion issued in support of the 2014 Recovery Permit issued to the MROSD.

• Any herbicide application in the upland areas subject to seeding shall be conducted under the requirements of the MROSD's Integrated Pest Management (IPM) program. Source: MROSD IPM Program adopted by the Board on December 10, 2014.

9 LIST OF PREPARERS

Hanford ARC
Mark Cederborg, Vice President
Peter Smith, P.E., Senior Engineer

cbec eco engineering, Inc.
Jon Parsons, E.I.T., Lead Drafter and Designer
Sam Diaz, P.E., Design Oversight
April Sawyer, M.S., Project Manager
Chris Hammersmark, P.E., Ph.D., Project Director

Kittleson Environmental Consulting
Gary Kittleson, M.S., Principal

Butano Geotechnical Engineering
Greg Bloom, PE, GE, Principal Geotechnical Engineer
Phillip Edwards, PE, Senior Engineer

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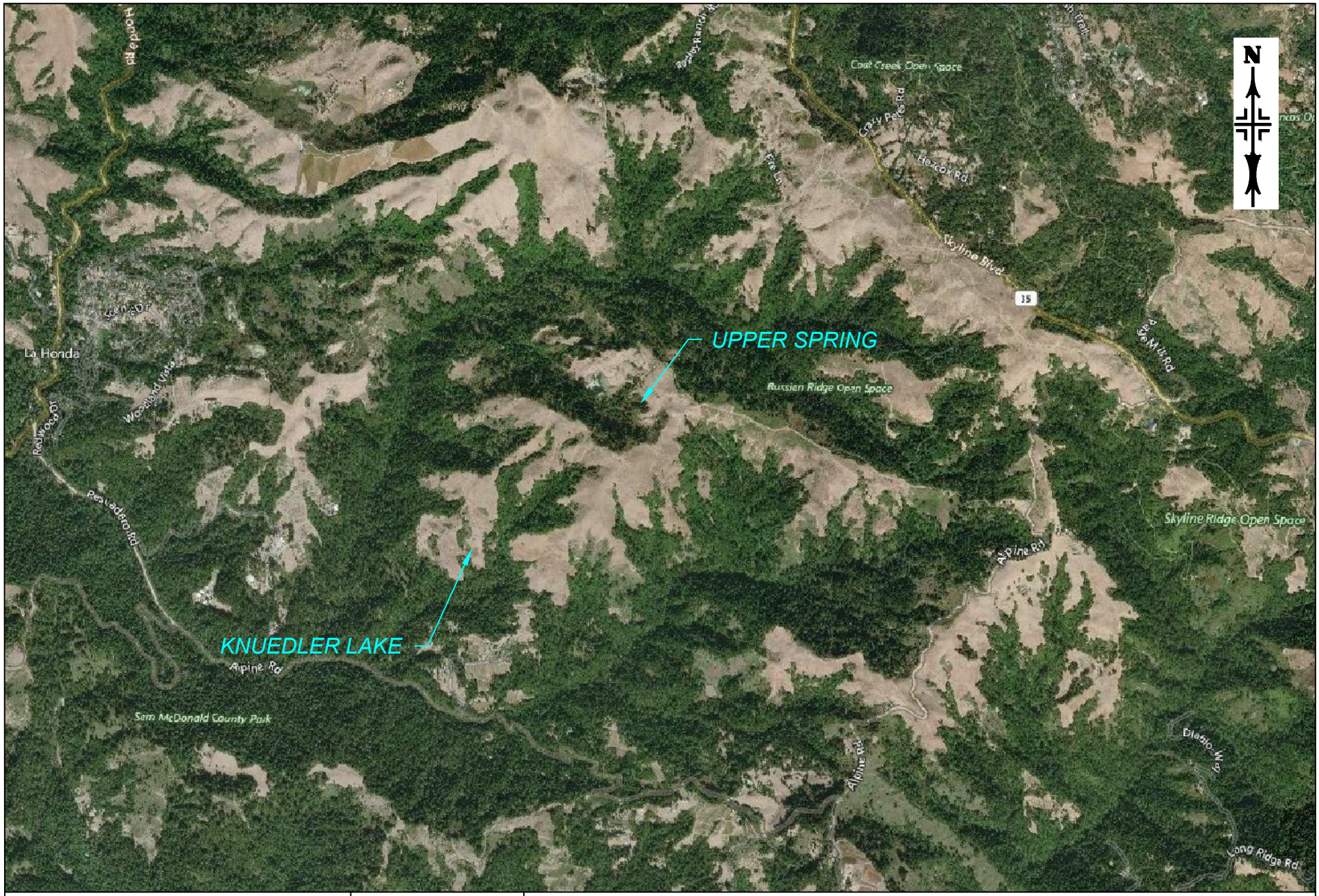
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U.S. Department of Agriculture, Natural Resources Conservation Service. Conservation Practice Standard. Spoil Spreading (572). January 2010.

U.S. Department of Agriculture, Natural Resources Conservation Service. Conservation Practice Standard. Woody Residue Treatment (384). October 2017.



Notes:	cbec eco engineering	*Mindego Ranch Ponds Enhancement Projects* **Project Location**		
		Project No. 18-1019	Created By: JWP	**Figure 1**

Project_Location.dwg
6/3/2019



	cbec eco engineering	*Mindego Ranch Ponds Enhancement Project* **Site Overview - Upper Spring**		
		Project No. 18-1019	Created By: JWP	**Figure 2**

Site_Overview_Upper_Spring.dwg
8/15/2018



	cbec eco engineering	*Mindego Ranch Ponds Enhancement Project*		
		Site Overview - Knuedler Lake		
		Project No. 18-1019	Created By: JWP	**Figure 3**

Site_Overview_Knuedler.dwg
8/15/2018



Notes: This photo was taken on September 19, 2018. It was taken from on top of the berm, facing southeast up the slope.

cbec eco engineering

Mindego Ranch Ponds Enhancement Project

Upper Spring Site Photo

Project No. 18-1019	Created By: JWP	**Figure 4**



Notes: This photo was taken on September 19, 2018. It was taken from an elevated position east of the pond.

Mindego Ranch Ponds Enhancement Project

Knuedler Lake Site Photo

Project No. 18-1019	Created By: JWP	**Figure 5**



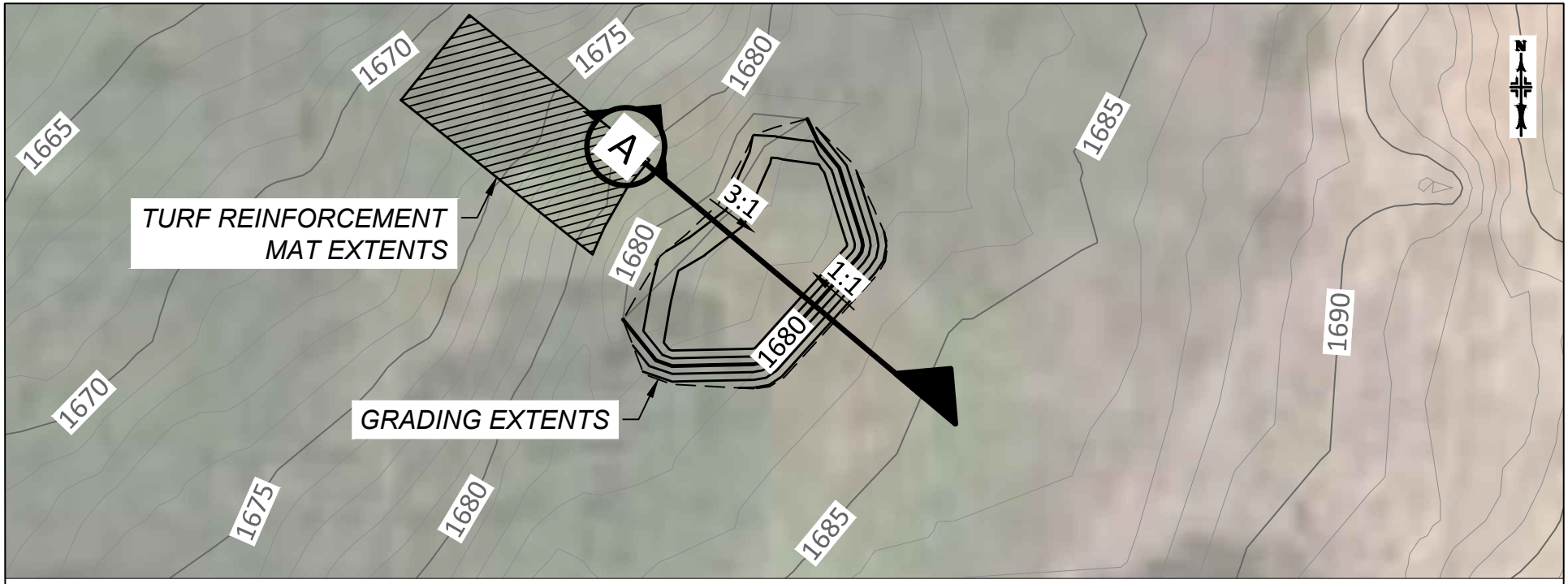
Notes:

Mindego Ranch Ponds Enhancement Project

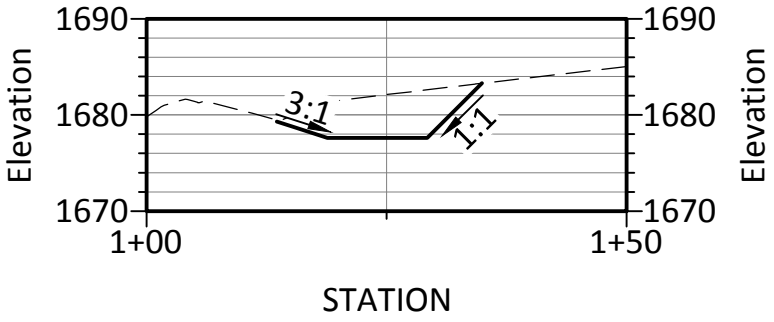
Upper Spring - Existing Concrete Box

Project No. 18-1019	Created By: JWP	**Figure 6**

Figure6_Upper_Spring_Concrete_Box.docx
6/4/2019



UPPER SPRING SITE PLAN
SCALE: 1" = 20'



UPPER SPRING TYPICAL SECTION A
SCALE: 1" = 20'

LEGEND

1675 — EXISTING GROUND CONTOURS

1680 — FINISHED GRADE CONTOURS

0 20 40 60 FT

1" = 20'

Notes:

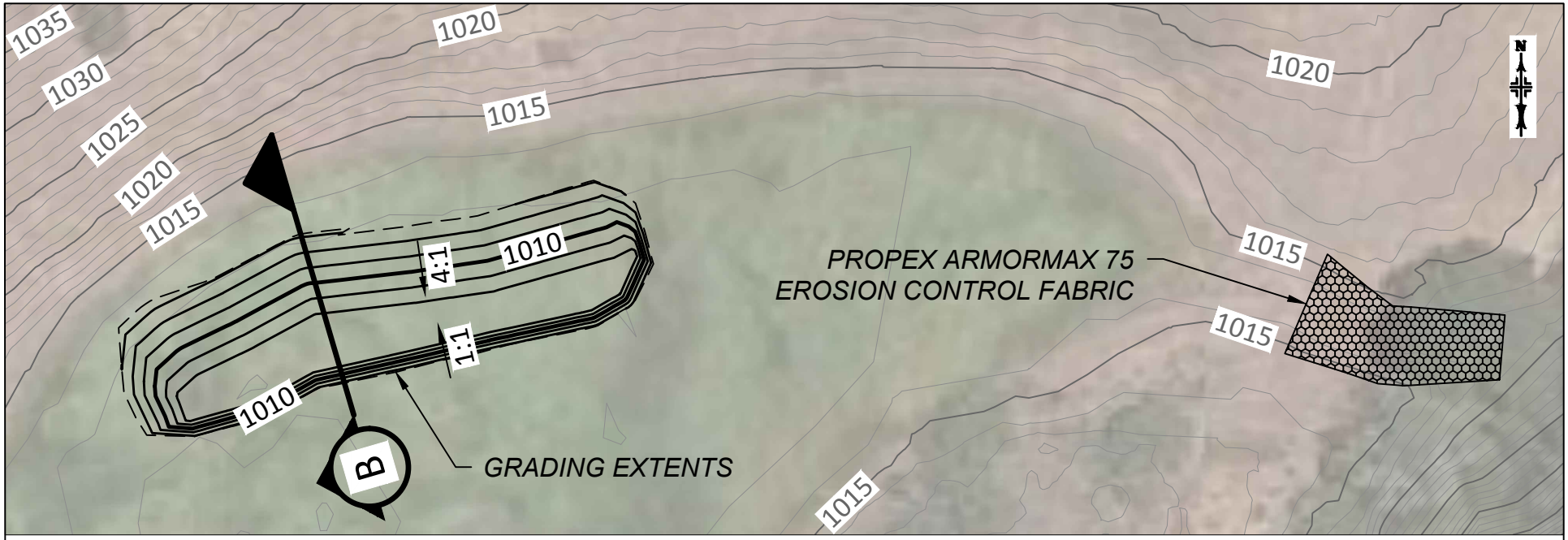
cbec eco engineering

Mindego Ranch Ponds Enhancement Project

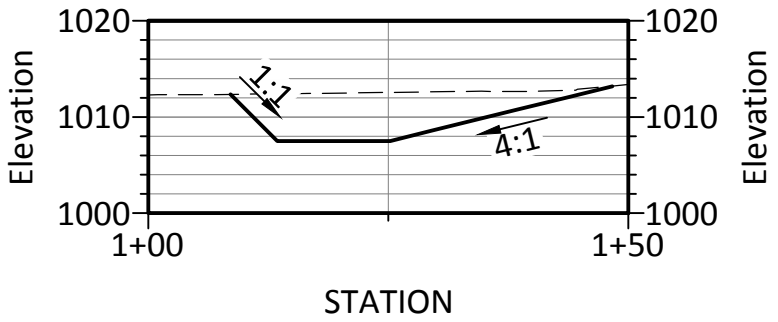
Upper Spring Design Plan and Typical Section

Project No. 18-1019 | Created By: JWP | **Figure 7**

Site_Plan_and_XS_Upper_Spring.dwg
6/4/2019



KNUEDLER LAKE SITE PLAN
SCALE: 1" = 40'



KNUEDLER LAKE TYPICAL SECTION B
SCALE: 1" = 20'

LEGEND

1015 — *EXISTING GROUND CONTOURS*

1010 — *FINISHED GRADE CONTOURS*

0 40 80 120 FT

1" = 40'

0 20 40 60 FT

1" = 20'

Notes:

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Mindego Ranch Ponds Enhancement Project

Knuedler Lake Design Plan and Typical Section

Project No. 18-1019 | Created By: JWP | **Figure 8**

Site_Plan_and_XS_Knuedler.dwg
6/4/2019

APPENDIX A

MINDEGO RANCH PONDS ENHANCEMENT PROJECT PROPOSAL

Proposal for
Design-Build Services
Mindego Ranch Ponds Enhancement Project



Photo Credit: Biosearch Environmental Consulting



Prepared for
Midpeninsula Regional Open Space District

Developed by

HANFORD ARC

cbec eco engineering

with support from

BUTANO GEOTECHNICAL ENGINEERING

IFLAND SURVEY
Surveying - Mapping - GPS

Kittleson Environmental Consulting

Proposal Manager
Chris Hammersmark, PhD, PE

519 Seabright Ave, Suite 102
Santa Cruz, CA 95062
916.231.6052

Proposal Number #17-74-2

June 2018



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519 Seabright, Avenue, Suite 102
Santa Cruz, CA 95062
916.231.6052
cbecoeng.com

June 6, 2018

Lupe Hernandez
Administrative Assistant
Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, CA 94022-1404

Dear Ms. Hernandez,

cbec, inc. eco engineering (cbec) and Hanford Applied Restoration & Conservation (Hanford ARC) are pleased to present this proposal for design build services to the Midpeninsula Regional Open Space District (District) supporting the Mindego Ranch Ponds Enhancement Project (Project). As described in our previously submitted statement of qualifications cbec and Hanford ARC have formed a design build entity (DBE) for the purposes of designing and implementing this Project. Our team includes Kittleson Environmental Consulting (KEC), Butano Geotechnical Engineering (BGE) and Ifland Survey, but we have removed BioSearch from our Design Build (DB) team.

cbec specializes in engineering analysis for complex aquatic and terrestrial ecosystems. Our expertise includes hydrology, hydraulic modeling, fluvial geomorphology, water quality monitoring, field services, restoration design and climate change services. Hanford ARC is a licensed general engineering and landscape contractor specializing in wetland mitigation and restoration, stream construction, soil bioengineering, revegetation, park construction and erosion control. Hanford ARC has constructed several projects located within San Francisco garter snake (SFGS) habitat and their staff have received identification, avoidance and sensitive training for SFGS. Our firms have successfully worked together to design and build successful environmental rehabilitation projects on Branciforte Creek, Butano Creek and Cordova Creek (a two-time award-winning project).

KEC has a depth of experience providing owner representation, permitting support (including regulatory negotiations), construction planning, compliance monitoring in sensitive habitats and wildlife surveys. BGE and Ifland Survey are a local geotechnical engineering firm and professional land surveying firm, respectively, both with strong track records on a diverse array of projects.

Despite our best efforts to reduce costs, our estimated cost for preliminary studies, design, permitting and construction of this project, exceeds the $200,000 to $300,000 range specified in the RFP. Compared to our previous design proposal (submitted in November 2017) our design costs have been reduced due to the change to a design-build approach; however, additional project elements (e.g., permitting) and implementation have now been included. Major drivers of the project cost are that construction progress will be slow relative to similar restoration activities (due to the biological requirements associated with this extremely sensitive site), and prevailing wage requirements.

We are excited to work with you on this project, particularly after our multiple site visits to Mindego Ranch and discussions which have followed with your staff.

Sincerely,



Chris Hammersmark, PhD, PE
cbec eco engineering

Proposal and Proposal Price

Our Design Build Entity (DBE), comprised of Hanford ARC, cbec eco-engineering (cbec), Kittleson Environmental Consulting (KEC), Butano Geotechnical Engineering (BGE), and Ifland Survey (Ifland), proposes to provide geotechnical, hydrologic, hydraulic, surveying, engineering, design, management, ecological consulting and construction services, to Midpeninsula Regional Open Space District (District) for the Mindego Ranch Ponds Enhancement Project. Two water bodies (Upper Spring and Kneudler Lake) will undergo habitat enhancement to support the San Francisco garter snake (SFGS) and the California red-legged frog (CRLF). The proposed enhancements to the ponds, their outlets, and earthen berms, will improve ponding depth and duration for sensitive species. Furthermore, designs will address existing scour concerns at the water bodies' outlets, improving the long-term viability of each water body.

Our general approach to the project, to be refined as-needed with the District, includes the following elements corresponding to the tasks listed in the RFP:

- Perform background research / literature review, site visit and project coordination
- Perform limited topographic and geotechnical investigations
- Perform hydrologic and hydraulic analyses including a water budget and 100-year design flow estimates to inform ecological enhancements and to design outlet / spillway improvements and to meet San Mateo County permitting requirements
- Prepare and submit 35% Project design
- Prepare all necessary permit applications
- Prepare a Revegetation Plan and Integrated Pest Management Individual Work Plan
- Prepare and submit a 65% Project design with plans and specifications
- Perform all construction services, including preconstruction meetings, bonding, soil and water pathogen transfer prevention, and prepare as-builts

Preliminary Conceptual Design

The following section briefly describes our proposed conceptual designs to meet Project objectives of providing a feasible and implementable habitat enhancement design for SFGS and its prey base including CRLF.

Upper Spring

Upper Spring (Figure 1), as delineated by the DBE using the most recent LiDAR dataset (provided by the District) and our observations from the May 17, 2018 site visit, covers approximately 0.03 acre (1,322 ft2) with a perimeter of 159 ft (it should be noted that this pond size is less than the size that is indicated in the RFP, and supporting documents). Vegetation signatures in aerial imagery falsely indicate a pond area closer to ~0.14 acre (as suggested by the RFP and supporting documents), but this includes ground elevations exceeding the observed water surface elevation from the site visit which we have assumed to constrain the pond extents. This 0.03-acre pond area assumption is carried through the design described below.

In order to achieve the habitat enhancement recommendations outlined in the San Francisco Garter Snake Habitat Management Plan (Management Plan), 75 cubic yards (CY) of sediment would be excavated from the central portion of the current pond area to maintain its shape and increase depth to approximately 3.5 ft over approximately 380 ft2 of the pond area, or 29% of Upper Spring's surface area. Up to 1,058 ft2 of emergent vegetation would be removed from the pond area. In addition, 50 linear feet or 30% of perimeter vegetation would be retained, and 109 linear feet of perimeter vegetation would be removed. Slopes in the 20 – 30 % range would be situated on the west near-berm side of the pond to maintain berm integrity.

Erosion at the pond outlet has created a minor gully in the crest and downstream face of the berm. The DBE proposes to level the outlet and protect it against further erosion. The proposed plan of action is to fill the ~ 7 foot bottom-width degraded notch area with ~ 1 ft of material specified and tested by a geotechnical engineer to the approximate elevation of 1,682 feet NAVD88. To reduce erosion potential on the outlet crest and down the face of the berm, we propose placing a 14-foot wide and 30-foot long section of low cost, durable ScourStop matting to stabilize the soil while allowing vegetation growth in the repaired spillway area.

We propose to improve the water collection box and inlet pipe (if needed as determined by additional analysis) to the tank situated below Upper Spring by repairing or replacing the existing concrete box, installing a trash rack system for the collection box, and replacing the pipe with a larger 3-inch diameter galvanized pipe installed above grade along the face of the berm.

Cattle exclusion fencing would be installed to protect the outlet, berm and majority of the deepened pool, and to preserve other native vegetation. Cattle will be allowed access on the southeast corner of the pond and deepened pool to help maintain perennial open water in this area. A gate would be added to the fence on the east side of the pond to allow access to the deepened pool area for grazing or maintenance.

Material excavated from the pond would be placed in a designated spoils area situated no more than 120 feet from the northern edge of Upper Spring. The spoils area will be prepared by mowing existing vegetation to the ground and roughening the surface prior to placement of pond material. Excavated pond material will be distributed evenly on the identified area and seeded with an appropriate native seed mixture.

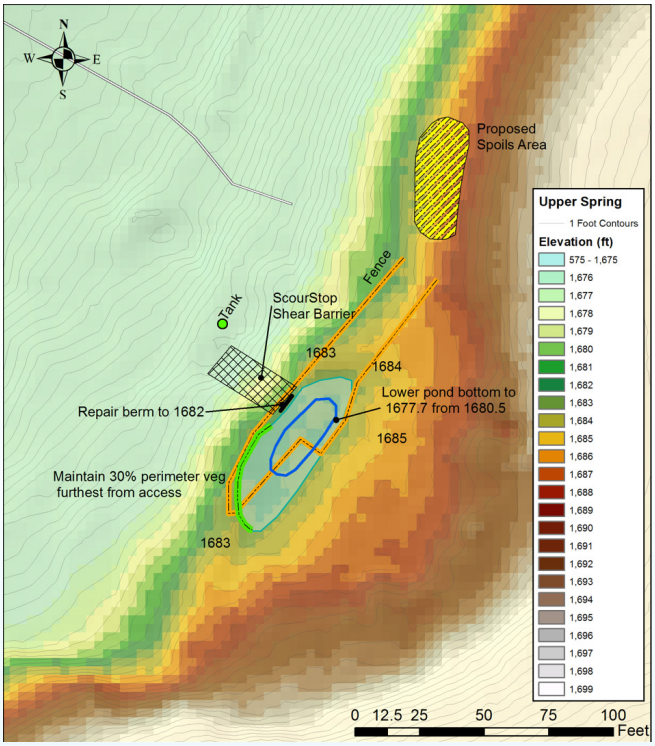


Figure 1. Upper Spring conceptual design

Kneudler Lake

Kneudler Lake (Figure 2) covers approximately 1.06 acres (46,194 ft2) as delineated by most recent LiDAR dataset (provided by the District), with a perimeter of 941 feet. To achieve habitat enhancement recommendations outlined in the Management Plan and maintain a reasonable Project cost, we propose to work on the Mindego Ranch Property only, which has an area of 23,891 ft2. For the purposes of this conceptual design, we used the anecdotal and field observations of the District and others regarding depth, such that the pond is assumed ~ 5 feet deep at the open water area. Using that assumption, we plan to remove ~ 719 CY of sediment from Kneudler Lake or ~10% of the entire pond area, within 50 feet from the lake margin to avoid additional costs associated with the excavator entering the pond. Within this excavation area, near to the existing open water area, water depth would be increased to ~ 4 feet deep, with banks sloping at 20 – 30% to pond edges. Up to 325 feet of perimeter vegetation would be removed, and ~ 65% of perimeter vegetation (including both District and CCSF property) would be preserved. Additionally, 80 – 90% of emergent vegetation would be removed from the pond within the Mindego Ranch Property.

To stabilize the headcut at the Lake outlet and to prevent it from migrating further upstream, we propose to install two rock grade control structures, using up to 120 tons of appropriately sized material. The grade control structures would be installed partially below existing ground to harden the slope and prevent further ground retreat into the outlet that could jeopardize the enhanced lake storage.

Cattle exclusion fencing would be installed to encompass the newly created deepened pool area. It is presumed that cattle will have access to open water in other areas of the pond and should be excluded from this new habitat area. The fence would enclose the east edge of the pond adjacent to the pool to assist restoration and help preserve egress through shoreline vegetation in the future. A gate would be added to the fence on the east side of the pond to allow access to the deepened pool area for grazing or maintenance.

Material excavated from the pond would be placed in a spoils area on the flat grassland to the southeast of the outlet no further than 350 feet from the northernmost excavation point in Kneudler Lake. The spoils area will be prepared by mowing existing vegetation to the ground and roughening the surface prior to placement of pond material. Excavated pond material will be distributed evenly on the identified area and seeded with

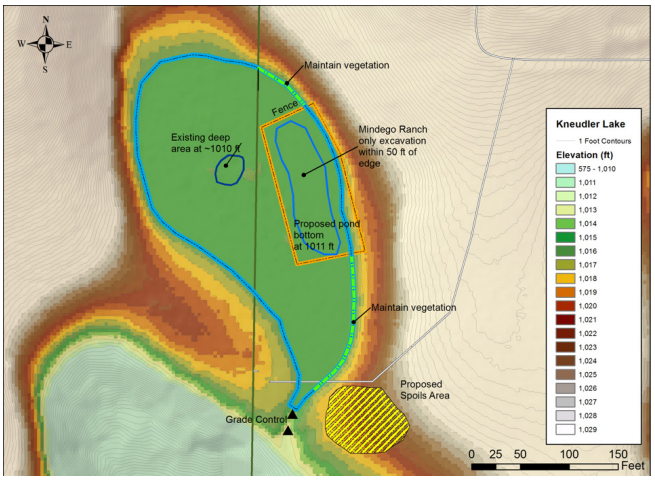


Figure 2. Kneudler Lake conceptual design

Alternative A for Kneudler Lake would include excavating ~ 3,129 CY of sediment or 36% of the pond area, clearing 615 ft of perimeter vegetation and 80 – 90 % of emergent vegetation. Excavation would only occur within 50 ft of the pond edge to avoid excavator entrance into the pond. This alternative would implementation costs significantly, with approximately the same design cost, as described in the Proposal Price section.

Scope of Services

◆ Task 1 | Background Research, Site Visit & Project Coordination

The DBE will coordinate with the District to obtain any available relevant documentation about the site to perform a brief review of the history and current condition of Mindego Ponds and Ranch. The DBE will review pertinent geotechnical and geologic maps, and all project materials and relevant back-ground information listed in the RFP regarding the project area.

A project kickoff meeting with the District and members of the DBE is proposed prior to the commencement of work, particularly field activities, to ensure all parties are in agreement regarding the intended scope of services as well as the budget and schedule.

cbec will maintain close communication with the District and its partners to ensure that all documents are technically accurate and completed within the project's proposed schedule and budget. Day to day project management, which will include the preparation of contracts, invoicing, financial management, and general project management activities, are included in this task. Moreover, the DBE's project director, Chris Hammersmark, and project manager, April Sawyer, will maintain regular telephone and email communications with the District staff and subconsultants. Finally, strategically timed meetings with the the District are included in the tasks described below. These meetings are planned at key decision points in the project's trajectory.

Assumptions:

- The District will provide any available documentation regarding Mindego Ranch
- The District will coordinate with local land owners to obtain permission for property access where necessary

Deliverables:

- Monthly progress reports and invoices
- Meeting notes

◆ Task 2 | Limited Topographic Survey and Geotechnical Investigations

Ifland will set two benchmarks at each site using fast static global position system (GPS) methods. cbec will use the locally established benchmarks to perform topographic surveys of each site using a Real Time Kinematic Global Positioning System (RTK-GPS) and total station (if needed) survey. Locally established benchmarks will also be used for construction staking. Each site will be surveyed to capture the existing land surface (including pond bathymetry), structures, and to verify the LiDAR data. This information will be integrated with the available LiDAR data to create a composite terrain model or topographic base map for each site.

BGE will explore the surface and subsurface conditions at the site to develop geotechnical recommendations for the design of the berm and pond improvements. In addition, BGE will provide a slope stability analysis for the berm each pond. The field exploration will consist of logging and interval sampling a total of 4 borings (up to 2 at each pond's berm feature) ranging in depth from 15 to 40 feet below ground surface. The soil samples obtained will be sealed and returned to the laboratory for testing. The borings will be drilled in the location of the existing ponds. The number and depth may vary depending on conditions encountered. BGE will also perform up to 3 hand augered borings at each pond to define the location of any underlying impermeable layers.

Following field exploration, BGE will perform laboratory testing of the selected samples considered representative of site conditions to ascertain or derive relevant engineering properties including:

- Moisture/Density
- Soil Classification
- Shear Strength
- Consolidation
- Permeability Testing

Finally, BGE will perform a geotechnical engineering analysis and evaluation of the resulting field and laboratory data. This will include a stability analysis to determine safe embankment

Scope of Services

gradients with respect to static and seismic conditions. A Geotechnical Report will be prepared to document findings, conclusions and recommendations in accordance with San Mateo County standards.

Assumptions:

- The DBE will set up a meeting with San Mateo County Geotechnical Engineers and Planning Department to describe the site and ascertain whether borings are required. Feedback from the County to date has been inconclusive on this matter

Deliverables:

- Two benchmarks at each site (four total), established in the field by a PLS
- GIS and/or computer-aided design (CAD) files for topographic base map
- Coordinates, description, and photos of locally established benchmarks
- 6 copies of Geotechnical Report signed and stamped by at P.E., or G.E.

◆ Task 3 | Hydrology Assessment and Reporting

A hydrologic investigation will be conducted to determine site conditions pertinent to developing wetlands for amphibian breeding. A hydrologic investigation will be conducted to determine site conditions and limitations to developing wetlands for amphibian breeding. A simple spreadsheet-based water budget analysis will be developed with locally and readily available climate, topography, and vegetation information. The daily water budget will consider local climatic conditions over the past few decades that adequately capture a range of dry, normal, and wet conditions. Inflows will include direct rainfall, runoff from the contributing watershed, and an estimate of spring inflow. Outflows will include evaporation, vegetation uptake (transpiration), and an estimate of percolation losses. The water budget analysis will form the basis for the expected hydrologic regime and inform construction recommendations related to pond depths.

Additionally, in accordance with San Mateo County standards, the 100-year flood discharge will be calculated for each site to inform outlet structure designs. A rainfall-runoff routing model appropriate for small watersheds, such as WinTR-55 (NRCS, 2013) will be used to calculate surface water inflows to each pond for the 100-year flood discharge. This will be used to assess downstream slope stability at each outlet and the appropriate slope stabilization measures.

Assumptions:

- Time period of water budget is dependent on available datasets
- We have not included field based hydrologic analyses (e.g. monitoring spring flow rates) in our proposal to control costs

Deliverables:

- Hydrological assessment report for Upper Spring and Kneudler Lake prepared according to San Mateo County Standards

◆ Task 4 | Plans, Specification & Supervisory Review

Following data collection (Task 2), hydrologic analysis (Task 3), the DBE will prepare 35% Project PSE and recommend preliminary design of the Project. The 35% design will be developed in accordance with the Management Plan and RFP and will include draft construction drawings, specifications table of contents, and a preliminary construction cost opinion. A preliminary Basis of Design memorandum to support permitting will be prepared.

Assumptions:

- Drawing scale is 1 inch = 20 feet unless otherwise noted
- Plans will consist of the following:
  - Cover sheet (1 sheet)
  - Access and staging/key plan (2 sheets, scale: 1 inch = 100 feet)

Scope of Services

- Existing conditions and temporary fencing (up to 2 sheets)
- Grading plans (up to 2 sheets)
- Grading cross sections (up to 2 sheets)
- Erosion and sediment control (up to 2 sheets)
- Planting, fencing and details (up to 3 sheets)
- Cattle water development notes, schedules, and details (up to 3 sheets)

- Cattle exclusion fencing will be included
- A SWPPP will not be prepared for the Project based on the assumption that the project will disturb less than one acre. If this changes, or the District requires a SWPPP, the DBE can provide this service for additional budget
- Review comments on the 35% construction documents will be provided during a design review meeting or as one consolidated set of comments, with all conflicting comments resolved
- Plans will be drafted in AutoCAD 2018 format and submitted in PDF format
- Specifications, construction cost opinion, and written responses to comments will be prepared in Microsoft Word and Excel

Deliverables:

- 35% design plans in pdf format for review and comment by the District
- A brief Basis of Design memorandum describing how the design will meet the Project's objectives, and will include a Project schedule and construction budget estimate
- Specifications table of contents

◆ Task 5 | Permitting

Select Project permitting will be completed by the District under the District's existing 10(a)(1)(A) Recovery Permit for the SFGS. The DBE, led by KEC and cbec, will prepare applications for other permits including Regional Water Quality Control Board Section 401 Waste Discharge Requirements, U.S. Army Corps of Engineers Section 404 Nationwide permit, California Department of Fish and Wildlife Lake and Streambed Alteration Agreement, and San Mateo County's grading permit. San Mateo County has indicated that a grading permit is required for both water bodies, and a Resource Management Permit may also be required. It is unlikely that we will be able to obtain a grading permit exemption through the Resource Conservation District. If required, KEC will prepare an Initial Study for the Project to comply with CEQA.

Assumptions:

- The DBE will set up a meeting with San Mateo County Geotechnical Engineers and Planning Department to discuss grading permit requirements and geotechnical analyses requirements. Feedback from the County to date has been inconclusive on this matter, though they have indicated that a grading permit is needed for both ponds

Deliverables:

- Completed permit applications (as outlined above) submitted to each respective agency on behalf of the District, following District review and approval

◆ Task 6 | Revegetation Plan and Integrated Pest Management Individual Work Plan

cbec with assistance from KEC will develop a revegetation plan in accordance with the District BMPs for revegetation or select disturbed areas included in the final 65% design.

KEC will develop a project-specific Integrated Pest Management Plan (IPM) for the pond enhancement areas and associated construction access routes. The IPM will be limited in geographic scope and will focus on areas subject

Scope of Services

to construction and restoration disturbance. KEC will rely on guidance from the District's Programmatic Integrated Pest Management Plan and EIR (MROSD, 2014), existing botanical surveys, as well as current grazing plans and ongoing vegetation management practices.

Deliverables:

- Revegetation plan
- Integrated Pest Management Plan

◆ Task 7 | Design Development

cbec will prepare 65% plans and specifications to further the design enhancements at both sites. cbec will lead preparation of the plans and specifications and will prepare the access, demolition (i.e., clearing and grubbing), grading and erosion control plans. The 35% designs will be advanced to a 65% complete design by incorporating the comments from the District from Task 4. KEC will specifically review any District comments on the 35% plans related to the ecological aspects of the design. The final 65% design package will include draft construction drawings, draft specifications, an updated cost opinion, and an updated Basis of Design memorandum.

The 65% plans will be used to support the multiple permits being prepared by the DBE. It is anticipated that during the permit review period, which could exceed 6 months, that the permitting agencies and the District may develop additional comments on the 65% plans, which may require further modifications. The 65% PSE will include final construction drawings, specifications, and a cost opinion. BGE will perform geotechnical review of the 65% design package as part of this task.

Assumptions:

- Construction document scope and budget assumptions:
  - The DBE will prepare front-end plan sheets and specifications (general conditions, supplementary conditions, contract clauses, etc
  - The District will provide general requirement specification sections from previous and similar project(s), and the DBE will tailor them to this project
- Review comments on the draft 65% construction documents will be provided during a design review meeting, or as one set of written consolidated comments, with all conflicting comments resolved
- Comments on construction specifications will be made in track changes
- The DBE will be responsible for modifications to the berms, however the long-term stability of the berms (particularly the areas not impacted by the DBE) will be the responsibility of the District

Deliverables:

- Draft 65% design plans in PDF format for District review
- Draft 65% construction specifications in Word format
- Revised 65% design plans in PDF format incorporating the District comments for submittal to and review by permitting agencies
- Revised 65% construction specifications in PDF format
- Revised 65% Basis of Design memorandum
- 5 printed sets (24" x 36") of submittal ready design plans for Maintenance and repair of Upper Spring and Kneudler Lake prepared by a P.E., including an estimate of how much grading (cut and fill) is required
- 5 sets of erosion control plans (including dewatering, sediment removal/placement, dust control, and stormwater plans if needed)
- 5 printed sets of the design report
- Responses to permitting agency comments

Scope of Services

◆ Task 8 | Preconstruction Meeting and Construction Services

Hanford ARC will serve as the General Contractor and perform all implementation including:

- Mobilization
- General Conditions preparation
- Site clearing and grubbing
- Habitat exclusion fencing
- Sediment removal and spreading at spoils areas
- Outlet works improvements and grade control installation
- Site restoration
- Cattle exclusion fencing installation

During construction, Hanford ARC will work with the cbec to track compliance with the plans and specifications. This task includes attending a preconstruction kickoff meeting.

The DBE will establish staking for Hanford ARC to mark limits of disturbance, site grading, and revegetation. Hanford ARC will be responsible for maintaining grade stakes and for establishing and maintaining offsets from the grade stakes. cbec will perform an as-built survey and prepare as-built plans for submission to the District.

Assumptions:

- We anticipate, that the construction period will last approximately 3 weeks and that the level of effort described in this task is adequate.
- The District will provide biological construction monitoring
- The level of effort will be commensurate with the budget

Deliverables:

- Construction staking
- Copies of all RFIs with responses
- As-built planset

◆ Task 9 | Soil and Water Pathogen Transfer Prevention

All construction traffic and on-site workers (including site visits and surveys conducted as part of Tasks 1 and 2) will follow the requirements outlined in Guidelines for Minimizing *Phytophthora* Pathogens and Decontamination for Professionals to avoid the spread of soil and water pathogens. Alternative methods, if required, will be submitted to the District for approval.

Proposal Price

Despite our best efforts to reduce costs, our estimated cost for preliminary studies, design, permitting and construction of this project (provided in the budget table below), exceeds the $200,000 to $300,000 range specified in the RFP. Compared to our previous design proposal (submitted in November 2017, our design costs have been reduced due to the change to a design-build approach; however, additional project elements (e.g., permitting) beyond implementation have been included. Major drivers of the project cost are that construction progress will be slow relative to similar restoration activities, due to the biological requirements associated with this extremely sensitive site, and prevailing wage requirements.

As detailed in the tables below, our proposed price to complete the project as described in the RFP and this proposal is $405,321, made up of $267,933 for construction, and $137,388 for all other activities (i.e., analyses, design, permitting, management, etc.). Our proposed price to complete Alternative A of the project is $661,986, made up of $524,598 for construction, and $137,388 for all other activities (i.e., analyses, design, permitting, management, etc.).

Our team has made substantial efforts to minimize the costs of this project while still ensuring that the project can be successfully designed, permitted and constructed to achieve the District's habitat enhancement objectives. The cost-savings measures that we have pursued include, but are not limited to, the following:

- Reducing design costs by pursuing a design build relationship with a trustworthy, experienced and reputable contractor and reducing level of design advancement necessary to ensure successful project completion,
- The design build approach also provides greater cost certainty, avoids surprise claims or change orders, and enables the design team to amend designs earlier in design process to achieve reduced construction costs,
- Eliminating all markup on subconsultants as well as design and permitting expenses, and
- Forgoing overhead/markup on construction staff and materials.

Our team is committed to providing the District with a design, permitting and construction approach that will ensure successful implementation of the project with judicious use of budget resources. We welcome discussion with the District with regard to our cost estimate and determining the best path forward, in order to allow the District to understand why our estimated costs are higher than were predicted. In addition, we would typically recommend including a contingency in the budget to support unforeseen costs; however, we have not included any contingency in the cost estimate provided.

Proposal Price

ESTIMATED PROJECT BUDGET SUMMARY			
Task #	**Task Description**	**Subtotal for DBE**	**Optional Task (Kneudler Alt. A)**
1	Background Research, Site Visit & Project Coordination	$18,200.00	$18,200.00
2	Limited Topographic Survey, Hydrological Survey and Geotechnical Investigations	$33,315.00	$33,315.00
3	Hydrology Assessment and Reporting	$9,375.00	$9,375.00
4	Plans, Specification & Supervisory Review	$23,610.00	$23,610.00
5	Permitting	$9,200.00	$9,200.00
6	Revegetation Plan and Integrated Pest Management Individual Work Plan	$4,000.00	$4,000.00
7	Design Development	$22,350.00	$22,350.00
8	Preconstruction Meeting and Construction Services	$267,933.00	$524,598.00
	Labor Fee	**$387,983.00**	**$644,648.00**
	Reimbursables	**$2,390.00**	**$2,390.00**
	Permitting Fees	**$14,948.00**	**$14,948.00**
	Total Project Budget	**$405,321.00**	**$661,986.00**

Proposal Price

The following table summarizes staff involvement by task for design, permitting and construction management efforts. It does **not** include an hours estimate or staff allocation for construction activities.

PROPOSED HOURS PER STAFF PERSON

Task Number	Task Actions	Chris Hammersmark	April Sawyer	Chris Campbell	Sam Diaz	Luke Tillman	Juma Mohammadi	Jordan Fields	cbec Subtotas	Gary Kittleson	Greg Bloom	Philip Edwards	Field Technician	BGE Subtotals	Gary Ifland	Jeanmarie Bostley	Ifland Subtotals
1	Background Research, Site Visit & Project Coordination	22	52	2	0	0	0	0	76	15	4	8	0	12	0	0	0
2	Limited Topographic Survey and Geotechnical Investigations	3	12	0	0	0	0	22	37	20	26	92	14	132	9	9	18
3	Hydrology Assessment and Reporting	6	10	2	0	45	0	0	63	0	0	0	0	0	0	0	0
4	Plans, Specification & Supervisory Review	8	44	2	24	0	120	0	198	15	4	8	0	12	0	0	0
5	Permitting	4	10	0	0	0	0	0	14	68	0	0	0	0	0	0	0
6	Revegetation Plan and Integrated Pest Management Individual Work Plan	0	0	0	0	0	0	0	0	40	0	0		0	0	0	0
7	Design Development	12	36	2	40	0	80	0	170	0	0	0	0	0	0	0	0
8	Preconstruction Meeting and Construction Services	6	10	0	0	0	20	32	68	0	4	8	40	52	0	0	0
	Totals	**61**	**174**	**8**	**64**	**45**	**220**	**54**	**626**	**158**	**38**	**116**	**54**	**208**	**9**	**9**	**18**

Proposal Price

STAFF HOURLY BILLING RATES			
Firm	**Position Level**	**Rate**	**Relevant Staff**
cbec			
	President/Managing Director	$240	
	Director	$225	Chris Hammersmark Chris Campbell
	Senior Eco-Engineer II / Eco-Hydrologist II	$205	
	Senior Eco-Engineer I / Eco-Hydrologist I	$165	Sam Diaz
	Eco-Engineer II / Eco-Hydrologist II	$150	April Sawyer
	Eco-Engineer I / Eco-Hydrologist I	$135	Luke Tillman
	Technician II	$120	Jordan Fields
	Technician I	$90	Juma Mohammadi
	Desktop Publishing	$85	
	Clerical/Admin	$85	
KEC			
	Principal	$100	Gary Kittleson
BGE			
	Principal Geotechnical Engineer	$165	Greg Bloom
	Senior Engineer	$150	Philip Edwards
	Field Technician	$120	
Ifland Survey			
	Principal Surveyor	$240	Gary Ifland
	Project Surveyor II	$150	Jeanmarie Bostley
	Survey Technician	$120	
	Survey Crew (2 Persons; prevailing wage)	$400	

Proposal Price

ESTIMATED PERMIT FEES				
Permit Name	**Permitting Agency**	**Estimated Cost**	**Assumptions**	**Reference**
Section 401 Waste Discharge Requirements	Regional Water Quality Control Board	$1,500.00	800 CY dredged material	https://www.waterboards.ca.gov/resources/fees/docs/fy1718_fee_schedule.pdf
Section 404 Nationwide Permit	US Army Corps or Engineers	$100.00		http://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf
Lake and Streambed Alteration Permit	CDFG	$6,370.00	Two projects costing <$200,000 each	https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=152857&inline
Grading Permit	San Mateo County	$3,489.00	101-1000 CY grading	https://planning.smcgov.org/sites/planning.smcgov.org/files/documents/files/Planning-Fee-Schedule-10-21-11.pdf
Resource Management Plan	San Mateo County	$572.00-$3,489.00	Need more guidance from San Mateo County	
Total		**$12,031.00-$14,948.00**		

Technical Design and Construction Expertise

Our proposed DB Team consists of the following firms. Since submitting our SOQ, we have removed Biosearch from our team consistent with the guidance from the District to no longer include biological monitoring services as part of our proposed scope of work.

Firm Name	Project Roles	Areas of Expertise
cbec eco engineering	• Engineering • Design • Project management • Permitting support	• Ecoengineering services including hydrology, hydraulics, geomorphology, water quality, restoration design and field services
Hanford ARC	• Design support • Constructability review and implementation advisement • Construction	• Wetland mitigation and restoration, stream construction, soil bioengineering, revegetation, park construction and erosion control
Kittleson Environmental Consulting	• Permitting support • Biological monitoring support	• Natural resource management services including owner representation, regulatory negotiations, construction planning, compliance monitoring and wildlife surveys
Butano Geotechnical Engineering	• Geotechnical assessment and design support	• Geotechnical services including earth embankment restoration, dam and levee design, slope stability analysis, trail maintenance, retaining walls, and trail bridges
Ifland Survey	• Professional land surveying	• Surveying and mapping services including boundary, topographic and construction surveys for development, utilities, infrastructure, parks, open space and recreation facilities

Key Personnel

Staff Name / Title / Affiliation	Time Commitment	Contact Information	Licenses / Registration / Permits
Chris Hammersmark Director, Ecohydrologist cbec eco engineering	20%	c.hammersmark@cbecoeng.com 916.668.5236 519 Seabright Ave, Suite 102, Santa Cruz, CA 95062	Licensed Civil Engineer: California PE #66595
April Sawyer Ecohydrologist cbec eco engineering	50%	a.sawyer@cbecoeng.com 916.668.5234 2544 Industrial Blvd West Sacramento, CA 95691	N/A
Chris Campbell Director, Ecohydrologist cbec eco engineering	10%	c.campbell@cbecoeng.com 916.668.5232 2544 Industrial Blvd West Sacramento, CA 95691	N/A
Sam Diaz Senior Ecoengineer cbec eco engineering	25%	s.diaz@cbecoeng.com 530.478.0680 2544 Industrial Blvd West Sacramento, CA 95691	Licensed Civil Engineer: California PE #68217 CPESC: California #7473
Mark Cederborg Principal, Project Manager Hanford ARC	20%	mark@hanfordarc.com 707.975.3105 23195 Maffei Road Sonoma CA 95476	Licensed General Engineering Contractor: California #461167 (This license applies to Hanford ARC as a firm)
Gary Kittleson Principal, Environmental Consultant Kittleson Environmental Consulting	20%	garykit@pacbell.net 831.251.0215 3284 Malibu Drive, Santa Cruz, CA 95062	Kittleson holds several U.S. Fish and Wildlife Service Authorized Biologist for Federal Biological Opinions Permits (1-8-05-F-27; 1-8-07-F-26: 1-8-08-F-19: 1-8-06-F-25; 1-8-06-F-37: 1-8-07-F-18; 1-802/F/C 70/07793:OHW; & 151422SWR2002SR6273:BL) and Steelhead 4(d) Permit (18425), and a California Department of Fish Wildlife Scientific Collection Permit (SC-007999)
Greg Bloom Owner, Principal Geotechnical Engineer Butano Geotechnical Engineering	5%	greg@butanogeotech.com 831.724.2612 231 Green Valley Road, Suite E, Freedom, CA 95019	Licensed Civil Engineer: California #58819 Licensed Geotechnical Engineer: California #2691
Philip Edwards Senior Engineer Butano Geotechnical Engineering	15%	philip@butanogeotech.com 831.724.2612 231 Green Valley Road, Suite E, Freedom, CA 95019	Licensed Civil Engineer: California #86451
Gary Ifland Principal Surveyor Ifland Survey	5%	gary@iflandsurvey.com 831.426.7941 5300 Soquel Avenue, #101 Santa Cruz, CA 95062	California Licensed Surveyor #7367
Jeanmarie Bostley Licensed Land Surveyor Ifland Survey	10%	jeanmarie@iflandsurvey.com 831.426.7941 5300 Soquel Avenue, #101 Santa Cruz, CA 95062	California Licensed Surveyor #8452

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Chris Hammersmark, PhD, PE
Director / Ecohydrologist



Education

PhD, 2008, Hydrologic Sciences, University of California Davis, Center for Watershed Sciences, Davis, CA

MS, 2003, Hydrologic Sciences, University of California Davis, Center for Watershed Sciences, Davis, CA

BS, 1996, Civil and Environmental Engineering, Forestry minor, University of California Berkeley, Berkeley, CA

Professional Registration

2003, Professional Civil Engineer, California, #66595

Professional Experience

cbec, inc., eco-engineering, West Sacramento, CA
Director / Ecohydrologist, 2009-present

Independent Hydrologist, 2000-2008

University of California Davis, Center for Watershed Sciences, Davis, CA, Post-Doctoral Researcher, 2008

University of California Davis, Center for Watershed Sciences, Davis, CA, Research & Teaching Assistant, 2000-2007

University of California Davis, Department of Civil and Environmental Engineering, Davis, CA, Post-Graduate Researcher, 2003

University of California, Department of Civil and Environmental Engineering, Davis, CA, Research Assistant, 2000-2002

Dr. Hammersmark is a registered civil engineer specializing in hydraulics, hydrology, geomorphology, ecology, and ecosystem rehabilitation/restoration. He has over 18 years of experience on a diverse array of projects involving stream, meadow and floodplain restoration, sediment transport and water quality, flood inundation and water supply. The environmental settings for these projects range from natural to urban, from headwater streams and adjacent meadows and forests through lowland alluvial rivers to tidally influenced coastal rivers and estuaries. While a majority of Dr. Hammersmark's experience is gained from projects within California, he has also participated in interdisciplinary projects in Alaska, Arizona, Utah, Washington, British Colombia, and Scotland.

Dr. Hammersmark has extensive experience in the design and evaluation of estuarine, stream and river restoration/rehabilitation projects. Facets of this experience include the assessment of hydrologic, hydraulic, geomorphic and ecological effects of a variety of restoration and rehabilitation efforts (e.g., levee breaching, channel and floodplain reconfiguration, bank stabilization, dam removal, structure placement, and vegetation planting/removal). Assessments have included the collection and comparison of before and after physical and biological data, in addition to the utilization of hydraulic, hydrologic and statistical species prediction models to predict the potential outcome of proposed designs, as well as retrospectively evaluate the benefits gained.

Dr. Hammersmark's technical experience includes a blend of computation analyses with a variety of field methods. Examples of skills and tools typically utilized include numerical hydraulic and hydrologic modeling (e.g., HEC, USGS, USBR and DHI models), habitat suitability modeling, terrain modeling, GIS and a variety of types of field investigations including sediment characterization and sediment transport measurements, habitat characterization and mapping, vegetation sampling, topographic and bathymetric surveys, water quality sampling, flow gaging, groundwater sampling, water table measurement, soil infiltration and compaction monitoring.

Dr. Hammersmark has been involved in interdisciplinary research regarding environmental restoration and water resources for more than 13 years, with a focus placed on identifying physical drivers of ecological processes. He has published a number of peer-review articles in scientific journals (e.g., River Research and Applications, Restoration Ecology, Wetlands, Ecological Engineering, Natural Hazards Review, and Hydrogeology Journal), and has presented at a variety of professional conferences and meetings. Dr. Hammersmark has taught, or assisted in teaching several field and classroom based university courses (e.g., Fluvial Geomorphology, Ecogeomorphology of Rivers and Streams), as well as university extension short courses (e.g., Understanding Riparian Processes, Geomorphic and Ecological Fundamentals of River and Stream Restoration, Streambank Assessment and Restoration).

Drawing from his diverse academic and consulting background, Dr. Hammersmark seeks innovative and sustainable process-based solutions to complex multi-objective water resource and ecosystem restoration challenges, while operating within the specific constraints of each project. He is committed to the conservation, preservation and rehabilitation of aquatic, wetland and terrestrial ecosystems.

SELECTED PROJECTS

Butano Creek Floodplain Restoration Design, Pescadero, CA
Resource Conservation District of San Mateo County, 2015-2016

Project director for a design effort to restore channel and floodplain habitat by installing a series of engineered log jams, roughened channel grade control structures and floodplain access channels. Implementation of the project will restore natural function to the creek, reduce incision of the creek bed and erosion of its banks, restore wetland habitat, restore the floodplain's ability to store sediment, help address water quality

SELECTED PROJECTS *(CONTINUED)*

impairment from sediment, create and enhance off-stream habitat, and enhance ecological values for multiple federal and state listed species. The project includes topographic surveys, 2D hydrodynamic modeling, sediment transport modeling, design and the development of plansets.

Butano Creek Cumulative Effects Analysis and Sediment Transport Modeling, Pescadero, CA
Resource Conservation District of San Mateo County and US Fish & Wildlife Service, 2015-2016

Project director for a modeling effort to assess the potential benefits of multiple floodplain restoration and upland sediment reduction actions upon channel and floodplain habitat and downstream sediment delivery. The project includes topographic surveys, sediment sampling, and sediment transport modeling.

Potential Sedimentation/Scour Analysis for the Cougar Wetlands Unit, Sacramento County, CA
Ducks Unlimited, 2012-2013

Project manager responsible for assessing potential sedimentation/scour related to the engineered breaching of levees bounding the Cougar Wetlands, adjacent to the Cosumnes River. The project entailed field surveys, 2D hydrodynamic modeling and analysis.

Phoenix Lake Preservation & Restoration Plan. Sonora, CA
Tuolumne Utilities District as a sub-consultant to Horizon Water and Environment, 2010-2012

Task manager for the multifaceted preservation and restoration plan investigations. Activities include: flow gaging, watershed sediment source reconnaissance, development of sediment management options, volume estimates of reservoir sedimentation, and development of dredging plan designs and drawings.

College Lake Improvement and Watershed Management Project, Santa Cruz County, CA
Resource Conservation District of Santa Cruz County, 2012-2014

Project manager for the development of an integrated management plan for College Lake, located on Salsipuedes Creek, a tributary to the Pajaro River. The project entails field measurements (topographic surveys and stream gaging), hydrologic and hydraulic model development and application, water budget analysis, data review and the development of conceptual designs and management strategies. Project objectives include: water supply, flood control, migratory waterfowl habitat, Steelhead rearing habitat and migration, and agriculture.

Santa Cruz County Stream Wood Assessments, Santa Cruz, CA
Santa Cruz County, 2015-present

Project director and engineering geomorphologist for an ongoing project that provides site assessments to inform the management of stream wood with a focus placed on recommendations related to resulting flood risk, geomorphic risk and habitat potential of stream wood assemblages in streams within the county.

American River - Spawning/Rearing Habitat - Gravel Augmentation Design, Rancho Cordova, CA
Water Forum, US Bureau of Reclamation and US Fish & Wildlife Service, 2010-present

Project manager for a multi-year gravel placement and side channel creation effort to improve spawning and rearing habitat for Chinook salmon and steelhead. Activities include field surveys, data collection, 2D hydraulic modeling, habitat suitability modeling, preparation of construction drawings and Basis of Design reports, and performance evaluation of past projects. To date six separate projects have been designed and constructed.

Bear Creek Restoration Project - Hydrologic, Geomorphic and Ecological Effects Assessment, Fall River Mills, CA
Independent Hydrologist, *2003-2008*

Project director/manager for a study that evaluated the hydrologic, geomorphic and ecological effects of pond and plug stream channel restoration in a mountain meadow. A combination of field (flow gaging and water-table measurement, hydrogeologic characterization, channel substrate characterization, topographical surveys) and computational modeling (1D, 2D and 3D hydraulic and hydrologic) methods were used in the hydrologic assessment. Effects upon the distribution of a number of plant species were determined with a hydrologic-habitat suitability modeling approach.

Folsom Reservoir and American River Temperature Monitoring and Modeling, Sacramento, CA
Water Forum, 2009-present

Project manager for a multifaceted hydrodynamic and water temperature modeling project encompassing Folsom Reservoir, Lake Natoma and the lower American River. Aspects of the project include temperature and stage monitoring, bathymetric surveys, the development and application of a HEC-RAS hydrodynamic and water quality model, modernization and improvement of the existing Coldwater Pool Management Model (iCPMM), and application of CEQUAL-W2 water temperature models for Folsom Reservoir and Lake Natomas. The HEC-RAS and CEQUAL-W2 models are used to evaluate reservoir and river conditions for a variety of scenarios reflecting 82 years of historic hydrology as simulated CALSIM II a water supply optimization model. This effort has required the development of disaggregation techniques to post-process monthly CALSIM model outputs into, daily or hourly time series for use and boundary conditions for the HEC-RAS and CEQUAL-W2 models.

Cache Creek Turbidity and Suspended Sediment Monitoring Program, Yolo County, CA
Community Development Agency, 2004-2007

Project manager for a multi-year investigation of the suspended sediment yield of Cache Creek. Conducted monthly and event based turbidity and suspended sediment sampling at six locations along Cache Creek to assess the spatial and temporal variation of suspended sediment load, as well as estimates of annual yield.

Branciforte Dam Removal Design, Santa Cruz County, CA
Resource Conservation District of Santa Cruz County, 2012-2013

Project manager for assessing various design alternatives for the removal of Branciforte Dam, located on Branciforte Creek. The 8 foot tall dam is no longer used for its original purpose; however, it continues to present an impediment to the upstream migration of anadromous salmonids, and alters the geomorphic process of coarse sediment transport, impounding both fine and coarse sediment. Specific components of the project include: (1) field surveys to measure topography, impounded sediment volume and substrate texture; (2) hydraulic modeling to determine hydraulic effects of removing the dam; and (3) development of 60% and 100% level construction drawings, cost estimates and a basis of design report. The objective of the project is to remove the dam structure such that natural hydrologic, geomorphic and biologic processes function as they did prior to dam construction.

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April Sawyer, MS
Ecohydrologist



Education

MS, 2015, Geosciences, University of Montana, Missoula MT. Thesis: Chute cutoff formation in a wandering gravel-bed river.

BS, 2007, Environmental & Resource Science, Hydrobiology, University of California Davis, Davis, CA

Professional Experience

cbec, inc., eco-engineering, West Sacramento, CA
Ecohydrologist, 2010-2014, 2015-present

Cardno ENTRIX, Inc., Sacramento, CA, Assistant Staff and Senior Staff Scientist, 2008-2010

Other Experience

University of Montana, Missoula, MT, Teaching Assistant, 2013-2014

University of Montana, Missoula, MT, Graduate Research Assistant, 2013-2015

University of California Davis, Land, Air and Water Resources, Hydrology Department, Davis, CA, Student Researcher, 2004-2008

Short Courses

"Geomorphic and Ecological Fundamentals for River and Stream Restoration" Sagehen Creek Field Station, Truckee, CA, August 13-17, 2012

April joined the water resources and fluvial geomorphology field in 2008. She graduated with a M.S. in fluvial geomorphology from the Geosciences Department at the University of Montana in 2015 and a B.S. in Environmental and Resource Science (Hydrobiology) at the University of California, Davis in 2007. She joined cbec in 2010 after gaining experience supporting a large hydroelectric FERC relicensing project, and returned upon completion of her M.S. thesis. She completed her M.S. thesis investigating the role of flood magnitude and duration on forming chute channels utilizing a 2D hydraulic model of the Clark Fork River, MT, Milltown Dam Removal Superfund site. She has considerable field experience including topographic surveying, flow and velocity measurements (using Acoustic Doppler Current Profilers and Velocimeters), geomorphic feature mapping, sediment sampling, and biological population sampling. April's fluvial geomorphology and biological background are supported by proficiency in ArcGIS, MIKE21 FM, MIKEFLOOD, Delft3D, iRIC (Nays2DH), HEC-DSS, HEC-RAS (1D and 2D), River2D, and MATLAB. April applies her diverse background to varied water resources projects, with specific interest in process-based design and management for aquatic habitat rehabilitation.

SELECTED PROJECTS

Yolo Bypass Drainage and Infrastructure Improvement Study, Yolo County, CA
Yolo County, 2012-2013

Project manager for a study to improve the availability and quality of data for planning drainage and water infrastructure improvements that benefit wetlands and agriculture in the Yolo Bypass, which will assist Yolo County and the Yolo Basin Foundation in securing future funding for projects or feasibility studies to benefit agriculture and wetland operations.

Yuba River Hallwood Channel and Floodplain Restoration Project, Hallwood, CA
US Fish & Wildlife Service and Anadromous Fish Restoration Program, 2016-present

Project Manager on a large restoration project on the "Daguerre Alley" Reach on the lower Yuba River (see below). Project management activities include coordinating and advising subconsultants' permitting and monitoring activities, addressing clients concerns, supervising and performing quality review for technical analyses, coordinating with numerous stakeholders, agencies and landowners on project design and implementation details, overseeing public outreach including a project website, presenting at local stakeholder group meetings, running team meetings, coordinating restoration implementation cost estimates, writing sections of Basis of Design report and other documents, and writing proposals to seek further funding for non-funded implementation phases.

Decker Island Habitat Restoration Project, Legal Delta, CA
California Department of Water Resources, 2015-2016

Project manager and hydrologist for modeling and design support to evaluate efficacy and potential adverse effects of levee breach scenarios at Decker Island, near the Sacramento-San Joaquin River confluence. The analyses supported the CVFPB Encroachment Permit, and Clean Water Act Section 401 Permit. Project management duties included client and prime consultant design meetings and correspondence and tracking scope, schedule, and budget. Technical duties included running tidal hydrodynamics in a MIKE 21FM model, assessing design scenarios for flushing time with advection dispersion modeling, flood scenario hydraulics, and channel self-maintenance.

Yolo Bypass Phytoplankton Particle Tracking Modeling, Legal Delta, CA
California Department of Water Resources, 2015-2017

Project hydrologist leading particle tracking simulations within a 2D hydrodynamic model of the Cache Slough Complex (see below) to understand fate and transport of phytoplankton generated in the Yolo Bypass during fall agricultural drainage periods. Analyses included spatiotemporal tracking of particle classes released during different times by zones and using animations, and comparison with observed chlorohyll data.

SELECTED PROJECTS *(CONTINUED)*

Development of Habitat Enhancement Alternatives for Daguerre Alley, Lower Yuba River, Yuba County, CA
Yuba River Management Team, 2012-2013

Project hydrologist/geomorphologist supporting the development of habitat enhancement alternatives for a 2-mile side channel on the lower Yuba River immediately downstream of Daguerre Point Dam. Tasks include concept development of habitat enhancement features, analysis of alternatives, and preliminary development of construction sequencing options.

Feasibility Assessment for Barrier Construction at Sagehen Creek, Truckee, CA
California Department of Fish and Game, 2012

Project hydrologist, involved in a field reconnaissance effort to identify potential locations for construction of permanent and temporary barriers for the exclusion of non-native trout species and Lahontan cutthroat trout reintroduction. Sites were identified based on valley width, proximate bedrock and other geomorphic indicators.

Hydrologic and Geomorphic Analysis to Support Rehabilitation Planning for the Lower Yuba River, Yuba County, CA
South Yuba Citizens League, 2013

Project hydrologist/geomorphologist on a study developing potential rehabilitation actions and projects for the lower Yuba River between Parks Bar and Marysville, with a focus on increasing/improving rearing habitat available to salmonids. Activities included an analysis detailing the historical geomorphic evolution, development of an estimated depth to water table map, an ecologically significant flow frequency analysis, development of potential enhancement actions and identification of potential sites for rehabilitation projects.

Wallace Weir Improvement and Fish Exclusion Project, Yolo County, CA
Reclamation District 108, 2015-present

Project hydrologist to support hydraulic and flood impacts analyses for a proposed adjustable height weir with a fish (straying salmon and sturgeon) collection facility in the Knights Landing Ridge Cut intersection to the Yolo Bypass. Performed HEC-RAS simulations to assure compliance of fish collection facility hydraulics to NMFS Anadromous Salmonid Passage Facility Design Criteria, and optimize weir gate operations over a range of flows.

Santa Clara River Parkway Modeling, Ventura, CA
California State Coastal Conservancy, 2011

Project hydrologist, developed a MIKEFLOOD (coupled 1D-2D) model for approximately 40 miles of the Santa Clara River, California, including delineating all lateral and inline structures for assessing the flood attenuation benefits of multiple levee setback alternatives. The flood attenuation benefits of these multipurpose setbacks to support increased floodplain habitat area was assessed.

Riparian Habitat Joint Venture Integrative Floodplain Design-Vegetation and Velocity Distribution Modeling, Feather River Setback Area, CA
Three Rivers Levee Improvement Authority, 2011

Project hydrologist, utilized an existing MIKE21C curvilinear grid 2D hydrodynamic and sediment transport model of the Feather River to assess the impacts of differing vegetation types and distribution within 2 separate planting areas within the Feather River Levee Setback area. The purpose of this modeling exercise was to assess velocity, depth and stage impacts of vegetation on the active floodway, and also to provide an educational tool demonstrating that vegetation and flood control do not always conflict.

Numerical Modeling of Nearshore Conditions for the Selby Slag Site EIR, Carquinez Strait, Rodeo, CA
Department of Toxic Substances Control, 2016

Project hydrologist supporting EIR analyses for site improvements to contain contaminated sediments from a metal smelting and refinery. Technical duties included developing a global habitat suitability index for eelgrass present at the site. Assisted with post-processing 2D tidal hydrodynamic and morphodynamic model results to assess potential impacts to existing eelgrass beds.

Prospect Island Tidal Restoration Project, Solano County, CA
California Department of Water Resources and the California Department of Fish and Wildlife Fish Restoration Program Agreement, 2012-2013

Project hydrologist assisting in the bathymetric surface update, computational mesh optimization and recalibration of an existing 2D hydrodynamic model of the Cache Slough Complex, for the purpose of also calibrating advection-dispersion (salinity) for modeling transport of dissolved organic carbon originating from restored wetlands. The calibrated existing conditions model was used to screen restoration alternatives for DOC impacts to water distributed from the system.

Yolo Ranch Tidal Wetland Restoration Project, Channel Sizing Modeling, North Sacramento-San Joaquin Delta, CA
State and Federal Water Contractors Agency, 2011-2012

Project hydrologist, developed a MIKEFLOOD (coupled 1D-2D) model of proposed tidal channel alignment, channel geometry and grading plans for restoration of tidal wetlands in the North Delta. April ran and analyzed simulations to optimize channel geometry to obtain in-channel velocities sufficient for channel self-maintenance and tidal prism conveyance. April also assisted in performing soil surveys in the project area to characterize the duripan location for tidal channel excavation and design purposes.

NAVFAC Bangor P990 Mitigation Survey and Modeling – Shine Tidelands State Park Tidal Lagoon Restoration Feasibility, Puget Sound, WA
NAVFAC Atlantic, 2011-2012

Project hydrologist, performed topographic survey and assisted in developing a two-dimensional hydrodynamic model of tidal and nearshore hydrodynamics at the Shine Tidelands State Park proposed restoration site by using Delft3D modeling system (Deltares). The Shine Tidelands model was developed to simulate two-dimensional flow, lagoon tidal prism and waves.

Northern Liberty Island Fisheries Enhancement Project Assessment, Phase 2 Modeling, North Sacramento-San Joaquin Delta, CA
Wildlands, Inc., 2011

Project hydrologist, performed a RTK GPS based topographic LiDAR verification survey and bathymetric survey on a proposed restoration site in the North Delta. This included surveying tidal channels, tule stands and other features within the tidal marsh system. April updated bathymetry and mesh resolution of an existing MIKE21FM 2D model of the Liberty Island area to improve existing conditions and support restoration alternatives modeling.

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Chris Campbell, MS
Director / Ecohydrologist



Education

MS, 2003, Biological and Agricultural Engineering, University of Idaho, Moscow, ID

BS, 1998, Agricultural Engineering (summa cum laude), University of Idaho, Moscow, ID

Professional Registration

1999, Engineer-in-Training, Idaho, #4896

Professional Experience

cbec, inc., eco-engineering, West Sacramento, CA, Director / Ecohydrologist, 2008-present

Philip Williams and Associates (PWA), Ltd., Sacramento, CA, Hydrologist to Senior Associate, 2001-2008

Chris Campbell has more than eighteen years of engineering and project management experience with an emphasis in ecohydraulics and ecohydrology. He specializes in hydrodynamics, physical hydrology, sediment transport, geomorphology, water resources, and ecosystem restoration. As a Director at cbec, Chris applies his technical experience in numerical modeling and field studies to projects ranging from seasonal wetlands to lowland alluvial rivers to tidally influenced rivers and estuaries. Chris directs and provides quality control for 1D, 2D, and 3D numerical modeling using a range of public and proprietary software packages (e.g., HEC-RAS, MIKE 11/21, TUFLOW, Delft3D, FLOW-3D, FEFLOW). Chris also directs and performs a range of field studies to include topographic and bathymetric surveying, water quality monitoring, climate monitoring, flow gauging, sediment characterization, and sediment transport sampling.

Chris Campbell has worked on a range of ecosystem restoration projects with an emphasis on vernal pool restoration in the Sacramento Valley and tidal wetland and floodplain habitat restoration in the Yolo Bypass, Cache Slough Complex, and North Delta. Chris has been the principal investigator of a vernal pool research project since 2008 to understand the potential hydrologic impacts of constructed pools on natural pools to inform design standards for vernal pool creation. This has involved four years of monitoring and subsequent 3D vadose zone modeling. Chris has also been working in the Yolo Bypass for more than a decade on various data collection, restoration, and mitigation projects. These include field data collection efforts to support hydrodynamic model development; hydrodynamic model development, calibration, and alternatives evaluation for the USBR/DWR Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR; realignment of Putah Creek through the Yolo Bypass Wildlife Area; tidal restoration projects in the southern Yolo Bypass such as the Lower Yolo Ranch Tidal Restoration Project and the Yolo Flyway Farms Restoration Project; hydrodynamic modeling and design support of various mitigation banking projects throughout the Yolo Bypass to include Fremont Landing Conservation Bank (constructed), Capital Conservation and Mitigation Bank, Liberty Island Conservation Bank (constructed), and North Delta Fish Conservation Bank; identification and prioritization of drainage and infrastructure issues within the Yolo Bypass; and contributions to land management plans for the Yolo Bypass Wildlife Area and the Liberty Island Ecological Reserve.

Chris has also been working in the North Delta for more than a decade on a range of tidal habitat restoration projects to include McCormack-Williamson Tract Levee Modification and Habitat Development Project, Little Egbert Multi-Objective Project, Decker Island Habitat Restoration Project, and Prospect Island Tidal Restoration Project.

SELECTED PROJECTS

Calero County Park Pond and Wetland Restoration Project, Santa Clara County, CA
Santa Clara Valley Habitat Agency, 2015-present

To meet the goals of their Habitat Plan, this project aims to enhance habitat for California Red-Legged Frog and California Tiger Salamander at an existing stock pond and wetland seep. Working with H. T. Harvey and Associates, cbec is preparing the hydrologic assessment to inform pond / wetland design through topographic data collection, water budget calculations as well as preparing the grading plans. Chris is the project director responsible for the hydrologic assessment, to include a detailed monitoring and seep investigation, and developing the enhancement design plans.

California Red-Legged Frog Pond Creation and Enhancement Opportunities and Constraints at Stanford University's Upper Quarry Site, Santa Clara County, CA

SELECTED PROJECTS *(CONTINUED)*

Stanford University, 2015-present

To meet the needs of the Stanford University Habitat Conservation Plan, the goal of this project is to prepare a feasibility assessment to evaluate opportunities to both enhance the existing pond and construct at least two new ponds for California Red-Legged Frog breeding with the Matadero/Deer Creek Basin. Working with H. T. Harvey and Associates, cbec is preparing the hydrologic assessment to inform site selection and pond design through field reconnaissance, water budget calculations, and shallow groundwater monitoring. Chris is the project manager responsible for conducting the hydrologic assessment.

Suisun Creek Preserve Mitigation Wetland, Solano County, CA
Solano Transportation Authority, 2015

This project includes design of seasonal freshwater wetlands and riparian corridor enhancements along a section of Peltier Creek as mitigation for habitat being impacted by the I-80/I-680/SR12 Interchange Phase 1 Project. The main project objective is to create a wetland and riparian corridor complex that re-establishes lost functions and values within this restored creek channel and wetland system. cbec performed an independent review the hydrologic basis of design. Chris provided the expert review for this effort.

Hydrologic Monitoring and Modeling of Hardpan Vernal Pools to Support Restoration Design, Butte and Placer Counties, CA
US Fish and Wildlife Service and US Bureau of Reclamation, 2008-2017

Per research grants agreement between cbec and the US Fish and Wildlife Service and the US Bureau of Reclamation, this project will provide important design information for the restoration, enhancement, or creation of vernal pools on lands containing existing pools. The hydrologic regime of existing and created vernal pools was monitored for a period of four years at two mitigation sites, to include a combination of groundwater monitoring, climate monitoring, topographic surveys, and ground penetrating radar surveys. This data is currently being used to develop and calibrate a 3D vadose zone model called FEFLOW that will be used to simulate the potential hydrologic impacts to existing pools associated with restoration actions or land use alterations. Chris is the principal investigator for this research project.

Redwing Preserve Habitat Conservation and Enhancement Plan, Placer County, CA
Del Webb Corp., 2006-2007

The purpose of this project is to mitigate for the loss of vernal pool habitat associated with a future housing development. The Preserve will conserve and enhance existing vernal pool habitats and construct new vernal pool habitats. Responsibilities as PM include applying a GIS-based hydrologic model to the HCEP to evaluate the potential hydrologic impacts of constructed pools on existing pools. The hydrologic model is the first of its kind to be applied to vernal pools at the landscape scale.

Butte County Highway Improvement Vernal Pool Preserve Habitat Conservation and Enhancement Plan (HCEP), Butte County, CA
Butte County Association of Governments and Caltrans, 2005-2008

The project objective was to mitigate for the loss of vernal pool habitat associated with improvements along four Butte County highways. The Preserve will conserve and enhance existing vernal pool habitats and create new vernal pool habitats. Responsibilities as PM include development of a GIS-based hydrologic model for vernal pool landscapes and application of the model to the HCEP to evaluate the potential hydrologic impacts of constructed pools on existing pools. The hydrologic model developed in-house is the first of its kind to be applied to vernal pools at the landscape scale.

McCormack-Williamson Tract Levee Modification and Habitat Development Project, Sacramento County, CA
The Nature Conservancy and Reclamation District 2110, 2015-present

As a key component of the North Delta Flood Control and Ecosystem Restoration Project with the Final Environmental Impact Report approved by DWR in 2010, this project aims to provide flood protection benefits by modifying levees (both enhancing and degrading) and creating habitat restoration opportunities (both tidal and fluvial) by reconnecting the floodplain to the Mokelumne River. Working with GEI and West Yost Associates, cbec is preparing the hydrodynamic, particle tracking, and sediment transport modeling and the habitat grading design for the island interior. The modeling will be used to refine the restoration design to maximize onsite habitat benefits while minimizing offsite flood and geomorphic impacts. As project manager, Chris directed the modeling and physical components of the habitat restoration design.

Lower Putah Creek Restoration Project, Yolo County, CA
Yolo Basin Foundation and funded by the California Department of Fish and Wildlife, 2012-present

This project aims to improve passage, rearing, and emigration of adult and juvenile salmonids on Putah Creek, enhance habitats for salmonids and other Delta native fish and wildlife within a realigned Putah Creek channel on the Yolo Bypass Wildlife Area, and enhance ecological functions of the recently restored tidal habitat on the Wildlife Area. Working with Environmental Science Associates and Stillwater Sciences, the project team has collected engineering design field data and prepared engineering and hydraulic modeling analyses to inform the restoration design of the realigned channel that meets ecological goals in the context of ongoing agricultural operations, Wildlife Area uses and benefits, and flood protection. Not unlike other restoration efforts planned in the Delta, implementation of this action presents considerable challenges related to reconciling the goals of restoration of habitats and ecological functions that support native species with the realities of working within a highly managed Delta system. As project manager for cbec, Chris directed the flow monitoring, developed the restoration design hydrology and design channel geometry, and directed the hydrodynamic model calibration and long-term simulations using the Yolo Bypass TUFLOW model to assess project performance.

Yolo Flyway Farms Restoration Project, Yolo County, CA
Reynier Fund, LLC., 2014-present

This southern Yolo Bypass project will restore tidal interaction to 360 acres and preserve agricultural in the remaining 80 acres. This restoration will enhance and create habitat for special status fish with the objectives to enhance regional food web productivity in support of delta smelt recovery; provide rearing habitats for out-migrating salmonids; supporting a broad range of other aquatic and wetland-dependent species; and provide ecosystem functions associated with the combination of Delta habitats that existed historically. With input from a scientific advisory committee, cbec designed the 360 acre tidal marsh restoration with a combination of swale and wetland terrace excavation and selective agricultural berm leveling to enhance tidal marsh habitat via conversion from managed grasslands. Chris directed the 2D hydrodynamic modeling and development of the concept, design plans, and cost opinions.

cbec eco engineering

Hydrology | Hydraulics | Geomorphology | Design | Field Services

Sam Diaz, PE, CPESC, QSP/QSD
Senior Ecoengineer



Education

BS, 1998, Biological Resources Engineering, Cooperative Education Program-Civil Engineering, University of Maryland, College Park, MD

Professional Registration

2005, Professional Engineer, California, #68217

2013, CPESC, California #7473

2015, QSP/QSD, California

Professional Experience

cbec, inc., eco-engineering, West Sacramento, CA, Senior Ecoengineer, 2009-present

Kleinschmidt Associates, Grass Valley, CA, Senior Engineer, 2008-2009

Kennedy/Jenks Consultants, Sacramento, CA, Project Engineer, 2005-2008

Creegan + D'Angelo Engineers, Fairfield, CA, Project Engineer, 2004-2005

Nelson Engineering, Jackson, WY, Design Engineer, 2002-2004

Park Engineering, Jackson, WY,mDesign Engineer, 2000-2001

Charles P. Johnson & Assoc., Silver Spring, MD, Design Engineer, 1993-1998

Mr. Diaz is a registered California PE with eighteen years of experience that covers a wide range of civil engineering projects. He has worked on projects related to land development, water and wastewater treatment and infrastructure, water resources management and planning, and hydroelectric generation. He has been involved in all aspects of the projects, from planning and scheduling, to permitting, design and preparation of construction documents, cost opinions and reports, and construction monitoring. In his work, Mr. Diaz has interacted with municipalities, water, wastewater and irrigation districts and private developers and planning and federal regulatory agencies.

Currently, Mr. Diaz is currently involved in several restoration projects. These projects vary in application and include optimizing erosion control measures for habitat value on the banks of a large, leveed river, designing biotechnical bank stabilization measures for an urban drainage, restoring ecological function to an urban drainage through channel rerouting and redesign, and increasing the habitat value of river and tidal environments through floodplain reconnection. Many of his projects have included salmonid habitat enhancement as a goal of riverbank and floodplain restoration. The majority of Mr. Diaz's work involves hydraulic modeling (1- and 2-D) to inform design of sustainable stream and floodplain improvements, to increase habitat value, and to create multi-objective solutions.

Mr. Diaz is an expert CAD user, and has extensive construction document preparation experience. He is experienced in creating designs and producing construction documents. He is an experienced GIS operator, and is particularly informed on the interface between CAD and GIS. Mr. Diaz is familiar with a variety of hydraulic modeling software packages, including several open channel flow, and piped flow analysis programs. In addition to his current riverine hydraulic analysis work, he has performed hydraulic modeling to evaluate stormwater conveyance and treatment designs for a variety of development projects. He has performed hydraulic analyses to aid in designing both gravity and pressurized piping systems.

Mr. Diaz has experience with a diversity of construction projects, ranging from large scale projects such as municipal wastewater treatment plant improvements, residential and commercial developments to small scale projects such as private home sites and micro-hydroelectric developments on water and wastewater conveyances. He has been involved in reservoir sedimentation projects in the Sierra foothills and has developed plans for removing sediment and reducing future sedimentation. Mr. Diaz has provided client support during project construction in oversight roles on utility installation, roadway construction and site development projects. As a result, he is very effective at communicating design intent and details in construction documents. In addition to his design experience, he has extensive field experience in surveying. He has led survey crews for topographic data collection, construction staking and inspection. He is experienced using RTK GPS equipment on foot and aboard small watercraft, and using boat-mounted acoustic Doppler current profiling equipment. Mr. Diaz aims to gain a thorough understanding of his clients' goals, as well as the issues and science that influence his projects in order to create sustainable and informed solutions.

SELECTED PROJECTS

Calero County Park Pond and Wetland Restoration Project, Santa Clara County, CA
H. T. Harvey & Associates, 2015-present

To meet the goals of their Habitat Plan, this project aims to enhance habitat for California Red-Legged Frog and California Tiger Salamander at an existing stock pond and wetland seep. Working with H. T.

SELECTED PROJECTS *(CONTINUED)*

Harvey & Associates, cbec is preparing the hydrologic assessment to inform pond / wetland design through topographic data collection, water budget calculations as well as preparing the grading plans. Sam was the project manager responsible for design efforts, development of construction documents, bid support and quality control during construction.

Yolo Flyway Farms Restoration Project, Yolo County, CA
Reynier Fund, LLC, 2014-present

This project in the southern Yolo Bypass will restore tidal interaction to 360 acres and preserve agricultural use in the remaining 80 acres. The tidal restoration will enhance and create habitat for special status fish with the objectives to enhance regional food web productivity in support of delta smelt recovery; provide rearing habitats for out-migrating salmonids; supporting a broad range of other aquatic and wetland-dependent species; and provide ecosystem functions associated with the combination of Delta habitats that existed historically. Based on input from a scientific advisory committee, cbec designed the 360-acre tidal marsh restoration with a combination of swale and wetland terrace excavation and selective agricultural berm leveling to enhance tidal marsh habitat via conversion from managed grasslands. Sam assisted development of 2D models, evaluated concept alternatives and developed plans and cost opinions.

Moosa Creek Mitigation Bank Concept Design, San Diego County, CA
WRA, Inc., 2013-present

This project near Bonsall, CA plans to develop a mitigation bank at a former golf course to rehabilitate and re-establish wetlands, riparian floodplain, and upland buffer along the San Luis Rey River and Moosa Creek as well as provide mitigation for federally and state listed species, including the coastal California gnatcatcher, least Bell's vireo, southwestern willow flycatcher, and arroyo toad. Construction activities will include grading and removal of topsoil and native revegetation of riparian and upland areas. Working with WRA, Inc., cbec prepared the geomorphic and hydraulic basis of design developed a 2D hydrodynamic model based on the MIKE 21FM platform to inform the design using the state of the science for vegetation roughness and evaluate flood impacts, prepared the grading plans inclusive of biotechnical bank stabilization and erosion control measures, and supported the preparation of permits. As project manager, Sam designed biotechnical bank stabilization and erosion and sediment control measures, oversaw and contributed to design and preparation of construction documents, and provided client support and coordinated grading permit efforts.

Arcade Creek Park and Preserve, Citrus Heights, CA
Foothill Associates, 2012-2014

Mr. Diaz managed design of an urban stream restoration that is a part of the City's plan to revitalize a deteriorated natural corridor for public use. Biotechnical streambank stabilization techniques and inset floodplain terrace designs were implemented at three priority restoration sites. The project also required scour analysis, 2D modeling, and riprap design to protect abutments of two new pedestrian bridges. Mr. Diaz provided construction oversight during installation of bank restoration and protection features.

Crane / Domeyer / Willow Bar Feasibility Analysis and Initial Designs, Sauvie Island, OR
Columbia River Estuary Task Force, 2015-present

The goal of this project is to restore estuary habitat critical to the recovery of threatened and endangered salmon species utilizing the Columbia River Estuary, with habitat restoration actions targeted to benefit juvenile salmonids at three impaired sites on the island. Working with Wolf Water Resources, cbec collected topographic and bathymetric field data and developed a 2D hydrodynamic model of the river system from St Helens to Vancouver / Portland based on the SRH-2D platform. This data and modeling was used to better understand existing hydrodynamics and inform the initial restoration designs at each site. Sam provided quality control and supervision of topographic surface generation from survey data.

Cordova Creek Naturalization Project, Sacramento, CA
Water Forum, 2013-2017

Mr. Diaz was project manager and designer for this award-winning urban stream rehabilitation project that will bring ecological function back to an urban drainage while addressing channel erosion issues. Floodplain restoration was a major focus of the project; lowering the banks to reconnect the creek to its overbank areas and revegetating to provide benefits for habitat and flood management. The project involved geomorphic analysis, floodplain restoration, and biotechnical bank stabilization and grade control on a system with highly erosive soils and increased flows due to a hydromodified watershed. Specific tasks included riprap design, particle transport analysis and design compliance and quality control services during construction.

Eddleston River Restoration Planning, Peebles, Scotland,
University of Dundee, 2010

Mr. Diaz created a 1D model (MIKE11) of the river to evaluate effects of a levee setback project. The model was analyzed to assess benefits of the floodplain restoration to the village immediately downstream. The project served as a case study, undertaken in conjunction with the Scottish Environmental Protection Agency to investigate restoring river-floodplain interaction and function on a constrained river that experiences significant seasonal flooding.

Lower American River Gravel Augmentation Plan, Sacramento, CA
Water Forum, 2010-2011

Mr. Diaz developed CAD surface models to simulate the creation of a gravel bar in the Lower American River. He incorporated the surface models in a 2D hydraulic model (SRH2D) and evaluated and optimized them to create spawning habitat for Fall Run Chinook Salmon and Steelhead.

Lower Putah Creek Restoration Project, Yolo County, CA
Yolo Basin Foundation and funded by the California Department of Fish and Wildlife, 2012-present

This project aims to improve passage, rearing, and emigration of adult and juvenile salmonids on Putah Creek, enhance habitats for salmonids and other Delta native fish and wildlife within a realigned Putah Creek channel on the Yolo Bypass Wildlife Area, and enhance ecological functions of the recently restored tidal habitat on the Wildlife Area. Working with Environmental Science Associates and Stillwater Sciences, the project team has collected engineering design field data and prepared engineering and hydraulic modeling analyses to inform the restoration design of the realigned channel that meets ecological goals in the context of ongoing agricultural operations, Wildlife Area uses and benefits, and flood protection. Not unlike other restoration efforts planned in the Delta, implementation of this action presents considerable challenges related to reconciling the goals of restoration of habitats and ecological functions that support native species with the realities of working within a highly managed Delta system. Sam performed 1D model evaluations of channel configurations to provide fish passage and provided quality control of topographic data acquisition.

Mark Cederborg

Principal, Senior Project Manager, Hanford ARC

Mark Cederborg is a project manager for construction of ecological restoration and public works projects, and has served in this capacity since 1999 with Hanford ARC. He has managed over 90 restoration projects totaling more than $100 M to date, including stream restoration, dam removal, fish passage, spawning habitat, channel realignment, levee removal, tidal and non-tidal wetland restoration, revegetation, earthwork, bridge installation, utility work, and erosion control. Projects have included complicated planning and problem solving for difficult and remote access, work in wilderness areas, extensive stream bypass and dewatering systems, work in very close proximity to threatened and endangered species, and work under heavy scrutiny of permitting agencies.

Mark routinely works with project designers and engineers to ensure accurate installation of the design based on field conditions and design intent, and is responsible for estimating, budgeting, technical review and quality control, report writing and other pre- and post-project management tasks.

Prior to joining Hanford, Mark worked at Virginia Branch Environmental Quality Resources, Inc. in Gaithersburg, Maryland, a firm specializing in the construction of ecological restoration projects, including wetland mitigation, stream restoration, revegetation and storm water facilities. He was initially hired as a laborer, promoted to foreman, construction manager, and became branch manager. Mark also served as an Environmental Scientist for TetraTech, Inc.in Fairfax, VA where he conducted comprehensive field watershed assessment and reporting, and managed watershed based Geographic Information Systems (GIS) for Baltimore County, MD and the EPA Office of Wetlands Oceans and Watersheds; additional tasks included technical support, server management and FTP site management for a 100-computer network. Before working in the construction and consulting fields, Mark worked for the California DWR in the Northern District Office. He performed field and remote habitat surveying for Habitat Conservation Plans, primarily in the Delta Field Division, assessed large-scale dam construction mitigation projects, and conducted watershed assessments for various smaller scale DWR projects.

Education

Bachelor of Science in Physical Science, Environmental Science Option Honors CSU, Chico, 1995

Recent Project Experience

▪ **Willits Bypass Mitigation**	Caltrans District 1	$17.5M	Mendocino County, CA.
▪ **Cordova Creek Restoration**	County of Sacramento	$2.3M	Rancho Cordova, CA.
▪ **Salt River Restoration Lower/Mid**	Humboldt County RCD	$4M	Ferndale, CA.
▪ **Sonoma Creek Tidal Marsh**	Audubon California/USFWS	$2.6M	San Pablo Bay NWR, CA.
▪ **Quartermaster Reach**	Golden Gate Nat'l Parks Conserv.	$1M	Presidio, S.F.,CA.
▪ **Aramburu Island Restoration**	Audubon California	$0.75M	Richardson Bay, CA.
▪ **Napa River Reach 5,6,7,9**	Napa County DPW	$1.5M	Oakville& Rutheford,CA.
▪ **Dry Creek Habitat Project PH II**	Sonoma County Water Agency	$4.5M	Healdsburg, CA.
▪ **Cullinan Ranch Tidal Marsh**	Ducks Unlimited/USFWS	$2.3M	Vallejo, CA.
▪ **Lower Redwood Creek**	Golden Gate Nat'l Parks Conserv.	$4.5M	Muir Beach, CA.
▪ **Coastal Dunes Restoration**	National Park Service	$2.6M	Point Reyes NS, CA.
▪ **Giacomini Wetland Restoration**	National Park Service	$2.6M	Point Reyes NS, CA.
▪ **Coastal Watershed Restoration**	National Park Service	$2M	Point Reyes NS, CA.
▪ **Angora Creek Restoration**	El Dorado County	$2.5M	South Lake Tahoe, CA.



GARY KITTLESON

EDUCATION

M.S. Natural Resource Management and Administration
Antioch/New England Graduate School. 1991

B.A. Anthropology with Environmental Studies
Boston University. 1987

PROFESSIONAL EXPERIENCE

2000 - present **Principal, *Kittleson Environmental Consulting, Santa Cruz, CA***
Kittleson Environmental Consulting conducts natural resource management and biological consulting services for public agencies and land managers in the San Francisco and Monterey Bay region. KEC manages state and federal resource agency consultations on protected species, with a focus on coastal steelhead, western pond turtle, and California red-legged frog habitats. KEC maintains long-term contracts for research, permitting, habitat restoration, flood control and fish passage projects with County of Santa Cruz, City of Santa Cruz, and City of Watsonville.

1998 - 2000 **Senior Associate, *Swanson Hydrology & Geomorphology, Inc., Santa Cruz, CA***
Managed and conducted biological consulting activities for City of Santa Cruz and US Army Corps of Engineers San Lorenzo River Flood Control and Environmental Restoration Project. Performed wetland and stream habitat assessments and biological inventories in salmonid streams for private, public and non-profit clients in the Monterey Bay, Central Valley and Lake Tahoe Basins.

1995 - 1998 **Senior Hydrologist, *Balance Hydrologics, Inc., Berkeley, CA***

Managed field hydrology studies and feasibility investigations for water resource management activities and specific hydrologic requirements of coastal streams and wetlands in San Mateo, Santa Clara, Santa Cruz, and Monterey Counties. Conducted geomorphic analyses for channel restoration, fish passage and wetland mitigation projects.

1992 - 1995 **Basin Management Planner/Hydrology Technician,**
Monterey County Water Resources Agency, Salinas, CA

Performed wetland and riparian habitat assessments, steelhead spawning surveys, hydrologic analyses, and water demand projections for the Salinas BMP. Conducted water quality and wildlife assessments for over one hundred potential water supply alternatives considered in the Salinas BMP. Completed initial studies, CEQA applications, USACE Section 404 permits, and California Department of Fish and Game Streambed Alteration Permits. Also conducted compliance monitoring for in-channel groundwater recharge demonstration project.

1990 - 1991 **Assistant Planner, *City of Watsonville, CA***

Conducted urban planning tasks following the Loma Prieta earthquake including CEQA analysis, architectural plan review, historic designations, zoning enforcement and wetland resource mapping for the City's General Plan update.

SCIENTIFIC PERMITS

Current USFWS Authorized Biologist for Federal Biological Opinions:

1-8-05-F-27; 1-8-07-F-26: 1-8-08-F-19: 1-8-06-F-25; 1-8-06-F-37:
1-8-07-F-18; 1-802/F/C 70/07793:OHW; & 151422SWR2002SR6273:BL

Steelhead 4(d) Permit #18425 (*Pajaro R. Western Pond Turtle Study*)

DFW Scientific Collection Permit SC-007999 (Valid through 8/30/2019)

KEY PERSONEL

Greg A. Bloom, Owner, Principal Geotechnical Engineer



- Bachelor of Applied Science in Civil Engineering, California Polytechnic State University, San Luis Obispo
- Civil Engineer – California License No. 58819
- Geotechnical Engineer – California License No. 2691
- Member, ASFE (Associated Soil and Foundation Engineers)

Mr. Bloom has practiced geotechnical engineering in the greater Monterey Bay and San Francisco Bay areas for the past 22 years. His completed projects include dam repairs, trail bridges, road stabilization, and public works. He has provided numerous design recommendations for foundation systems, retaining walls, pipelines, roadways and pavement sections, trail projects, dams, and cell towers. Mr. Bloom also has project experience with multiple transportation projects including bridges, road repairs, interchanges, and light rail projects. Project environments have varied from soft and liquefiable soils to competent bedrock, each with their own design requirements. Mr. Bloom manages all of the firm's projects from the design phase through the completion of construction

Philip T. Edwards, Senior Engineer



- Bachelor of Applied Science in Civil Engineering, University of California Davis
- Maters in Geotechnical Engineering, San Jose State University
- APWA Monterey Bay Board of Directors
- Civil Engineer – California License No. 86451

Mr. Edwards has worked for Butano Geotechnical Engineering, Inc. since graduating with honors from U.C. Davis. His specialty is with site a field mapping for subsurface design and slope stability analysis. His completed projects have encompassed designs for creek restoration, embankment stabilization, and landslide mitigation. He has experience with geotechnical engineering analysis, field investigations, laboratory work, and field observation and testing. He also performs civil and drafting services for the preparation of details, plans and reports.

IFLAND SURVEY
Surveying - Mapping - GPS

Gary R. Ifland

President

Contact Info:

Address: 5300 Soquel Avenue, #101
Santa Cruz, CA 95062
Tel: (831) 426-7941
Email: gary@iflandsurvey.com

Licenses: LS #7367 (Licensed Land Surveyor – California - 1997)
CA Real Estate License # 01494114 (2006)

Education: Cabrillo College – General Education studies '82-'84
Biola University, Business Administration studies '84-'86

Other Certifications: GPS Data Processing & RTK Surveys (Trimble Navigation)
sUAS Remote Pilot (FAA)

Professional Associations: California Land Surveyors Association (CLSA)
American Society of Civil Engineers (ASCE)

Mr. Ifland is the principal responsible for the management and coordination of all survey work for Ifland Survey. In addition to his broad range of surveying experience, he has been involved in the design of many land development and roadway projects for both public and private sector clients. His 35+ years of extensive surveying experience on both large and small projects, include boundary and topographic surveys, right of way surveys, geodetic control surveys, GPS surveys, Laser Scan surveys, sUAS flight surveys and construction surveys. Additionally, Mr. Ifland has provided Expert Witness Testimony and 3rd party surveys and reviews in boundary disputes cases. Mr. Ifland has directed and/or coordinated the surveying and construction staking for over 2500 projects. A very brief sample of his project experience is listed below:

Control Networks & Monumentation Preservation, *Santa Cruz, CA* - Project management of GPS surveying and mapping services for aerial control and first order monuments at over 75 locations for the City of Santa Cruz. Performed adjustment of previous survey control to current CCS83 coordinate system and prepared project reports and associated Record of Survey maps. Performed survey and mapping of various monumentation preservation projects for the County of Santa Cruz including portions of the Soquel Augmentation Rancho, Mount Hermon Road and Soquel Drive.

Subdivision Work, *Santa Cruz County, CA* - *Skypark Development, 191 Lots, Scotts Valley, CA - Bay Breeze Development, 114 Lots, Watsonville, CA – Ranchview Terrace, Santa Cruz, CA* - Survey coordination and management of initial boundary, aerial and topographic surveys. Construction Surveys, Monumentation and Final Tract Mapping. Filed and recorded more Tract and Parcel Maps in Santa Cruz County than any other currently active surveyor.

Utility Mapping Projects, *Monterey & SF Bay Areas, CA* – Survey and Mapping for various utility mapping projects including Crystal Springs Reservoir (Cruz Bros/URS/City of San Francisco), Harry Trace Water Treatment Plant (SFPUC), various water projects for Soquel Creek Water District and City of Santa Cruz, ground sampling and monitoring wells including AutoCAD and GEO-tracker submittals (Cruz Bros/ARCADIS) and many more.

Boundary & Topo Surveys, *Monterey & SF Bay Areas, CA* – Performed and produced more than 500 boundary and/or topo surveys for private, public and quasi-public property owners/clients including Barry Swenson Builder, Bogard Construction, California GIANT, County of Santa Cruz, City of Santa Cruz, City of Scotts Valley, City of Watsonville, Dominican Hospital, DEVCON, DR Horton, Boys & Girls Clubs of America, Girl Scouts of America, Gordon M. Ball, Granite Construction, KB Homes, Mercy Housing, Mid Pen Housing, Mid-Peninsula Regional Open Space District, Palo Alto Medical Foundation, PAVEX, SETI Institute, Soquel Creek Water District, Soquel Unified School District, UC Santa Cruz, CSUMB & URS Corporation.

Construction Surveys – In addition to the extensive subdivision and residential construction staking as previously mentioned, performed construction staking for commercial, industrial, educational, medical and retail sites including Aptos Village Center, Bethany/1440 Multiversity Campus, Pajaro Valley High School, Scotts Valley High School, Sutter Health, First Community Housing, Carmel River Lagoon Restoration, Gateway Shopping Center, San Lorenzo River Levee, Tannery Arts & Digital Media Center, Live Oak Business Park & many more.

Legal Support & Expert Witness Testimony – Surveying and related support services including expert witness testimony for legal cases involving disputes over property lines, title and easement rights including work for Santa Cruz County Sheriff's Department, First American Title Company, Travelers' Insurance Company, Farmers Insurance Company and various private clients.

OTHER RELEVANT PROJECT EXPERIENCE

Gary Ifland has been the principal-in-charge and provided oversight and leadership support for all the projects listed in the resume's provided under this proposal. In addition to those already listed in other team resumes, following are a few more relevant projects performed by Ifland Survey directly for the district or as sub- consultant.

- San Lorenzo River Flood Control - Topographic Survey & Mapping (1998)
- San Lorenzo River Levee - Construction Survey Staking (2000)
- North Coast Water Pipeline – Topographic survey, Mapping & As-built surveys(2001, 2015)
- Storm Drain Pipeline Realignment - Sea Bright Beach - Topographic Survey & Mapping (2015)
- City Water Department River Street Property - Topographic Survey & Mapping (2016)
- City Storm Repairs Projects – Topographic Survey & Mapping (2017)
- County Storm Damage Repair Projects - Topographic Survey & Mapping (2006 - 2018)

IFLAND SURVEY
Surveying - Mapping - GPS

Jeanmarie L. Bostley

Licensed Land Surveyor

Contact Info:	*Address*:	5300 Soquel Avenue, #101 Santa Cruz, CA 95062
	Tel:	(831) 426-7941
	Email:	jeanmarie@iflandsurvey.com

Licenses:	LS #8452 (Licensed Land Surveyor – California – 2008)
Education:	CA State University, Fresno – BS – Land Survey Engineering ('99)
Awards/ Affiliations:	National Deans List (SBCC) Lambda Sigma – Land Surveying Engineering Honor Society (CSUF) California Land Surveyors Association (CLSA)
Prior Employment History:	Mark Thomas & Co, Sacramento, CA (2010-2011) Martin Geomatic Consultants, Lethbridge, AB (2006-2009) Albion Surveys, St Helena, CA (2000-2005) B&H Surveying, Belmont, CA (2000)

Ms. Bostley, a licensed land surveyor, is a project manager / surveyor for the company. Her 15+ years of field and office survey work experience covers a wide range of surveying projects and includes boundary and topographic surveys, right of way surveys, GPS surveys, cliff monitoring surveys, lot line adjustment surveys, residential and commercial construction surveys, infrastructure surveys, as-built surveys and tunnel & cave surveys. Below is a brief sample of relevant project experience:

Boundary / Topographic Mapping Projects – Project management, research, analysis, CAD mapping and field survey work for the following projects:

- Monumentation Preservation Survey and Mapping projects for County of Santa Cruz, Public Works Department (2011 – 2014)
- Road and Utility surveys, various locations, Santa Cruz County for Soquel Creek Water District (2011-2015)
- Topographic Survey & Mapping, District Property, City of Santa Cruz Water Dept. (2016)
- Topographic Survey & Right of Way Mapping, Valencia Rd Pipeline Project, County of Santa Cruz. (2016)
- Topographic Survey & Mapping, Mt. Hermon Crossing improvements. (2016)
- Topographic Survey & Right of Way Mapping, Santa Cruz City Sanitary Sewer Re-alignment. (2017)
- Topographic Survey & Mapping, Aldo's Sea Wall Replacement, Santa Cruz Harbor. (2017)
- Campus Boundary & Topographic Survey for School Modernization Project, Santa Cruz City School District. (2017)

Rural Boundary / Topographic Survey Projects – Project management, field management, and field & office support for the following recent rural survey projects (Fee shown represents the survey and mapping portion):

- Mindego Ranch, Santa Cruz Mountains, Santa Cruz County / MROSD - boundary and underground utility flagging ties. Prepare legal descriptions and exhibits for waterline easement. (2013)
- Mt. Umunhum, Santa Cruz Mountains, Santa Clara County / MROSD – boundary and CA State Plane Coordinate System ties. Set survey monuments & prepare Record of Survey. (2013 –2014)
- Blackberry Hill Rd., Santa Cruz Mountains, Los Gatos, CA / MROSD – Byron Navid – boundary & topographic. Prepare legal description for Access Easement. (2016)
- Alma College, Santa Cruz Mountains, Santa Cruz County / PGAdesign Landscape Architects – topographic survey & mapping. (2017)
- Purisima Farms, Purisima Creek Road, San Mateo County / MROSD –Boundary and CA State Plane Coordinate System ties. Prepare a Lot Line Adjustment application map, legal descriptions and exhibits. Record of Survey pending completion of LLA agreement. (2014 -2018)

Construction Staking Projects – Survey coordination & management, staking calculations, field survey work and construction survey support for recent construction staking projects including:

- 1440 Foundation, Bethany College Campus, Scotts Valley, CA (2013 - 2017)
- North Coast Water Project, City of Santa Cruz Water Department (2015 - 2018)
- Aptos Village Project, Aptos, CA for Swenson Builders (2016 – 2018)

DIR Registration

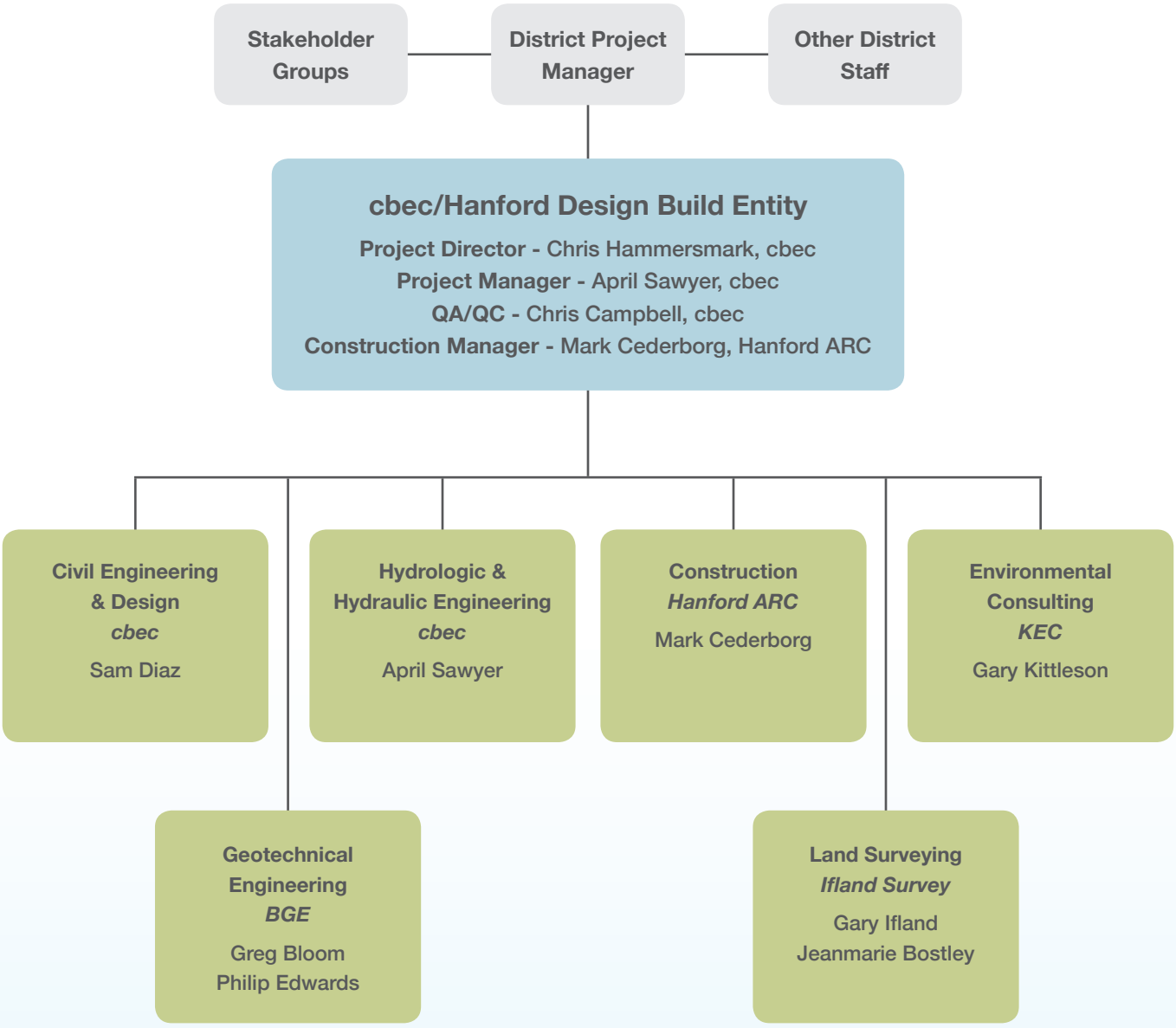
Below are the registrations numbers for each contractor, subcontractor, or firm that will be providing services subject to prevailing wage requirements pursuant to Labor Code section 1720 et seq.

Company	DIR Number	DIR Expiration
cbec eco engineering	1000037567	06/30/2018
Hanford ARC	1000000222	06/30/2019
Ifland Survey	1000007882	06/30/2019

Contractor License

Hanford ARC will be providing Construction Services on the Project. Hanford ARC is a Licensed General Engineering Contractor in California, #461167.

Organizational Chart



References

◆ cbec eco engineering

Tom Gohring
Executive Director, Water Forum
916.808.1998
tgohring@waterforum.org

Max Busnardo
Principal, H. T. Harvey & Associates
408.458.3222
mbusnardo@harveyecology.com

Terah Donovan
Principal Program Manager, Santa Clara Valley Habitat Agency
669.253.6566
terah.donovan@scv-habitatagency.org

◆ Hanford ARC

Lorraine Parsons
Vegetation/Wetland Ecologist, National Park Service, Point Reyes National Seashore
415.464.5193
Lorraine_Parsons@nps.gov

Sharon Farrell
Associate Director of Park Projects, Golden Gate National Parks Conservancy
415.561.3065
SFarrell@parksconservancy.org

Irina Kogan
Senior Stewardship Project Manager, Peninsula Open Space Trust
650.854.7696 x 363
richandirina@gmail.com

◆ Kittleson Environmental Consulting

Brian Lockwood
General Manager, Pajaro Valley Water Management Agency
831.722.9292
Lockwood@pvwater.org

Steve Palmisano
Director of Public Works, City of Watsonville
831.768.3100
steve.palmisano@cityofwatsonville.org

Mark Dettle
Director of Public Works, City of Santa Cruz
831.420.5153
mdettle@cityofsantacruz.com

◆ Butano Geotechical Engineering

Robyn Cooper
Senior Engineer/Engineering Director, Fall Creek Engineering
831.426.9054 ext 103
rcooper@fallcreekengineering.com

Damon Adlao
County of Santa Cruz, Capital Projects
831.454.2343
Damon.Adlao@santacruzcounty.us

Marc L. Douvia
Project Manager, University of California, Santa Cruz
Physical Plant Services - Work Management
831.502.8162
mdouvia@ucsc.edu

◆ Ifland Survey

Robert Hambelton
Project Manager, County of Santa Cruz Public Works
831.454.2783
robert.hambelton@santacruzcounty.us

Taj Dufour, PE
Engineering Manager/Chief Engineer, Soquel Creek Water District
831.475.8501
tajd@soquelcreekwater.org

Douglas Valby, PE
Associate Civil Engineer, City of Santa Cruz Water Department
831.420.5212
dvalby@cityofsantacruz.com

Task List

The Task List is a replication of the table shown on page 11. It does **not** include an hours estimate or staff allocation for construction activities.

PROPOSED HOURS PER STAFF PERSON

Task Number	Task Actions	Chris Hammersmark	April Sawyer	Chris Campbell	Sam Diaz	Luke Tillman	Juma Mohammadi	Jordan Fields	cbec Subtotas	Gary Kittleson	Greg Bloom	Philip Edwards	Field Technician	BGE Subtotals	Gary Ifland	Jeanmarie Bostley	Ifland Subtotals
1	Background Research, Site Visit & Project Coordination	22	52	2	0	0	0	0	76	15	4	8	0	12	0	0	0
2	Limited Topographic Survey and Geotechnical Investigations	3	12	0	0	0	0	22	37	20	26	92	14	132	9	9	18
3	Hydrology Assessment and Reporting	6	10	2	0	45	0	0	63	0	0	0	0	0	0	0	0
4	Plans, Specification & Supervisory Review	8	44	2	24	0	120	0	198	15	4	8	0	12	0	0	0
5	Permitting	4	10	0	0	0	0	0	14	68	0	0	0	0	0	0	0
6	Revegetation Plan and Integrated Pest Management Individual Work Plan	0	0	0	0	0	0	0	0	40	0	0		0	0	0	0
7	Design Development	12	36	2	40	0	80	0	170	0	0	0	0	0	0	0	0
8	Preconstruction Meeting and Construction Services	6	10	0	0	0	20	32	68	0	4	8	40	52	0	0	0
	Totals	**61**	**174**	**8**	**64**	**45**	**220**	**54**	**626**	**158**	**38**	**116**	**54**	**208**	**9**	**9**	**18**

Schedule

Our team has adopted the project schedule provided by the District's RFP with an assumed start date of July 16, 2018 following notice to proceed. The design and construction timelines are contingent upon the scheduled notice to proceed dates. A more specific construction window can be provided as the design advances, permit applications are submitted, and regulatory agency approval is obtained.

Date	Deliverable
June 28, 2018	Issuance of Notice of Award
July 16, 2018	Issuance of Notice to Proceed with Design Services only
July 16 - August 3, 2018	Complete geotechnical, topographic, and hydro fieldwork
August 31, 2018	Submit final drafts of all fieldwork survey reports
September 21, 2018	Submit 35% design with preliminary construction cost estimate
October 19, 2018	Submit 65% design, revegetation plan, IPM individual work plan, and all permit applications
November 23, 2018	Final Design Approval
April 15, 2019	Submit notification of delays (in encountered) due to permit-ting in writing to the District
July 16, 2018 - May 1, 2019	Permitting
July 19, 2019	Issuance of Notice to Proceed for Construction
August 1 - October 31, 2019	Construction
May 1 - November 15, 2019	Biological monitoring
October 19 - November 15, 2019	Site revegetation
November 30, 2019	Completion of As-Built Drawings
December 7, 2019	Project Close Out

Management and Staffing Plan

The project will be staffed by the key personnel described in this proposal along with supporting personnel shown in our labor spreadsheet in the Proposal Cost section as well as hours summary in Task List section. These tables summarize staffing by task and thereby indicate an approximate staffing schedule for design and permitting efforts. Staffing for construction will be determined as the design is advanced and specific design elements, construction approach and necessary equipment and personnel are more precisely identified. Our team can provide additional details as requested by the District.

Life Cycle Costs

We are unable to provide an estimate of the 20-year life cycle cost. Maintenance should be expected in response to sediment accumulation in the ponds and/or vegetation growth. We are not able to predict the rate of sediment delivery to the lake, and providing this estimate is beyond what we have included in our proposal. Furthermore, the active earth movement that we observed upstream of Kneudler Lake makes estimating the potential sediment delivery rate even more challenging. In the areas that we excavate to full depth, vegetation will have a challenging time establishing and persisting, but it could happen in a sequence of drought years if pond levels remain low. The margins and shallower areas where vegetation is removed will support the re-establishment of vegetation, and for that reason will likely need to be cleared again at some point in the future. Also, if significant sediment is delivered to either pond, that will result in a shallowing of depths which will in turn support more rapid colonization by emergent vegetation. The engineering infrastructure is not expected to require significant maintenance during a 20-year period.



Photo Credit: Biosearch Environmental Consulting



APPENDIX B

GEOTECHNICAL INVESTIGATIONS

GEOTECHNICAL INVESTIGATION
DESIGN PHASE

FOR
MINDEGO PONDS – UPPER SPRING
RUSSIAN RIDGE OPEN SPACE PRESERVE
SANTA MATEO COUNTY, CALIFORNIA

PREPARED FOR
MIDPENINSULA REGIONAL OPEN SPACE DISTRICT

PROJECT NO. 18-180.2-SM

PREPARED BY
BUTANO GEOTECHNICAL ENGINEERING, INC.

DECEMBER 2018

BUTANO GEOTECHNICAL ENGINEERING, INC.
231 GREEN VALLEY ROAD, SUITE E, FREEDOM, CALIFORNIA 95019
PHONE: 831.724.2612
WWW.BUTANOGEOTECH.COM

December 17, 2018
Project No. 18-180.2-SM

Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, California 94022

ATTENTION: Zachary Alexander

SUBJECT: **GEOTECHNICAL INVESTIGATION - DESIGN PHASE**
Pond Enhancement and Restoration
Mindego Ponds – Upper Spring
Russian Ridge Open Space Preserve
San Mateo County, California

Dear Mr. Alexander:

In accordance with your authorization, we have completed a geotechnical investigation for the subject project. This report summarizes the findings, conclusions, and recommendations from our field exploration, laboratory testing, and engineering analysis. It is a pleasure being associated with you on this project. If you have any questions, or if we may be of further assistance, please do not hesitate to contact our office.

Sincerely,

BUTANO GEOTECHNICAL ENGINEERING, INC.

Greg Bloom, PE, GE
Principal Engineer

Philip Edwards, PE
Senior Engineer
R.C.E. 86451

Appendices
Appendix A Figures and Standard Details
Appendix B Field Exploration Program
Appendix C Laboratory Testing Program
Appendix D Dam Stability Analysis

Distribution: (4) Addressee

1.0 INTRODUCTION

This report presents the results of our geotechnical investigation for the proposed pond enhancement and dam repair of Upper Spring located in the Russian Ridge Open Space Preserve, San Mateo County, California. The existing pond is managed by Midpeninsula Regional Open Space District (MROSD).

The purpose of our investigation is to provide preliminary geotechnical design parameters and recommendations for the pond enhancement and dam repair. Conclusions and recommendations related to site grading and drainage are presented herein.

Our work included site reconnaissance, subsurface exploration, engineering analyses and preparation of this report. The scope of services for this investigation is outlined in our agreement revision dated September 11th, 2018 and attached as Exhibit A in the Hanford Arc/Butano joint agreement revision dated May 4th, 2018.

The recommendations contained in this report are subject to the limitations presented in Section 8.0 of this report. The Association of Engineering Firms Practicing the Geosciences has produced a pamphlet for your information titled “Important Information About Your Geotechnical Report”. This pamphlet has been included with the copies of your report.

2.0 PROJECT DESCRIPTION

Based on our field investigation, engineering analysis, and our discussions with: the applicant (MROSD), the project civil/environmental engineer (CBEC Eco Engineering), and the project contractor (Hanford ARC), the project consists of enhancing the pond environment and rebuilding the existing dam. The pond is habitat for the California red legged frog and other sensitive and endangered biota.

Improvements will consist of rebuilding the existing dam, building a spillway system, and increasing the pond depth.

The following document was provided to us for use in our design:

> CBEC Eco Engineering, *Mindego Ranch Ponds Enhancement Project, San Mateo County, California, Midpeninsula Regional Open Space District*, Job Number 18-1019, Dated Oct 2018

3.0 FIELD EXPLORATION AND LABORATORY TESTING PROGRAMS

Our field exploration program included drilling, logging, and interval sampling of 6 borings. Borings B1 through B3 were advanced on September 19, 2018 with a 3-inch diameter hand auger. Borings B4 through B6 were advanced on November 20, 2018 via continuous sampling with portable equipment. The borings were advanced to depths ranging from 3 ½ to 18 feet below existing grade. Details of the field exploration program, including the Boring Logs, are presented in Appendix B, Figures B-3 through B-8.

Representative samples obtained during the field investigation were taken to the laboratory for testing to determine physical and engineering properties. Details of the laboratory testing program are presented in Appendix C. Test results are presented on the Boring Logs and in appendix C.

4.0 SITE AND PROJECT DESCRIPTION

4.1 Location

The project site is located south of Highway 35 (Skyline Blvd.) within the Russian Ridge Open Space Preserve in unincorporated San Mateo County, California. The site location is shown on the Site Location Map, Appendix A, Figure A-1.

4.2 Surface Conditions

The pond is located on a northwest facing slope and is formed by an artificial dam embankment within a natural drainage. The pond has an approximate surface area of 3,000 square feet and a watershed area of approximately 5.6 acres. The current water depth is approximately 2 feet.

The slopes above the pond are moderate with natural gradients of approximately 25 percent. The slopes are relatively open and covered with grass and some brush. The slope to the south is densely forested with large and small trees and brush.

An earthen dam is located on the southwest side of the pond. The embankment is approximately 110 feet long. The current height of the dam, as measured from the in-situ bedrock to the highest point of the crest, is 11 feet.

The dam has an earth spillway through the center that crests the dam and flows over the dam face. The spillway is protected with small cobbles and gravel. There is a concrete drainage box north of the primary spillway that collects and pipes water to a tank northwest of the dam.

The slope below the dam is moderately steep with natural gradients of approximately 20 percent. The slope is heavily vegetated with small trees and shrubs.

The embankment fill slope has gradients up to 50 percent on the dam face and is vegetated with grass and small shrubs.

4.3 Subsurface Conditions

The site is geologically mapped as Landslide Debris (Qls). The landslide overlies Mindego Basalt (Tbm). These formations are generally described as:

> *Qls: Landslide rubble*. Quaternary in age. *(2007)*
>
> *Tbm: Extrusive basaltic rocks; age, Miocene to Oligocene (Zemorrian or Saucesian Stages). Basalt-diabase submarine flows, flow breccias, and tuff breccias, black, massive. (2007)*

The conditions encountered are in general conformance with the geologic mapping.

Three borings were advanced in the pond, borings B1 through B3. The pond has up to 3 feet of sediment deposits consisting of very soft and highly organic silt. The sediment deposits are overlying very soft to firm fat clay to the maximum depth explored of 5 feet (Qc – Colluvium or Qls-Landslide).

Three borings were advanced through the pond embankment and into the underlying native material, borings B4 through B6. The embankment fill consists of an approximately 3 feet thick crust of firm to stiff sandy fat clay, overlying soft to stiff fat clay with sand. The embankment is overlying colluvium/landslide deposits consisting of very stiff sandy fat clay on the south side, boring B4. The embankment is directly overlying basalt from the central portion of the dam to the north side. The maximum height of the embankment fill is approximately 12 feet.

Two unconfined compression tests were conducted in the embankment fill, five more tests were attempted but the soil was too soft to conduct the test. The dry densities, unconfined compressions, and moisture contents are inconsistent across the samples taken within the fill. The dam fill has a high degree of saturation that is near the liquid limit of the soil.

Boring B1 was drilled in the pond with a water depth of approximately 1 ½ feet. Groundwater was encountered at 3, 2 ½, 8, 12, and 11 feet below existing grade in borings B2 through B6 respectively. The depth to groundwater may vary seasonally and with the pond depth.

Complete soil profiles are presented on the Boring Logs, Appendix B, Figures B-3 through B-8. The boring locations are shown on the Boring Site Plan, Plate B-1. Two cross sections depicting the subsurface profiles are included in Appendix B, Plate B-1.

5.0 GEOTECHNICAL HAZARDS

5.1 General

In our opinion the geotechnical hazards that could potentially affect the proposed project are:

- Intense seismic shaking
- Collateral seismic hazards
- Erosion
- Dam Embankment Stability
- Deep Seated Landsliding

5.1.1 Intense Seismic Shaking

The hazard of intense seismic shaking is present throughout central California. Intense seismic shaking may occur at the site during the design lifetime of the proposed structure from an earthquake along one of the regions many faults. Generally, the intensity of shaking will increase the closer the site is to the epicenter of an earthquake, however, seismic shaking is a complex phenomenon and may be modified by local topography and soil conditions. The transmission of earthquake vibrations from the ground into the structure may cause structural damage.

The County of San Mateo has adopted the seismic provisions set forth in the 2016 California Building Code to address seismic shaking. The seismic provisions in the 2016 CBC are minimum load requirements for the seismic design for the proposed structure. The provisions set forth in the 2016 CBC will not prevent structural and nonstructural damage from direct fault ground surface rupture, coseismic ground cracking, liquefaction and lateral spreading, seismically induced differential compaction, seismically induced landsliding, or seismically induced inundation.

Table 1 has been constructed based on the 2016 CBC requirements for the seismic design of the proposed structure. The Site Class has been determined based on our field investigation and laboratory testing.

Table 1. Seismic Design Parameters

S_S	S_1	Site Class	F_a	F_v	S_{DS}	S_{D1}	F_{PGA}	PGA_M	Risk Category	Seismic Design Category
1.945	0.912	C	1.0	1.3	1.297	0.790	1.000	0.764	II	N/A

Latitude: 37.315003º Longitude: -122.227728º

5.1.2 Collateral Seismic Hazards

In addition to intense seismic shaking, other seismic hazards that may have an adverse affect to the site and/or the structure are: fault ground surface rupture, coseismic ground cracking, seismically induced liquefaction and lateral spreading, seismically induced differential compaction, seismically induced landsliding, and seismically induced inundation (tsunami and seiche). It is our opinion that the potential for collateral seismic hazards to affect the site and to damage the proposed structure is low except for dam embankment stability and deep seated landsliding.

5.1.3 Erosion

The slopes uphill of the pond are actively eroding. This process delivers sediment to the pond reducing its capacity over time.

5.1.4 Dam Embankment Stability

Quantitative slope stability analyses were performed on the existing dam profile (see cross-section Y-Y'). We utilized the modified Bishop's method of analysis. Details of the analyses and figures are shown in Appendix D. Our work was limited to analyzing the stability of the embankment and shallow soil. A deep seated analysis of the upslope and downslope hillside was beyond our scope of work.

A static factor of safety of 1.13 and seismic factor of safety of 0.65 was calculated for section Y-Y'. A factor of safety less than 1.5 for static and 1.1 for seismic is considered unstable. **The dam is considered unstable for static and seismic conditions in its present configuration.**

The slope stability was run with the water level for the pond at the elevation of the existing spillway.

If the existing dam embankment is replaced with engineered fill per section 7.2.2 it will be considered stable with gradients up to 2:1 (H:V). The slope stability analysis with this configuration yielded a static factor of safety of 8.04 and seismic factor of safety of 2.95.

The final design configuration will be based on the geotechnical data and a pond depth conducive to California red legged frog breeding. Our firm should review the final configuration.

5.1.5 Deep Seated Landsliding

An analysis of deep seated landsliding was beyond our scope of work. As such, the hazard of deep seated landsliding is indeterminate.

6.0 DISCUSSIONS AND CONCLUSIONS

Based on our field investigation, engineering analysis, and discussions with MROSD personnel it is proposed that the dam be rebuilt, the spillway improved, and the pond deepened.

The results of the stability analysis are in Appendix D. **The results indicate that the existing dam configuration is considered unstable both statically and seismically.** Our analysis indicates that the pond embankment was poorly compacted during construction. Values of cohesion used in the stability analysis were based on the highly variable, soft, and nearly saturated soil. The soil in many of the samples was too soft to test for unconfined compression. These soils had moisture contents close to their liquid limit and are in a nearly flowable state (sensitive).

The low water level in the pond is related to sediment deposition.

The spillway should include a redundant system with primary flow being piped beyond the dam embankment.

The area surrounding the pond is currently used to graze cattle. This use denudes the slopes, increasing surface flow, and accelerates the upslope erosion and resulting sedimentation.

Fat clay was encountered in the pond basin to the maximum depth drilled of 5 feet. This layer of colluvium/landslide debris(?) is functioning as a pond liner.

7.0 RECOMMENDATIONS

7.1 General

Based on the results of our field investigation, laboratory testing, and engineering analysis it is our opinion that from the geotechnical standpoint, the subject site will be suitable for the pond enhancements and repair.

The pond embankment should be over-excavated down to the underlying colluvium or basalt and replaced with engineered fill.

The entire watershed upslope of the pond should be fenced off to eliminate cattle grazing. Although this will not stop the upslope erosion, it will slow the process.

7.2 Site Grading

7.2.1 Site Clearing

The site should be cleared of loose soil, organics, and debris within the project limits.

7.2.2 Preparation of On-Site Soils

All fill should be moisture conditioned 3 to 5 percent over optimum and compacted with heavy vibratory equipment to a minimum of 87 percent relative compaction. **Fill placed as part of the dam should be compacted to a minimum of 93 percent relative compaction.** Fill should be compacted by mechanical means in uniform horizontal loose lifts not exceeding 8 inches in thickness. The relative compaction and required moisture content shall be based on the maximum dry density and optimum moisture content obtained in accordance with laboratory test procedure ASTM D1557.

The existing embankment fill may be re-used as engineered fill once it is processed. Processing should include moisture conditioning and removing any deleterious material. All soils, both existing on-site and imported, to be used as fill within the **dam embankment**, should contain a minimum of 80 percent fines, with the fines fraction having a minimum liquid limit of 50 and plasticity index of 30. **All soil both on-site and imported should be verified by a representative of Butano Geotechnical Engineering, Inc. prior to placement as fill.**

The recent highly organic sediment deposits may not be re-used as engineered fill and should be spread on-site.

Any surface or subsurface obstruction, or questionable material encountered during grading, should be brought immediately to the attention of the Geotechnical Engineer for proper processing as required.

7.2.3 Dam Embankment

The existing embankment should be removed and replaced. The new enbankment should be keyed into the underlying colluvium or basalt.

The base of the dam should be keyed a minimum of 2 feet into the underlying basalt bedrock or medium dense colluvium. The dam fill should be keyed and benched and placed according to section 7.2.2. For a typical keying and benching diagram see Appendix A, Figure A-2.

Drainage for the dam should be designed by a licensed civil engineer and according to section 7.2.6.

7.2.4 Cut and Fill Slopes

Temporary cuts within the on-site soil should be made no steeper than 1:1 (H:V) to a maximum height of 20 feet. Temporary cuts within the bedrock may be laid back at near vertical to a height of 4 feet and 1:1 (H:V) above 4 feet to a height of 20 feet.

Permanent cut and fill slopes should be graded no steeper than 2:1 (H:V).

All cut and fill slopes should be reviewed by a representative of Butano Geotechnical Engineering, Inc.

7.2.5 Excavating Conditions

The on-site soil may be excavated with conventional earthwork equipment. The Mindego basalt may require rock teeth to excavate.

7.2.6 Surface Drainage

It is recommended that the primary spillway does not allow water to flow onto the dam face. The primary spillway should pipe water a minimum of 10 feet past the base of the embankment and released into a level spreader or other energy dissipator.

The secondary spillway may be routed over the dam face. This should be protected with Mirafi 500 stabilization fabric (or equivalent) and with cobbles. The secondary spillway protection should extend a minimum of 10 feet past the base of the dam.

7.2.7 Erosion Control

Erosion control should be placed on any disturbed slopes. This should be designed by the project civil/environmental engineer.

7.3 Plan Review

The recommendations presented in this report are based on preliminary design information for the proposed project and on the findings of our geotechnical investigation. When completed, the Grading Plans, Foundation Plans and design loads should be reviewed by the geotechnical engineer of record, Inc. prior to submitting the plans and contract bidding. Additional field exploration and laboratory testing may be required upon review of the final project design plans.

7.4 Observation and Testing

Field observation and testing must be provided by a representative of Butano Geotechnical Engineering, Inc. to enable them to form an opinion regarding the adequacy of the site preparation, the adequacy of fill materials, and the extent to which the earthwork is performed in accordance with the geotechnical conditions present, the requirements of the regulating agencies, the project specifications, and the recommendations presented in this report. Any earthwork performed in connection with the subject project without the full knowledge of, and not under the direct observation of the geotechnical engineer of record, will render the recommendations of this report invalid.

Butano Geotechnical Engineering, Inc. should be notified at least 5 working days prior to any site clearing or other earthwork operations on the subject project in order to observe the stripping and disposal of unsuitable materials and to ensure coordination with the grading contractor. During this period, a preconstruction meeting should be held on the site to discuss project specifications, observation and testing requirements and responsibilities, and scheduling.

8.0 LIMITATIONS

The recommendations contained in this report are based on our field explorations, laboratory testing, and our understanding of the proposed construction. The subsurface data used in the preparation of this report was obtained from the borings drilled during our field investigation. Variation in soil, geologic, and groundwater conditions can vary significantly between sample locations. As in most projects, conditions revealed during construction excavation may be at variance with preliminary findings. If this occurs, the changed conditions must be evaluated by the Project Geotechnical Engineer and the Geologist, and revised recommendations be provided as required. In addition, if the scope of the proposed construction changes from the described in this report, our firm should also be notified.

Our investigation was performed in accordance with the usual and current standards of the profession, as they relate to this and similar localities. No other warranty, expressed or implied, is provided as to the conclusions and professional advice presented in this report.

This report is issued with the understanding that it is the responsibility of the Owner, or of his Representative, to ensure that the information and recommendations contained herein are brought to the attention of the Architect and Engineer for the project and incorporated into the plans, and that it is ensured that the Contractor and Subcontractors implement such recommendations in the field. The use of information contained in this report for bidding purposes should be done at the Contractor’s option and risk.

This firm does not practice or consult in the field of safety engineering. We do not direct the Contractor's operations, and we are not responsible for other than our own personnel on the site; therefore, the safety of others is the responsibility of the Contractor. The Contractor should notify the Owner if he considers any of the recommended actions presented herein to be unsafe.

The findings of this report are considered valid as of the present date. However, changes in the conditions of a site can occur with the passage of time, whether they be due to natural events or to human activities on this or adjacent sites. In addition, changes in applicable or appropriate codes and standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, this report may become invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and revision as changed conditions are identified.

The scope of our services mutually agreed upon did not include any environmental assessment or study for the presence of hazardous to toxic materials in the soil, surface water, or air, on or below or around the site. Butano Geotechnical Engineering, Inc. is not a mold prevention consultant; none of our services performed in connection with the proposed project are for the purpose of mold prevention. Proper implementation of the recommendations conveyed in our reports will not itself be sufficient to prevent mold from growing in or on the structures involved.

REFERENCES

ASTM International (2015). Annual Book of ASTM Standards, Section Four, Construction. Volume 4.08, Soil and Rock (I): D 430 - D 5611.

ASTM International (2015). Annual Book of ASTM Standards, Section Four, Construction. Volume 4.09, Soil and Rock (II): D 5714 - Latest.

Geologic Map of the Mindego Hill Quadrangle, San Mateo , Santa Clara, and Santa Cruz Counties, California – 2007, Dibblee, T.W., and Minch J.A.: Dibblee Geologic Foundation, Dibblee Foundation Map DF – 349, scale: 1:24,000

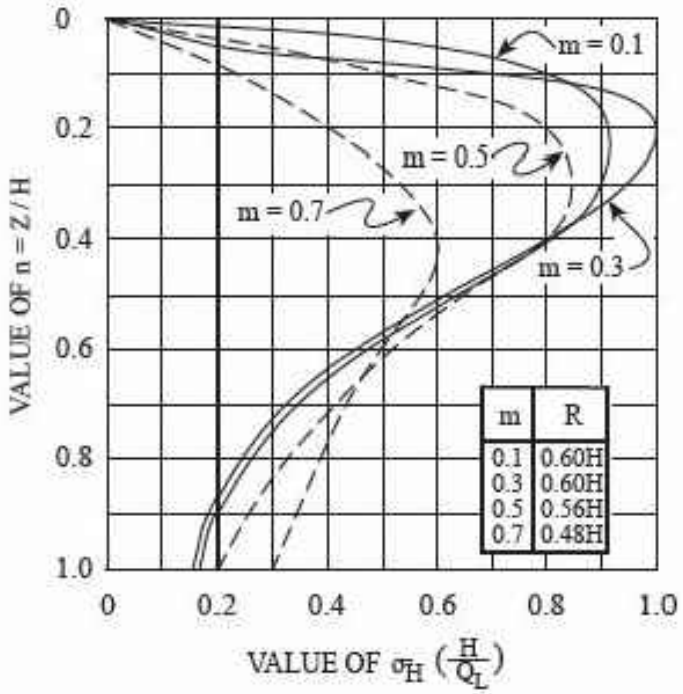
California Building Code (2016).

APPENDIX A

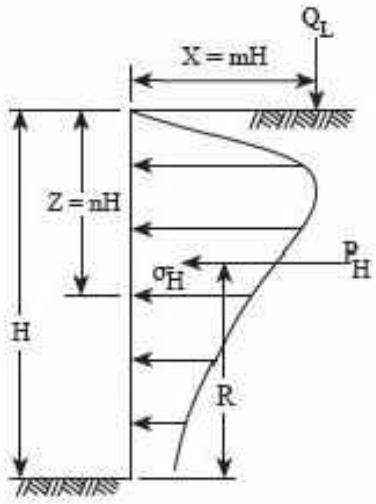
FIGURES AND STANDARD DETAILS

Surcharge Pressure Diagram	Figure A-1
Keying and Benching Typical	Figure A-2

LINE LOAD



m	R
0.1	0.60H
0.3	0.60H
0.5	0.56H
0.7	0.48H



FOR m ≦ 0.4:

$$\sigma_H \left(\frac{H}{Q_L}\right) = \frac{0.20\,n}{(0.16+n^2)^2}$$

$$P_H = 0.55\,Q_L$$

FOR m > 0.4:

$$\sigma_H \left(\frac{H}{Q_L}\right) = \frac{1.28\,m^2 n}{(m^2+n^2)^2}$$

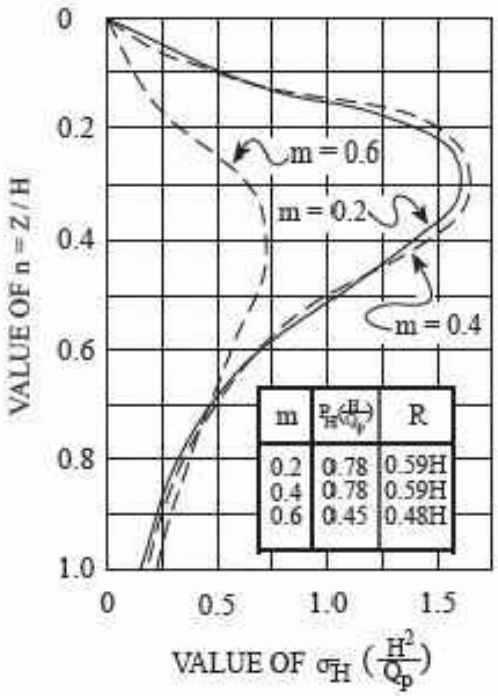
RESULTANT $P_H = \frac{0.64\,Q_L}{(m^2+1)}$

PRESSURES FROM LINE LOAD Q_L

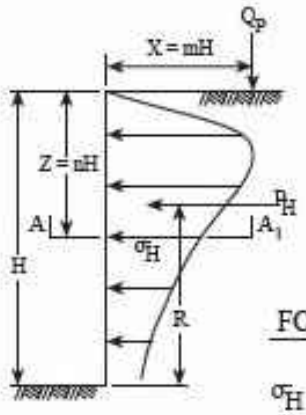
(BOISSINESQ EQUATION MODIFIED BY EXPERMENT)

REFERENCE: Design Manual
NAVFAC DM-7.02
Figure 11
Page 7.2-74

POINT LOAD



m	$\frac{P_H}{Q_p}\left(\frac{H}{Q_p}\right)$	R
0.2	0.78	0.59H
0.4	0.78	0.59H
0.6	0.45	0.48H



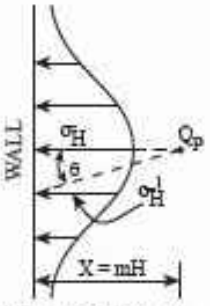
FOR m ≦ 0.4:

$$\sigma_H \left(\frac{H^2}{Q_p}\right) = \frac{0.28\,n^2}{(0.16+n^2)^3}$$

FOR m > 0.4:

$$\sigma_H \left(\frac{H^2}{Q_p}\right) = \frac{1.77\,m^2 n^2}{(m^2+n^2)^3}$$

$$\sigma_H^1 = \sigma_H \cos^2(1.1\,\theta)$$

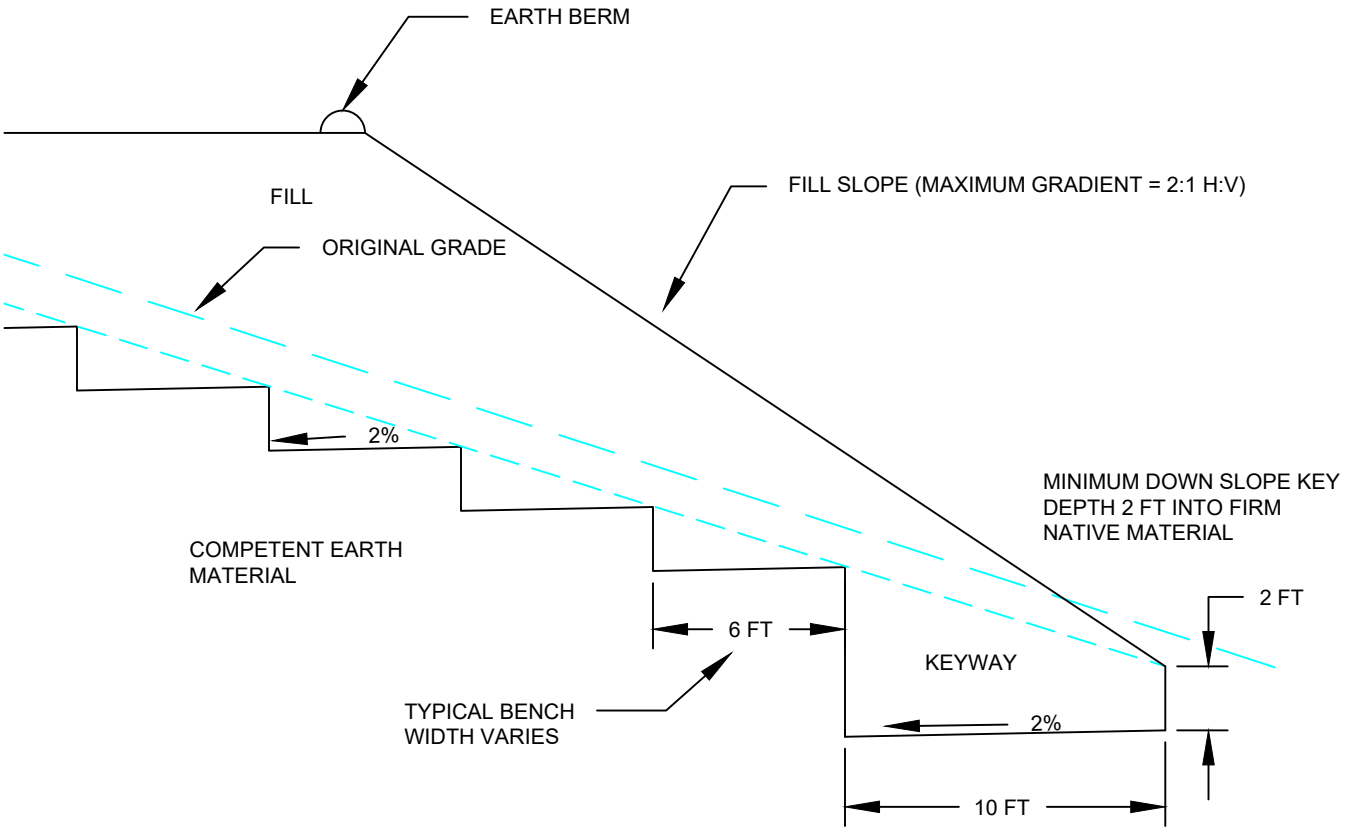


SECTION A-A_1

PRESSURES FROM POINT LOAD Q_P

(BOISSINESQ EQUATION MODIFIED BY EXPERMENT)

BUTANO GEOTECHNICAL ENGINEERING, INC.	**S□□C□A□□E P□ESS□□E □IA□□AM**	FIGURE A-1



NOTES:

1. DRAWING IS NOT TO SCALE
2. FILLS SITUATED ON SLOPES STEEPER THAN 5:1 (H:V) SHOULD BE KEYED AND BENCHED.
3. FILL MATERIAL SHOULD BE PLACED PER THE RECOMMENDATIONS IN THE GEOTECHNICAL REPORT.
4. LOCATIONS SHALL BE DETERMINED IN THE FIELD BY THE GEOTECHNICAL ENGINEER.

N.T.S.

BUTANO GEOTECHNICAL ENGINEERING, INC.	**□E□IN□ AN□ □ENC□IN□ T□PICAL**	FIGURE A-2

APPENDIX B

FIELD EXPLORATION PROGRAM

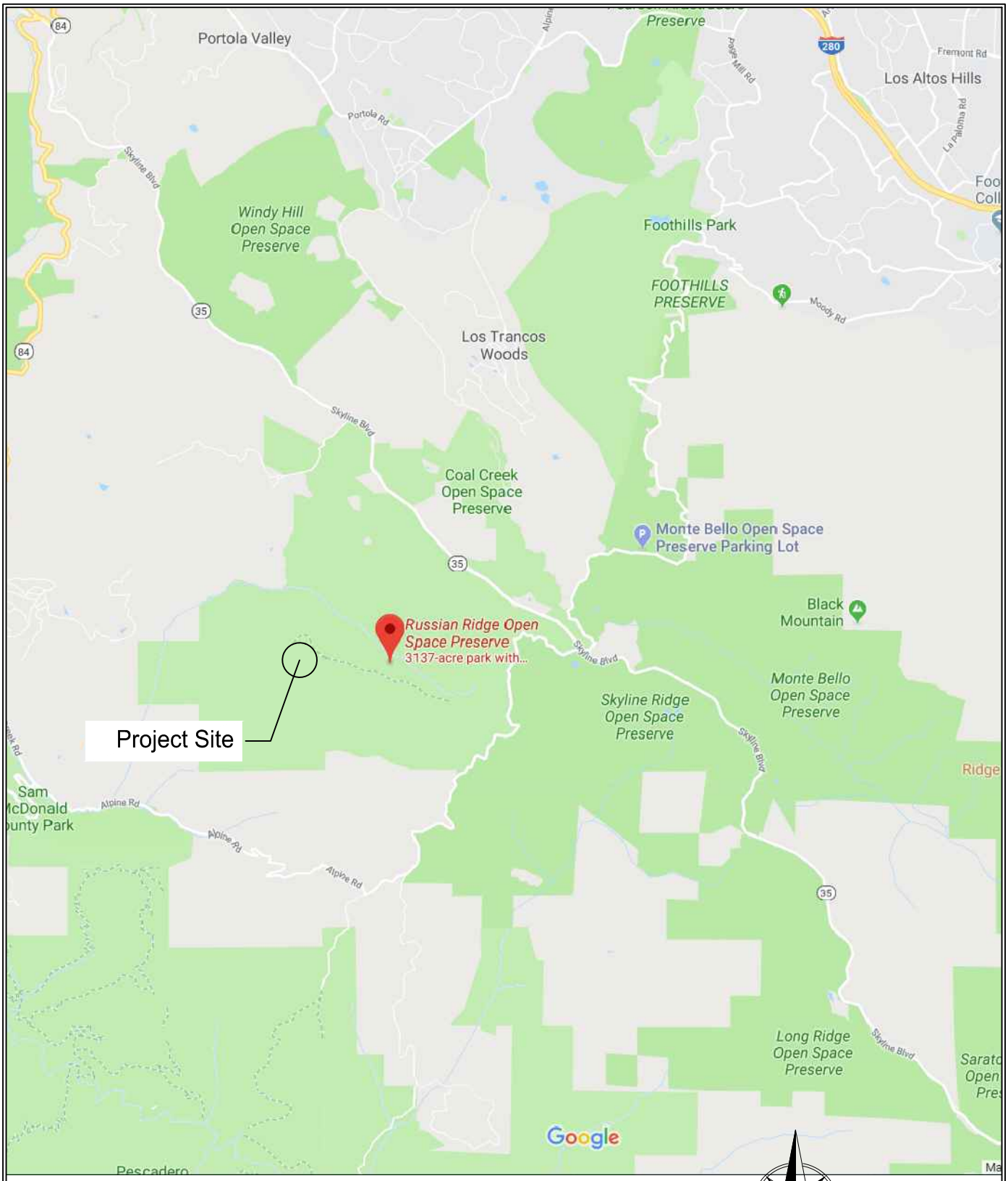
Field Exploration Procedures	Page B-1
Site Location Plan	Figure B-1
Key to the Logs	Figure B-2
Logs of the Borings	Figures B-3 through B-8
Boring Site Plan & Cross Sections	Plate B-1

FIELD EXPLORATION PROCEDURES

Subsurface conditions were explored by advancing 6 borings below existing grade. Borings B1 through B3 were advanced on September 19, 2018 using a 4-inch diameter hand auger. Borings B4 through B6 were advanced via continuous sampling with hand equipment on November 20, 2018. The Key to The Logs and the Logs of the Borings are included in Appendix B, Figures B-2 through B-8. The approximate locations of the borings are shown on the Boring Site Plan, Plate B-1. Borings B1 through B3 were located in the field by CBEC Eco Engineering using a robotic total station. Borings B4 through B6 were located in the field by tape measurements from known landmarks. The locations as shown are within the accuracy of such measurement.

The soils encountered in the borings were continuously logged in the field by a representative of Butano Geotechnical Engineering, Inc. Bulk and relatively undisturbed soil samples for identification and laboratory testing were obtained in the field. These soils were classified based on field observations and laboratory tests. The classification is in accordance with the Unified Soil Classification System (Figure B-3).

Two geologic cross sections have been provided depicting the surface and subsurface soil profiles at the site (Plate B-1). The surface profiles were constructed using the topographic survey provided by CBEC Eco Engineering. Subsurface data was interpolated from surface gradients and subsurface soil conditions encountered in the borings, the accuracy of the cross sections is limited by the site investigation and data collection methods.



N.T.S.

BUTANO	**SITE LOCATION PLAN**	FIGURE
GEOTECHNICAL ENGINEERING, INC.	Mindego Ponds - U□□er □□ring	B-1

KEY TO LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS More than half of the material is larger than the No. 200 sieve	GRAVELS More than half of the coarse fraction is larger than the No. 4 sieve	CLEAN GRAVELS (Less than 5% fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More than half of the coarse fraction is smaller than the No. 4 sieve	CLEAN SANDS (Less than 5% fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SAND WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More than half of the material is smaller than the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50		ML	Inorganic silts and very fine sands, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomacaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

GRAIN SIZE LIMITS

SILT AND CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

No. 200 No. 40 No. 10 No. 4 3/4 in. 3 in. 12 in.

US STANDARD SIEVE SIZE

RELATIVE DENSITY	
SAND AND GRAVEL	BLOWS/FT*
VERY LOOSE	0 - 4
LOOSE	4 - 10
MEDIUM DENSE	10 - 30
DENSE	30 - 50
VERY DENSE	OVER 50

CONSISTENCY	
SILT AND CLAY	BLOWS/FT*
VERY SOFT	0 - 2
SOFT	2 - 4
FIRM	4 - 8
STIFF	8 - 16
VERY STIFF	16 - 32
HARD	OVER 32

MOISTURE CONDITION	
CLAY	DRY
	MOIST
	very moist
SAND	DRY
	DAMP
	WET
	very moist

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1 3/8 inch I.D.) split spoon (ASTM D-1586).

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B1
Project:	Mindego Ponds - Upper Spring	Location:	In pond near dam
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
0	ML		X	Black SILT, very soft, saturated, highly organic, sediment.									
1													
2													
3	CH		X	Bluish Fat CLAY, soft, saturated, (Qc - Colluvium or Qls - Landslide).				59.2				69.0	36.3
4													
5				Boring terminated at a depth of 5 feet due to hole colapse. Groundwater encountered at the surface during drilling.									
6													
7													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-3

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B2
Project:	Mindego Ponds - Upper Spring	Location:	Central pond
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
0	ML		X	Dark grey SILT, very soft, very moist, highly organic, sediment.				66.8					
	CH		X	Bluish grey Fat Clay, soft, very moist, (Qc - Colluvium or Qls - Landslide).				49.6					
1													
2													
	CH		X	Yellow Sandy Fat CLAY, stiff, saturated, (Qc - Colluvium or Qls - Landslide). ▽									
3													
4				Boring terminated at a depth of 3 1/2 feet. Groundwater encountered at 3 feet during drilling.									
5													
6													
7													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-4

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B3
Project:	Mindego Ponds - Upper Spring	Location:	Upper pond
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
0	CH		X	Bluish Fat CLAY, soft, very moist.				57.0					
1	CH		X	Dark grey Sandy Lean CLAY, soft, very moist, (Qc - Colluvium or Qls - Landslide).				59.1					
2				▽									
3				Yellow Sandy Fat CLAY, stiff,									
4				Boring terminated at a depth of 4 feet due to auger refusal. Groundwater encountered at 2 1/2 feet during drilling.									
5													
6													
7													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-5

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B4
Project:	Mindego Ponds - Upper Spring	Location:	Southwest dam
		Elevation:	
Date:	November 20, 2018	Method of Drilling:	Portable equipment
Logged By:	PE		

2" Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH			Dark brown Sandy Fat CLAY with gravel, stiff, moist, (FILL).	22	10	75.0	26.5			TS		
	(FILL)			Firm.	12	6	60.2	47.8			TS		
	GM			Greenish brown Silty GRAVEL with sand, very loose, damp.	6	3		31.2		23.9			
5	CH			Brown Fat CLAY with sand, firm, very moist.	9	6		53.8					
				Firm, saturated. ▽	7	5		46.4					
10				Stiff.	12	9		46.4					
				Stiff.	17	10	77.0	44.4			TS		
				Stiff.	15	11		49.8					
15								42.5					
	CH			Yellow Sandy Fat CLAY, very stiff, saturated, (Qc - Colluvium or Qls - Landslide).	24	23		41.2					
20				Boring terminated at a depth of 18 feet. Groundwater encountered at 8 feet during drilling.									
25													
30													
35													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-6

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B5
Project:	Mindego Ponds - Upper Spring	Location:	Center of dam
		Elevation:	
Date:	November 20, 2018	Method of Drilling:	Portable Equipment
Logged By:	PE		

2" Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH (FILL)			Dark brown Sandy Fat CLAY with gravel, very stiff, slightly moist, (FILL).	36	16	83.6	29.9			TS	60.0	29.3
				Firm.	12	7							
5				Brown Fat CLAY with sand, stiff, very moist.	13	9		40.3					
				Stiff.	17	9	69.1	30.3				66.3	34.7
							72.9	48.8			1420		
10	BR			Bluish grey BASALT, loose, saturated, highly weathered and friable, (Tbm - Mindego Basalt).	8	5		43.6					
				▽	20	17		30.8					
15				Boring terminated at a depth of 14 feet. Groundwater encountered at 12 feet during drilling.									
20													
25													
30													
35													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-7

LOG OF EXPLORATORY BORING

Project No.:	18-180.2-SM	Boring:	B6
Project:	Mindego Ponds - Upper Spring	Location:	Northeast dam
		Elevation:	
Date:	November 20, 2018	Method of Drilling:	Portable Equipment
Logged By:	PE		

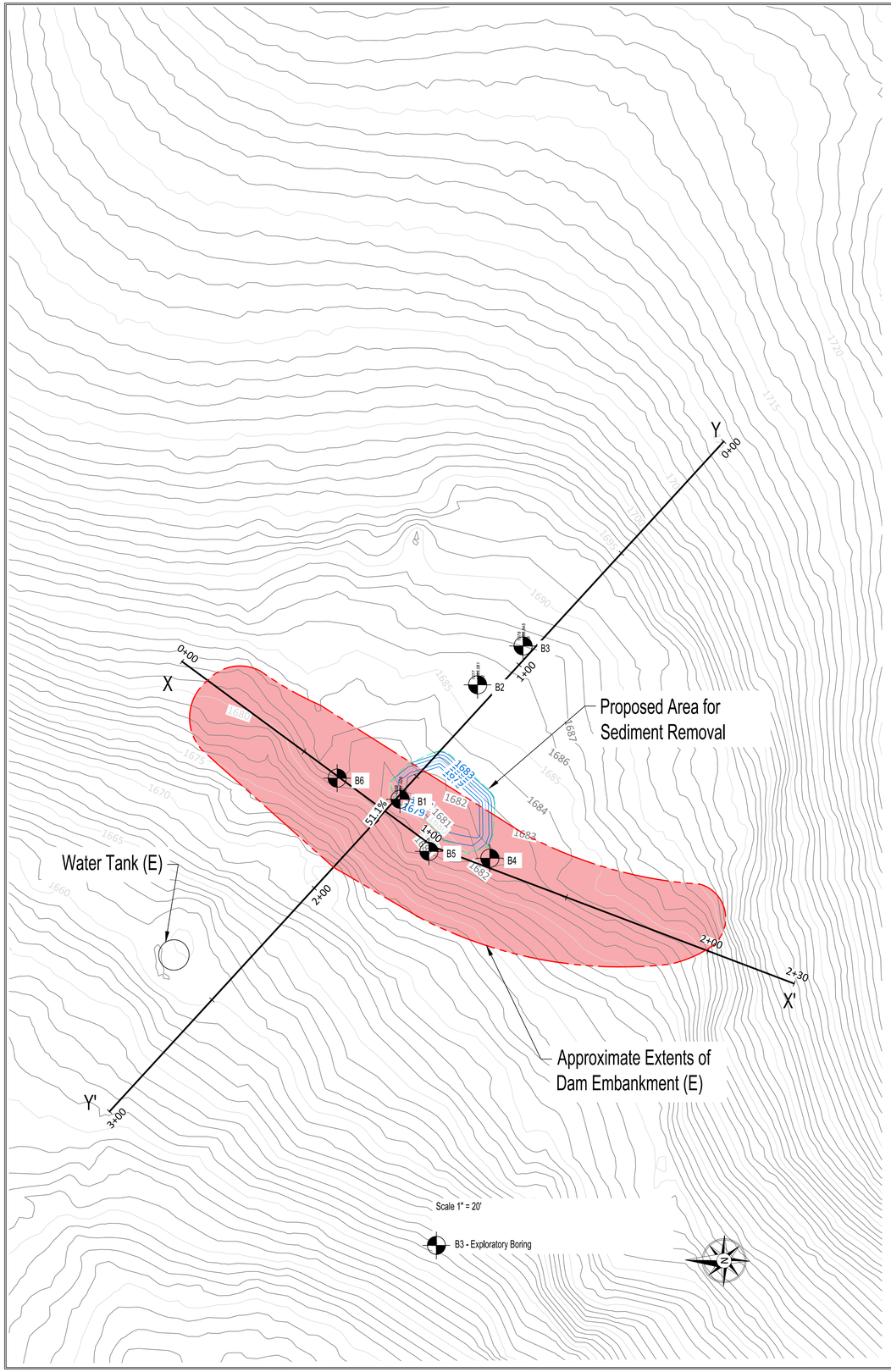
2" Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table | Soil Boundary | Soil Boundary with No Change in Depositional Environment

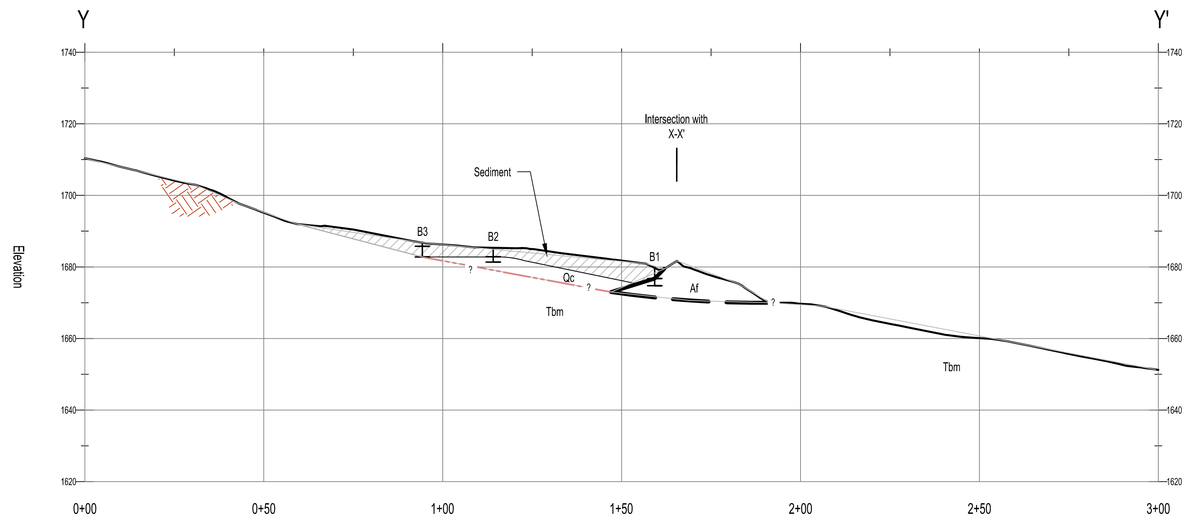
Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH			Dark brown Sandy Fat CLAY with gravel, firm, moist, (FILL).	14	7		33.2					
	(FILL)			Firm, no gravel.	13	7	66.1	41.2		64.9	TS		
				Brown Fat CLAY with sand, firm, very moist.	11	7		34.6				53.0	26.4
5				Soft.	5	3		48.0					
				Soft.	7	4	73.0	44.8			585		
10				Soft. ▽	6	4		34.7					
	BR			Bluish grey BASALT, loose, saturated, highly weathered and friable, (Tbm - Mindego Basalt).	10	8		46.3					
15				Boring terminated at a depth of 14 feet. Groundwater encountered at 11 feet during drilling.									
20													
25													
30													
35													

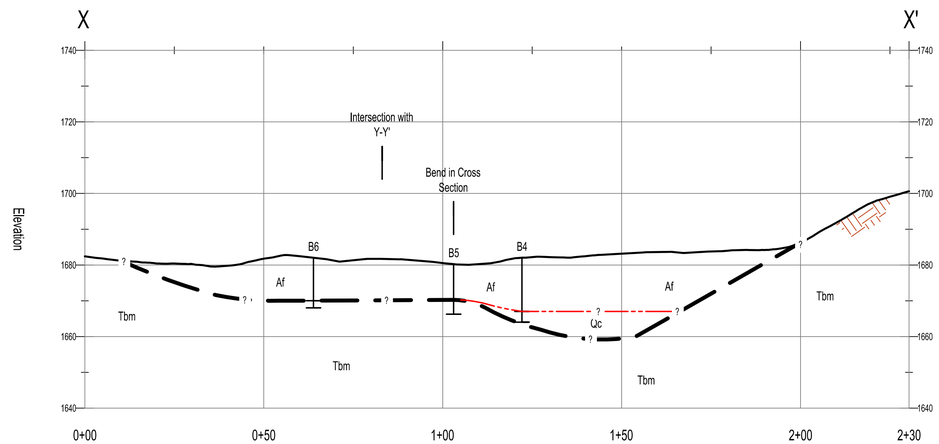
BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-8

BUTANO	**BORING SITE PLAN & CROSS SECTIONS**	PLATE
GEOTECHNICAL ENGINEERING, INC.	Mindego Ponds - Upper Spring	B-1







Legend

Scale 1" = 20'

Af - Artificial Fill of Dam
Sediment - Recent Sediment Deposit
Qc - Elastic Silt, Fat Clay-Colluvium/Landslide Deposit
Tbm - Mindego Basalt

? - Queried Where Unknown

B3 - Exploratory Boring

APPENDIX C

LABORATORY TESTING PROGRAM

Laboratory Testing Procedures	Page C-1
Atterberg Limits Summary	Figure C-1
Particle Size Analysis	Figure C-2 and C-3

LABORATORY TESTING PROCEDURES

Classification

Soils were classified according to the Unified Soil Classification System in accordance with ASTM D 2487 and D 2488. Moisture content and density determinations were made for representative samples in accordance with ASTM D 2216. Results of moisture density determinations, together with classifications, are shown on the Boring Logs, Figures B-3 through B-8b.

Atterberg Limits

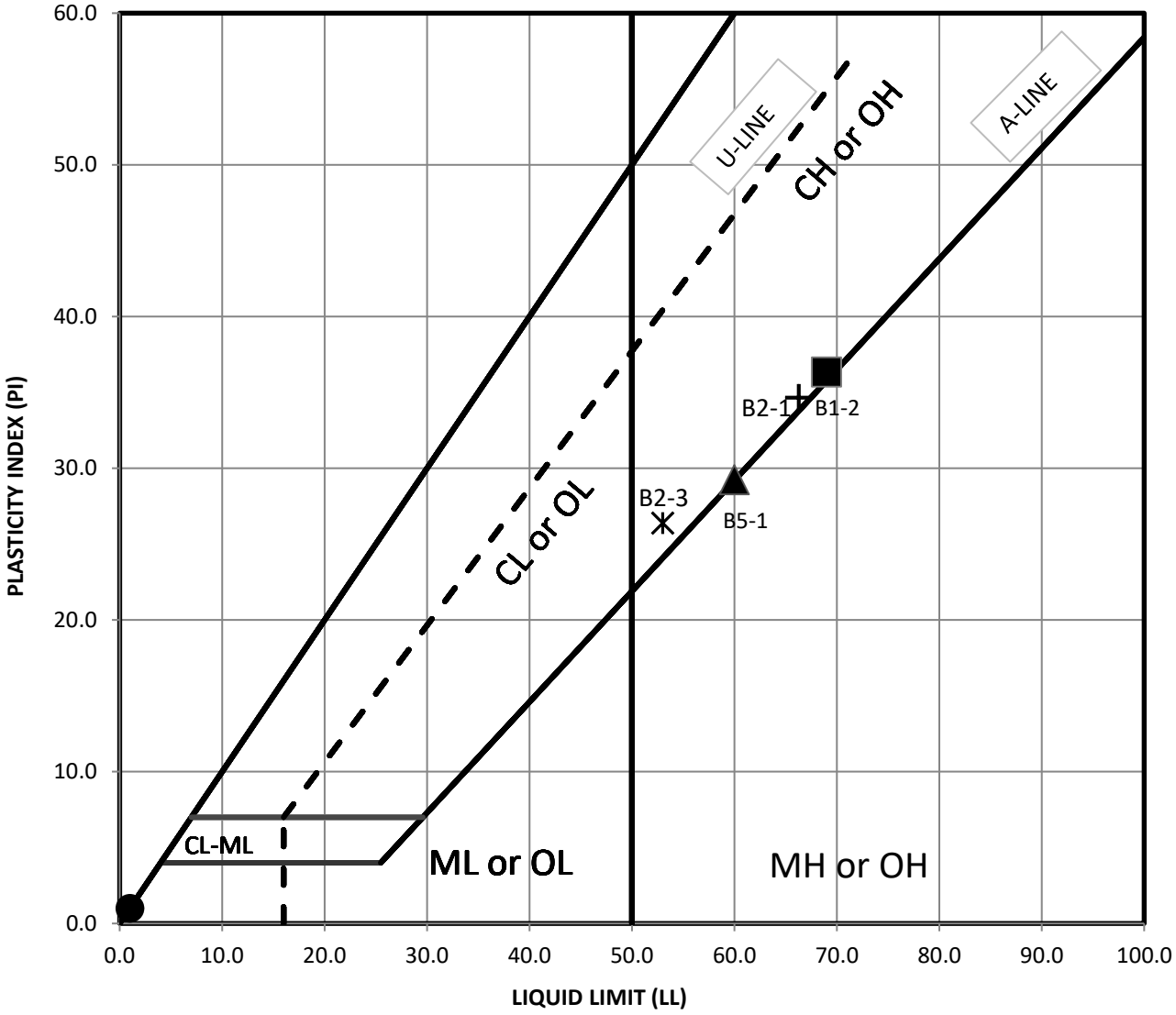
Four Atterberg limits tests were performed in accordance with ASTM D-4318. The results are shown on the Boring Logs, Figures B-3 through B-8, and summarized on Figure C-1

Unconfined Compression

Two unconfined compression tests were performed in accordance with ASTM D-2166. The results are shown on the boring logs as q_u, Figures B-3 through B-8. Five addtitional unconfined compression tests were attempted and failed due to very soft soil. The untestable samples are labeled as ‘TS’ on the boring logs.

Particle Size Analysis

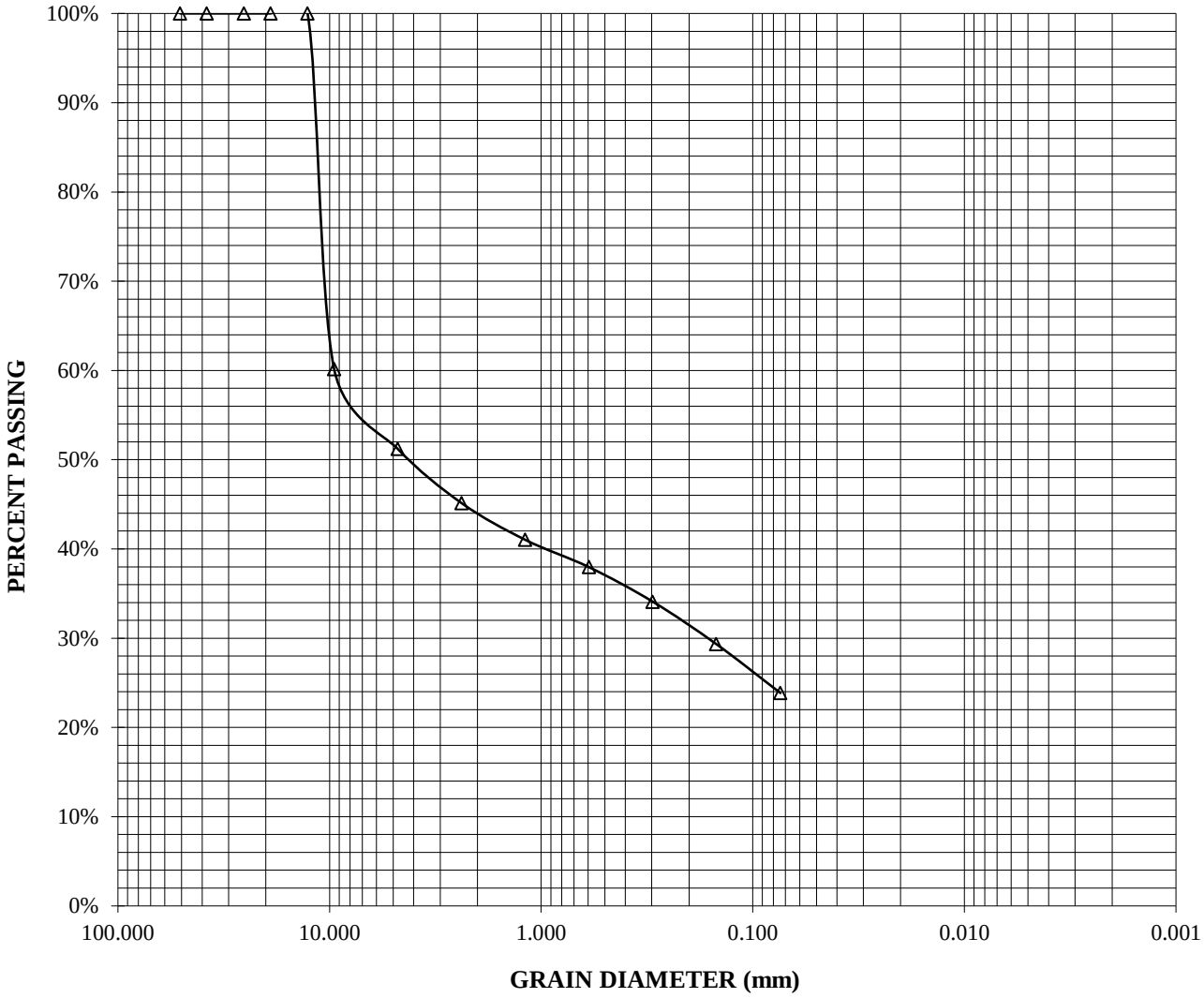
Two sieves were performed on representative samples in accordance with C117 and C136. The grain size distributions from the results of the particle size analysis are shown in Figures C-2 and C-3



Sample	Depth	Description	LL	PL	PI
B1-2	3 ft	Fat CLAY	69.0	32.7	36.3
B5-1	2 ft	Fat CLAY	60.0	30.7	29.3
B5-4	8 ft	Fat CLAY	66.3	31.6	34.7
B6-3	10 ft	Fat CLAY	53.0	26.6	26.4

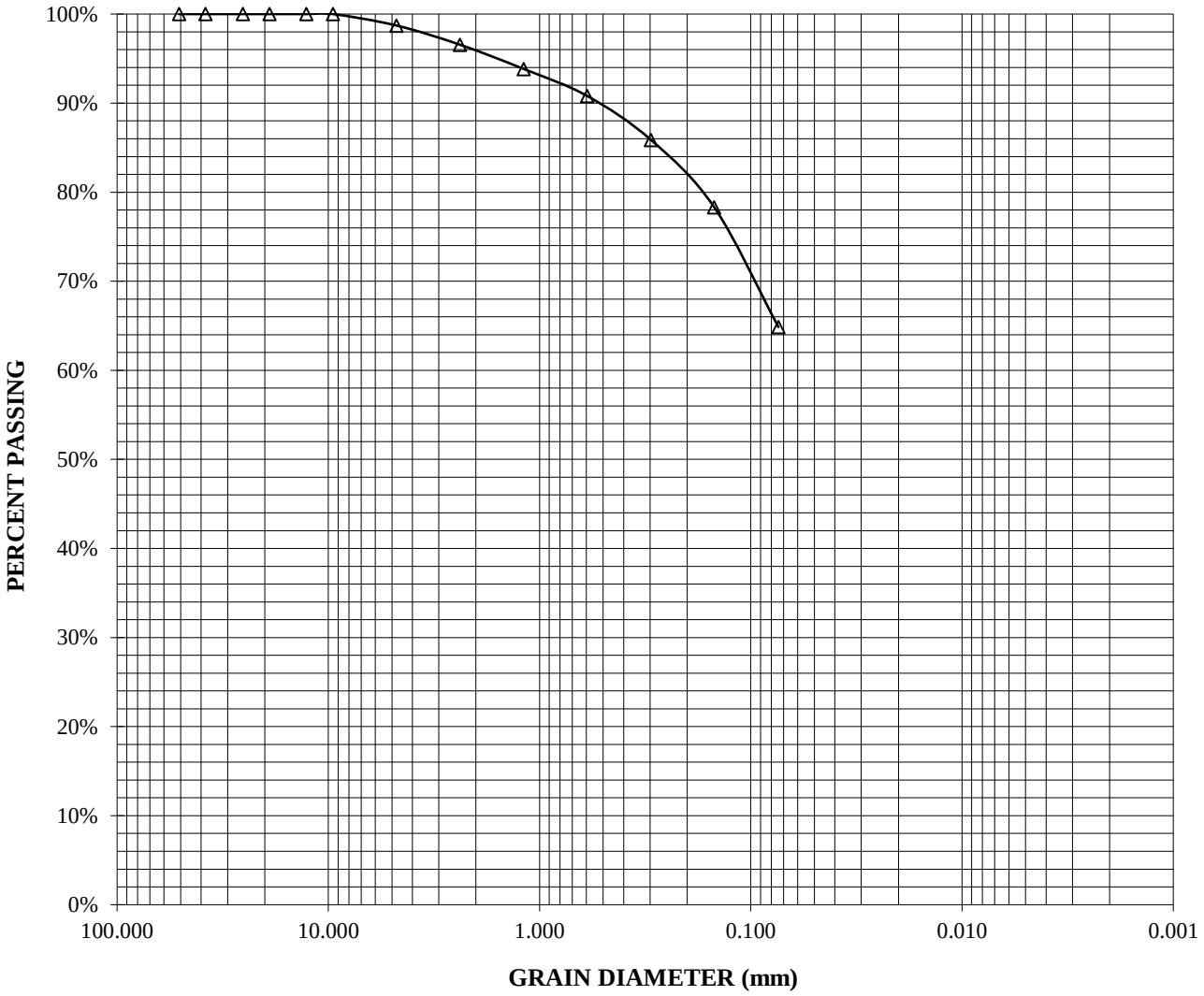
BUTANO GEOTECHNICAL ENGINEERING, INC.	**ATTERBERG LIMITS SUMMARY** Mindego Ponds - Upper Springs	FIGURE C-1

BORING:	B4-3	PERCENT	PERCENT
DEPTH (ft):	4.0	PASSING No. 4	PASSING No. 200
SOIL TYPE (USCS):	GM	51.2%	23.9%



BUTANO	**GRAIN SIZE DISTRIBUTION**	FIGURE
GEOTECHNICAL ENGINEERING, INC.	Mindego Ponds - Upper Springs	C-2

BORING:	B6-2	PERCENT	PERCENT
DEPTH (ft):	4.0	PASSING No. 4	PASSING No. 200
SOIL TYPE (USCS):	CH	98.7%	64.9%



BUTANO	**GRAIN SIZE DISTRIBUTION**	FIGURE
GEOTECHNICAL ENGINEERING, INC.	Mindego Ponds - Upper Springs	C-3

APPENDIX D

SLOPE STABILITY PROGRAM

Slope Stability Analysis and Procedures — Page D-1

Slope Stability Analysis and Properties

- Cross-Section Y-Y', static Pond Full — Figure D-1
- Cross-Section Y-Y', Seismic Pond Full — Figure D-2
- Proposed Cross-Section Y-Y', Seismic Pond Full — Figure D-3
- Proposed Cross-Section Y-Y', Seismic Pond Full — Figure D-4

METHODOLOGY

Slope stability calculations were performed on the cross-sections and slopes discussed under the Slope Stability section of this report, and are considered representative of the ranges of conditions at the site.

The stability of the slope was analyzed using the computer program ReSSA 3.0 by ADAMA Engineering, Inc., 2016. This program utilizes a limiting equilibrium method for determining the Factor of Safety against sliding on an assumed failure surface. The cross-section analyzed and the result of the analysis is presented in the attached summary.

Material properties chosen for these analyses are based on field and laboratory tests and our experience.

The slope was analyzed under wet static and seismic conditions for a full pond.

One proposed configuration was analyzed with a 2:1 (H:V) embankment slope. This is a typical configuration. The final configuration should be sent to our firm for analysis.

It must be cautioned that slope stability analysis is an inexact science; and that the mathematical models of the slopes and soils contain many simplifying assumptions, not the least of which is homogeneity. Slope stability analyses and the generated factors of safety should be used as indicating trend lines. A slope with a safety factor less than one will not necessarily fail, but the probability of slope movement will be greater than a slope with a higher safety factor. Conversely, a slope with a safety factor greater than one may fail, but the probability of stability is higher than a slope with a lower safety factor.

Figure D-1

Mindego Ponds - Upper Spring

Report created by ReSSA(3.0): Update #4.21: Copyright (c) 2001-2016, ADAMA Engineering, Inc.

PROJECT IDENTIFICATION

Title: Mindego Ponds - Upper Spring
Project Number: 18-180.1-SM -
Client: Mid-Pen
Designer: Philip Edwards

Description:
Upper Spring Static

Company's information:

Name: Butano Geotechnical Engineering Inc
Street: 231 Green Valley Road Suite E
Freedom, CA 95019
Telephone #: 831.724.2612
Fax #:
E-Mail:

Original file path and name: C:\Users\B ..... \Engineering\18-180.1-SM Upper Springs Seismic.MSE
Original date and time of creating this file: Thu Nov 22 09:52:46 2018

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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INPUT DATA (EXCLUDING REINFORCEMENT LAYOUT)

SOIL DATA

========== Soil Layer #: ==========	Unit weight, γ [lb/ft ^{3}]	Internal angle of friction, ϕ [deg.]	Cohesion, c [lb/ft ^{2}]
1	120.0	0.0	100.0
2	100.0	0.0	100.0
3	120.0	36.0	8000.0

REINFORCEMENT

Analysis of slope WITHOUT reinforcement.

WATER

Unit weight of water = 62.45 [lb/ft ^{3}]
Water pressure is defined by phreatic surface in Effective Stress Analysis.

SEISMICITY

Not Applicable

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DRAWING OF SPECIFIED GEOMETRY - GENERAL - Quick Input

-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY

Soil profile contains 3 layers (see details in next page)

WATER GEOMETRY

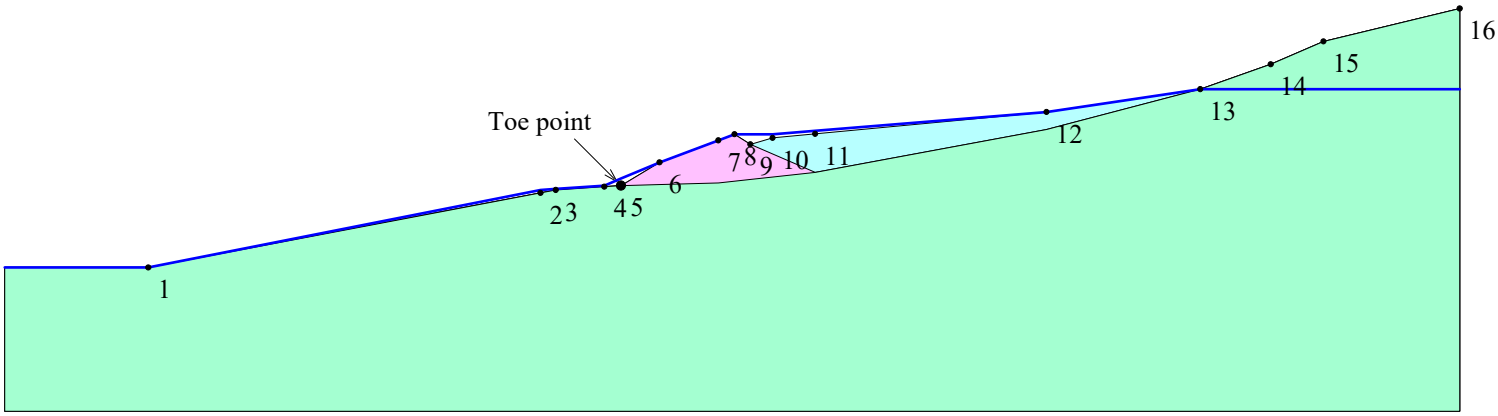
Phreatic line was specified.

UNIFORM SURCHARGE

Surcharge load, Q1.....None
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD

.....None.....



SCALE:

0 24 48 [ft]

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TABULATED DETAILS OF GEMERAL SPECIFIED GEOMETRY

Soil profile contains 3 layers. Coordinates in [ft.]
Water was described by phreatic line.

	#	Xi	Yi
Top of Layer 1	1	0.00	1653.20
	2	93.00	1670.90
	3	107.90	1671.90
	4	116.70	1677.20
	5	133.80	1683.60
	6	137.40	1681.30
	7	142.50	1682.80
	8	205.00	1688.70
	9	240.10	1693.90
	10	256.20	1699.60
	11	268.20	1704.80
	12	299.30	1712.30
Top of Layer 2	13	0.00	1653.20
	14	93.00	1670.90
	15	107.90	1671.90
	16	116.70	1677.20
	17	133.80	1683.60
	18	137.40	1681.30
	19	152.20	1674.90
	20	205.00	1684.70
	21	240.10	1693.90
	22	256.20	1699.60
	23	268.20	1704.80
	24	299.30	1712.30
Top of Layer 3	25	0.00	1653.20
	26	93.00	1670.90
	27	107.90	1671.90
	28	130.10	1672.50
	29	152.20	1674.90
	30	205.00	1684.70
	31	240.10	1693.90
	32	256.20	1699.60
	33	268.20	1704.80
	34	299.30	1712.30
Top of Phreatic Line	36	0.00	1653.20
	37	89.50	1670.90
	38	104.10	1671.90
	39	116.70	1677.20
	40	133.80	1683.60
	41	137.40	1683.60
	42	142.50	1683.60
	43	205.00	1688.70
	44	240.10	1693.90

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TABULATED DETAILS OF GEMERAL SPECIFIED GEOMETRY

Soil profile contains 3 layers. Coordinates in [ft.]
Water was described by phreatic line.

	#	Xi	Yi
Top of Layer 1	1	0.00	1653.20
	2	93.00	1670.90
	3	107.90	1671.90
	4	116.70	1677.20
	5	133.80	1683.60
	6	137.40	1681.30
	7	142.50	1682.80
	8	205.00	1688.70
	9	240.10	1693.90
	10	256.20	1699.60
	11	268.20	1704.80
	12	299.30	1712.30
Top of Layer 2	13	0.00	1653.20
	14	93.00	1670.90
	15	107.90	1671.90
	16	116.70	1677.20
	17	133.80	1683.60
	18	137.40	1681.30
	19	152.20	1674.90
	20	205.00	1684.70
	21	240.10	1693.90
	22	256.20	1699.60
	23	268.20	1704.80
	24	299.30	1712.30
Top of Layer 3	25	0.00	1653.20
	26	93.00	1670.90
	27	107.90	1671.90
	28	130.10	1672.50
	29	152.20	1674.90
	30	205.00	1684.70
	31	240.10	1693.90
	32	256.20	1699.60
	33	268.20	1704.80
	34	299.30	1712.30
Top of Phreatic Line	36	0.00	1653.20
	37	89.50	1670.90
	38	104.10	1671.90
	39	116.70	1677.20
	40	133.80	1683.60
	41	137.40	1683.60
	42	142.50	1683.60
	43	205.00	1688.70
	44	240.10	1693.90

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TABULATED DETAILS OF SPECIFIED GEOMETRY

Soil profile contains 3 layers. Coordinates in [ft.]
Water was described by phreatic line. Y values are tabulated in the right most column.

#	X	Y1	Y2	Y3	Yw (phreatic)
1	0.00	1653.20	1653.20	1653.20	1653.20
2	89.50	1670.23	1670.23	1670.23	1670.90
3	93.00	1670.90	1670.90	1670.90	1671.14
4	104.10	1671.64	1671.64	1671.64	1671.90
5	107.90	1671.90	1671.90	1671.90	1673.50
6	116.70	1677.20	1677.20	1672.14	1677.20
7	130.10	1682.22	1682.22	1672.50	1682.22
8	133.80	1683.60	1683.60	1672.90	1683.60
9	137.40	1681.30	1681.30	1673.29	1683.60
10	142.50	1682.80	1679.09	1673.85	1683.60
11	152.20	1683.72	1674.90	1674.90	1684.39
12	205.00	1688.70	1684.70	1684.70	1688.70
13	240.10	1693.90	1693.90	1693.90	1693.90
14	256.20	1699.60	1699.60	1699.60	1693.90
15	268.20	1704.80	1704.80	1704.80	1693.90
16	299.30	1712.30	1712.30	1712.30	1693.90

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	133.33	1683.42	112.42	1674.75	117.53	1692.00	17.98	0.65	. On extreme X-entry
2	271.49	1705.59	64.08	1666.54	157.08	1742.90	120.34	7.22	
3	409.65	1712.30	64.79	1665.66	219.48	1820.13	218.61	4.83	
4	547.80	1712.30	64.85	1665.61	287.78	1880.78	309.84	4.28	
5	685.96	1712.30	63.33	1666.97	353.10	1985.63	430.70	3.96	
6	824.12	1712.30	64.89	1665.56	425.26	2001.59	492.72	3.73	
7	962.27	1712.30	70.31	1668.11	494.20	2136.07	631.41	3.54	
8	1100.43	1712.30	71.42	1667.11	562.97	2212.44	734.17	3.36	
9	1238.59	1712.30	63.28	1666.56	617.45	2549.82	1042.71	3.28	
10	1376.74	1712.30	63.68	1666.62	695.79	2391.31	961.64	3.06	
11	1514.90	1712.30	64.80	1665.64	764.70	2470.58	1066.67	2.95	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	64.80	1665.64	1514.90	1712.30	764.70	2470.58	1066.67	2.95	
2	71.66	1666.91	1238.59	1712.30	637.54	2141.64	738.64	3.28	
3	78.07	1668.58	685.96	1712.30	362.47	1962.18	408.76	4.06	
4	84.79	1670.09	271.49	1705.59	168.39	1739.13	108.42	7.99	
5	91.71	1671.11	1514.90	1712.30	780.98	2463.15	1049.96	3.02	
6	98.92	1671.33	409.65	1712.30	239.68	1802.54	192.43	5.29	
7	104.69	1672.69	1514.90	1712.30	788.32	2456.95	1040.40	3.05	
. 8	112.42	1674.75	133.33	1683.42	117.53	1692.00	17.98	0.65	. OK
9	119.31	1678.28	133.33	1683.43	125.33	1683.56	8.00	0.89	
10	126.16	1680.79	133.33	1683.43	129.23	1683.49	4.10	1.75	
11	132.60	1683.66	1514.90	1712.30	808.51	2433.53	1009.53	3.12	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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Figure D-3

Mindego Ponds - Upper Spring

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PROJECT IDENTIFICATION

Title: Mindego Ponds - Upper Spring
Project Number: 18-180.1-SM -
Client: Mid-Pen
Designer: Philip Edwards

Description:
Upper Spring Static - Proposed Configuration

Company's information:

Name: Butano Geotechnical Engineering Inc
Street: 231 Green Valley Road Suite E
Freedom, CA 95019
Telephone #: 831.724.2612
Fax #:
E-Mail:

Original file path and name: C:\Users\B ..... ring\18-180.1-SM Upper Springs Proposed Static.MSE
Original date and time of creating this file: Thu Nov 22 09:52:46 2018

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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DRAWING OF SPECIFIED GEOMETRY - GENERAL - Quick Input

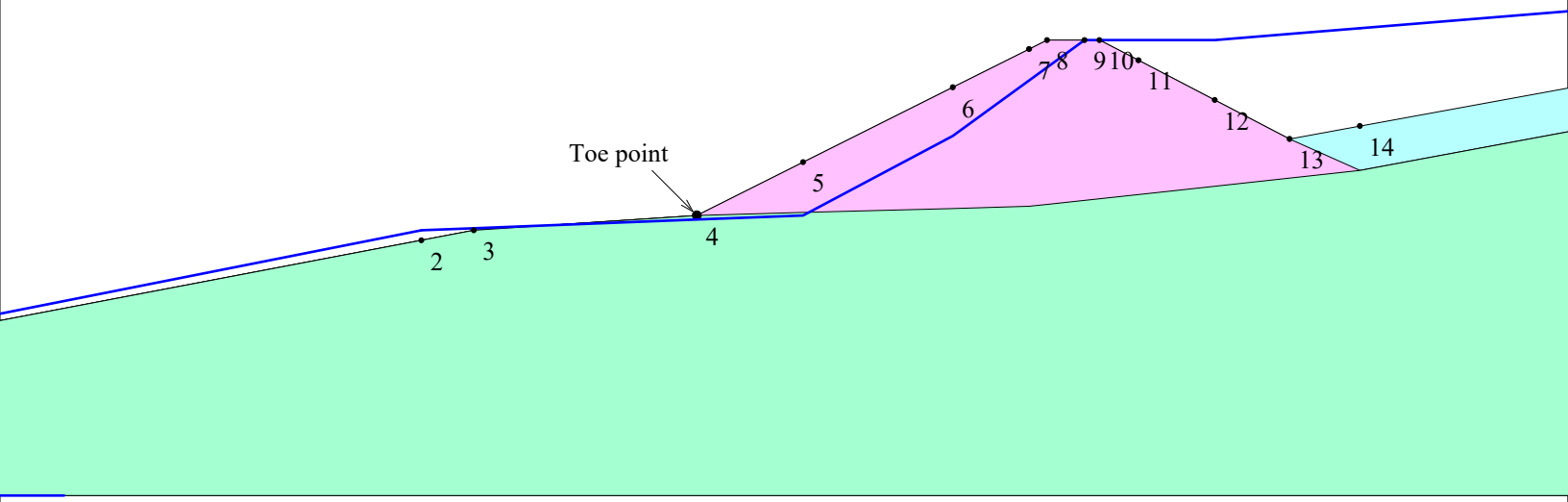
-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY
Soil profile contains 3 layers (see details in next page)

WATER GEOMETRY
Phreatic line was specified.

UNIFORM SURCHARGE
Surcharge load, Q1.....None
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD
.....None.....



SCALE:

0 2 4 6 8 10 [ft]

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TABULATED DETAILS OF GEMERAL SPECIFIED GEOMETRY

Soil profile contains 3 layers. Coordinates in [ft.]
Water was described by phreatic line.

	#	Xi	Yi
Top of Layer 1	1	0.00	1653.20
	2	93.00	1670.90
	3	107.90	1671.90
	4	131.30	1683.60
	5	134.80	1683.60
	6	147.50	1677.00
	7	240.10	1693.90
	8	256.20	1699.60
	9	268.20	1704.80
	10	299.30	1712.30
Top of Layer 2	11	0.00	1653.20
	12	93.00	1670.90
	13	107.90	1671.90
	14	131.30	1683.60
	15	134.80	1683.60
	16	147.50	1677.00
	17	152.20	1674.90
	18	205.00	1684.70
	19	240.10	1693.90
	20	256.20	1699.60
	21	268.20	1704.80
	22	299.30	1712.30
Top of Layer 3	23	0.00	1653.20
	24	93.00	1670.90
	25	107.90	1671.90
	26	130.10	1672.50
	27	152.20	1674.90
	28	205.00	1684.70
	29	240.10	1693.90
	30	256.20	1699.60
	31	268.20	1704.80
	32	299.30	1712.30
Top of Phreatic Line	34	0.00	1653.20
	35	89.50	1670.90
	36	115.00	1671.90
	37	125.00	1677.20
	38	133.80	1683.60
	39	137.40	1683.60
	40	142.50	1683.60
	41	205.00	1688.70
	42	240.10	1693.90

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
. 1	133.33	1683.60	112.56	1674.24	119.58	1686.38	14.03	8.04	. On extreme X-entry
2	143.09	1679.29	112.27	1674.19	-223.23	3794.39	2146.58	12.49	
3	409.65	1712.30	64.70	1665.76	220.12	1815.44	215.78	13.97	
4	547.80	1712.30	64.85	1665.61	287.78	1880.78	309.84	16.58	
5	685.96	1712.30	63.33	1666.97	353.10	1985.63	430.70	20.45	
6	824.12	1712.30	64.89	1665.56	425.26	2001.59	492.72	25.09	
7	962.27	1712.30	70.38	1668.00	493.39	2151.94	642.75	31.03	
8	1100.43	1712.30	71.59	1666.95	561.29	2250.31	761.66	36.66	
9	1238.59	1712.30	63.28	1666.56	617.45	2549.82	1042.71	41.55	
10	1376.74	1712.30	63.98	1666.27	693.01	2469.49	1020.21	47.08	
11	1514.90	1712.30	64.80	1665.64	764.70	2470.58	1066.67	53.80	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	64.70	1665.76	409.65	1712.30	220.12	1815.44	215.78	13.97	
2	71.56	1667.01	409.65	1712.30	223.96	1813.87	211.65	14.26	
3	78.51	1668.16	409.65	1712.30	228.96	1803.60	202.44	14.58	
4	84.79	1670.09	271.49	1705.59	168.39	1739.13	108.42	22.28	
5	91.71	1671.20	409.65	1712.30	236.05	1804.93	196.77	15.23	
6	97.32	1672.54	409.65	1712.30	233.45	1849.79	223.49	15.96	
7	104.69	1672.87	409.65	1712.30	242.76	1804.05	190.45	15.89	
. 8	112.56	1674.24	133.33	1683.60	119.58	1686.38	14.03	8.04	. OK
9	119.30	1677.70	133.33	1683.60	124.71	1684.47	8.66	11.92	
10	126.17	1681.06	133.33	1683.60	128.92	1684.67	4.54	25.85	
11	132.60	1684.08	409.65	1712.30	261.62	1791.52	167.90	17.58	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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Figure D-4

Mindego Ponds - Upper Spring

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PROJECT IDENTIFICATION

Title: Mindego Ponds - Upper Spring
Project Number: 18-180.1-SM -
Client: Mid-Pen
Designer: Philip Edwards

Description:
Upper Spring Seismic - Proposed Configuration

Company's information:

Name: Butano Geotechnical Engineering Inc
Street: 231 Green Valley Road Suite E
Freedom, CA 95019
Telephone #: 831.724.2612
Fax #:
E-Mail:

Original file path and name: C:\Users\B ..... ring\18-180.1-SM Upper Springs Proposed Static.MSE
Original date and time of creating this file: Thu Nov 22 09:52:46 2018

PROGRAM MODE: Analysis of a General Slope using NO reinforcement material.

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DRAWING OF SPECIFIED GEOMETRY - GENERAL - Quick Input

-- Problem geometry is defined along sections selected by user at x,y coordinates.
-- X1,Y1 represents the coordinates of soil surface. X2,Y2 represent the coordinates of the end of soil layer 1 and start of soil layer 2, and so on.
-- Xw,Yw represents the coordinates of phreatic surface.

GEOMETRY

Soil profile contains 3 layers (see details in next page)

WATER GEOMETRY

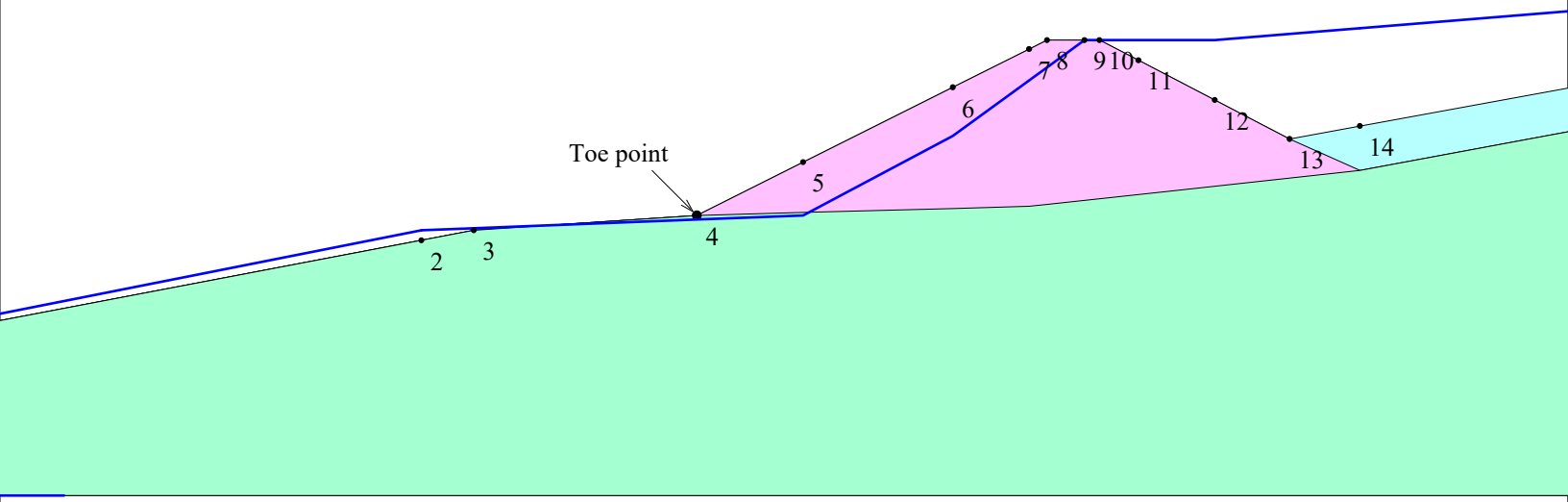
Phreatic line was specified.

UNIFORM SURCHARGE

Surcharge load, Q1.....None
Surcharge load, Q2.....None
Surcharge load, Q3.....None

STRIP LOAD

.....None.....



SCALE:

0 2 4 6 8 10 [ft]

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TABULATED DETAILS OF GEMERAL SPECIFIED GEOMETRY

Soil profile contains 3 layers. Coordinates in [ft.]
Water was described by phreatic line.

	#	Xi	Yi
Top of Layer 1	1	0.00	1653.20
	2	93.00	1670.90
	3	107.90	1671.90
	4	131.30	1683.60
	5	134.80	1683.60
	6	147.50	1677.00
	7	240.10	1693.90
	8	256.20	1699.60
	9	268.20	1704.80
	10	299.30	1712.30
Top of Layer 2	11	0.00	1653.20
	12	93.00	1670.90
	13	107.90	1671.90
	14	131.30	1683.60
	15	134.80	1683.60
	16	147.50	1677.00
	17	152.20	1674.90
	18	205.00	1684.70
	19	240.10	1693.90
	20	256.20	1699.60
	21	268.20	1704.80
	22	299.30	1712.30
Top of Layer 3	23	0.00	1653.20
	24	93.00	1670.90
	25	107.90	1671.90
	26	130.10	1672.50
	27	152.20	1674.90
	28	205.00	1684.70
	29	240.10	1693.90
	30	256.20	1699.60
	31	268.20	1704.80
	32	299.30	1712.30
Top of Phreatic Line	34	0.00	1653.20
	35	89.50	1670.90
	36	115.00	1671.90
	37	125.00	1677.20
	38	133.80	1683.60
	39	137.40	1683.60
	40	142.50	1683.60
	41	205.00	1688.70
	42	240.10	1693.90

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	133.33	1683.60	112.56	1674.24	119.58	1686.38	14.03	5.06	
2	143.09	1679.29	112.27	1674.19	-223.23	3794.39	2146.58	5.54	
3	409.65	1712.30	64.70	1665.76	220.12	1815.44	215.78	4.83	
4	547.80	1712.30	64.85	1665.61	287.78	1880.78	309.84	4.28	
5	685.96	1712.30	63.33	1666.97	353.10	1985.63	430.70	3.95	
6	824.12	1712.30	64.89	1665.56	425.26	2001.59	492.72	3.72	
7	962.27	1712.30	70.24	1668.22	494.98	2120.75	620.64	3.53	
8	1100.43	1712.30	71.42	1667.11	562.97	2212.44	734.17	3.36	
9	1238.59	1712.30	91.71	1671.12	643.90	2283.53	824.59	3.27	
10	1376.74	1712.30	63.68	1666.62	695.79	2391.31	961.64	3.06	
11	1514.90	1712.30	64.80	1665.64	764.70	2470.58	1066.67	2.95	On extreme X-entry

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	64.80	1665.64	1514.90	1712.30	764.70	2470.58	1066.67	2.95	On extreme X-exit
2	71.66	1666.91	1238.59	1712.30	637.54	2141.64	738.64	3.28	
3	78.07	1668.58	685.96	1712.30	362.47	1962.18	408.76	4.05	
4	84.79	1670.09	271.49	1705.59	168.39	1739.13	108.42	8.10	
5	91.71	1671.11	1514.90	1712.30	780.98	2463.15	1049.96	3.02	
6	98.20	1672.05	547.80	1712.30	306.31	1878.66	293.25	4.61	
7	104.69	1672.69	1514.90	1712.30	788.32	2456.95	1040.40	3.04	
8	111.35	1675.06	1514.90	1712.30	787.11	2674.28	1206.27	3.12	
9	119.24	1677.80	409.65	1712.30	252.29	1797.31	178.85	5.61	
10	125.44	1681.95	271.49	1705.59	191.63	1735.96	85.43	10.42	
11	132.60	1683.97	1514.90	1712.30	809.19	2408.72	991.48	3.12	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
THE BEST PEOPLE ON EARTH

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

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GEOTECHNICAL INVESTIGATION
DESIGN PHASE

FOR
MINDEGO PONDS - KNUEDLER LAKE
RUSSIAN RIDGE OPEN SPACE PRESERVE

SANTA MATEO COUNTY, CALIFORNIA

PREPARED FOR
MIDPENINSULA REGIONAL OPEN SPACE DISTRICT
PROJECT NO. 18-180.1-SM

PREPARED BY
BUTANO GEOTECHNICAL ENGINEERING, INC.
DECEMBER 2018

BUTANO GEOTECHNICAL ENGINEERING, INC.
231 GREEN VALLEY ROAD, SUITE E, FREEDOM, CALIFORNIA 95019
PHONE: 831.724.2612
WWW.BUTANOGEOTECH.COM

December 11, 2018
Project No. 18-180.1-SM

Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, California 94022

ATTENTION: Zachary Alexander

SUBJECT: **GEOTECHNICAL INVESTIGATION - DESIGN PHASE**
Pond Enhancement and Restoration
Mindego Ponds - Knuedler Lake
Russian Ridge Open Space Preserve
San Mateo County, California

Dear Mr. Alexander:

In accordance with your authorization, we have completed a geotechnical investigation for the subject project. This report summarizes the findings, conclusions, and recommendations from our field exploration, laboratory testing, and engineering analysis. It is a pleasure being associated with you on this project. If you have any questions, or if we may be of further assistance, please do not hesitate to contact our office.

Sincerely,

BUTANO GEOTECHNICAL ENGINEERING, INC.

Greg Bloom, PE, GE
Principal Engineer
R.C.E. 58819

Philip Edwards, PE
Senior Engineer
R.C.E. 86451

Appendices
Appendix A Figures and Standard Details
Appendix B Field Exploration Program
Appendix C Laboratory Testing Program
Appendix D Dam Stability Analysis

Distribution: (4) Addressee

1.0 INTRODUCTION

This report presents the results of our geotechnical investigation for the proposed enhancement of Knuedler Lake located in the Russian Ridge Open Space Preserve, San Mateo County, California. The existing pond is managed by Midpeninsula Regional Open Space District (MROSD).

The purpose of our investigation is to provide preliminary geotechnical design parameters and recommendations for the pond enhancement and restoration project. Conclusions and recommendations related to site grading and drainage are presented herein.

Our work included site reconnaissance, subsurface exploration, engineering analyses and preparation of this report. The scope of services for this investigation is outlined in our agreement revision dated September 11th, 2018 and attached as Exhibit A in the Hanford Arc/Butano joint agreement revision dated May 4th, 2018.

The recommendations contained in this report are subject to the limitations presented in Section 8.0 of this report. The Association of Engineering Firms Practicing the Geosciences has produced a pamphlet for your information titled “Important Information About Your Geotechnical Report”. This pamphlet has been included with the copies of your report.

2.0 PROJECT DESCRIPTION

Based on our discussions with the applicant (MROSD), the project civil/environmental engineer (CBEC Eco Engineering), and the project contractor (Hanford ARC), the project consists of pond enhancements. The pond is habitat for the California red legged frog and other sensitive and endangered biota.

Improvements will consist of protecting the existing spillway and dam face, and removing sediment buildup in the pond basin.

The following document was provided to us for use in our design:

> CBEC Eco Engineering, *Mindego Ranch Ponds Enhancement Project, San Mateo County, California, Midpeninsula Regional Open Space District*, Job Number 18-1019, Dated Oct 2018

3.0 FIELD EXPLORATION AND LABORATORY TESTING PROGRAMS

Our field exploration program included drilling, logging, and interval sampling of 6 borings. Borings B1 through B3 were advanced on September 19, 2018 with a 4-inch diameter hand auger. Borings B4 through B6b were advanced on October 26, 2018 with a 6-inch diameter solid stem auger on a track mounted drill. The borings were advanced to depths ranging from 5 ½ to 36 ½ feet below existing grade. Details of the field exploration program, including the Boring Logs, are presented in Appendix B, Figures B-3 through B-8b.

Additional test pits were advanced on October 26, 2018 in the spillway, on the west dam embankment, and on the northern slope in the slide scarp.

Representative samples obtained during the field investigation were taken to the laboratory for testing to determine physical and engineering properties. Details of the laboratory testing program are presented in Appendix C. Test results are presented on the Boring Logs and in appendix C.

4.0 SITE AND PROJECT DESCRIPTION

4.1 Location

The project site is located south of Highway 35 (Skyline Blvd.) within the Russian Ridge Open Space Preserve in unincorporated San Mateo County, California. The site location is shown on the Site Location Map, Appendix A, Figure A-1.

4.2 Surface Conditions

The pond is located on a south to southeast facing slope and is formed by an artificial dam embankment within a natural drainage. The pond has an approximate surface area of 35,000 square feet and a watershed area of approximately 11.7 acres. The current water depth is assumed to be no more than 3 feet.

The slopes above the pond are moderately steep with natural gradients of approximately 45 percent. The slopes are relatively open and covered with grass and some brush. There is currently one natural drainage to the northwest of the pond that is highly vegetated with large trees and brush. A slide with an approximate area of 4,500 square feet has developed on the slope above the dam.

An earthen dam forming the pond is located along its south side of the pond. The dam crest is approximately 370 feet long. The eastern extents of the dam crest are not distinguishable from the natural topography. The current height of the dam, as measured from the in-situ bedrock to the highest point of the crest, is 14 feet.

The dam was originally designed with a spillway that was cut through the dam face on the southeast corner of the pond. The spillway is currently 5 feet lower than the dam crest.

The slopes below the dam are moderately steep with natural gradients of approximately 40 percent. The slope is heavily vegetated with large trees and shrubs.

The embankment fill slope is vegetated with grass and small shrubs.

4.3 Subsurface Conditions

The site is geologically mapped as Purisima Formation bedrock (Tp). The Purisima Formation is described as:

> *Shallow marine and non-marine clastic, lithified; age, Pliocene to late Miocene. Siltstone, light gray, massive, locally diatomaceous, with some interbedded light gray soft fine grained sandstone. (2007)*

The conditions encountered are in conformance with the geologic mapping of the area.

Three borings were advanced in the pond, borings B1 through B3. The pond has approximately ½ to 1 ½ feet of sediment deposits consisting of very soft and highly organic silt. The sediment deposits are overlying very soft to firm fat clay to the maximum depth explored of 9 ½ feet.

Two borings were advanced through the pond embankment and into the underlying native material, borings B4 and B5.

The embankment fill consists of brown fat clay mixed with yellow brown siltstone gravel. The clay is stiff to very stiff. The dry densities, unconfined compressions, and moisture contents are relatively consistent across the five samples taken within the fill. A highly saturated layer has developed along the rock/fill interface. The depth of the fill is a maximum of about 14 feet thick at the crest of the dam (see cross sections, Appendix B).

The dam fill is founded on medium dense to very dense tan Purisima Formation siltstone.

One boring was advanced on the north side of the pond, boring B6which encountered 31 feet of stiff fat clay. The clay in this area is colluvium (Qc).

Bedrock is exposed at the surface in the dam spillway.

Highly weathered siltstone bedrock was encountered at or near the surface on the west slope adjacent to the dam fill and on the scarp of the upslope slide.

Groundwater was encountered at 1 foot, 1 ½ feet, 3 feet in borings B1 through B3 inside the pond. Groundwater was not encountered in borings B4 and B5. Groundwater was encountered at a depth of 27 feet in boring B6. The depth to groundwater may vary seasonally and with the pond depth.

Complete soil profiles are presented on the Boring Logs, Appendix B, Figures B-3 through B-8b. The boring locations are shown on the Boring Site Plan, Plate B-1.

5.0 GEOTECHNICAL HAZARDS

5.1 General

In our opinion the geotechnical hazards that could potentially affect the proposed project are:

- Intense seismic shaking
- Collateral seismic hazards
- Erosion
- Dam Embankment Stability
- Deep Seated Landsliding

5.1.1 Intense Seismic Shaking

The hazard of intense seismic shaking is present throughout central California. Intense seismic shaking may occur at the site during the design lifetime of the proposed structure from an earthquake along one of the regions many faults. Generally, the intensity of shaking will increase the closer the site is to the epicenter of an earthquake, however, seismic shaking is a complex phenomenon and may be modified by local topography and soil conditions. The transmission of earthquake vibrations from the ground into the structure may cause structural damage.

The County of San Mateo has adopted the seismic provisions set forth in the 2016 California Building Code to address seismic shaking. The seismic provisions in the 2016 CBC are minimum load requirements for the seismic design for the proposed structure. The provisions set forth in the 2016 CBC will not prevent structural and nonstructural damage from direct fault ground surface rupture, coseismic ground cracking, liquefaction and lateral spreading, seismically induced differential compaction, seismically induced landsliding, or seismically induced inundation.

Table 1 has been constructed based on the 2016 CBC requirements for the seismic design of the proposed structure. The Site Class has been determined based on our field investigation and laboratory testing.

Table 1. Seismic Design Parameters

S_S	S_1	Site Class	F_a	F_v	S_{DS}	S_{D1}	F_{PGA}	PGA_M	Risk Category	Seismic Design Category
1.753	0.811	C	1.0	1.3	1.168	0.703	1.000	0.695	II	N/A

Latitude: 37.304824º Longitude: -122.241820º

5.1.2 Collateral Seismic Hazards

In addition to intense seismic shaking, other seismic hazards that may have an adverse affect to the site and/or the structure are: fault ground surface rupture, coseismic ground cracking, seismically induced liquefaction and lateral spreading, seismically induced differential compaction, seismically induced landsliding, and seismically induced inundation (tsunami and seiche). It is our opinion that the potential for collateral seismic hazards to affect the site and to damage the proposed structure is low.

5.1.3 Erosion

The drainage swale and slopes uphill of the pond are actively eroding. This process delivers sediment to the pond reducing its capacity over time.

5.1.4 Dam Embankment Stability

Quantitative slope stability analyses were performed on the existing dam profile (see cross-section Y-Y'). We utilized the modified Bishop's method of analysis. Details of the analyses and figures are shown in Appendix D. Our work was limited to analyzing the stability of the embankment and shallow soil. A deep seated analysis of the upslope and downslope hillside was beyond our scope of work.

A static factor of safety of 17.9 and seismic factor of safety of 5.9 was calculated for section Y-Y'. This indicates that the existing configuration is considered stable. The factor of safety for the dam is high due to the low gradient slopes of the dam face and the shallow bedrock foundation.

The slope stability was run with the water level for the pond based on the existing dam height.

The final design configuration will be based on the geotechnical data and a pond depth conducive to California red legged frog breeding. Our firm should review the final configuration.

5.1.5 Deep Seated Landsliding

An analysis of deep seated landsliding was beyond our scope of work. As such, the hazard of deep seated landsliding is indeterminate.

6.0 DISCUSSIONS AND CONCLUSIONS

Based on our field investigation and discussions with Midpeninsula Open Space District personnel it is proposed that the pond be deepened, and the spillway protected.

The results of the stability analysis are in Appendix D. The results indicate that the existing configuration is considered stable both statically and seismically. Our analysis indicates that the pond embankment was compacted during construction.

It is our understanding the dam will not be raised.

The low water level in the pond is related to sediment deposition.

The spillway as it currently exists is approximately 5 feet lower than the dam crest and is unprotected allowing for downward erosion that will continue to lower the pond water elevation over time. Typically, a dam spillway going over or through the dam would be utilized as a secondary spillway with the primary spillway being a pipe and riser system. Knuedler Lake does not have a primary and secondary spillway system. Knuedler Lake has a single spillway that flows directly on exposed rock. This configuration of the spillway is not currently causing headward erosion of the dam face. This single spillway system when protected from erosion may function but adding redundancy to the system should be considered by the applicant and has been included as an option in the recommendations.

The area surrounding the pond is currently used to graze cattle. This use denudes the slopes, increasing surface flow, and accelerates the upslope erosion and resulting sedimentation.

There is a small slide on the slope north of the dam. Small slides and erosional features are common in this area and may contribute to sediment deposits in the dam. The slide does not pose a risk to the stability of the dam. For the location of the slide see the Boring Site Plan, Appendix B, Plate B-1.

Fat clay was encountered in the pond basin to the maximum depth drilled of 9 ½ feet. This layer of colluvium is functioning as a pond liner.

7.0 RECOMMENDATIONS

7.1 General

Based on the results of our field investigation, laboratory testing, and engineering analysis it is our opinion that from the geotechnical standpoint, the subject site will be suitable for the pond enhancements and repair.

The recently deposited sediment may be removed and a pond liner consisting of the fat clay should be maintained.

The spillway may be raised to within 2 feet of the lowest adjacent dam crest, see section 7.2.3.

The entire watershed upslope of the pond should be fenced off to eliminate cattle grazing. Although this will not stop the upslope erosion, it will slow the process.

7.2 Site Grading

7.2.1 Site Clearing

The site should be cleared of loose soil, organics, and debris within the project limits.

7.2.2 Preparation of On-Site Soils

All fill should be moisture conditioned 3 to 5 percent over optimum and compacted with heavy vibratory equipment to a minimum of 87 percent relative compaction. **Fill placed on the dam face or crest should be compacted to a minimum of 93 percent relative compaction.** Fill should be compacted by mechanical means in uniform horizontal loose lifts not exceeding 8 inches in thickness. The relative compaction and required moisture content shall be based on the maximum dry density and optimum moisture content obtained in accordance with laboratory test procedure ASTM D1557.

The existing embankment fill may be re-used as engineered fill once it is processed. Processing should include moisture conditioning and removing any deleterious material. All soils, both existing on-site and imported, to be used as fill on the **dam embankment**, should contain a minimum of 80 percent fines, with the fines fraction having a minimum liquid limit of 50 and plasticity index of 20. All material should be verified by a representative of Butano Geotechnical Engineering, Inc. in the field during grading operations.

The recent sediment deposits may not be re-used as engineered fill and should be spread on-site.

Any surface or subsurface obstruction, or questionable material encountered during grading, should be brought immediately to the attention of the Geotechnical Engineer for proper processing as required.

7.2.3 Raising the Dam Spillway

If desired the dam spillway may be raised to deepen the pond using concrete or other suitable erosion resistant material. The concrete should be keyed into the bedrock a minimum of 2 feet and such that there is a minimum of 8 feet of horizontal cover to daylight measured laterally from the bottom of the excavation.

7.2.4 Cut and Fill Slopes

Temporary cuts within the embankment fill should be made not steeper than 1:1 (H:V) to a maximum height of 14 feet.

Permanent cut and fill slopes should be graded no steeper than 2:1 (H:V).

7.2.5 Excavating Conditions

The on-site soil may be excavated with conventional earthwork equipment. The purisima formation sandstone may require rock teeth to excavate.

7.2.6 Surface Drainage

It is recommended that no water be allowed to sheet flow onto the dam face. A properly designed spillway system should minimize the potential for erosion.

The protection on the existing spillwayshould end a minimum of 10 feet downslope of the toe of the dam and be founded on bedrock. The spillway should be lined with stabilization fabric that is placed directly on the bedrock and extends a minimum of 2 feet laterally under the dam embankment fill. The spillway may release back into the natural drainage.

As an option a primary spillway using a pipe and riser system may be incorporated into the design. The existing spillway may be backfilled with soil and utilized as a secondary system. The dam fill should be keyed and benched into the existing dam.

7.2.7 Erosion Control

Erosion control should be placed on any disturbed slopes. This should be designed by the project civil/environmental engineer with the assistance of the geotechnical engineer.

7.5 Plan Review

The recommendations presented in this report are based on preliminary design information for the proposed project and on the findings of our geotechnical investigation. When completed, the Grading Plans, Foundation Plans and design loads should be reviewed by the geotechnical engineer of record, Inc. prior to submitting the plans and contract bidding. Additional field exploration and laboratory testing may be required upon review of the final project design plans.

7.6 Observation and Testing

Field observation and testing must be provided by a representative of Butano Geotechnical Engineering, Inc. to enable them to form an opinion regarding the adequacy of the site preparation, the adequacy of fill materials, and the extent to which the earthwork is performed in accordance with the geotechnical conditions present, the requirements of the regulating agencies, the project specifications, and the recommendations presented in this report. Any earthwork performed in connection with the subject project without the full knowledge of, and not under the direct observation of the geotechnical engineer of record, will render the recommendations of this report invalid.

Butano Geotechnical Engineering, Inc. should be notified at least 5 working days prior to any site clearing or other earthwork operations on the subject project in order to observe the stripping and disposal of unsuitable materials and to ensure coordination with the grading contractor. During this period, a preconstruction meeting should be held on the site to discuss project specifications, observation and testing requirements and responsibilities, and scheduling.

8.0 LIMITATIONS

The recommendations contained in this report are based on our field explorations, laboratory testing, and our understanding of the proposed construction. The subsurface data used in the preparation of this report was obtained from the borings drilled during our field investigation. Variation in soil, geologic, and groundwater conditions can vary significantly between sample locations. As in most projects, conditions revealed during construction excavation may be at variance with preliminary findings. If this occurs, the changed conditions must be evaluated by the Project Geotechnical Engineer and the Geologist, and revised recommendations be provided as required. In addition, if the scope of the proposed construction changes from the described in this report, our firm should also be notified.

Our investigation was performed in accordance with the usual and current standards of the profession, as they relate to this and similar localities. No other warranty, expressed or implied, is provided as to the conclusions and professional advice presented in this report.

This report is issued with the understanding that it is the responsibility of the Owner, or of his Representative, to ensure that the information and recommendations contained herein are brought to the attention of the Architect and Engineer for the project and incorporated into the plans, and that it is ensured that the Contractor and Subcontractors implement such recommendations in the field. The use of information contained in this report for bidding purposes should be done at the Contractor’s option and risk.

This firm does not practice or consult in the field of safety engineering. We do not direct the Contractor's operations, and we are not responsible for other than our own personnel on the site; therefore, the safety of others is the responsibility of the Contractor. The Contractor should notify the Owner if he considers any of the recommended actions presented herein to be unsafe.

The findings of this report are considered valid as of the present date. However, changes in the conditions of a site can occur with the passage of time, whether they be due to natural events or to human activities on this or adjacent sites. In addition, changes in applicable or appropriate codes and standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, this report may become invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and revision as changed conditions are identified.

The scope of our services mutually agreed upon did not include any environmental assessment or study for the presence of hazardous to toxic materials in the soil, surface water, or air, on or below or around the site. Butano Geotechnical Engineering, Inc. is not a mold prevention consultant; none of our services performed in connection with the

proposed project are for the purpose of mold prevention. Proper implementation of the recommendations conveyed in our reports will not itself be sufficient to prevent mold from growing in or on the structures involved.

REFERENCES

ASTM International (2015). Annual Book of ASTM Standards, Section Four, Construction. Volume 4.08, Soil and Rock (I): D 430 - D 5611.

ASTM International (2015). Annual Book of ASTM Standards, Section Four, Construction. Volume 4.09, Soil and Rock (II): D 5714 - Latest.

Geologic Map of the Mindego Hill Quadrangle, San Mateo , Santa Clara, and Santa Cruz Counties, California – 2007, Dibblee, T.W., and Minch J.A.: Dibblee Geologic Foundation, Dibblee Foundation Map DF – 349, scale: 1:24,000

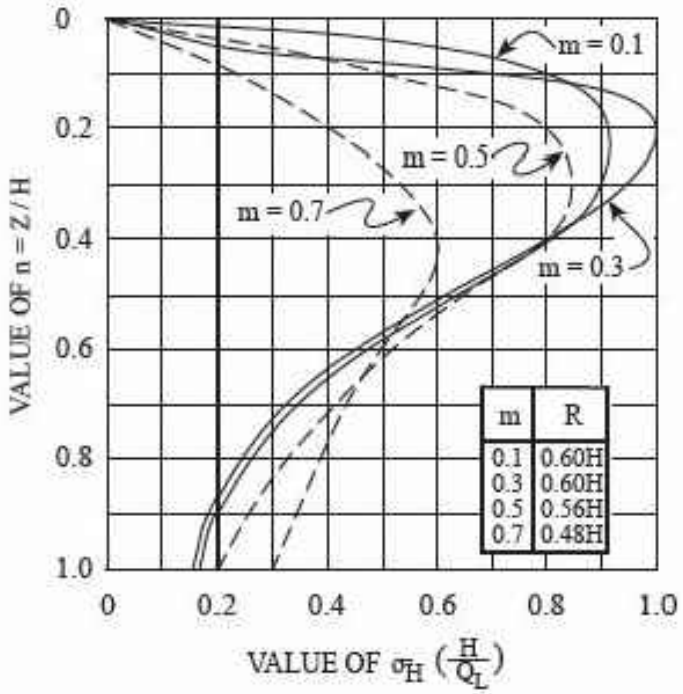
California Building Code (2016).

APPENDIX A

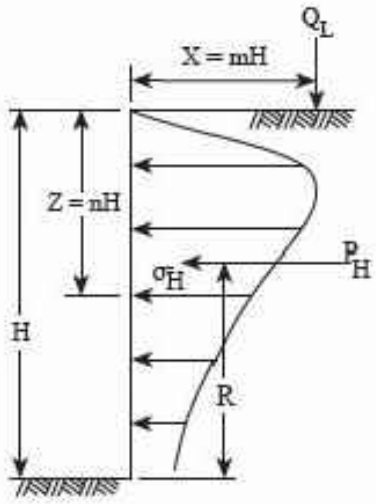
FIGURES AND STANDARD DETAILS

Surcharge Pressure Diagram Figure A-1

LINE LOAD



m	R
0.1	0.60H
0.3	0.60H
0.5	0.56H
0.7	0.48H



FOR m ≦ 0.4:

$$\sigma_H \left(\frac{H}{Q_L}\right) = \frac{0.20\,n}{(0.16+n^2)^2}$$

$$P_H = 0.55\,Q_L$$

FOR m > 0.4:

$$\sigma_H \left(\frac{H}{Q_L}\right) = \frac{1.28\,m^2 n}{(m^2+n^2)^2}$$

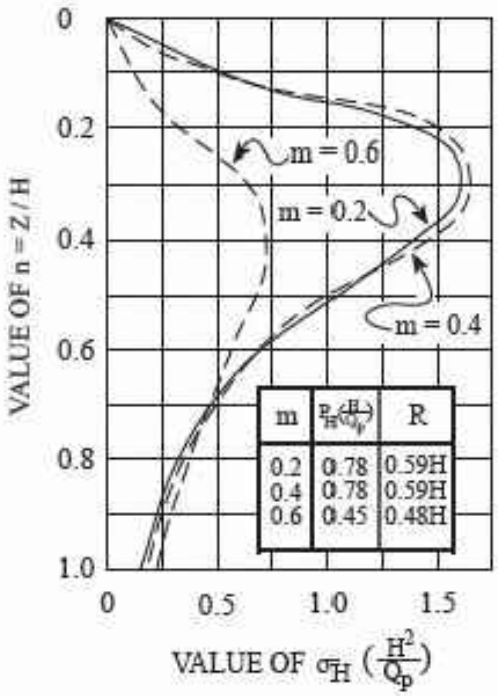
RESULTANT $P_H = \frac{0.64\,Q_L}{(m^2+1)}$

PRESSURES FROM LINE LOAD Q_L

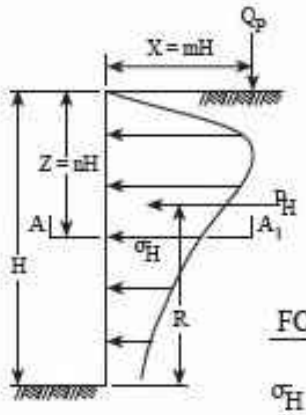
(BOISSINESQ EQUATION MODIFIED BY EXPERMENT)

REFERENCE: Design Manual
NAVFAC DM-7.02
Figure 11
Page 7.2-74

POINT LOAD



m	$\frac{P_H}{Q_p}\left(\frac{H}{Q_p}\right)$	R
0.2	0.78	0.59H
0.4	0.78	0.59H
0.6	0.45	0.48H



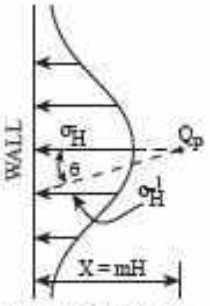
FOR m ≦ 0.4:

$$\sigma_H \left(\frac{H^2}{Q_p}\right) = \frac{0.28\,n^2}{(0.16+n^2)^3}$$

FOR m > 0.4:

$$\sigma_H \left(\frac{H^2}{Q_p}\right) = \frac{1.77\,m^2 n^2}{(m^2+n^2)^3}$$

$$\sigma_H^1 = \sigma_H \cos^2(1.1\,\theta)$$



SECTION A-A_1

PRESSURES FROM POINT LOAD Q_P

(BOISSINESQ EQUATION MODIFIED BY EXPERMENT)

BUTANO GEOTECHNICAL ENGINEERING, INC.	**S□□C□A□□E P□ESS□□E □IA□□AM**	FIGURE A-1

APPENDIX B

FIELD EXPLORATION PROGRAM

Field Exploration Procedures	Page B-1
Site Location Plan	Figure B-1
Key to the Logs	Figure B-2
Logs of the Borings	Figures B-3 through B-8b
Boring Site Plan	Plate B-1
Cross Sections	Plate B-2

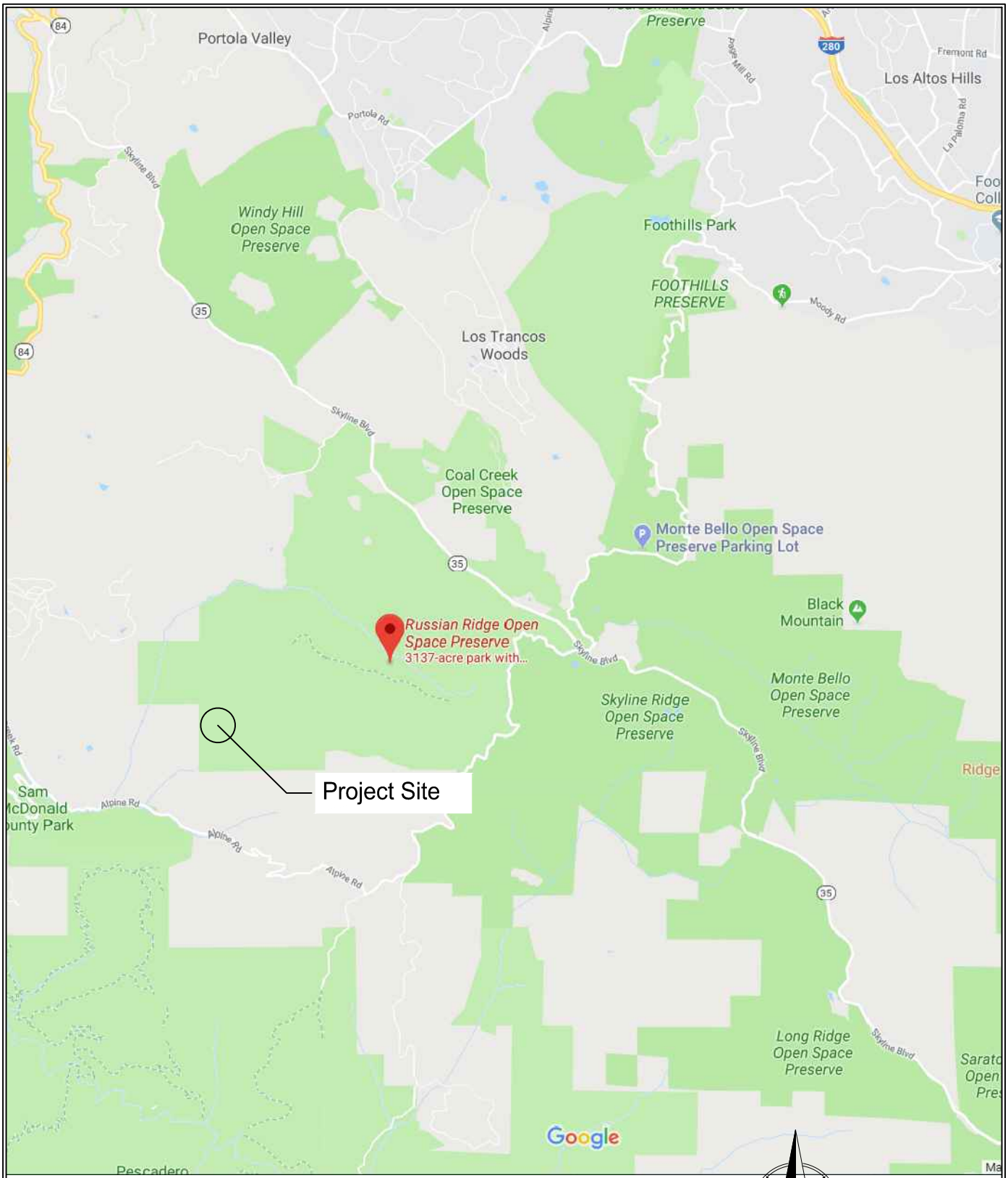
FIELD EXPLORATION PROCEDURES

Subsurface conditions were explored by advancing 6 borings below existing grade. Borings B1 through B3 were advanced on September 19, 2018 using a 4-inch diameter hand auger. Borings B4 through B6 were advanced on October 26, 2018 with a 6-inch diameter solid stem auger on a track mounted drill. The Key to The Logs and the Logs of the Borings are included in Appendix B, Figures B-2 through B-8b. The approximate locations of the borings are shown on the Boring Site Plan, Plate B-1. Borings B1 through B3 were located in the field by CBEC Eco Engineering using a robotic total station. Borings B4 through B6 were located in the field by tape measurements from known landmarks. The locations as shown are within the accuracy of such measurement.

Additional hand exploration was completed on October 26, 2018. The hand exploration was done in the spillway, on the west dam embankment and in the slide on the north slope.

The soils encountered in the borings were continuously logged in the field by a representative of Butano Geotechnical Engineering, Inc. Bulk and relatively undisturbed soil samples for identification and laboratory testing were obtained in the field. These soils were classified based on field observations and laboratory tests. The classification is in accordance with the Unified Soil Classification System (Figure B-3).

Two geologic cross sections have been provided depicting the surface and subsurface soil profiles at the site (Plate B-2). The surface profiles were constructed using the topographic survey provided by CBEC Eco Engineering. Subsurface data was interpolated from surface gradients and subsurface soil conditions encountered in the borings, the accuracy of the cross sections is limited by the site investigation and data collection methods.



N.T.S.

BUTANO GEOTECHNICAL ENGINEERING, INC.	**SITE LOCATION PLAN** Mindego Ponds - Knuedler Lake	FIGURE B-1

KEY TO LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS More than half of the material is larger than the No. 200 sieve	GRAVELS More than half of the coarse fraction is larger than the No. 4 sieve	CLEAN GRAVELS (Less than 5% fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More than half of the coarse fraction is smaller than the No. 4 sieve	CLEAN SANDS (Less than 5% fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SAND WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More than half of the material is smaller than the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50		ML	Inorganic silts and very fine sands, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomacaceous fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

GRAIN SIZE LIMITS

SILT AND CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		
No. 200	No. 40	No. 10	No. 4	3/4 in.	3 in.	12 in.	

US STANDARD SIEVE SIZE

RELATIVE DENSITY	
SAND AND GRAVEL	BLOWS/FT*
VERY LOOSE	0 - 4
LOOSE	4 - 10
MEDIUM DENSE	10 - 30
DENSE	30 - 50
VERY DENSE	OVER 50

CONSISTENCY	
SILT AND CLAY	BLOWS/FT*
VERY SOFT	0 - 2
SOFT	2 - 4
FIRM	4 - 8
STIFF	8 - 16
VERY STIFF	16 - 32
HARD	OVER 32

MOISTURE CONDITION	
CLAY	DRY
	MOIST
	very moist
SAND	DRY
	DAMP
	WET
	very moist

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1 3/8 inch I.D.) split spoon (ASTM D-1586).

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B1
Project:	Mindego Ponds - Knuedler Lake	Location:	Central Pond
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Other Tests: Swell (psf)	Other Tests
0	ML		X	Black SILT, very soft, saturated, highly organic, sediment. ▽				164.8					
	CH		X	Black Fat CLAY, soft, saturated, (Qc - Colluvium?).				146.5					
5			X					153.6					
10				Boring terminated at a depth of 9 1/2 feet. Groundwater encountered at 1 foot during drilling.									
15													
20													
25													
30													
35													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-3

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B2
Project:	Mindego Ponds - Knuedler Lake	Location:	Northern Pond Edge
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	ML		X	Grey SILT, very soft, saturated, highly organic				65.2				58.8	23.9
	CH		X	Grey Fat CLAY, soft, saturated, (Qc - Colluvium?).				52.5					
5			X					55.6				51.9	25.8
10				Boring terminated at a depth of 5 1/2 feet. Groundwater encountered at 1 1/2 feet during drilling.									
15													
20													
25													
30													
35													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-4

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B3
Project:	Mindego Ponds - Knuedler Lake	Location:	Southern Pond Edge Near Dam
		Elevation:	
Date:	September 19, 2018	Method of Drilling:	4-inch diameter hand auger
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	ML		X	Grey SILT, very soft, saturated, highly organic				54.2					
	CH		X	Grey Fat CLAY, very soft, saturated, (Qc - Colluvium?)				158.6					
5	CH		X	Grey Fat Clay, firm, saturated.				46.2				63.4	32.7
10				Boring terminated at a depth of 7 feet. Groundwater encountered at 3 feet during drilling.									
15													
20													
25													
30													
35													

BUTANO GEOTECHNICAL ENGINEERING, INC.

FIGURE B-5

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B4
Project:	Mindego Ponds - Knuedler Lake	Location:	Central Dam
		Elevation:	
Date:	October 26, 2018	Method of Drilling:	6-inch solid stem auger on a
Logged By:	PE		track mounted drill rig

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH (FILL)	☒		Dark brown Fat CLAY, stiff, slightly moist, (dam fill).	15	10	69.0	20.7				62.8	32.0
5		☒		Brown sandy Fat CLAY with siltstone gravels, stiff, moist.	15	10	81.0	30.0			3700		
10		☒		Stiff.	19	13	39.2	81.5			2100	65.4	37.8
	BR			Light brown SILTSTONE, medium dense, damp, (Tp-Purisima Formation Bedrock).									
15		☒		Medium dense.	46	24	88.9	34.5					
20		☒		Medium dense.	49	27	83.6	48.4					
25		▯		Very dense.	65	92		30.8					
				Boring terminated at a depth of 26 1/2 feet.									
30				No groundwater encountered during drilling.									
35													

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B5
Project:	Mindego Ponds - Knuedler Lake	Location:	East Dam
		Elevation:	
Date:	October 26, 2018	Method of Drilling:	6-inch solid stem auger on a track mounted drill rig
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH			Brown Sandy Fat CLAY with siltstone gravel, very stiff, damp, (dam fill).	31	18	93.1	21.4			15000	68.8	44.3
5	BR			Tan SILTSTONE, medium dense, damp, (Tp-Purisima Formation Bedrock).	21	21		35.7					
10				Medium dense.	18	19		46.2					
15				Very dense.	43	55		29.2					
20				Boring terminated at a depth of 16 1/2 feet. No groundwater encountered during drilling.									
25													
30													
35													

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B6 (1 of 2)
Project:	Mindego Ponds - Knuedler Lake	Location:	Lake Head
		Elevation:	
Date:	October 26, 2018	Method of Drilling:	6-inch solid stem auger on a track mounted drill rig
Logged By:	PE		

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Atterberg Limits L.L.	Atterberg Limits P.I.
	CH			Dark brown Fat CLAY, stiff, moist, colluvium.	31	18	98.2	21.9			3100	51.2	28.5
5				Grey, stiff.	21	21		25.9					
10				Stiff.	18	19		32.9					
15				Stiff.	43	55		32.5					
20													
25				Stiff.	13	11	75.1	48.3					
30													
	BR												
35													

LOG OF EXPLORATORY BORING

Project No.:	18-180.1-SM	Boring:	B6 (2 of 2)
Project:	Mindego Ponds - Knuedler Lake	Location:	Lake Head
		Elevation:	
Date:	October 26, 2018	Method of Drilling:	6-inch solid stem auger on a
Logged By:	PE		track mounted drill rig

2" Ring Sample | 2.5" Ring Sample | Bulk Sample | Terzaghi Split Spoon Sample | Static Water Table

Depth (ft.)	Soil Type	Undisturbed	Bulk	Description	Blows / Foot	N_{60}	Dry Density (pcf)	Moisture Content (%)	Expansion Index	Fines Content (%)	Unconfined - q_u (psf)	Other Tests: Swell (psf)	Other Tests
	BR												
35				Tan SILTSTONE, dense, damp, (Tp-Purisima Formation Bedrock).	26	38		40.0					
				Boring terminated at a depth of 36 1/2 feet.									
40				Groundwater encountered at 27 feet during drilling.									
45													
50													
55													
60													
65													

BUTANO	**BORING SITE PLAN**	PLATE
GEOTECHNICAL ENGINEERING, INC.	Mindego Ponds - Knuedler Lake	B-1

Scale 1" = 20'

B3 - Exploratory Boring

N

Y

0+00

Slide

1+00

2+00

B6

3+00

B2

4+00

B1

5+00

6+00

6+50

Y'

Proposed Area for
Sediment Removal

1013
1012
1011
1010
1009
1008

Knuedler Lake

1014
1013
1012

B3

3+00

B5

3+94

X'

Spillway (E)

B4

2+00

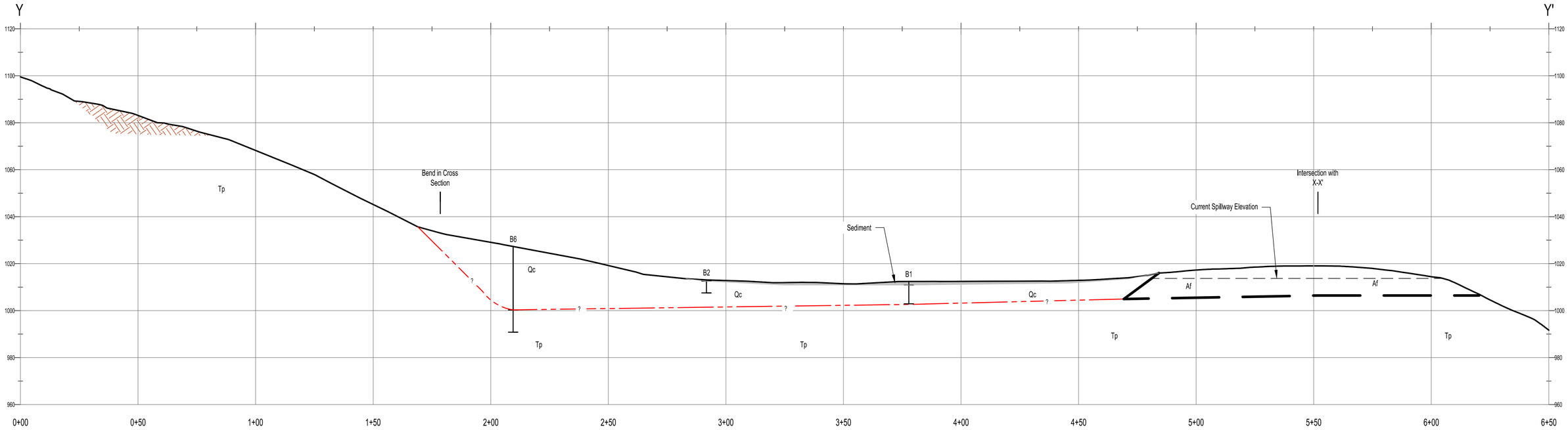
Dam (E)

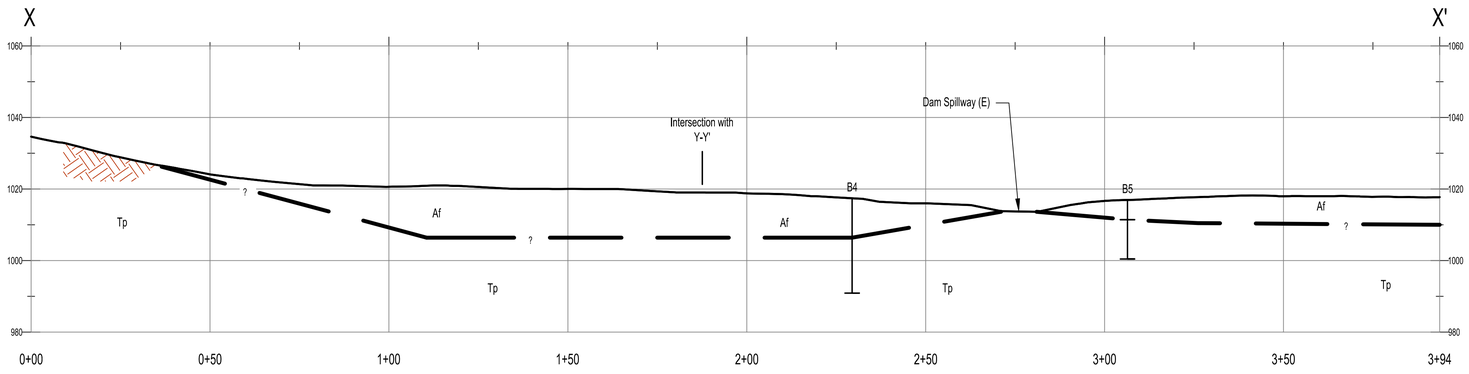
1+00

0+00

X

BUTANO GEOTECHNICAL ENGINEERING, INC.	**GEOLOGIC CROSS SECTIONS** Mindego Ponds - Knuedler Lake	PLATE B-2





Legend

Scale 1" = 20'

Af - Artificial Fill of Dam
Sediment - Recent Sediment Deposit
Qc - Elastic Silt, Fat Clay/Colluvium
Tp - Purisima Formation Sandstone

? - Queried Where Unknown

B3 - Exploratory Boring

APPENDIX C

LABORATORY TESTING PROGRAM

Laboratory Testing Procedures	Page C-1
Atterberg Limits Summary	Figure C-1

LABORATORY TESTING PROCEDURES

Classification

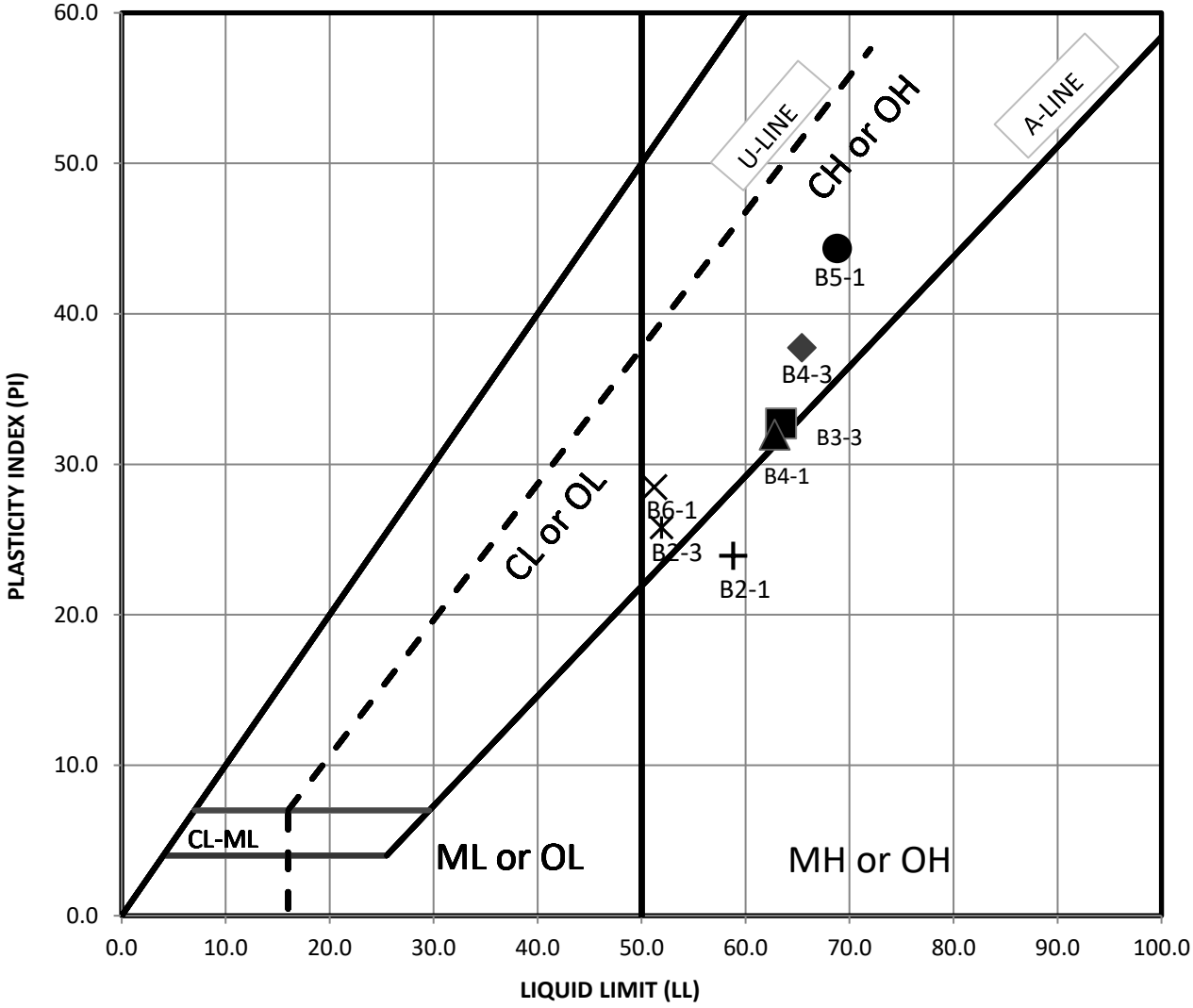
Soils were classified according to the Unified Soil Classification System in accordance with ASTM D 2487 and D 2488. Moisture content and density determinations were made for representative samples in accordance with ASTM D 2216. Results of moisture density determinations, together with classifications, are shown on the Boring Logs, Figures B-3 through B-8b.

Atterberg Limits

Seven Atterberg limits tests were performed in accordance with ASTM D-4318. The results are shown on the Boring Logs, Figures B-3 through B-8b, and summarized on Figure C-1

Unconfined Compression

Four unconfined compression tests were performed in accordance with ASTM D-2166. The results are shown on the boring logs as q_u, Figures B-3 through B-8b.



Sample	Depth	Description	LL	PL	PI
B2-1	1/2 ft	Elastic SILT	58.8	34.9	23.9
B2-3	4 ft	Fat CLAY	51.9	26.1	25.8
B3-3	5 ft	Fat CLAY	63.4	30.7	32.7
B4-1	1 ft	Fat CLAY	62.8	30.8	32.0
B4-3	10 ft	Fat CLAY	65.4	27.6	37.8
B5-1	2 ft	Fat CLAY	68.8	24.5	44.3
B6-1	2 ft	Fat CLAY	51.2	22.7	28.5

BUTANO GEOTECHNICAL ENGINEERING, INC.	**ATTERBERG LIMITS SUMMARY** Mindego Ponds - Knuedler Lake	FIGURE C-1

APPENDIX D

SLOPE STABILITY PROGRAM

Slope Stability Analysis and Procedures Page D-1

Slope Stability Analysis and Properties

Cross-Section Y-Y', static Pond Full Figure D-1

Cross-Section Y-Y', Seismic Pond Full Figure D-2

METHODOLOGY

Slope stability calculations were performed on the cross-sections and slopes discussed under the Slope Stability section of this report, and are considered representative of the ranges of conditions at the site.

The stability of the slope was analyzed using the computer program ReSSA 3.0 by ADAMA Engineering, Inc., 2016. This program utilizes a limiting equilibrium method for determining the Factor of Safety against sliding on an assumed failure surface. The cross-section analyzed and the result of the analysis is presented in the attached summary.

Material properties chosen for these analyses are based on field and laboratory tests and our experience.

The slope was analyzed under wet static and seismic conditions for a full pond.

It must be cautioned that slope stability analysis is an inexact science; and that the mathematical models of the slopes and soils contain many simplifying assumptions, not the least of which is homogeneity. Slope stability analyses and the generated factors of safety should be used as indicating trend lines. A slope with a safety factor less than one will not necessarily fail, but the probability of slope movement will be greater than a slope with a higher safety factor. Conversely, a slope with a safety factor greater than one may fail, but the probability of stability is higher than a slope with a lower safety factor.

Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

Version 3.0 ReSSA Version 3.0 ReSSA Version 3.0 ReSSA

RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	89.38	1018.98	28.97	1006.73	37.24	1120.99	114.56	17.99	
. 2	97.64	1019.00	28.76	1006.73	37.22	1158.81	152.31	17.93 .	OK
3	105.91	1018.91	29.07	1006.72	38.98	1192.48	186.03	18.03	
4	114.17	1018.49	29.20	1006.71	37.95	1255.90	249.34	19.22	
5	122.43	1018.07	28.70	1006.73	39.77	1308.09	301.56	20.13	
6	130.69	1017.66	29.11	1006.71	41.79	1365.92	359.43	21.29	
7	138.95	1017.24	28.19	1006.75	44.01	1429.56	423.11	22.67	
8	147.21	1016.82	28.60	1006.73	46.44	1499.15	492.74	24.16	
9	155.48	1016.41	28.44	1006.72	41.00	1680.11	673.51	26.86	
10	163.74	1015.99	28.07	1006.73	42.89	1788.20	781.61	28.72	
11	172.00	1015.04	28.39	1006.72	45.74	1951.48	944.91	30.79	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

****

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	22.31	1006.41	97.64	1019.00	26.23	1214.53	208.17	26.03	
. 2	28.76	1006.73	97.64	1019.00	37.22	1158.81	152.31	17.93 .	OK
3	35.76	1009.93	97.64	1019.00	57.59	1076.66	70.21	18.52	
4	42.11	1013.28	97.64	1019.00	66.15	1052.32	45.85	21.78	
5	48.94	1014.05	97.64	1019.00	70.76	1041.48	35.05	22.72	
6	55.77	1014.77	97.64	1019.00	75.05	1033.28	26.73	25.04	
7	62.34	1015.71	97.64	1019.00	78.88	1029.32	21.42	30.26	
8	68.97	1016.57	97.64	1019.00	82.48	1027.62	17.44	40.03	
9	75.61	1017.43	97.64	1019.00	86.08	1025.91	13.47	60.57	
10	82.30	1018.22	97.64	1019.00	89.69	1024.21	9.51	132.49	
11	89.05	1018.95	89.38	1018.99	89.20	1019.07	0.20	2883.45	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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RESULTS OF ROTATIONAL STABILITY ANALYSIS

Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each entry point (considering all specified exit points)

Entry Point #	Entry Point (X, Y) [ft]		Exit Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	89.38	1018.98	35.36	1010.08	54.64	1061.42	54.84	6.95	
2	97.64	1019.00	35.76	1009.93	57.59	1076.66	70.21	6.35	
3	105.91	1018.91	35.46	1010.01	60.44	1095.52	89.08	6.08	
4	114.17	1018.49	35.78	1009.91	63.38	1120.14	113.63	5.94	
5	122.43	1018.07	35.24	1010.03	66.10	1152.01	145.30	5.96	
. 6	130.69	1017.66	35.48	1009.97	69.45	1182.56	175.91	5.90 .	OK
7	138.95	1017.24	35.73	1009.92	72.76	1219.00	212.34	5.91	
8	147.21	1016.82	34.86	1010.05	75.99	1263.08	256.35	5.96	
9	155.48	1016.41	35.03	1010.01	79.10	1317.34	310.47	6.07	
10	163.74	1015.99	35.19	1009.99	83.72	1350.19	343.65	5.95	
11	172.00	1015.04	35.35	1009.95	87.98	1434.15	427.45	6.01	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-entry' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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Results in the tables below represent critical circles identified between specified points on entry and exit. (Theta-exit set to 50.00 deg.) The most critical circle is obtained from a search considering all the combinations of input entry and exit points.

Critical circles for each exit point (considering all specified entry points).

Exit Point #	Exit Point (X, Y) [ft]		Entry Point (X, Y) [ft]		Critical Circle (Xc, Yc, R) [ft]			Fs	STATUS
1	22.60	1006.40	172.00	1015.04	93.84	1070.55	95.86	7.74	
2	28.60	1006.73	147.21	1016.82	46.44	1499.15	492.74	5.97	
. 3	35.48	1009.97	130.69	1017.66	69.45	1182.56	175.91	5.90 .	OK
4	42.41	1013.05	147.21	1016.82	89.05	1175.22	168.74	6.22	
5	49.12	1013.89	122.43	1018.07	81.89	1084.02	77.40	6.36	
6	55.63	1014.80	138.95	1017.24	94.77	1102.17	95.74	6.47	
7	61.90	1015.77	172.00	1015.04	117.96	1168.01	162.23	6.57	
8	68.93	1016.48	172.00	1015.04	122.23	1141.53	135.93	6.81	
9	75.33	1017.46	172.00	1015.04	126.29	1120.84	115.26	7.19	
10	82.17	1018.23	172.00	1015.04	130.07	1100.66	95.33	7.53	
11	88.82	1019.10	172.00	1015.04	133.73	1085.19	79.91	8.01	

Note: In the 'Status' column, OK means the critical circle was identified within the specified search domain. 'On extreme X-exit' means that the critical result is on the edge of the search domain; a lower Fs may result if the search domain is expanded.

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Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
THE BEST PEOPLE ON EARTH

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
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APPENDIX C

UPPER SPRING BERM CHANGE ORDER

CHANGE ORDER TEMPLATE

Change Order No. 1

Project Mindego Ranch Ponds Enhancement Project

Purchase Order No. 2019-209

Contactor Hanford ***Date of Issue*** June 5, 2019

Contractor is directed to, and hereby agrees to, proceed promptly with the specific changes to the Work attached hereto and incorporated herein, in conformity with the Contract Documents:

The ADDITIONAL CHARGE or DEDUCTION (circle one) for the above work is	$0.00	
The original Contract Sum was	$405,321.00	
Net change by previous Change Orders	$0.00	
The Contract Sum prior to this Change Order was	$405,321.00	
The Contract Sum will be (increased) (decreased) (**unchanged**) by	$0.00	
The new Contract Sum including this Change Order will be	$405,321.00	
The Contract Time will be (increased) (decreased) (**unchanged**) by	0	cal.days
The Completion Date as of the date of this Change Order is		

Additional Comments (if any):

DBE shall design and construct improvements to Upper Springs and its berm as specified in Attachment A-1 of the contract document. District expressly agrees and acknowledges that following completion and acceptance of the constructed improvements but during the Warranty Period, the berm may lack integrity and partially or completely fail during a future seismic event as identified in the "Geotechnical Investigation Design Phase for Mindego Ponds - Upper Springs" report dated 12/17/18 prepared by Butano Geotechnical Engineering, Inc. With respect only to Upper Springs berm damage or failure that occurs during a future seismic event and to no other aspect of the improvements, District hereby waives its right to invoke the warranty provisions set forth in Section 11.2 of the Agreement. Furthermore the District agrees to hold harmless DBE for any failure of the berm except as a result of the DBE's active negligence, or willful misconduct.

Mark Cederborg Date: 7/1/19

Contractor

Date: 7/2/19

District Representative

APPENDIX D

HYDROLOGIC ASSESSMENT TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

Date:	2019-06-04
To:	Zachary Alexander – Midpeninsula Open Space District
From:	Luke Tillmann, April Sawyer, and Chris Hammersmark
Project:	18-1019 – Mindego Ranch Ponds Enhancement
Subject:	Hydrologic Assessment

1 Introduction

The hydrologic analysis for this project consisted of determining the 100-year inflow rates to Knuedler Lake and Upper Spring ponds (Section 2.1), constructing a water budget spreadsheet model to simulate pond stage throughout selected water years (Section 2.2), and perform hydraulic shear stress calculations to determine appropriate rock sizing or turf reinforcement mat erosion control for reinforcing pond outlets (Section 2.3).

All geographic processing steps rely on the NAD83 California State Plane III (ft) horizontal projection.

2 Analyses

2.1 100-Year Inflows

A simple rainfall-runoff simulation using the TR-55 method (NRCS 1986) was conducted to determine the 100-year event inflow rates to both Knuedler Lake and Upper Spring ponds. This inflow rate was subsequently used in Section 2.3 to determine design shear stresses over pond outlets and calculate appropriate rock sizing for slope stabilization. The methodology, explained in Section 2.1.2, involved GIS-based determinations of watershed areas and their component soil and land cover data to determine watershed response to a 100-year rainfall event, determined from meteorological records.

2.1.1 Watershed Delineation

The first step in determining the 100-year inflow was to delineate the watersheds contributing to Knuedler Lake and Upper Spring ponds. A 1-meter resolution LiDAR digital elevation model (DEM) (San Mateo County 2016) was processed using ArcGIS 9.3 (ESRI 2008) with the Spatial Analyst toolbox. Raster cells that were lower than adjacent cells, referred to as “sinks,” were filled to create continuous sloping features; this subsequent raster dataset was then used to generate a flow direction raster, which

determines the direction in which any given raster cell drains based on the elevations of the adjacent pixels. A flow accumulation raster was then created to illustrate connectivity between all raster pixels, and from this, the contributing watershed area for each pond was delineated by specifying the outlet points and allowing the algorithm to identify all upstream raster cells. The resulting watershed raster was converted to a multi-part polygon shapefile to calculate the areas of each watershed, in acres, and be subsequently used to process other geospatial data layers, as described below.

2.1.2 Curve Number Calculations

The next step involved determining the land cover and hydrologic soil classes for each watershed. A 30-meter resolution raster dataset was obtained from the National Land Cover Database (NLCD, Wickham et al. 2014) clipped to the study site, projected into NAD83 California State Plane III, converted to a polygon layer, and clipped by the watershed extents for Knuedler Lake and Upper Spring ponds. Similarly, polygon soils data were obtained from the SSURGO database (NRCS n.d.) for a custom area of interest, projected, and clipped to the pond watershed areas. The attribute table contained soil classification codes and was combined with a table for Hydrologic Soil Group values by soil classification code to yield a spatial distribution of hydrologic soils within each watershed. The land cover and soils polygons were then combined to create a spatial distribution of unique land cover class – hydrologic soil class pairings for each watershed. The resulting areas and percent cover for each pairing are summarized in Table 1.

Table 1. Land cover and hydrologic soil group characterization for Knuedler Lake and Upper Spring ponds.

Watershed	NLCD 2011 Cover Class	Hyd Soil Class	Area (ac)	% of Watershed
Knuedler	Developed, Open Space	B	0.212	1.80
		C	0.280	2.39
	Grassland / Herbaceous	B	1.968	16.78
		C	7.255	61.84
	Mixed Forest	B	0.014	0.12
		C	1.987	16.94
	Evergreen Forest	C	0.015	0.13
Total			11.73	100.00
Upper Spring	Grassland / Herbaceous	B	2.865	51.27
	Mixed Forest	B	2.723	48.73
Total			5.59	100.00

From the data presented in Table 1, a composite curve number (CN) was calculated for each watershed according to TR-55 (NRCS 1986). The CN effectively determines how much storage capacity exists in each watershed to determine how much runoff is generated from a defined rainfall intensity. To generate a composite CN for each watershed, individual component CNs were calculated within each watershed for each land cover – hydrologic soil class pairing (Table 1) according to definitions in TR-55. An area-weighted average of these component CN values was used. TR-55 uses different land cover designations than the NLCD 2011 described in Table 1, and also considers the 'condition' of the land by applying semi-

quantitative descriptive criteria to different classes (NRCS 1986). The component CN designations for each cover class – hydrologic soil group pairing are summarized in Table 2, including justifications for each designation.

Table 2. Component curve number designations.

Cover Class		Curve Number				Rationale
NLCD (2011)	TR-55	A	B	C	D	
Developed, Open Space	Pasture (poor)	68	79	86	89	This land cover region was mostly defined by a dirt road and associated with surrounding low-level grassland vegetation that has been grazed.
Grassland / Herbaceous	Pasture (fair)	49	69	79	84	These areas do not include dirt road features and are generally of "better" condition than the developed, open space NLCD designated areas but do not meet the requirements for "good" condition due to the level of grazing experienced.
Mixed Forest and Evergreen Forest	Woods (fair)	36	60	73	79	The TR-55 designation of fair reflects "woods [that] are grazed but not burned, and some forest litter covers the soil."

The program WinTR-55 (NRCS 2013) was used to calculate the overall watershed curve numbers by performing an area-weighted average of the component CN's from each land cover – hydrologic soil group pairing. The resulting composite curve numbers for the Knuedler Lake and Upper Spring watersheds were 76 and 65, respectively.

2.1.3 Meteorological Data

The 100-year inflow event using TR-55 is calculated by applying the 100-yr, 24-hour rainfall depth to the watershed. NOAA Atlas 14 (NOAA 2014) was used to determine this rainfall rate for a location between the Knuedler Lake and Upper Spring watersheds (37.3111° N, 122.2379° W), yielding a 100-yr, 24-hour precipitation depth of 9.18 inches.

2.1.4 Runoff Volume

The SCS (Soil Conservation Service, now the NRCS) Curve Number method (NRCS 1986) was used to determine the total storage capacity of each watershed and subsequently determine the depth of runoff generated from the 100-year, 24-hour rainfall event. The watershed storage is related directly to the CN, as shown in Equation 1:

$$S = \frac{1000}{CN} - 1 \qquad (1)$$

where *S* is the watershed storage (in), and *CN* is the curve number (dimensionless).

Further, the initial abstraction (I_a, in), defined as the amount of rainfall that occurs prior to the initiation of runoff, is based directly on the watershed storage, *S* (Equation 2):

$$\mathbf{I_a = 0.2S} \tag{2}$$

These watershed values are used in conjunction with the 100-year, 24-hour precipitation (*P*, in) to determine the depth of runoff (*Q*, in), according to Equation 3:

$$\mathbf{Q = \frac{(P - I_a)^2}{P - I_a + S}} \tag{3}$$

Applying these equations yielded runoff depths of 6.24 in for Knuedler Lake and 5.38 in for Upper Spring, which, when multiplied by the respective watershed areas, produced runoff volumes of 6.10 and 2.27 acre-ft, respectively (Table 3).

Table 3. Calculation of runoff volume using SCS CN method.

Watershed	CN	S (in)	I_a (in)	P (in)	Q (in)	Area (ac)	Q (ac-ft)
Knuedler Lake	76	3.16	0.63	9.18	6.24	11.73	6.10
Upper Spring	65	5.38	1.08		4.87	5.59	2.27

2.1.5 Peak Pond Inflow Rates

Having determined the total runoff volume, the final step in the TR-55 method was to determine the instantaneous peak inflows to both ponds using the Graphical Peak Discharge Method (NRCS 1986). This was done by determining the time of concentration for each watershed, or the time that it takes for the most hydraulically distant portion of the watershed to contribute flow to the defined outlet (NRCS 1986), and applying the SCS unit hydrograph method based on a Type I rainfall distribution (Appendix A – Exhibit 1)[1]. The spreadsheets used to calculate the peak inflow rates are shown in Appendix A – Exhibit 2.

The time of concentration is a function of the individual travel times for sheet flow, shallow concentrated flow, and open channel flow throughout a watershed (NRCS 1986, Equation 4):

$$\boldsymbol{T_c = T_{t1} + T_{t2} + \cdots T_{tm}} \tag{4}$$

[1] From Exhibit 1 of Appendix A, it is clear that the location of these ponds is near the boundary of the definition for Type I and Type IA storms. As a conservative assumption, the Type I storm pattern was assumed, which experiences a higher percentage of its total 100-year, 24-hour rainfall in a shorter period of time than a Type IA storm (Appendix A – Exhibit 1).

where T_c is the time of concentration and m is the number of flow segments.

For the Knuedler Lake and Upper Spring watersheds, the primary flow paths were considered to be sheet flow and shallow concentrated flow. Therefore, the time of concentration was defined according to Equation 5:

$$T_c = T_{tsf} + T_{tscf} \quad (5)$$

where T_{tsf} is the travel time for sheet flow and T_{tscf} is the travel time for shallow concentrated flow.

The general equation for travel time is a simple distance over velocity relationship, with a factor to allow for time unit conversion (Equation 6):

$$T_t = \frac{L}{3600V} \quad (6)$$

where T_t is travel time (hours), L is flow length (ft), and V is velocity (ft/s).

TR-55 provides an empirical relationship to adopt this general framework to calculating the travel time for sheet flow:

$$T_{tsf} = \frac{0.007(nL)^{0.8}}{P_2^{0.5} s^{0.4}} \quad (7)$$

where n is the Manning's roughness coefficient determined from Table 3-1 in TR-55 (NRCS 1986), L is the flow length (ft), P_2 is the 2-year, 24-hour rainfall (in), and s is the slope of the hydraulic grade line (ft/ft). Values for Knuedler Lake and Upper Spring watersheds for Equation 7 are summarized in Table 4.

For shallow concentrated flow, average velocities are read from Figure 3-1 in TR-55 (NRCS 1986), depending on the watercourse slope (s) and whether the course is paved or unpaved, and applied directly to Equation 6. Table 4 contains the input and output parameters used for shallow concentrated flow.

Table 4. Time of concentration calculation.

Watershed	Sheet Flow					Shallow Concentrated Flow				T_c
	n	L	P_2[2]	s	T_{tsf}	L	V	s	T_{tcsf}	
Knuedler	0.25	300	3.98	0.3	0.18	1,250	7.8	0.2	0.05	0.2
Upper Sp.	0.25	300		0.5	0.15	600	6.4	0.15	0.03	0.2

With known times of concentration for the watersheds, the final step was to compute the peak discharge according to Equation 8:

[2] As with the 100-yr, 24-hour rainfall value, this 2-year, 24-hour rainfall value was determined from Atlas 14 (NOAA 2014).

$$q_p = q_u A_m Q F_p \quad (8)$$

where q_p is the peak discharge (cfs), q_u is the unit peak discharge (cfs) calculated from Exhibit 4-1 of TR-55 (NRCS 1986) from the T_c (hours) and a parameter calculated as I_a / P, A_m is the area of the watershed in square miles, Q is the runoff depth (in), and F_p is a pond and swamp adjustment factor to account for watershed storage that may reduce the peak discharge, based on the percentage of pond and swamp areas in the watershed according to Table 4-2 of TR-55 (NRCS 1986).

The parameters and results of Equation 8 are summarized in Table 5. The F_p parameter was set to a value of 1, to avoid reductions in peak discharge due to ponding given the scarcity of pond and wetland features upstream of Knuedler Lake and Upper Spring in their respective watersheds and to avoid accounting for attenuation of inflow within Knuedler Lake and Upper Spring ponds.

Table 5. Peak discharge calculation.

Watershed	Unit Peak Discharge			A_m	Q	F_p	q_p
	I_a / P	T_c	q_u				
Knuedler	0.07	0.2	400	0.0183	6.24	1	46
Upper Sp.	0.12	0.2	400	0.0087	4.87	1	17

Based on professional judgement, the 100-yr peak inflow rates (q_p) summarized in Table 5 seemed too high, which could be an artifact of the extremely small watershed areas that these methods were being applied to for lack of better methods. For example, the 46 cfs for Knuedler Lake watershed would equate to an instantaneous rainfall intensity of 3.89 inches per hour over the entire watershed if the ground were nearly impervious. Given that the 100-year, 24-hour total is 9.18 inches, we'd expect roughly a third of that, about 3 inches, to fall in about 1 hour based on the Type I rainfall distribution (Appendix A – Exhibit 1).

Based on this overestimation of peak flows from the TR-55 method for these small watersheds, the inflows were reduced to approximated, round values of 40 cfs for Knuedler Lake and 15 cfs for Upper Spring pond with the acknowledgement that these are still likely overestimates of the 100-year flow rates produced in either of these watersheds.

2.2 Water Budget

A water budget model was constructed in Excel (Appendix B[3]) to simulate stage in Knuedler Lake and Upper Spring ponds throughout selected water years (WY's) for both existing (eg) and proposed (future ground or 'fg') conditions as a function of runoff inflows, direct pond precipitation, spring inflows, evapotranspiration, percolation, and pond outflows. Given budget and schedule constraints, none of these parameters had been measured at either pond directly, so each involved some level of approximation, modeling, or technical judgement for assumptions. The basic concept of the water budget

[3] Appendix B shows the water budget spreadsheets for Knuedler Lake and does not include Upper Spring pond.

is that the change in storage volume of the pond is a function of the inflows to and outflows from the pond (Equation 9):

$$\Delta \boldsymbol{Storage} = \boldsymbol{Inflows} - \boldsymbol{Outflows} \quad (9)$$

For the purposes of this model, inflows are defined as the sum of direct precipitation over the pond, watershed runoff, and spring flows. Conversely, the outflows are the sum of open water evaporation, pond vegetation transpiration, percolation, and flows through the pond outlet.

The model ran using a daily time step and starting pond stage of 1011.8 ft NAVD 88 for Knuedler Lake (the pond was considered dry at a stage of 1010.75 ft for eg and 1007.75 ft for fg[4]) and 1679.25 ft for Upper Spring (considered dry at 1679 ft for eg and 1677.5 ft for fg conditions). For each time step, it would calculate the sum of individual inflows and outflows and apply the net change in storage to the pond storage from the beginning of the day (the ending storage from the previous day) to determine a resulting pond storage value. Through the use of hypsometric curves (Appendix B), the model established relationships between stage, storage (volume), and surface area, which were used to calculate various component inflow and outflow metrics. All inflows and outflows were converted to units of acre-ft per day to facilitate these calculations.

Some parameters, such as spring-fed inflows to the pond, were subjective and had high model sensitivities, compared to more easily approximated parameters such as potential evaporation. In the absence of observed data, the results of the water budget model, discussed in Section 2.2.4, must be interpreted as an estimation of reality, which would require refinement with gaged inflow and outflow data to generate results with a high degree of confidence.

2.2.1 Inflows

For each daily time step, the model first determined the inflow to the pond based on direct precipitation. A daily precipitation time series was obtained from CIMIS Station 104 (DWR 2019), which was located approximately 25 miles from the study area. Because the CIMIS station was located away from the site and at a lower elevation, the PRISM 30-year normal annual precipitation gridded dataset (800-m resolution, NASCE 2019) was used to scale the CIMIS dataset to more adequately reflect conditions present at the study site. The PRISM 30-year normal annual precipitation value for the CIMIS station was 843 mm, while the site had a value of 900 mm. Therefore, a scaling factor of 1.07 was applied to the CIMIS station gage to represent the precipitation record experienced at the location of the ponds, ignoring microclimatic influences of topography as well as larger-scale variability in cloud patterns that may have produced greatly different precipitation depths at these locations for a given storm event, as a simplifying assumption. The model determined the starting pond surface area (acres) based on the hypsometric relationship with pond stage (Appendix B) and multiplied the daily rainfall rate (ft) by the pond area to get the direct rainfall volume (ac-ft).

[4] These estimates were based on the construction of stage-volume and stage-area curves for the eg and fg surfaces using a custom GIS tool (Rajasekar 2017), with an interval of 0.25 ft.

As a second source of inflow to the pond, the model calculated the contribution of watershed runoff using a modified TR-55 curve number method that included a basic soil moisture accounting scheme. The CN approach was developed for event-based, and not continuous, simulations, because the assumption is that within a given storm, the watershed's initial abstraction is exceeded by precipitation at some point, after which a portion of the subsequent precipitation becomes runoff. However, if this metric is applied to a daily timestep instead of a single event, the curve number must be allowed to change based on previous precipitation to ensure that the proper antecedent soil moisture conditions are captured. Hawkins (1978) proposed the following modified CN equation to provide for this:

$$\boldsymbol{CN_t = \frac{1200}{\left(\frac{1200}{CN_{t-1}}\right) + [ET - (P - Q)]_t}} \quad (10)$$

where CN_t is the curve number at time t (current time step), CN_{t-1} is the curve number from the previous time step, ET is the watershed evapotranspiration at time t, and P and Q are the precipitation and runoff depths (in), respectively, at time t.

Problematically, Q_t is dependent upon CN_t, which Equation 10 solves for. Hawkins (1978) therefore provides a nomographic solution. However, for the purpose of being able to rapidly compute daily runoff values for one water year at a time without the need for complex iteration algorithms that are not conducive to spreadsheet-based modeling, Equation 10 was modified to rely instead on the runoff value from the previous, and not the current, timestep, yielding Equation 11:

$$\boldsymbol{CN_t = \frac{1200}{\left(\frac{1200}{CN_{t-1}}\right) + (ET_t - (P_t - Q_{t-1}))}} \quad (11)$$

This simple, modified soil moisture accounting algorithm was considered appropriate given the limitations of applying the CN method to small watersheds and the hydrologic data assumptions described above.

The basin evapotranspiration (ET) component (in) was estimated in each daily time step by multiplying the daily reference ET (Table 6), computed for CIMIS Zone 3 (DWR 2012), by the basin's monthly-varying[5] crop coefficient (K_c) value (Table 6). With the CN and Q known from the previous time step and the ET and P known from the current one, the current CN was calculated according to Equation 11, which subsequently allowed for the calculation of Q for the current timestep by Equation 3, yielding the daily watershed runoff inflow to the pond.

[5] In this case, a constant monthly K_c value of 0.25 was used (Table 6) assuming that the watershed's plant composition would be comparable to barley, oats, sesame, and similar crops with respect to ET (FAO n.d.).

Spring flows represented the third and final inflow to the pond. In the absence of observed data, these were loosely assumed based on predicted seasonal patterns and quasi-calibrated to roughly match a single observed pond stage in the fall of 2018. The spring flows for Knuedler Lake were defined as 0.005 cfs for October, 0.01 cfs for November – April, 0.005 cfs for May – July, and 0.004 cfs for August and September. For Upper Spring, which has about half of the drainage area but is located much higher in its watershed, these spring flow rates were reduced by an order of magnitude as a simplifying assumption. This parameter was subjective, though the water budget model was very sensitive to this input during the late summer and early fall. During the wet season, this flux became less important, because the pond stages were generally near the outlet crest elevations, and excess inflow resulted in spilling through the outlets.

2.2.2 Outflows

To determine pond outflows for a given time step, the model first computed losses due to evapotranspiration, comprised of open water evaporation and transpiration from pond vegetation. For Knuedler Lake, the area of pond vegetation was specified as a constant 1.06 acres throughout each year, unless the stage of submergence, or 1016 ft NAVD 88, was reached, at which point the model assumed that all vegetation was submerged and therefore only open water evaporation would be occurring. For Upper Spring pond, the area of pond vegetation was specified as 0.05 acres and the stage of submergence was set to 1682 ft. Open water evaporation was calculated from the additional pond surface area, in excess of the vegetated area, unless the stage of submergence was reached, whereby the acreage contributing to open water evaporation was defined as the full area of the pond. As discussed for the watershed evapotranspiration calculation for the determination of runoff in Section 2.2.1, the daily reference ET was multiplied by the seasonally-varying crop coefficients used for open water and pond vegetation (Table 6, FAO n.d.).

Table 6. Monthly reference ET and crop coefficients.

Month	Daily Reference ET (in)[6]	Crop Coefficients (K_c)[7]		
		Pond Open Water	Pond Vegetation	Watershed
January	0.06	1.05	0.9	0.25
February	0.08	1.05	0.9	0.25
March	0.12	1.05	0.9	0.25
April	0.16	1.05	1.2	0.25
May	0.17	1.05	1.2	0.25
June	0.19	1.05	1.2	0.25
July	0.18	1.05	0.7	0.25
August	0.17	1.05	0.7	0.25
September	0.14	1.05	0.7	0.25
October	0.11	1.05	0.7	0.25

[6] Based on DWR (2012) for CIMIS Zone 3. The month of February was assumed to have 28 days.
[7] Crop coefficients were somewhat based on those presented by FAO (n.d.).

November	0.08	1.05	0.7	0.25
December	0.06	1.05	0.7	0.25

Pond percolation was added to the model, but hand auger sampling determined that thick clay layers were present at both ponds. Therefore, percolation was assumed to be negligible and set to 0 in/day.

The last outflow was gravity drainage through the pond outlet. Without directly observed outflow or pond stage data at either location, the calculation of this flux was speculative. The daily time step of the model also presented difficulties, due to the small storage capacity of the ponds. Knuedler Lake and Upper Spring ponds were therefore treated differently for this step. For Knuedler Lake, The pond outlet was assumed to operate as a broad-crested weir, due to the steep channel gradient downstream of the outlet situated on a hillslope that does not create backwater effects on the pond. The standard weir equation was therefore used to determine pond outflows at times when the pond stage was above the outlet crest elevation (1013.5 ft NAVD 88):

$$\boldsymbol{Q = CLH^{\frac{3}{2}}} \tag{12}$$

where *Q* is the discharge (cfs), *C* is a constant coefficient based on the geometry of the weir, *L* is the length of the weir (ft), and *H* is the height of the pond stage above the pond outlet crest elevation (ft). For Upper Spring pond, which is considerably smaller than Knuedler Lake, weir flow was not calculated. Initial calculations suggested that the pond would drain down to the outlet berm crest elevation in much less than one day if the pond level surpassed this stage. Therefore, in each daily time step, the model would determine how much available storage was left in the pond before the berm crest stage was reached. If the net inflow for that time step would cause the lake to exceed the berm level, the pond stage was set to the berm crest (1681.5 ft NAVD 88), otherwise the stage was calculated via the standard mass balance calculation.

To account for the complex geometry of the pond outlet for the weir calculations for Knuedler Lake, a reference table was used to specify the weir length and coefficient at various stage values (Table 7), from which values were linearly interpolated for initial pond stages within the corresponding range. Reduced weir coefficients were used to account for the limited storage capacity of the pond and the daily timestep. For example, if a standard weir coefficient for this channel geometry were used, on the order of 0.5, then the computed weir flow from the stage at the start of the day would cause a relatively large discharge to be specified for the entire day, leading to an instantaneous draining of the pond. To account for this, the weir coefficients were dramatically reduced to approximate the daily averaged weir flow as a result of declining pond stage as gravity flow over the outlet occurs. Alternative methods would have been to use a smaller time step, on the order of perhaps minutes, and potentially model the outlet as a sharp-crested triangular weir instead of a series of broad-crested, rectangular weirs. For the purpose of simplicity, however, the latter was chosen, and coefficients were selected to generate a reasonable-looking, continuous rating curve of stage versus computed flow (Appendix B). In the presence of observed outflow

data, these coefficients could be calibrated at a later time to provide a more accurate computation of pond outflow.

Table 7. Length, weir coefficient, and computed weir flow for defined stages for Knuedler Lake.

Stage (ft, NAVD 88)	Weir Length (ft)	Weir Coefficient	Flow (cfs)[8]
1013.5	8.85	0.03	0
1014	12.92	0.01	0.05
1015	22.23	0.0075	0.31
1016	40.99	0.005	0.81
1017	67.72	0.0032	1.42

2.2.3 Selection of Water Years

The water budget model was used to simulate pond stage over an array of water years with varying levels of total precipitation. Daily rainfall data from 1990-2018 for CIMIS station 104 (DWR 2019) were combined into water years and summed before subsequently being ranked (Appendix C). Water year 1998 was the wettest of the record, with a total rainfall of 57.52 inches, while WY 2014 was the driest with 6.73 inches. WY's 2005, 1991, and 2012 were at approximately the 25th, 50th, and 75th percentiles for exceedance probability, with rainfall totals of 41.55, 25.7, and 20.82 inches, respectively (Appendix C). The water budget model was run using these five water years for eg and fg conditions for both Knuedler Lake and Upper Spring ponds (Figures 1 – 20).

2.2.4 Results of Water Budget Model

As previously discussed, none of the inflows or outflows simulated using the water budget model were directly measured, which made parameter calibration infeasible. Figures 1 – 10 display the pond stage as well as inflows and outflows throughout each simulated WY for eg and fg conditions for Knuedler Lake. For small rainfall events, the inflow due to direct precipitation was nearly the same as that due to watershed runoff, despite the pond having a relatively small area compared with the watershed, because the storage capacity of the watershed had not been exceeded. However, for larger rainfall events, runoff became the largest source of inflow to the pond. The spring flows provided most of the inflow for the late summer and fall months. For outflows, gravity drainage over the outlet was the dominant flux when the reservoir stage was above the outlet crest elevation, while ET dominated otherwise. The persistence of spring inflows allowed the pond level to somewhat equilibrate in the late summer and fall months, as spring inflows were approximately balanced by ET at a semi-equilibrium stage (Figures 1 – 10). The model was highly sensitive to these spring inflow estimates and observed data would be exceedingly useful in refining this parameter.

[8] Determined using Equation 12.

Comparing eg and fg conditions, the stage in Knuedler Lake remains consistent across both conditions at times when the stage is above the outlet crest elevation, but differences occur during the dry season (Figures 1-10). In the fall, the starting lake level is the same, but under fg conditions the water is primarily confined to the small, excavated section of Knuedler Lake. Because of the steep side walls of the excavation, a small outflow in the form of ET causes a more pronounced drop in stage compared to eg conditions where the water is more distributed across a gentler-sloping area. During the wet season, when the stage is above the outlet weir crest and therefore spilling through gravity flow, the higher rates of ET under fg conditions, due to differences in hypsometry of Knuedler Lake as a result of the project, are offset by slightly lower gravity flow rates, yielding the same overall stage as eg conditions. Following the wet season, the increased volume of Knuedler Lake under fg conditions causes the stage to remain slightly higher than it does under eg conditions. During this time, the ET rate is the same because, although the pond has greater surface area under fg conditions at low stages, the model assumes that ET is occurring predominantly from pond vegetation which experiences sufficient root-zone inundation to maintain maximum ET rates. Open water evaporation is only considered once the level of submergence for the pond vegetation is reached, during the wet season.

For Upper Spring pond (Figures 11-20), the stage is also largely unchanged from eg to fg conditions. This is because, after the pond fills to the outlet berm crest elevation, the pond remains full throughout the year. In reality, there are several reasons why this may likely not be the case. First, the berm is not uniformly graded at 1681.5 ft, so overflow likely occurs at lower pond levels through narrow, depressed features, yielding higher-than-modeled pond outflows. Inversely, inflows to Upper Spring could be overestimated because spring flows are uncertain and are applied based on seasonal constants that are not tied to recent rainfall. While this simplification is necessary to avoid complex soil moisture accounting algorithms which require additional data and introduce further sources of uncertainty, it ultimately assumes that spring flows are the same in wet and dry years alike. This is why the pond is modeled as full in WY 2014 (Figures 19, 20), while this was not likely the case.

2.3 Pond Outlet Shear Stress

The final component of the hydrologic assessment was an estimation of peak shear stresses experienced at the outlet of Knuedler Lake and Upper Spring ponds from the 100-year event inflow, discussed in Section 2.1.5, for the purposes of rip-rap sizing for channel stability. HEC-RAS 5.0.6 (HEC 2018) was used to build a 2-dimensional (2-D) model of Knuedler pond, which proved challenging to simulate at the downstream end near the outlet, due to the steep channel gradient downhill from the pond and the relatively coarse resolution of the LiDAR dataset here compared to the survey data that was used to generate the bathymetry for the pond itself. For these reasons, the 2-D domain could not be extended downhill through the pond outlet and beyond. Instead, a lateral structure was added near the downstream end of the outlet to convey flow using the 1-D weir equation into a dummy 1-D storage area with nearly infinite capacity. This configuration allowed for the model extent to remain in the highly detailed portion of the topographic / bathymetric surface and eliminated flow errors associated with having the 2-D mesh on a steep gradient. However, it introduced uncertainty with the weir equation, because the selection of the weir coefficient is somewhat arbitrary and needs to be calibrated to observed

data due to the high sensitivity of computed stage and outlet velocity associated with the chosen weir coefficient.

In absence of observed outflow data, the model was run with two different weir coefficients, meant to bracket the range of possible conditions. For one configuration, the coefficient was set to a value of 2.6, which would be analogous to flow traveling over a levee or roadway elevated several feet above natural ground. This value indicates a relatively high amount of flow over the outlet structure, which would yield lower upstream stages and higher water velocities over the outlet than a lower coefficient. For the second configuration, the coefficient was set to 0.5, indicating flow over non-elevated natural ground. In reality, the true coefficient probably exists somewhere between 0.5 and 2.6, because it is flowing over a non-elevated natural ground feature but also likely experiences flow acceleration due to the steep gradient downstream of the outlet. These configurations were run for steady-state inflows of 40 cfs, representing the 100-year inflow rate (Section2.1), and 20 cfs, arbitrarily chosen as half of the 100-year inflow. Manning's roughness was assumed to be constant at 0.10, representing pond vegetation[9]. Results of the simulations for peak shear stress and peak velocity are indicated in Table 8.

Table 8. Peak shear stress and velocity for Knuedler Lake outlet.

Flow	Outlet Weir Coefficient	Peak Shear Stress (lb/ft^2)	Peak Velocity (ft/s)
40 cfs	2.6	4.14	4.25
	0.5	0.72	1.86
20 cfs	2.6	3.45	3.65
	0.5	0.9	1.91

At a maximum, the peak shear stress experienced at the Knuedler Lake outlet was on the order of 4.1 lb/ft^2 (Table 8), but as previously discussed, the actual shear stress would likely be lower than this estimate.

For Upper Spring pond, HEC-RAS 5.0.6 was similarly used to construct a 2-D model, but the outlet configuration was simpler to simulate compared to Knuedler Lake. The area downslope of the outlet berm was simulated within the 2-D flow area, and the weir connection to the 1-D storage area with near-infinite storage capacity, used to remove flow from the model domain, was situated far enough downslope to not have impacts on the hydraulic calculations on or just downstream of the berm. Similarly to Knuedler Lake, the applied Manning's roughness throughout the 2-D domain for Upper Spring pond was kept at 0.10. Table 9 indicates peak velocity and shear stresses under 15 and 7.5 cfs flow rates.

[9] The model did not vary the roughness over the Knuedler Lake outlet, which would be lower than 0.10 and depend on the size of the selected reinforcement material, leading to even higher velocities and shear stresses. However, the use of 40 cfs as the rate of inflow to Knuedler Lake was already considered to be conservative in that it likely provided an over-estimate of the 100-year inflow.

Table 9. Peak shear stress and velocity for Upper Spring pond outlet.

Flow	Peak Shear Stress (lb/ft^2)	Peak Velocity (ft/s)
15 cfs	7.41	4.56
7.5 cfs	4.67	3.95

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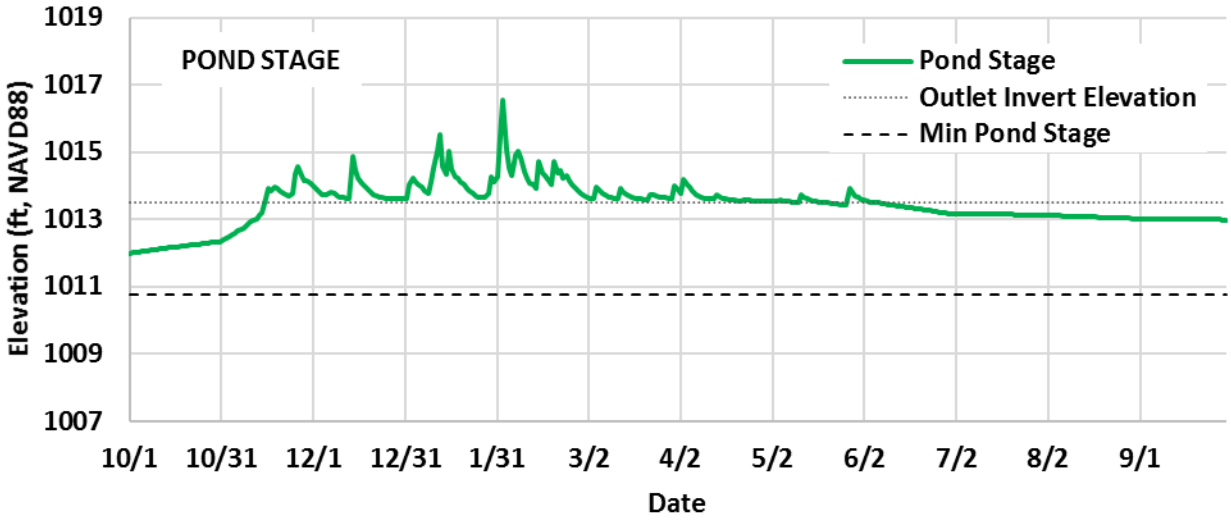
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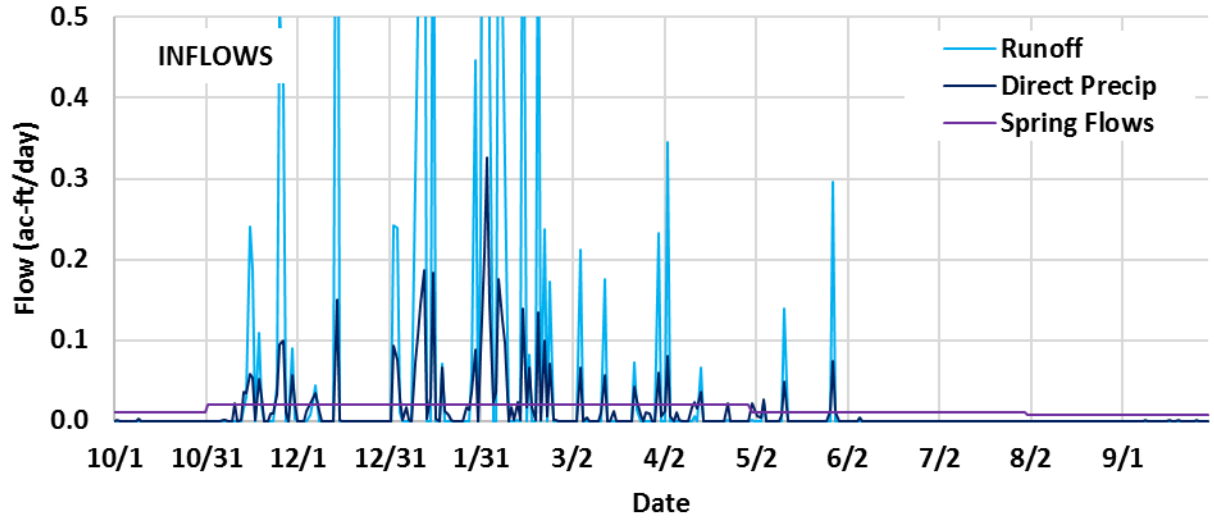
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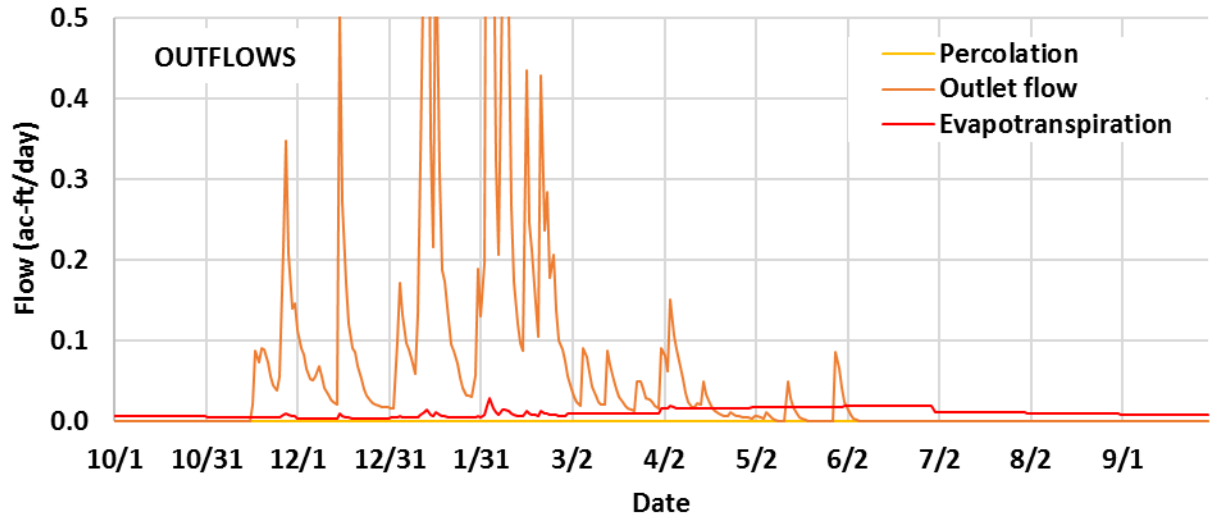
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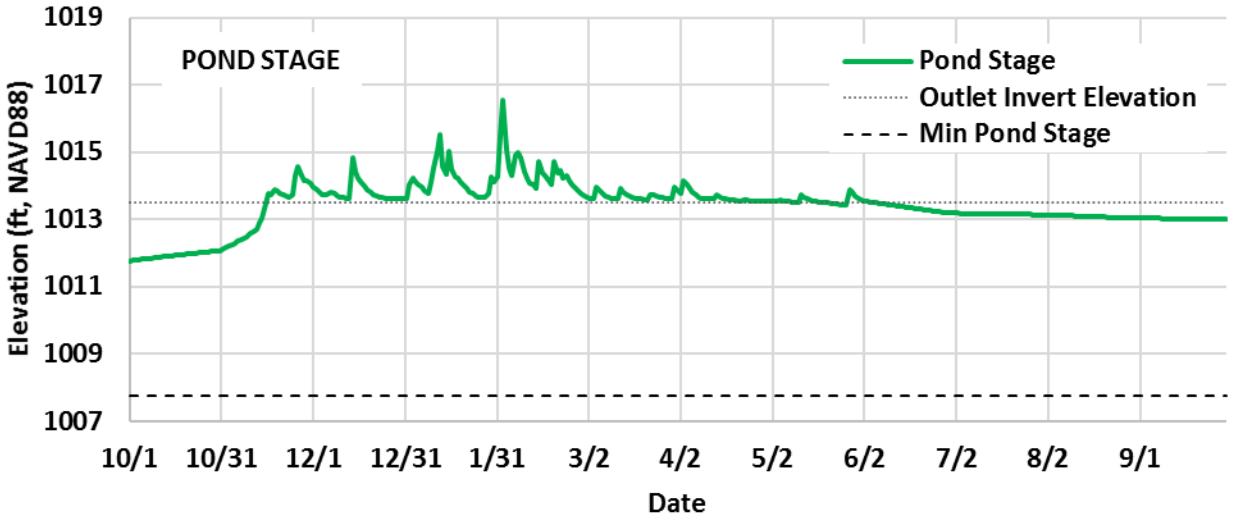
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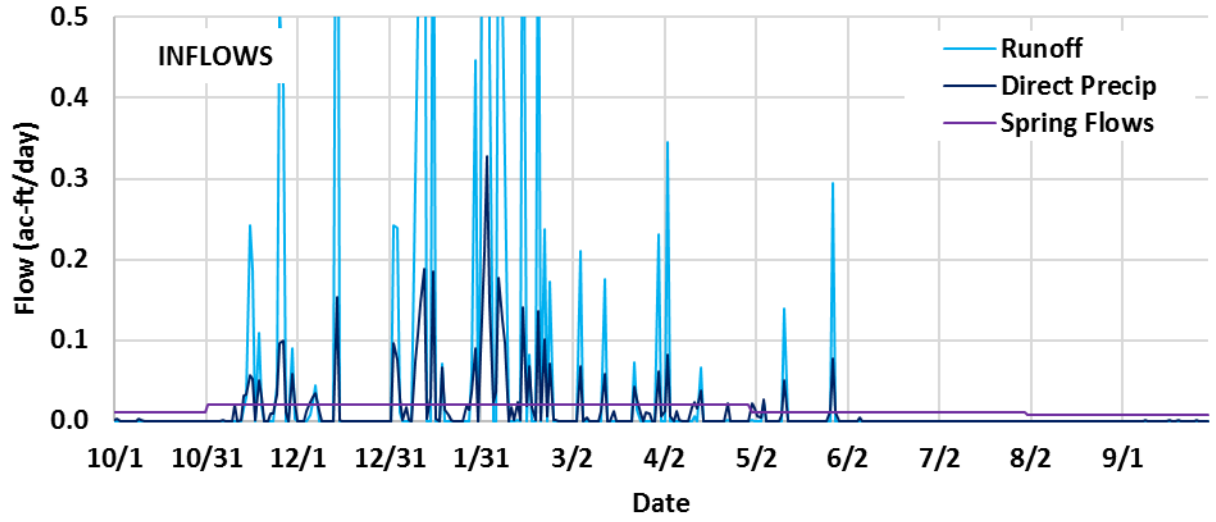
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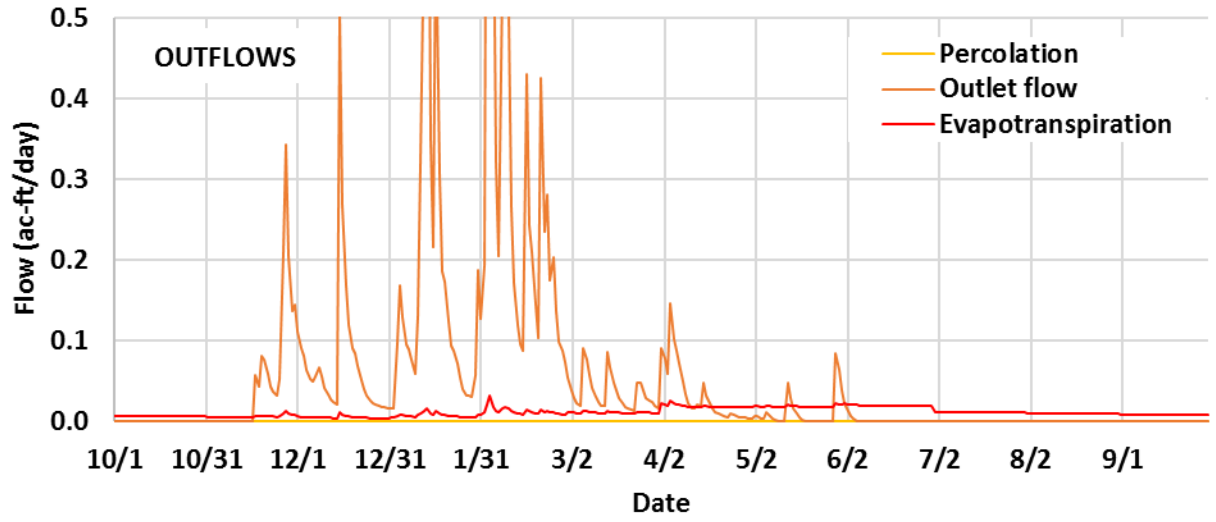
Mindego Ranch Ponds Enhancement

Water Budget: Knuedler: WY 1998 (eg)

Project No. 18-1019	Created By: LST	**Figure 1**







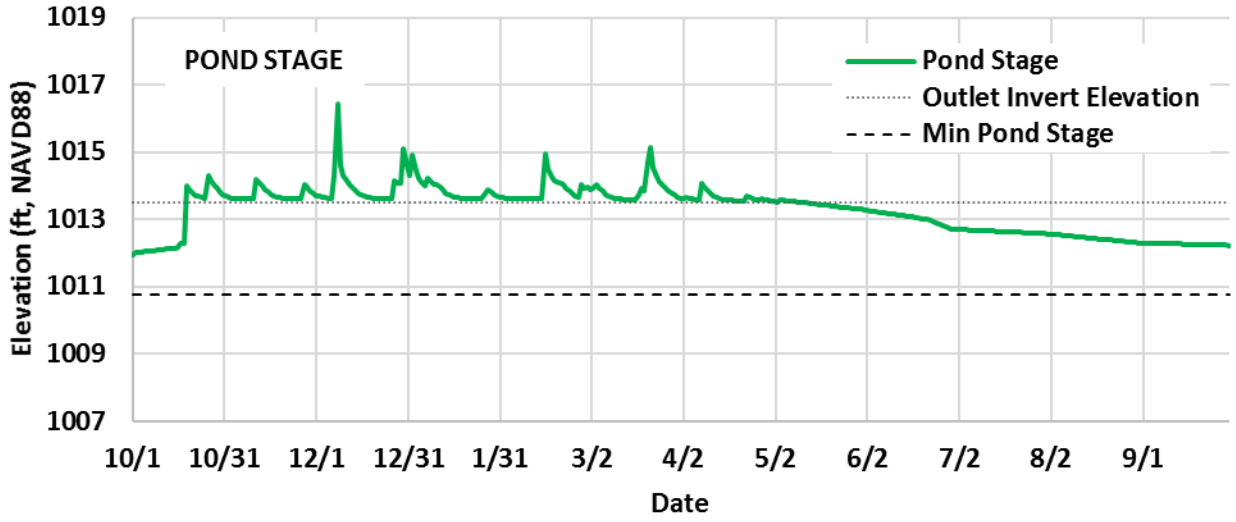
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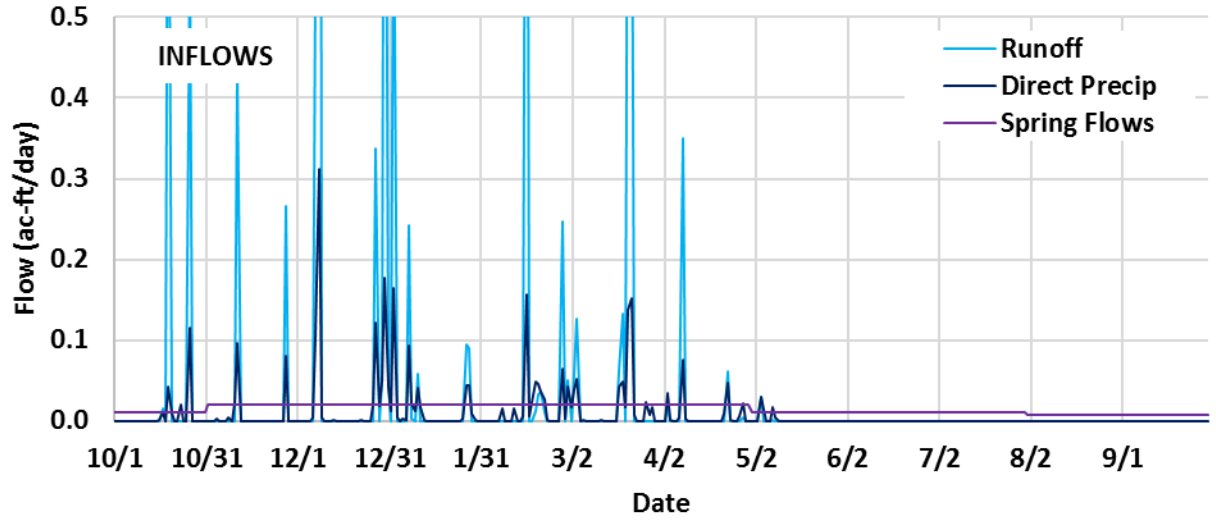
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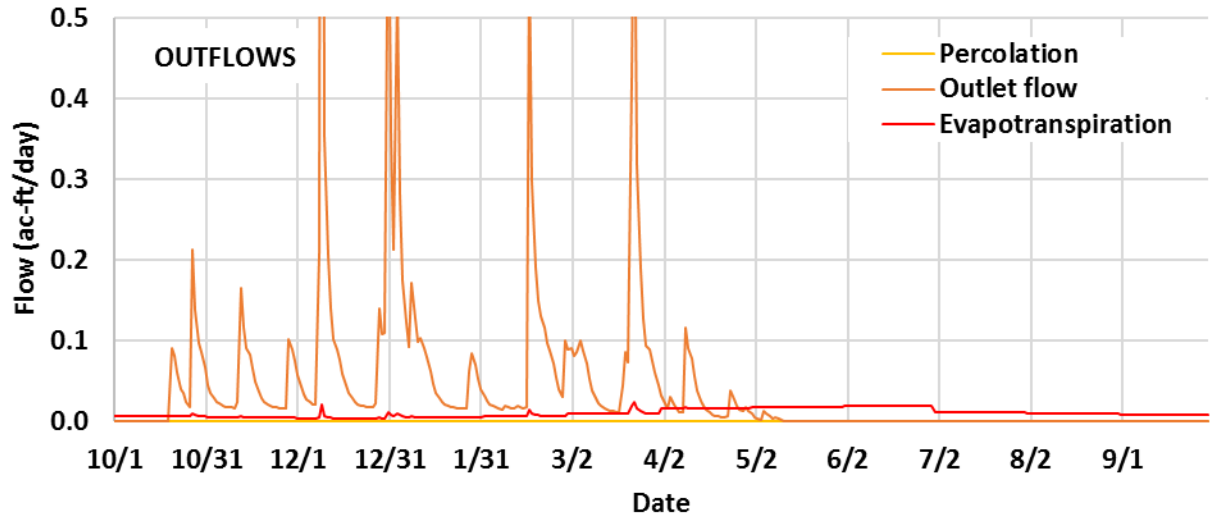
Mindego Ranch Ponds Enhancement

Water Budget: Knuedler: WY 1998 (fg)

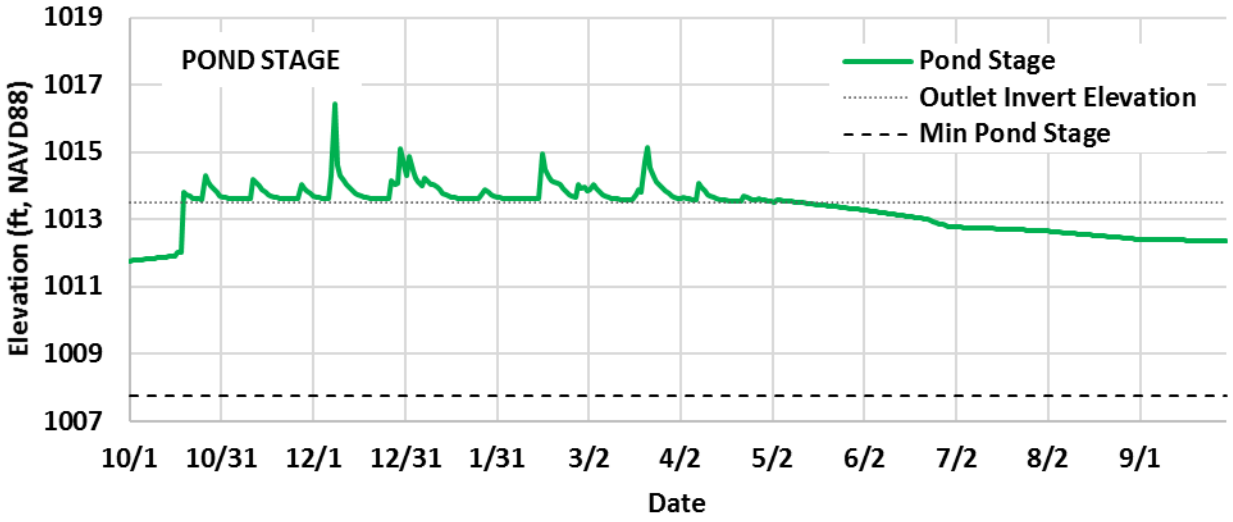
Project No. 18-1019	Created By: LST	**Figure 2**

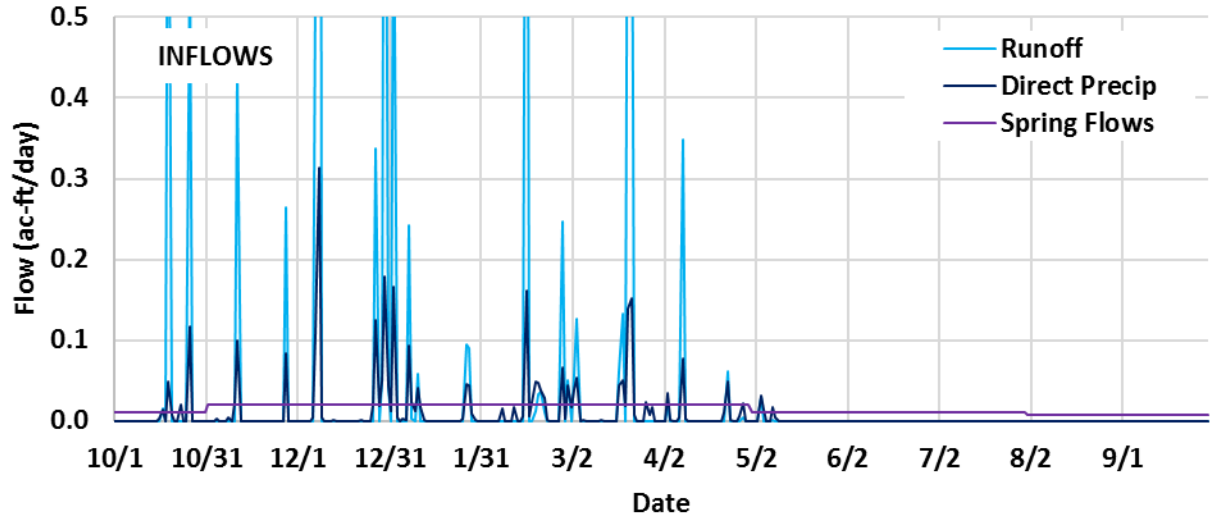


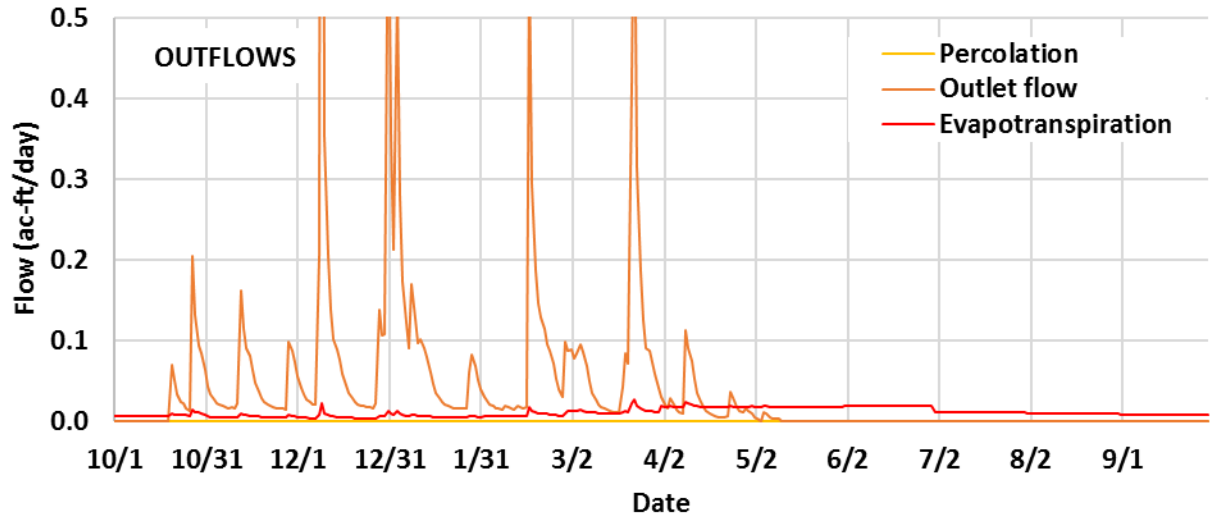




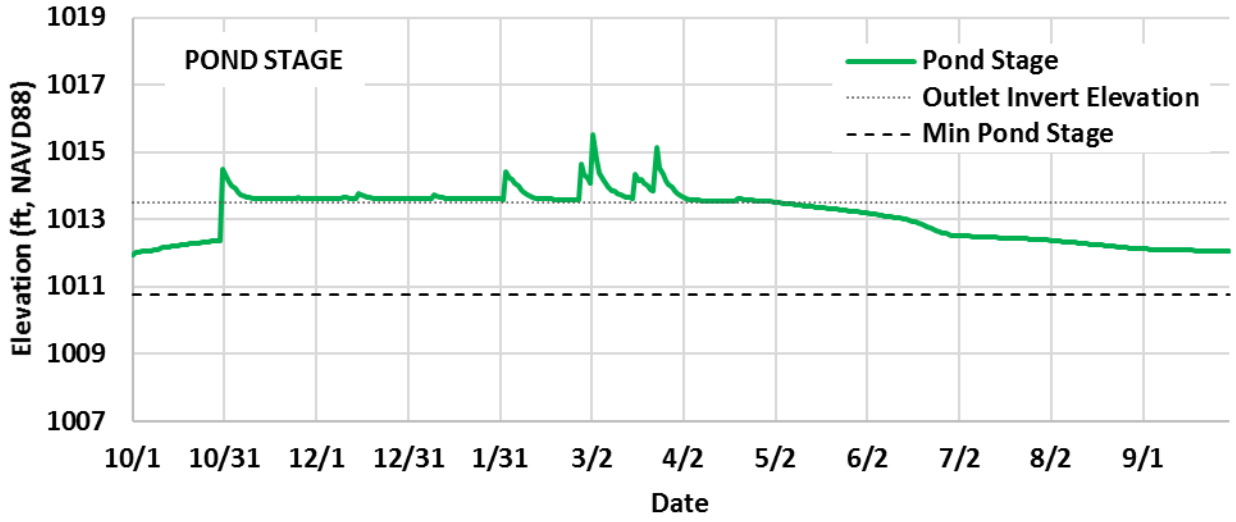
Notes: WY 2005 was at the 25th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2005 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 3**

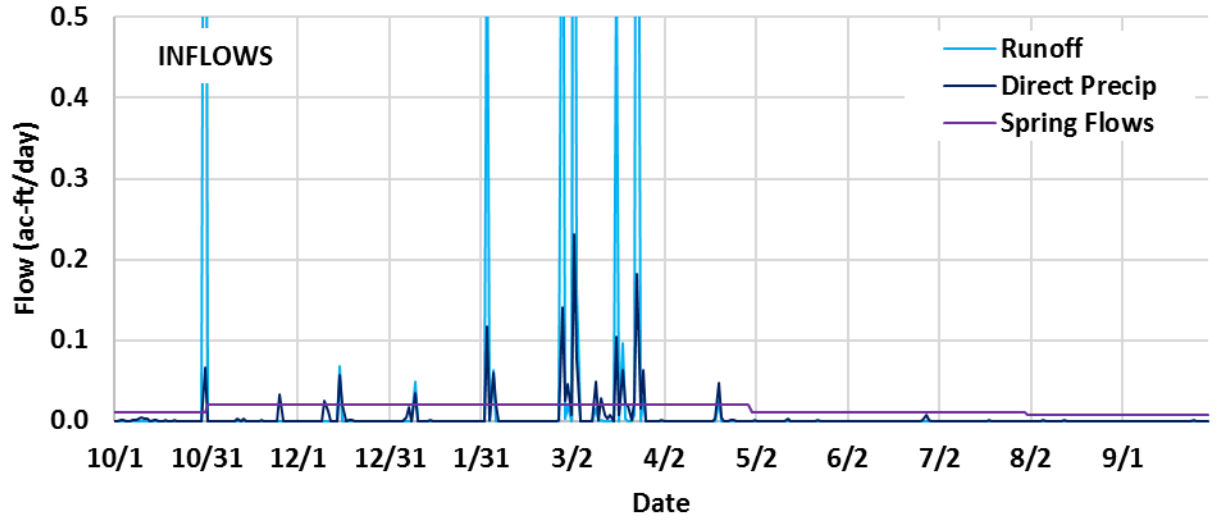


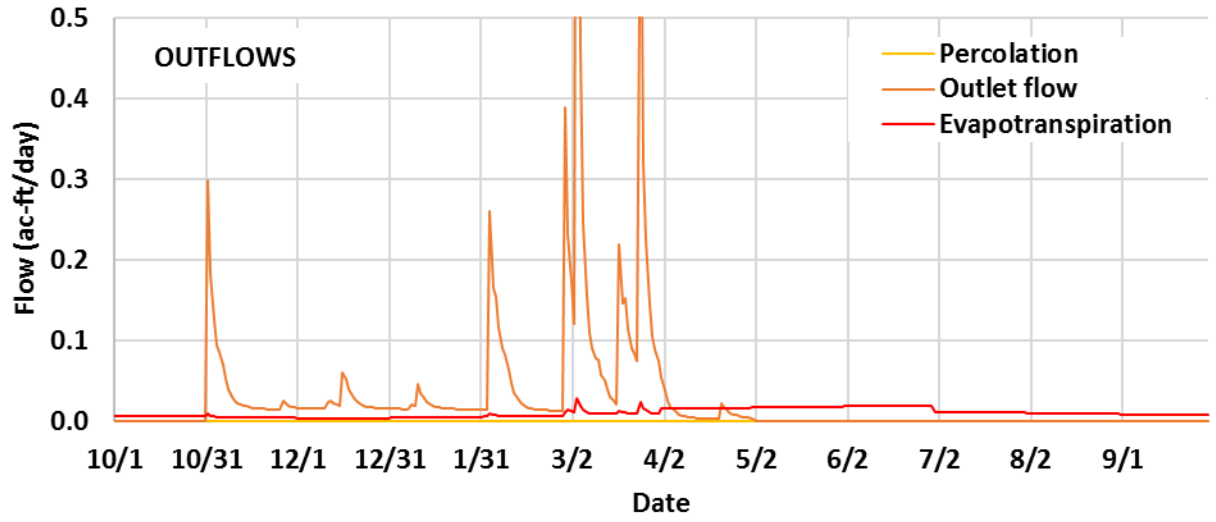




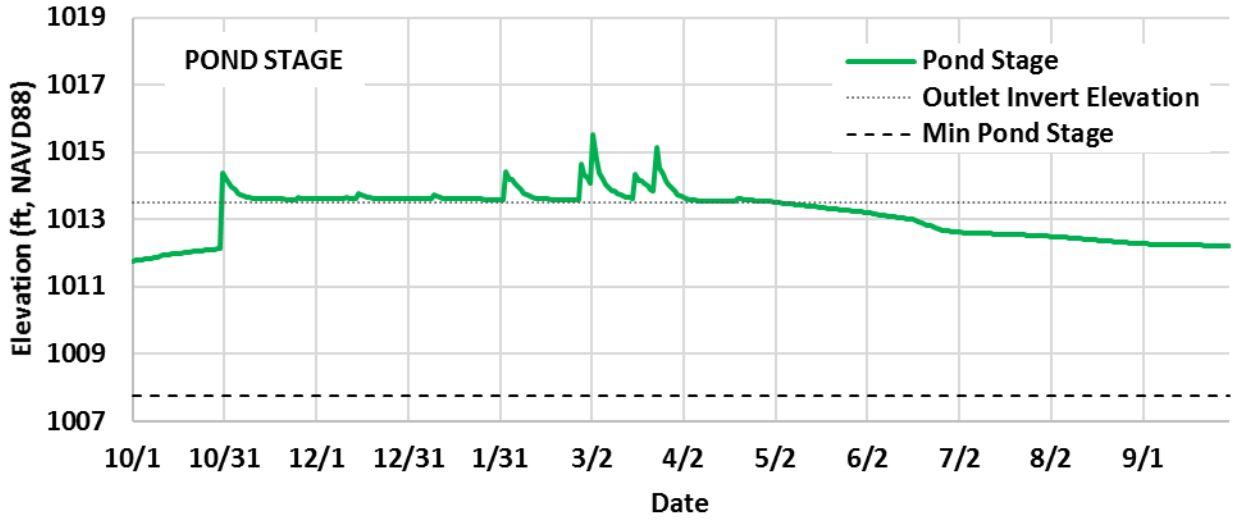
Notes: WY 2005 was at the 25th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2005 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 4**

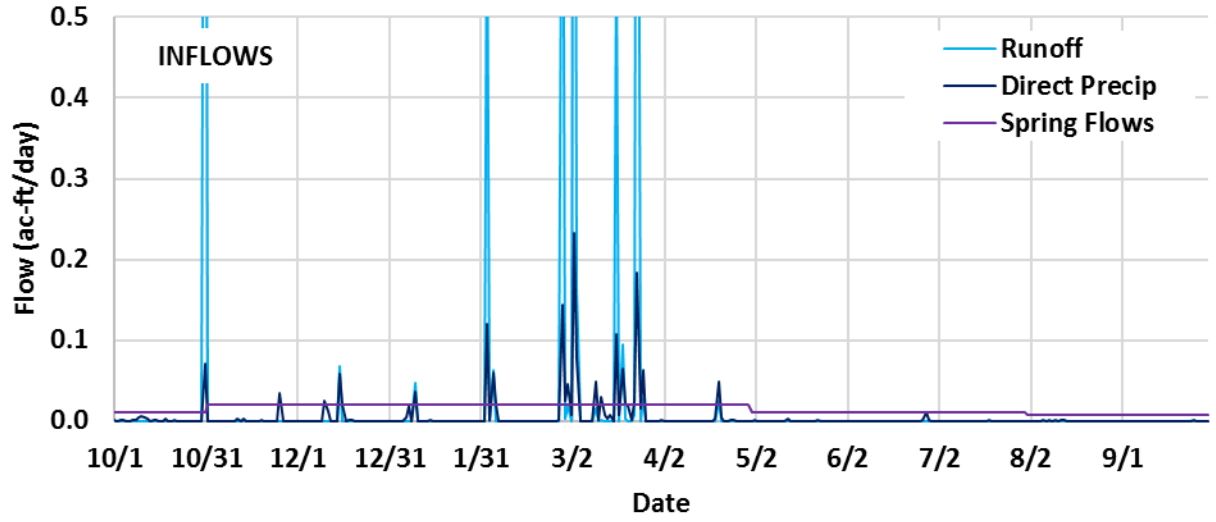


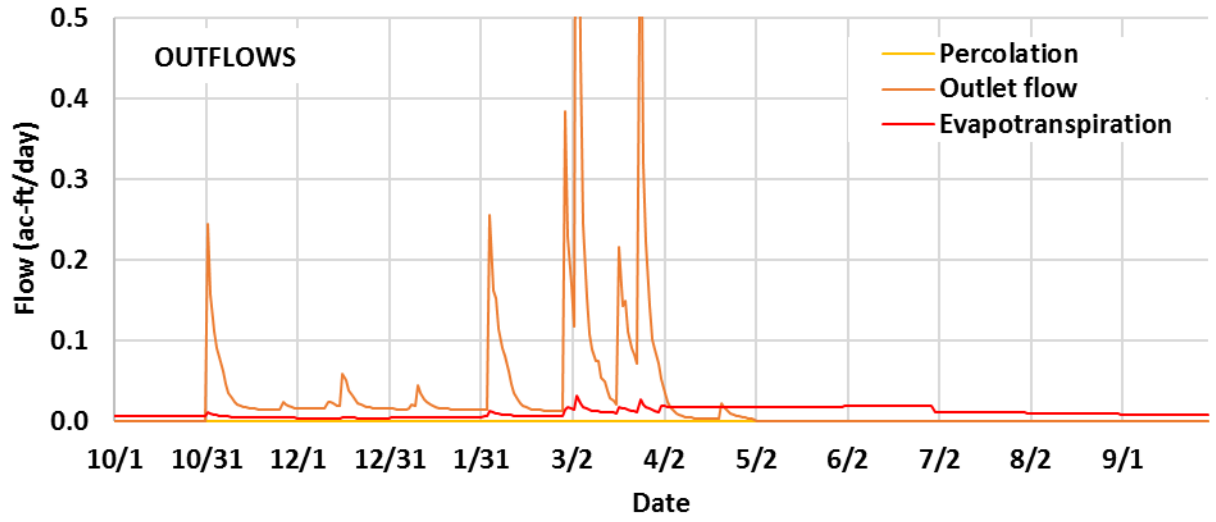




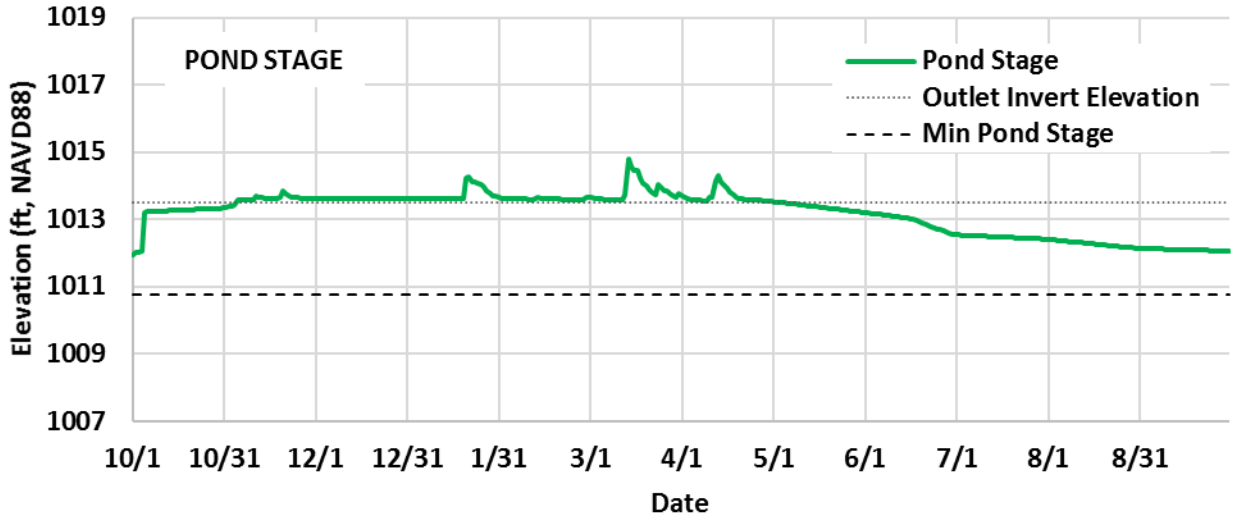
Notes: WY 1991 was at the 50th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 1991 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 5**

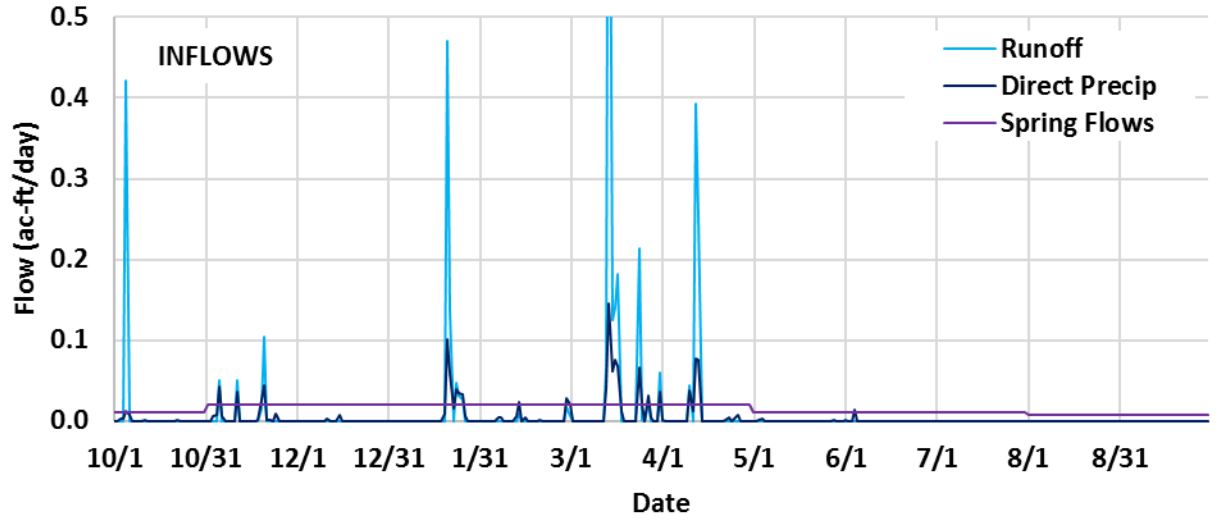


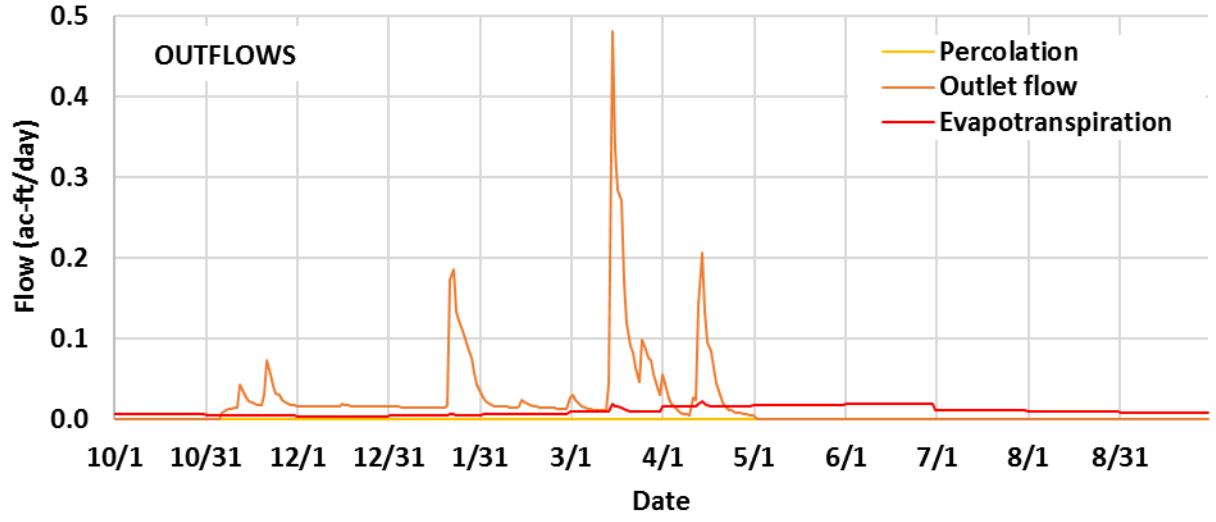




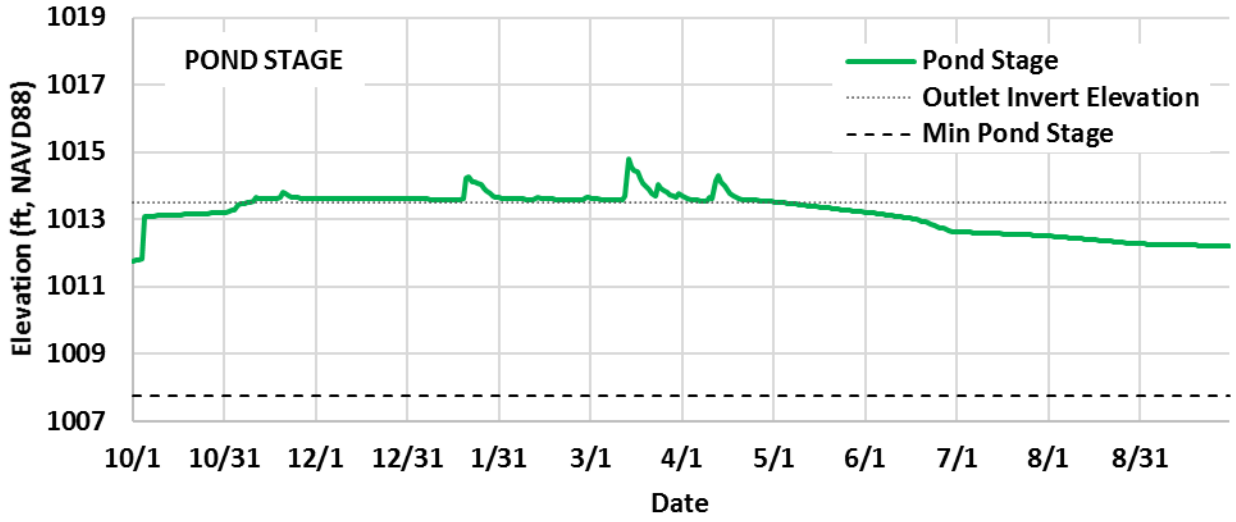
Notes: WY 1991 was at the 50th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 1991 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 6**

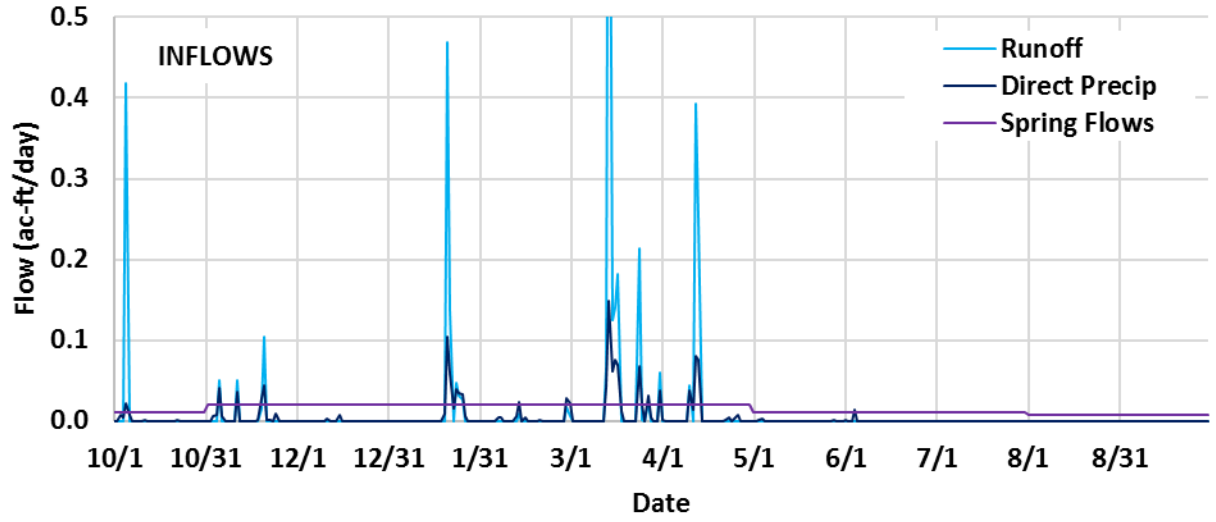


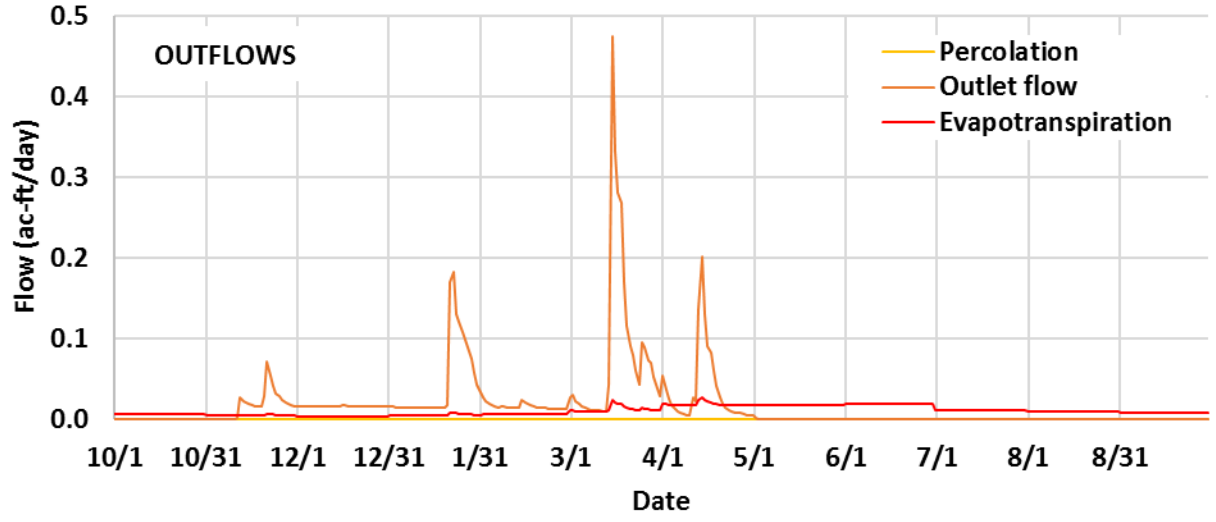




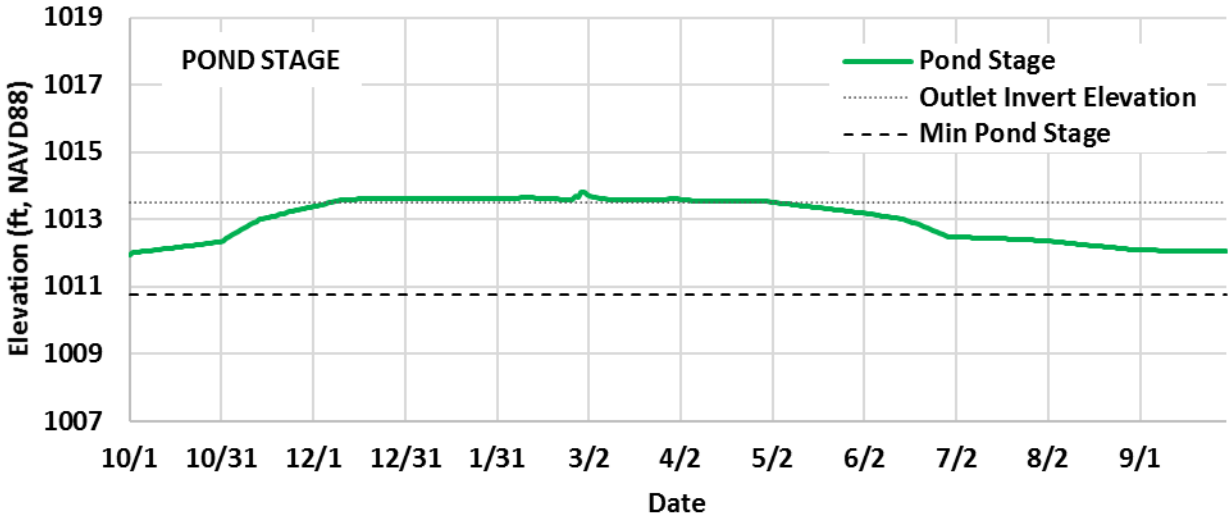
Notes: WY 2012 was at the 75th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2012 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 7**

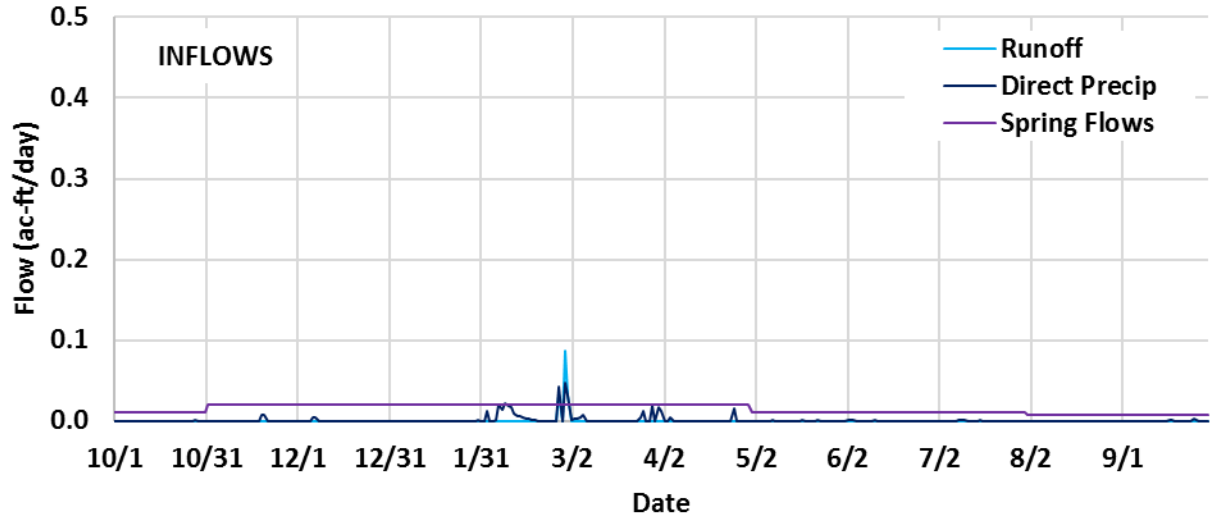


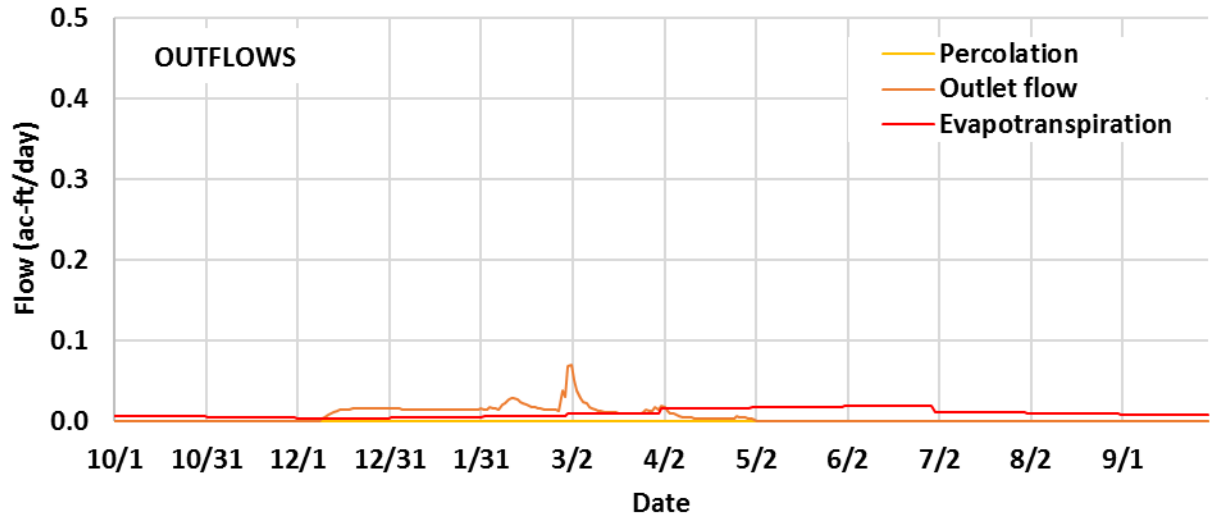




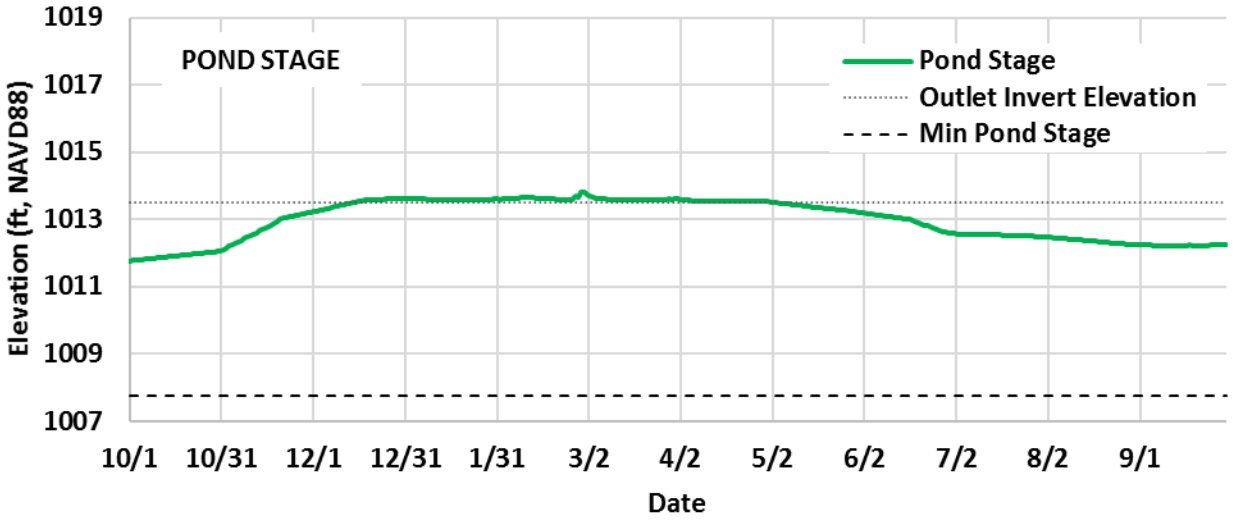
Notes: WY 2012 was at the 75th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2012 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 8**

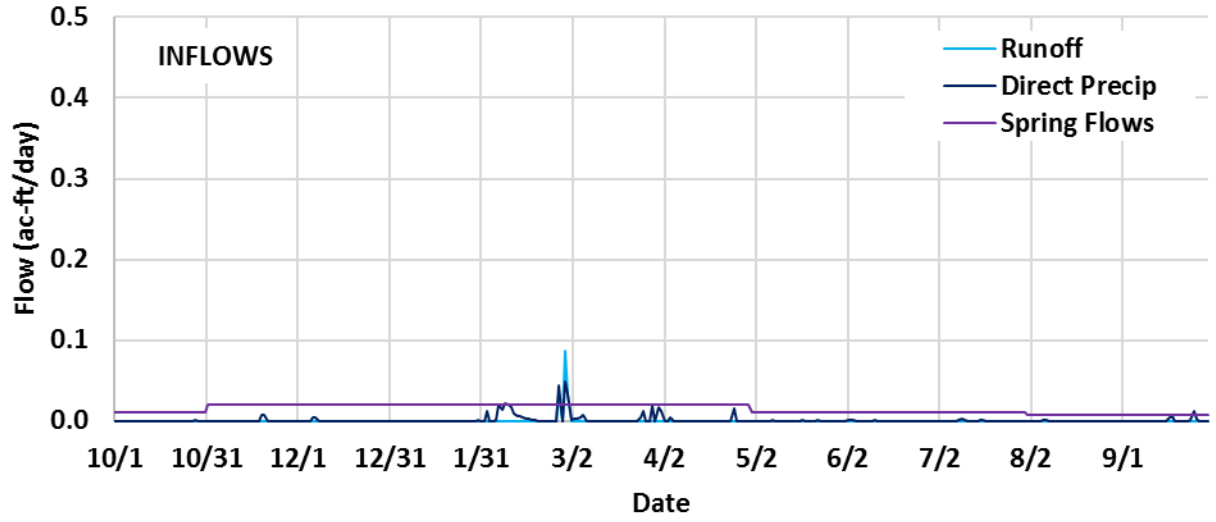


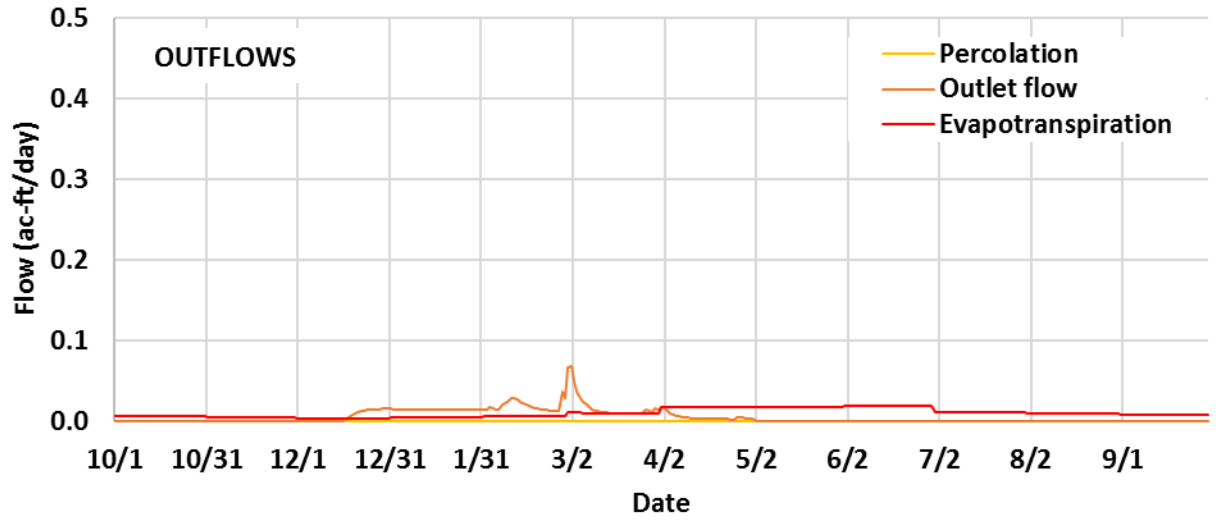




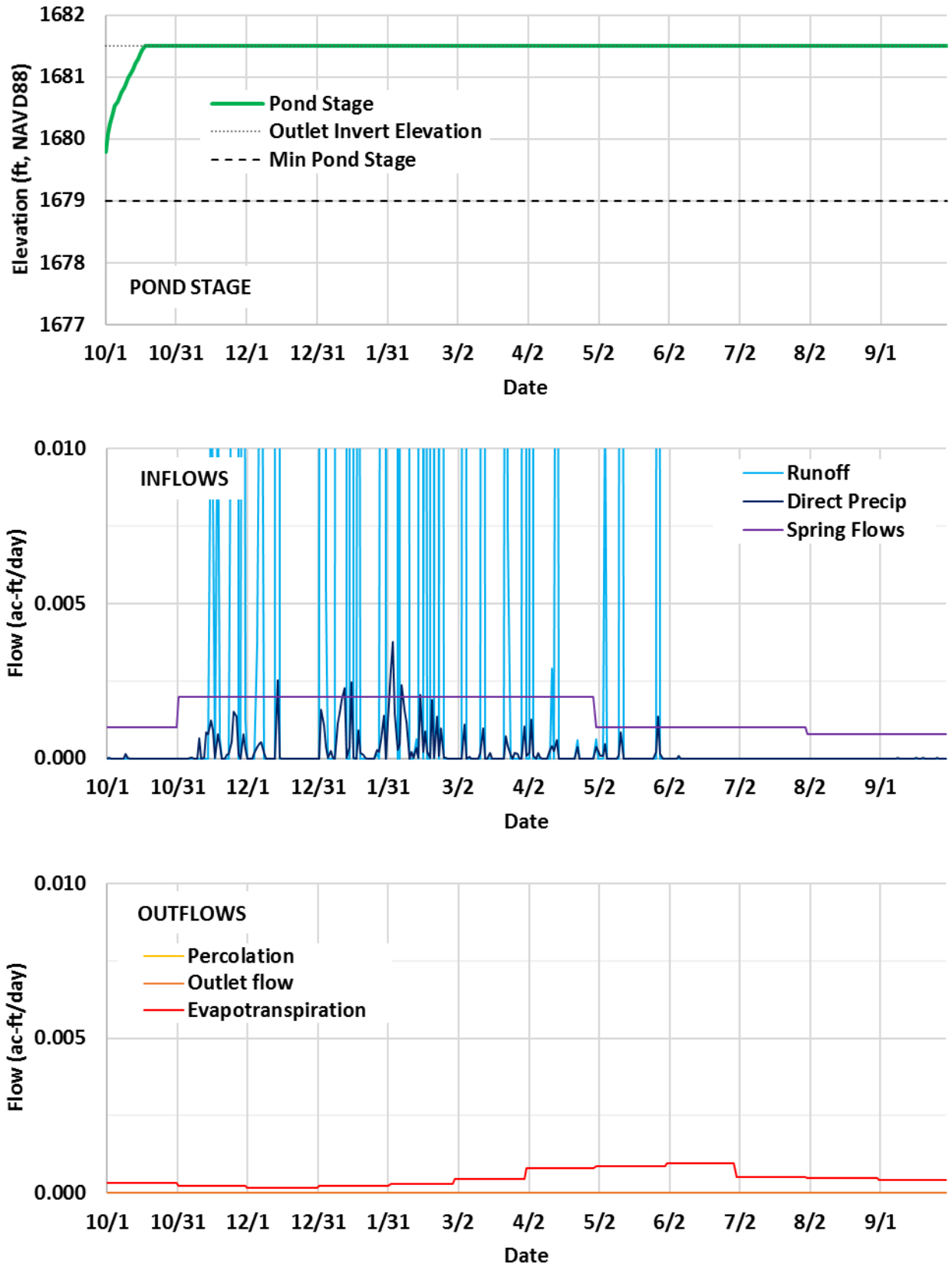
Notes: WY 2014 was the driest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2014 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 9**



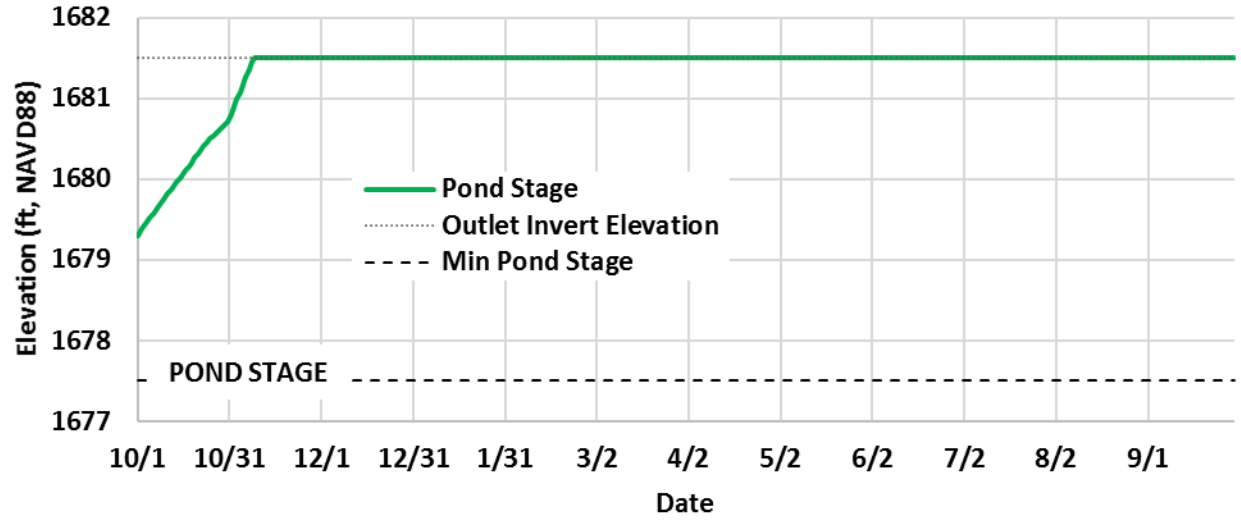


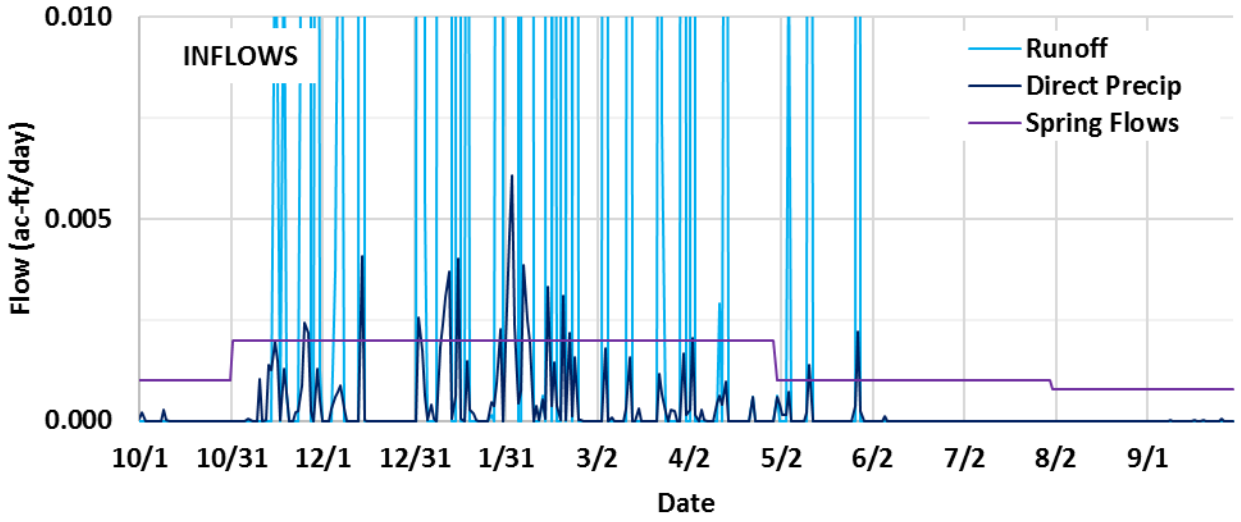


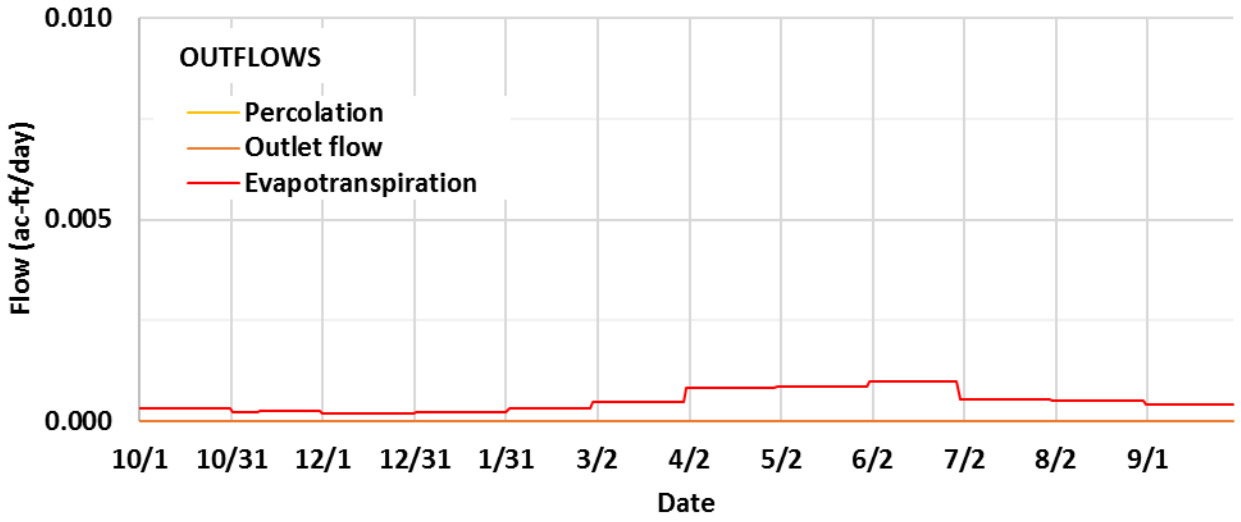
Notes: WY 2014 was the driest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Knuedler: WY 2014 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 10**



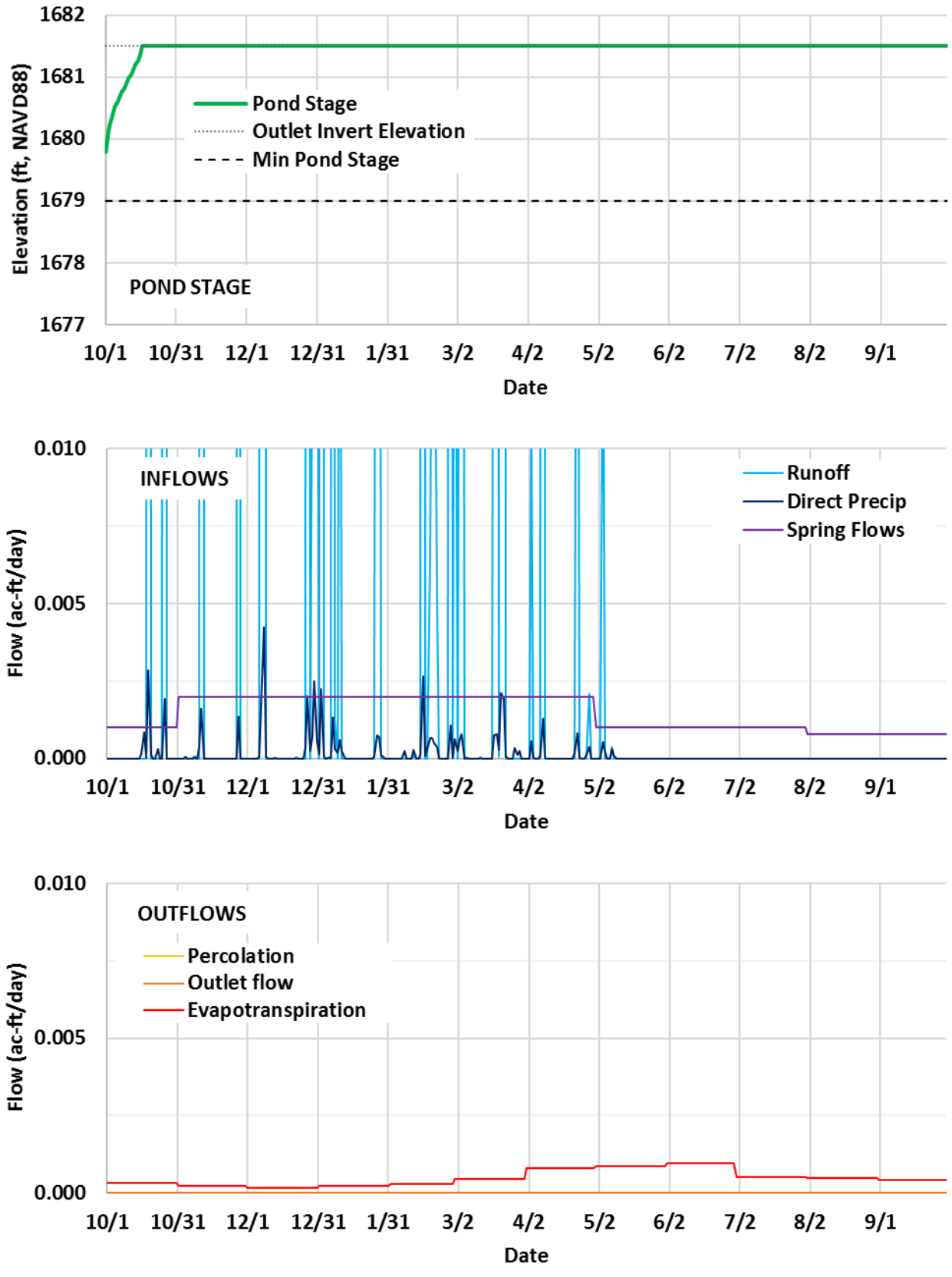
Notes: WY 1998 was the wettest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 1998 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 11**



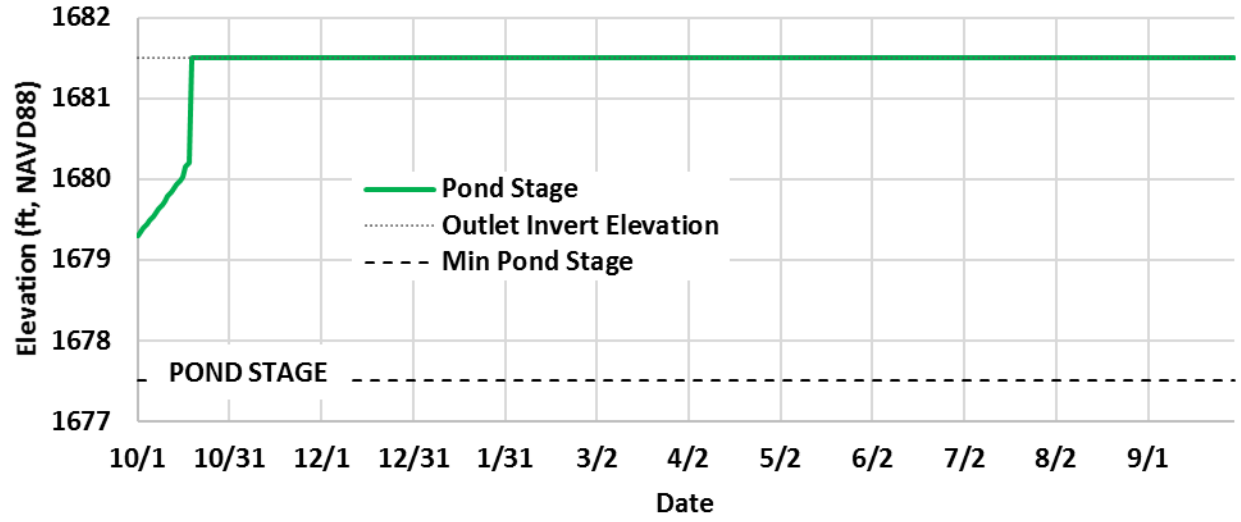


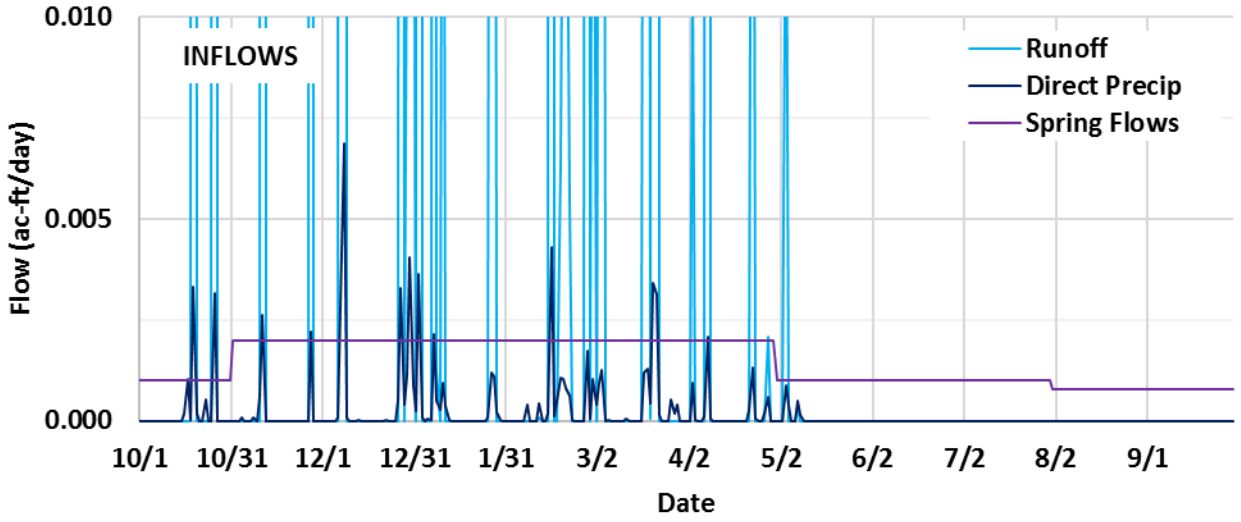


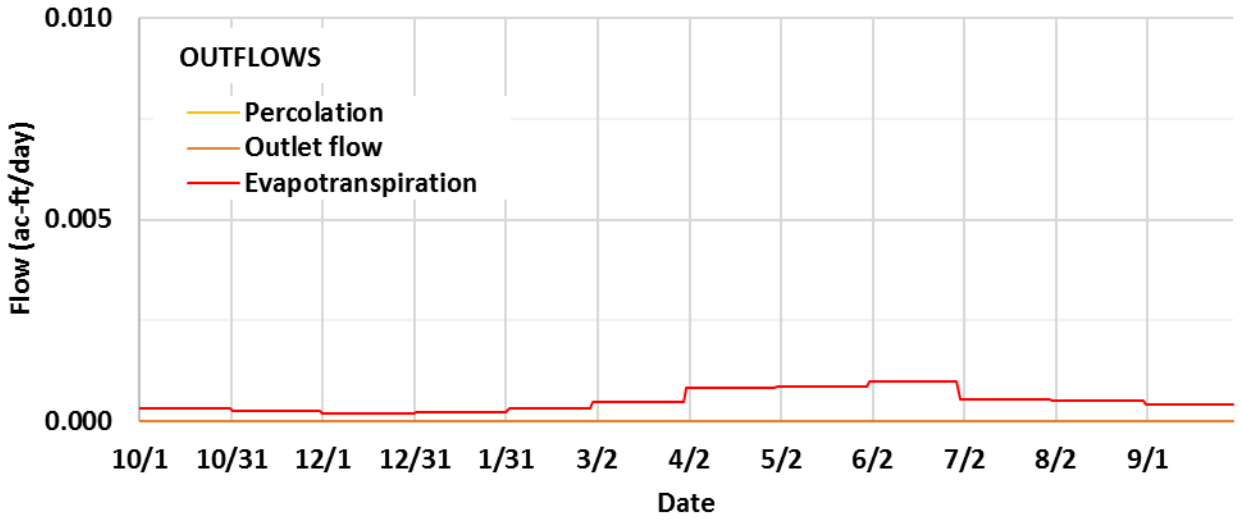
Notes: WY 1998 was the wettest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 1998 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 12**



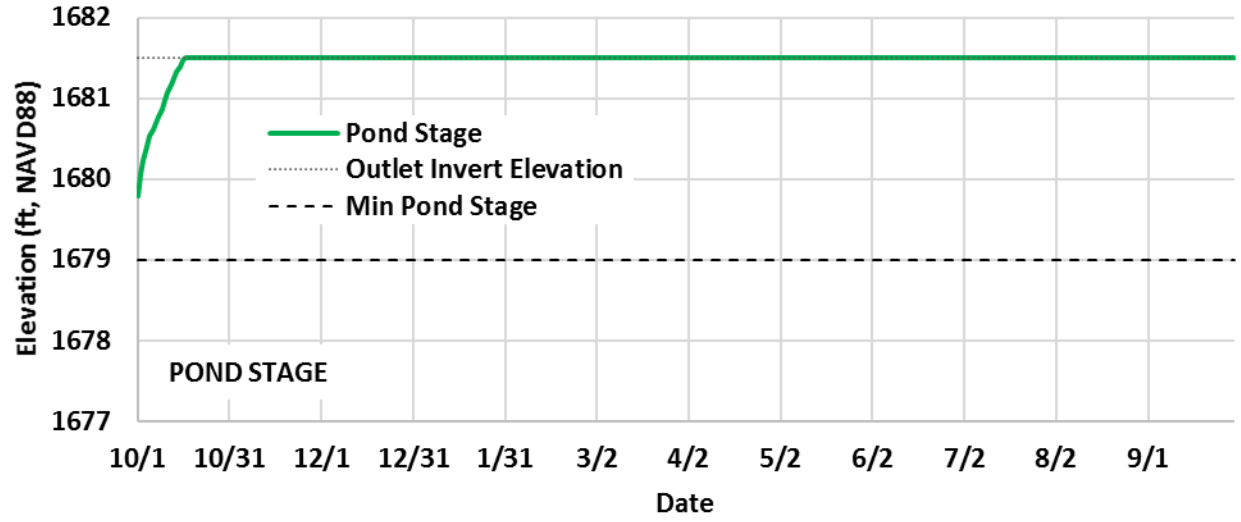
Notes: WY 2005 was at the 25th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2005 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 13**

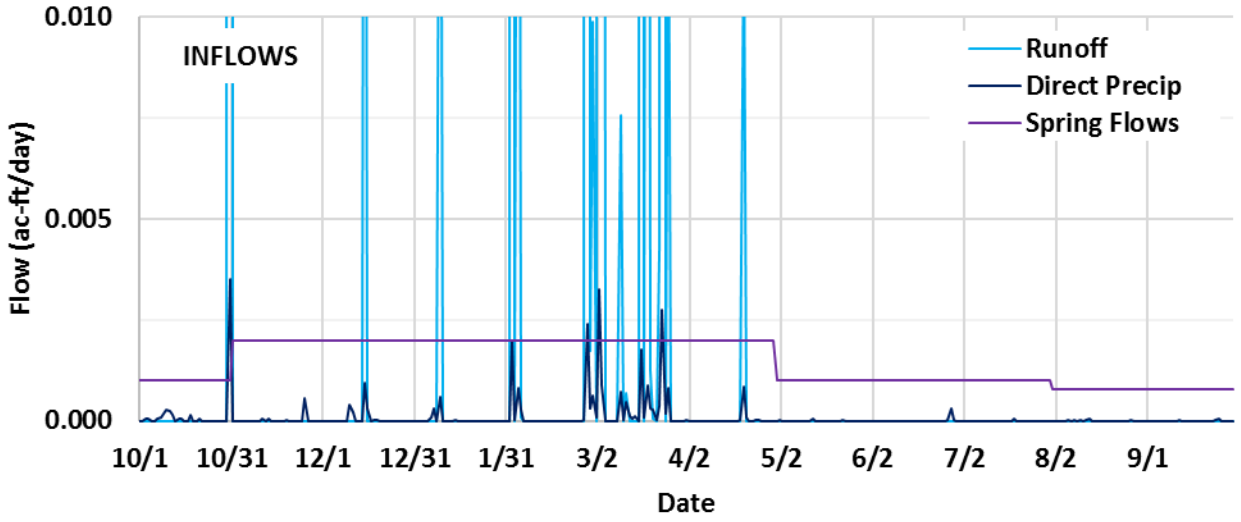


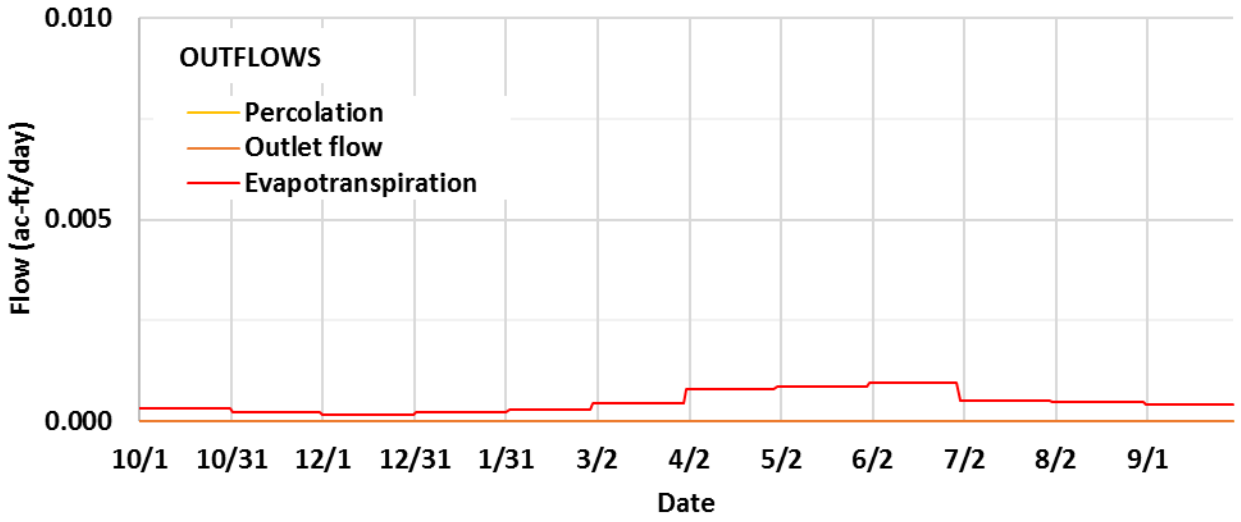




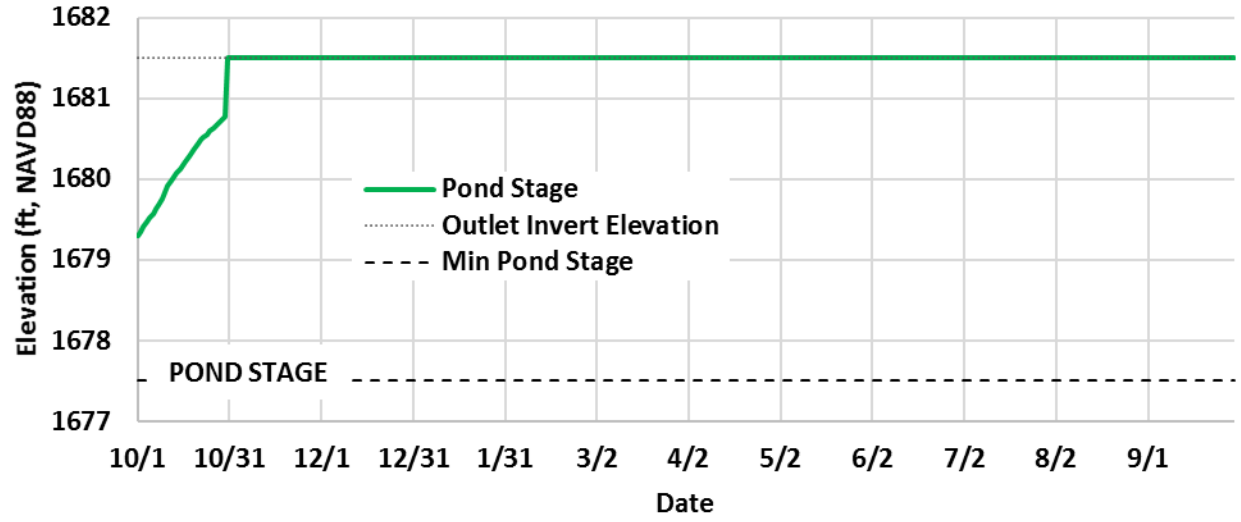
Notes: WY 2005 was at the 25th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2005 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 14**

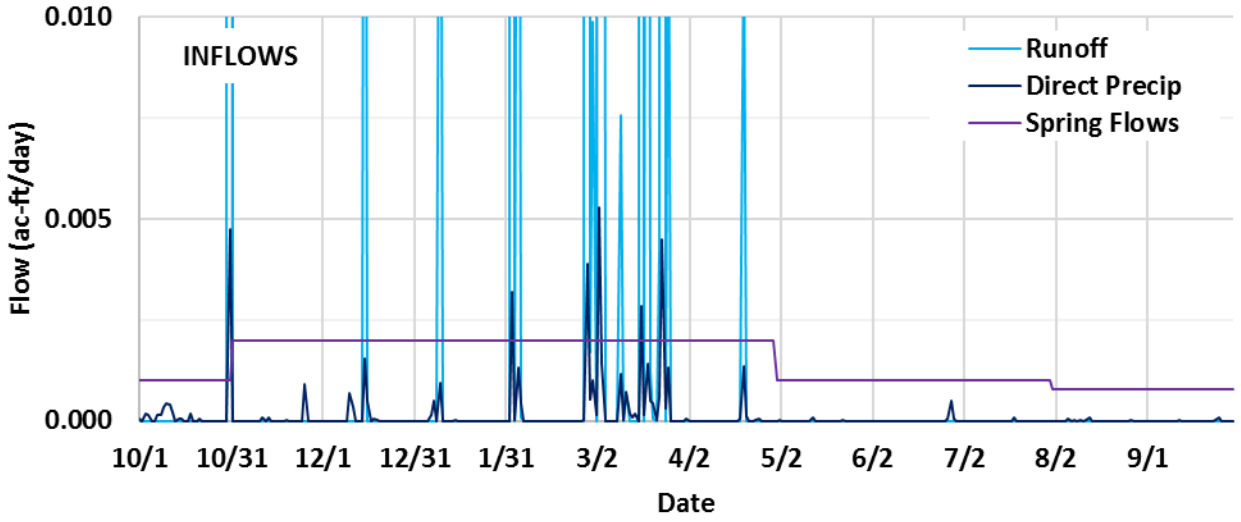


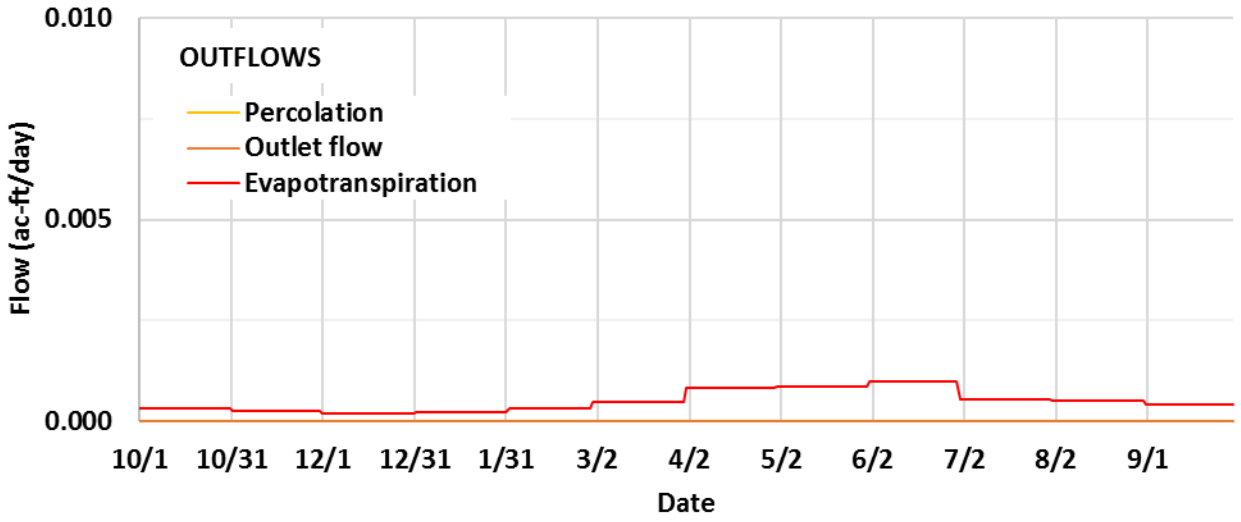




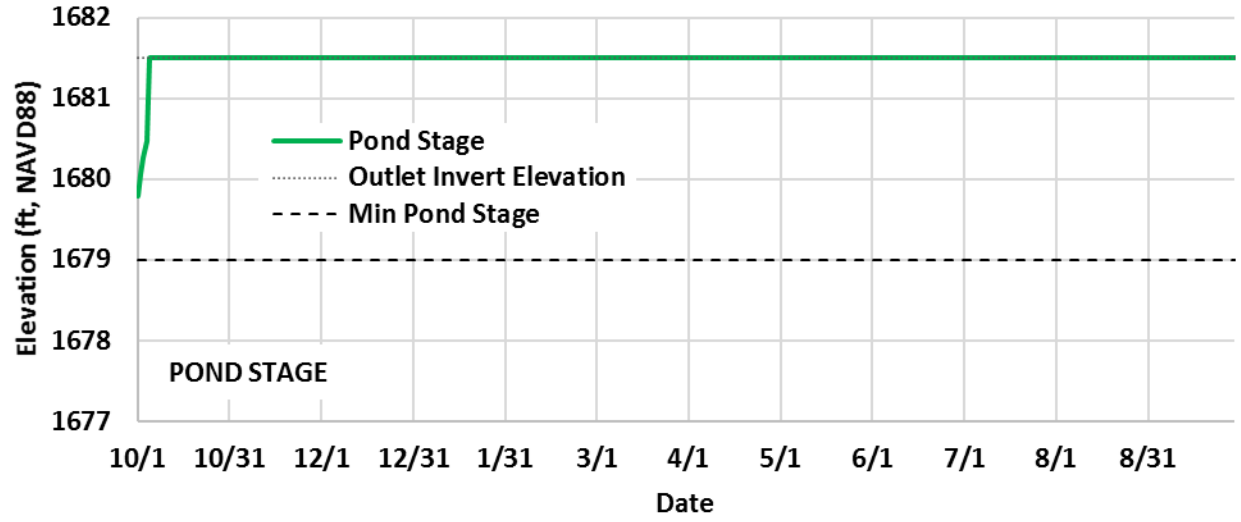
Notes: WY 1991 was at the 50th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 1991 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 15**

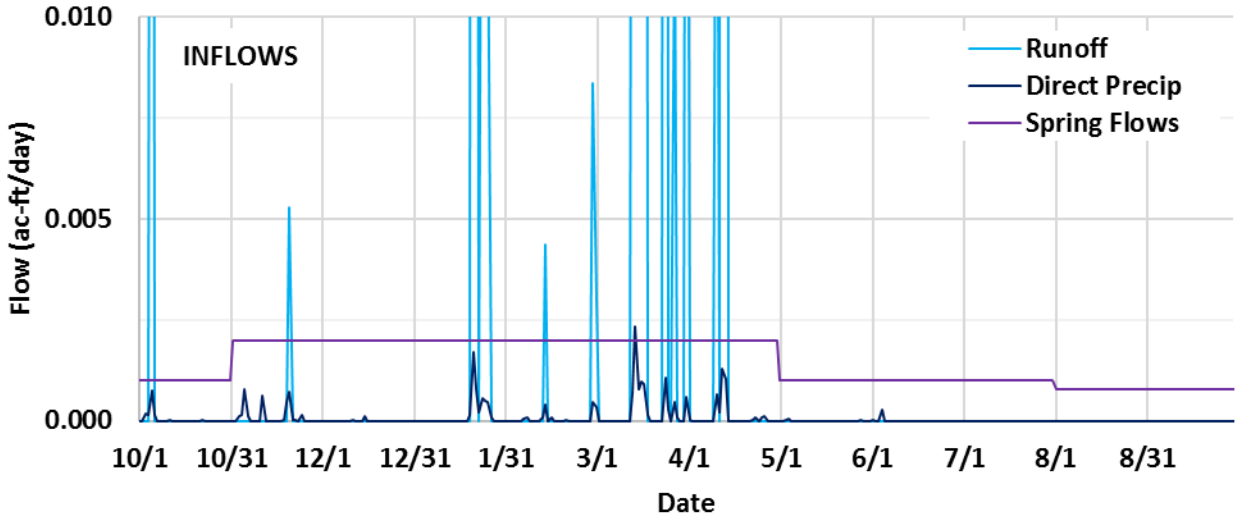


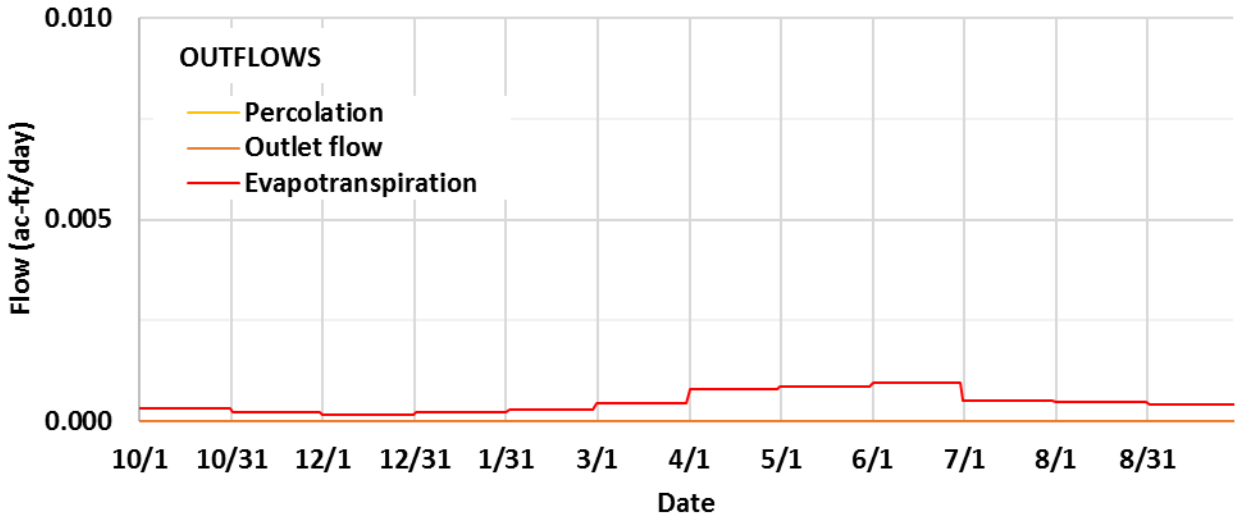




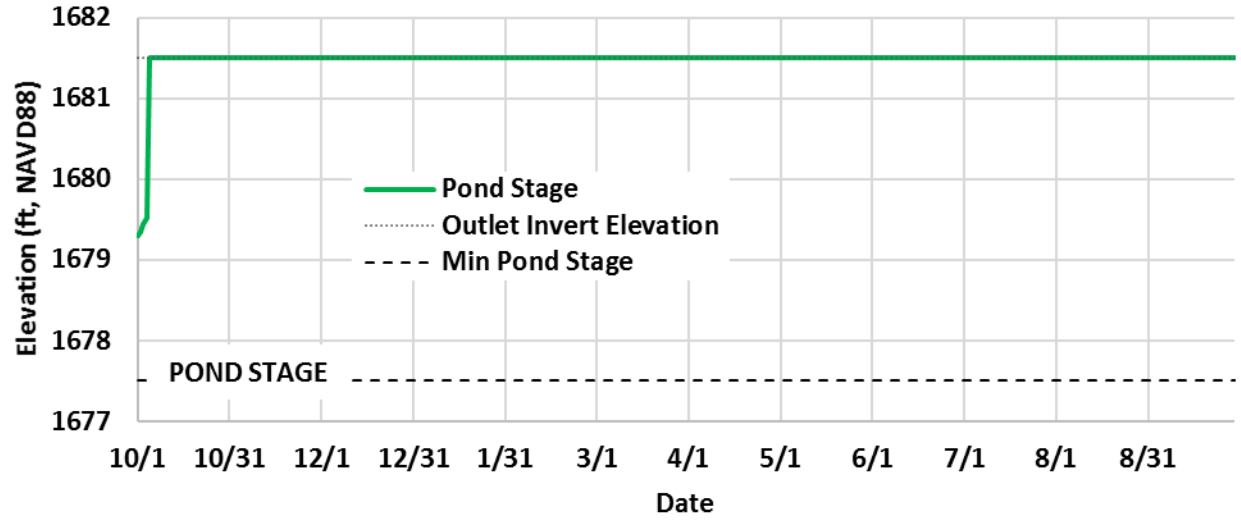
Notes: WY 1991 was at the 50th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 1991 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 16**

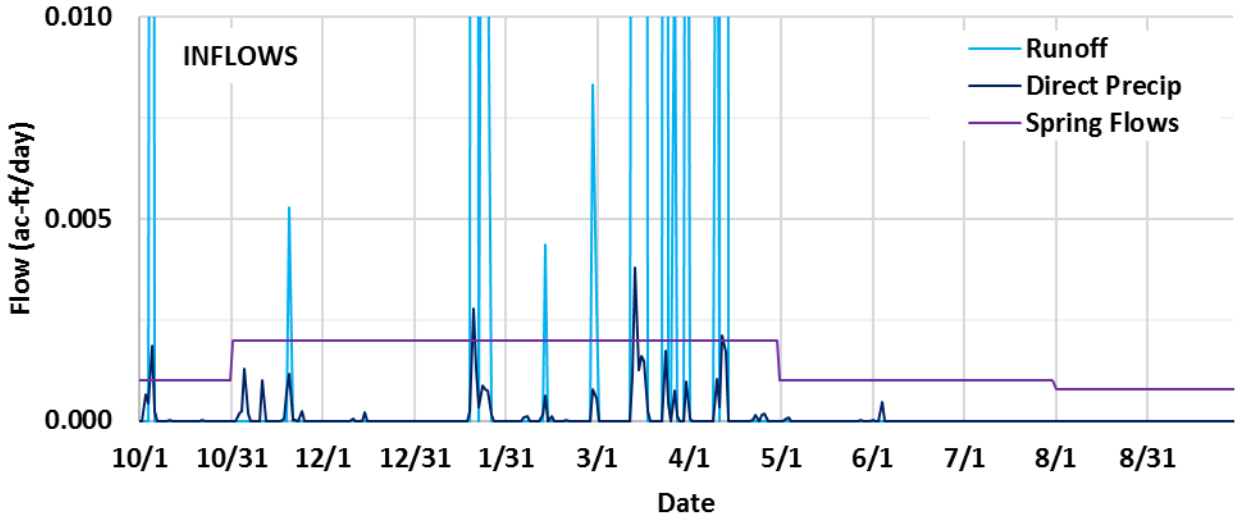


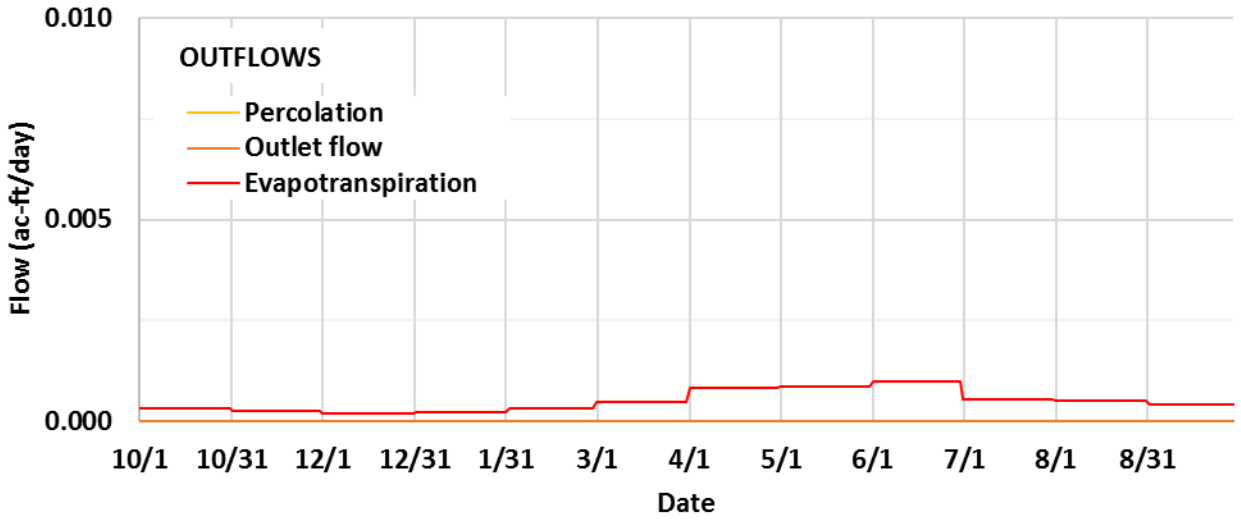




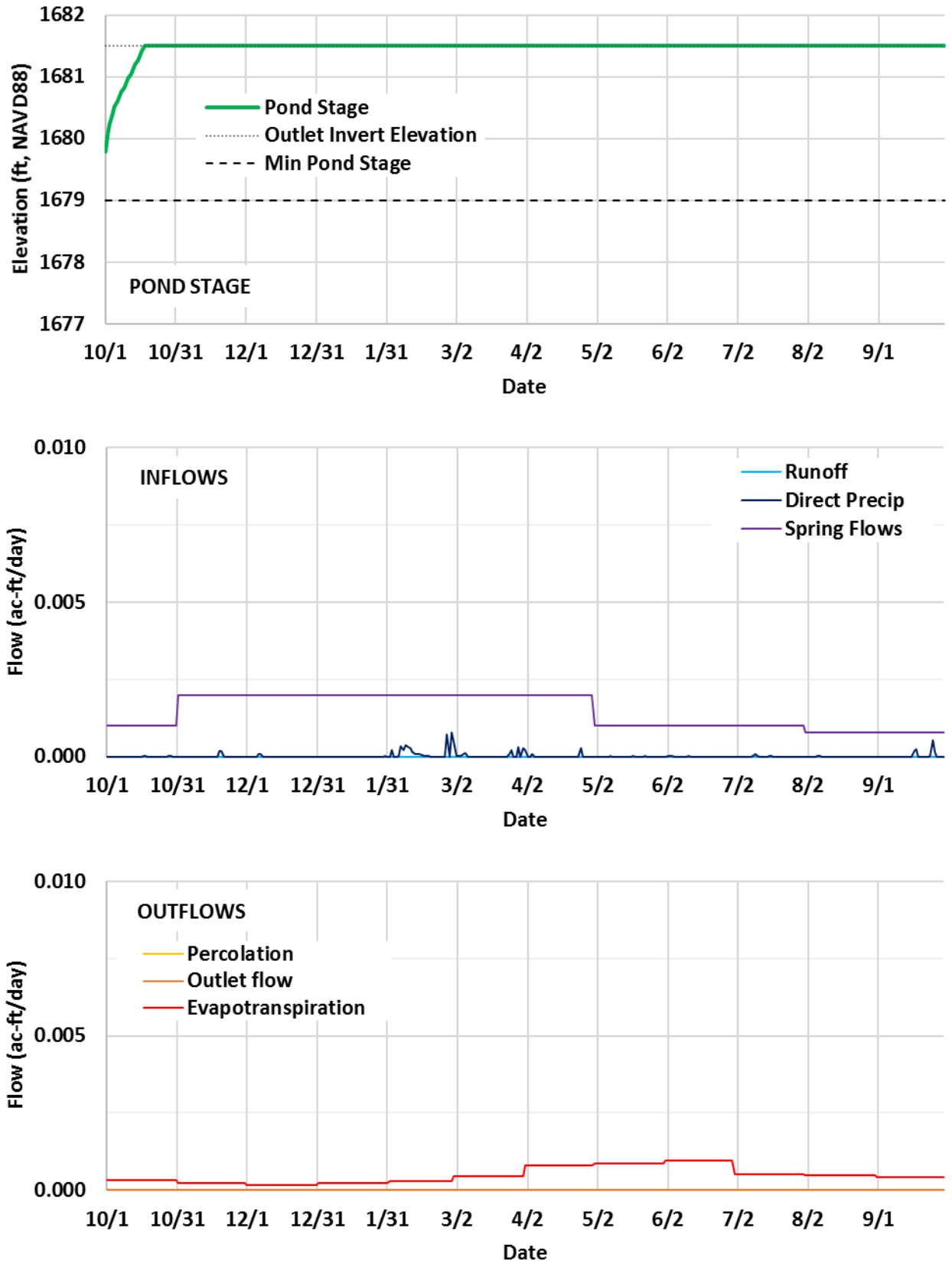
Notes: WY 2012 was at the 75th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2012 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 17**



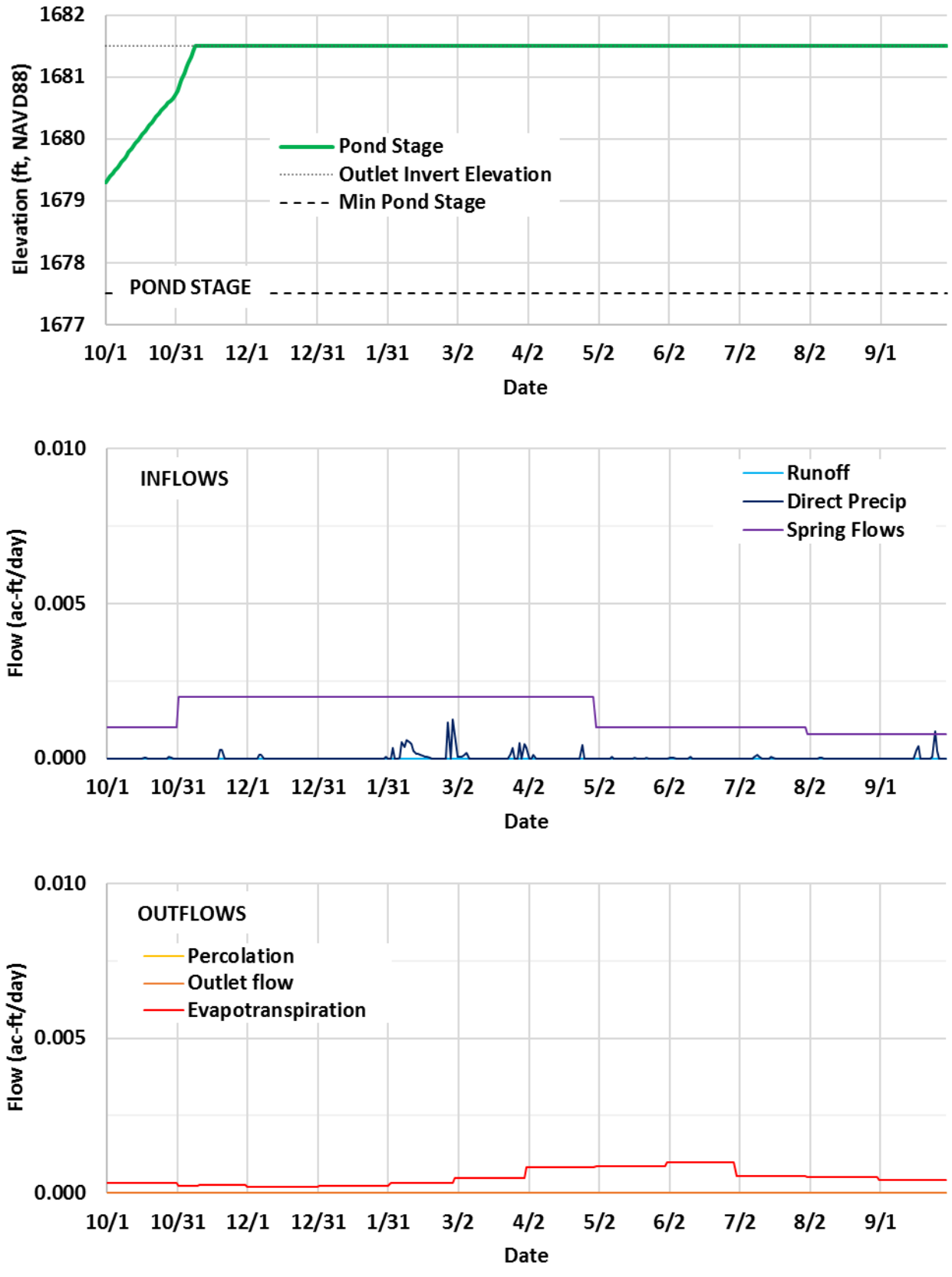




Notes: WY 2012 was at the 75th percentile for exceedance probability for total rainfall.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2012 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 18**



Notes: WY 2014 was the driest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2014 (eg)**		
		Project No. 18-1019	Created By: LST	**Figure 19**



Notes: WY 2014 was the driest water year of the examined record.	cbec eco engineering	*Mindego Ranch Ponds Enhancement* **Water Budget: Upper Spring: WY 2014 (fg)**		
		Project No. 18-1019	Created By: LST	**Figure 20**

Appendix A:

NRCS (SCS) Method to Determine 100-year Inflows

to Knuedler Lake and Upper Spring ponds

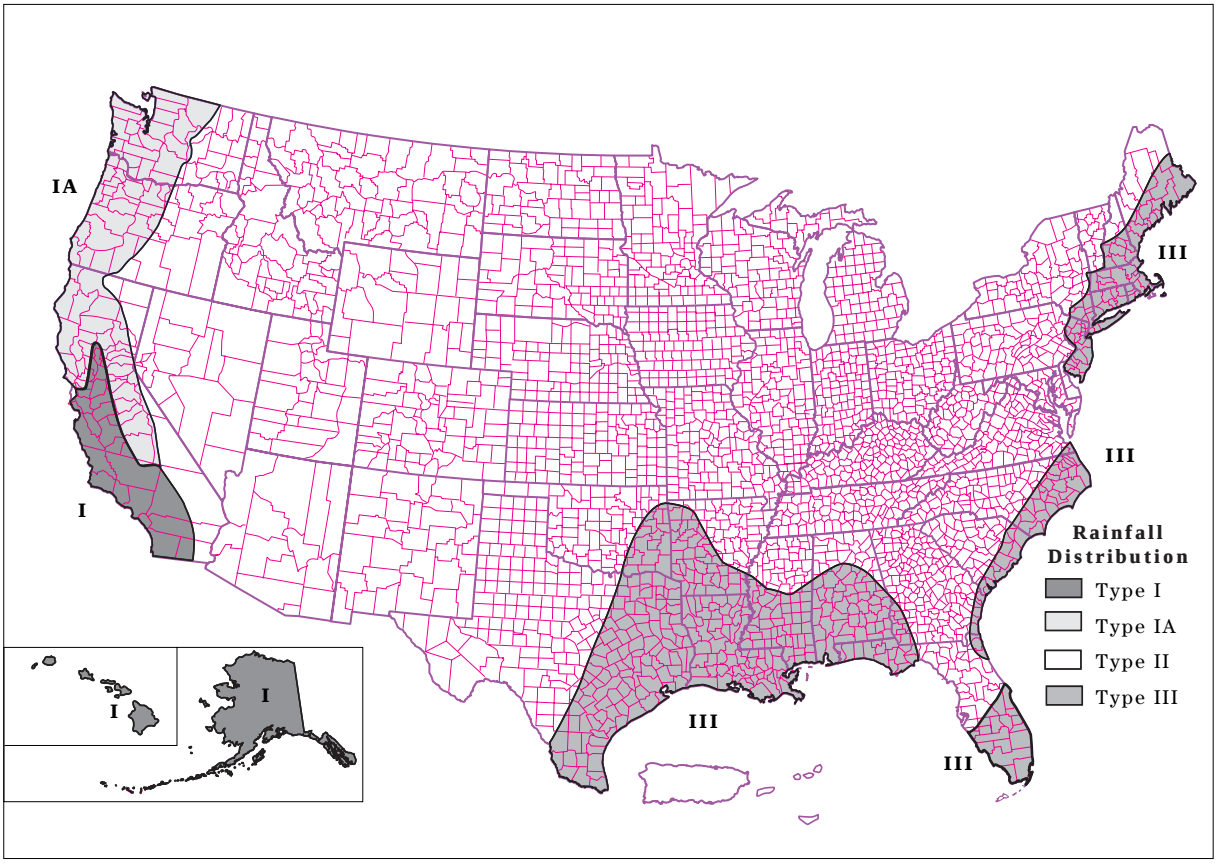
Appendix A:

Exhibit 1:

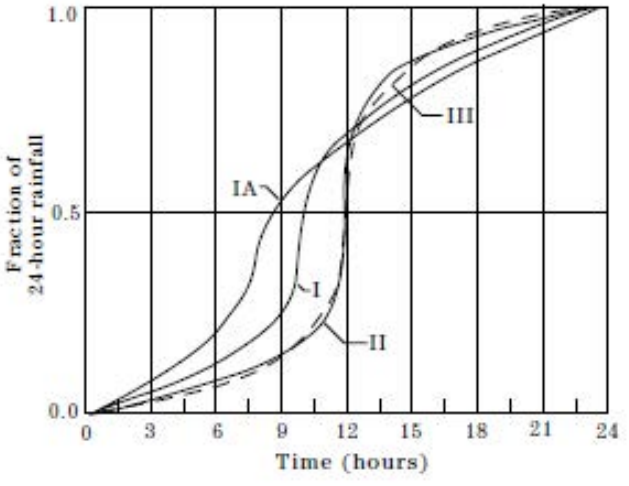
NRCS (SCS) Rainfall Distributions

(Figures adopted directly from TR-55)

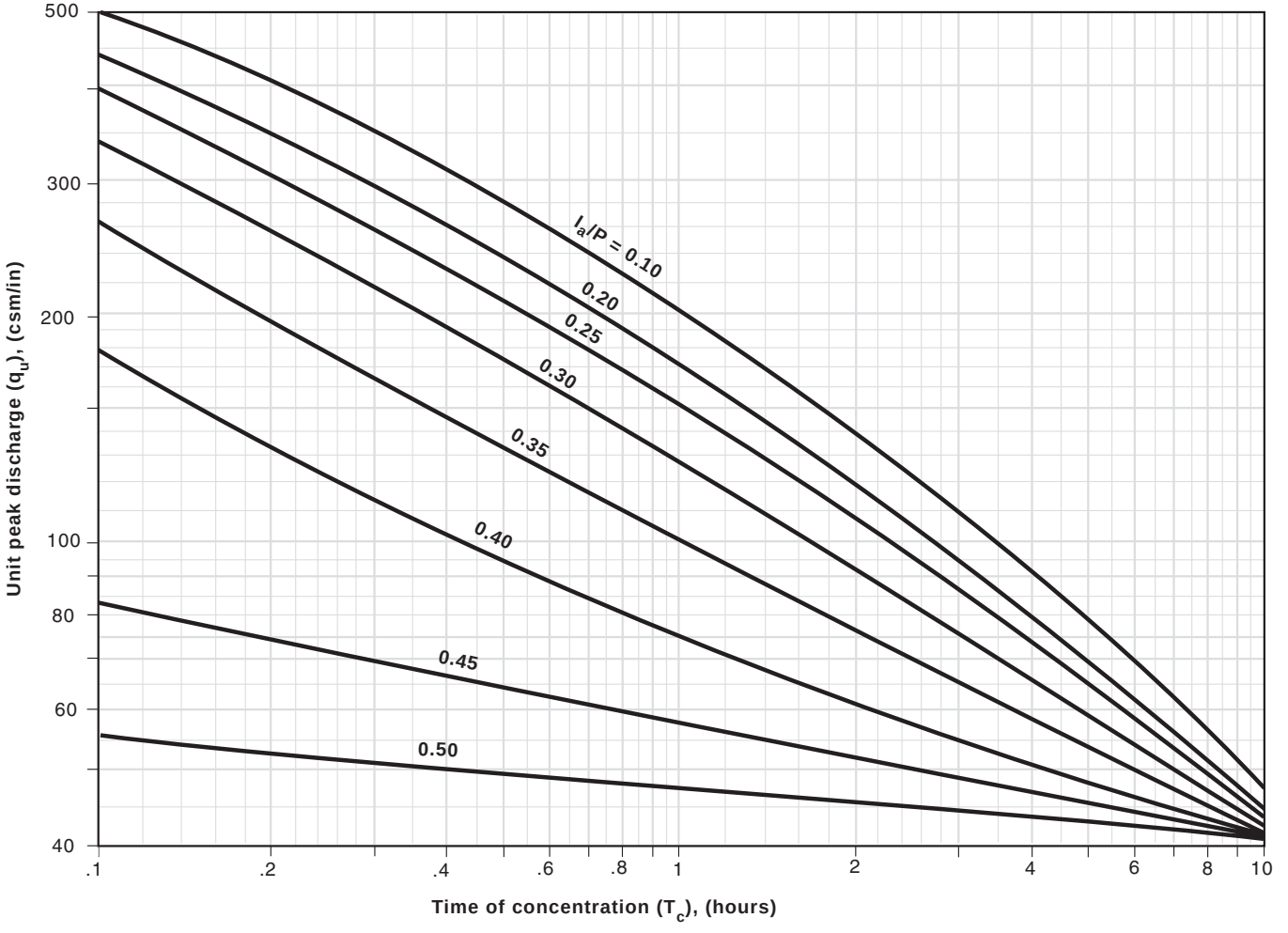
Approximate geographic boundaries for NRCS (SCS) rainfall distributions



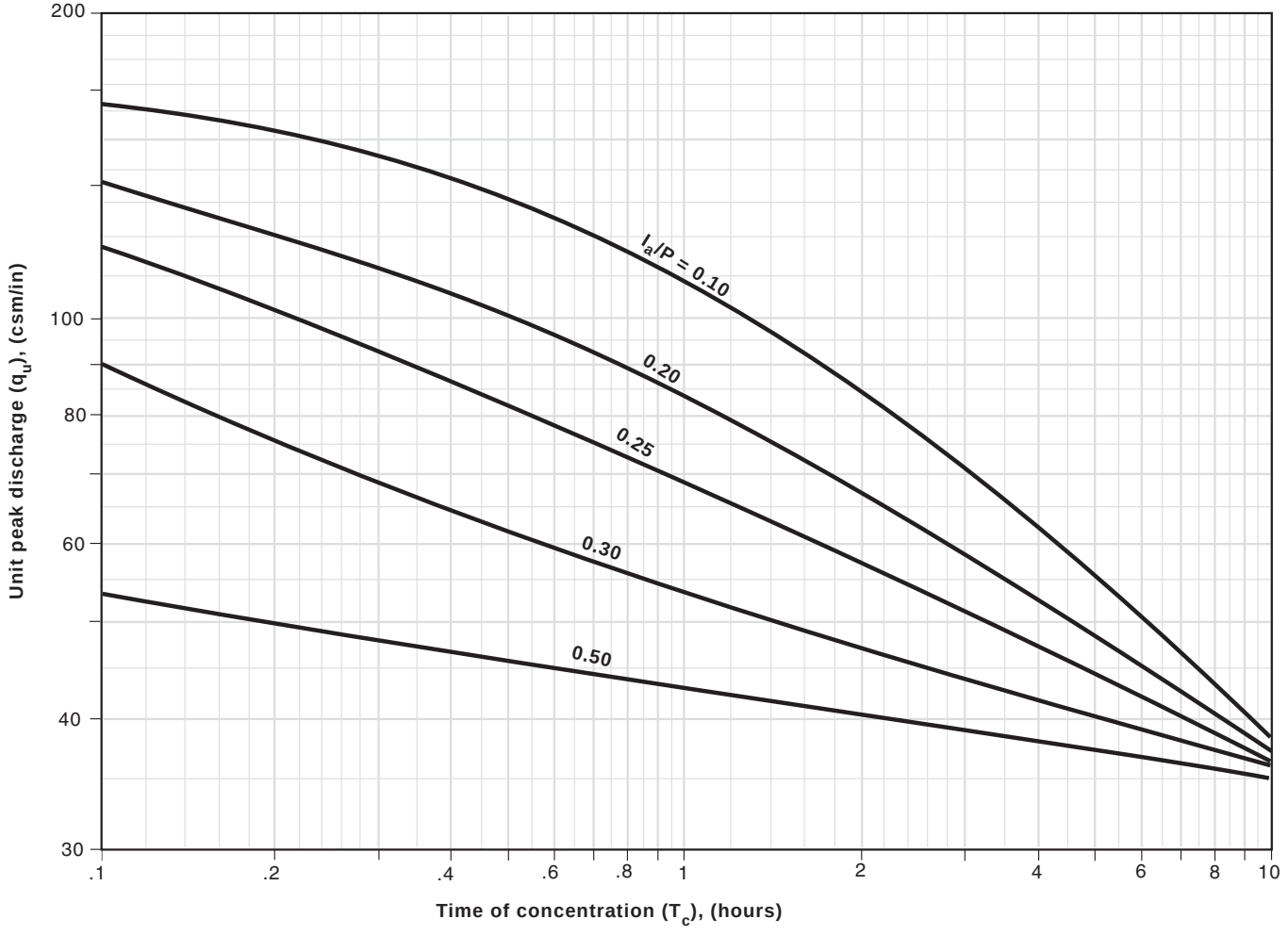
SCS 24-hour rainfall distributions



Unit peak discharge (q_u) for NRCS (SCS) type I rainfall distribution



Unit peak discharge (q_u) for NRCS (SCS) type IA rainfall distribution



Appendix A:

Exhibit 2:

Calculation of Peak Inflow

Precip (in)	
100-yr, 24hr	9.18

Total Runoff Volume	
Area (ac)	11.73
CN	76
I_a (in)	0.63
S (in)	3.16
Q (in)	6.24

Peak flow: 46 cfs

Knuedler

Time of Concentration

Sheet Flow	
n	0.25
L	300
P_2	3.98
s	0.3
T_t	0.18

Shallow conc. Flow	
L	1250
V	7.8
s	0.2
T_t	0.045

T_c	0.2

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

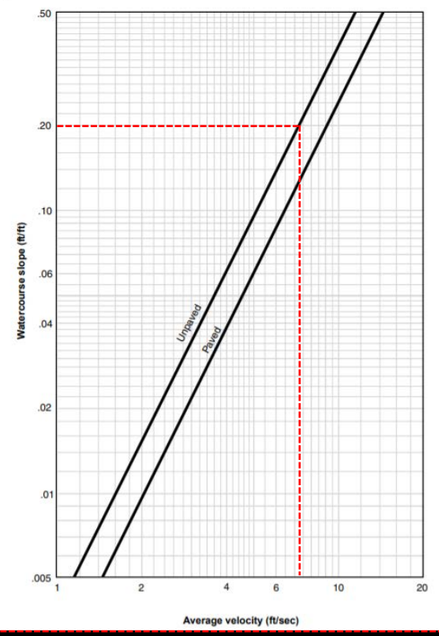
Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Peak Flow	
q_u	400
A_m	0.0183
Q	6.24
F_p	1
q_p	45.76

I_a/P	0.07
t_c (hour)	0.2

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is:

$$q_p = q_u A_m Q F_p \qquad \text{[eq. 4-1]}$$

where:

q_p = peak discharge (cfs)
q_u = unit peak discharge (csm/in)
A_m = drainage area (mi^2)
Q = runoff (in)
F_p = pond and swamp adjustment factor

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Exhibit 4-I Unit peak discharge (q_u) for NRCS (SCS) type I rainfall distribution

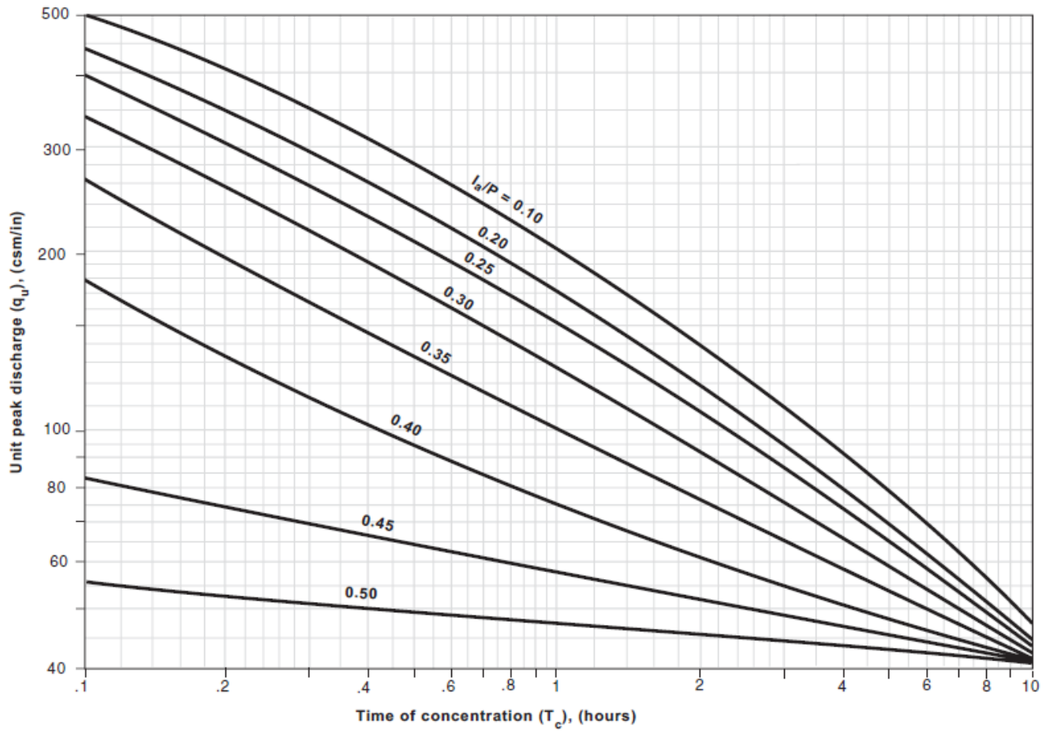


Table 4-2 Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Upper Spring

Precip (in)	
100-yr, 24hr	9.18

Peak flow: 17 cfs

Total Runoff Volume	
Area (ac)	5.59
CN	65
I_a (in)	1.08
S (in)	5.38
Q (in)	4.87

Time of Concentration

Sheet Flow	
n	0.25
L	300
P_2	3.98
s	0.5
T_t	0.15

Shallow conc. Flow	
L	600
V	6.4
s	0.15
T_t	0.026

T_c	0.2

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

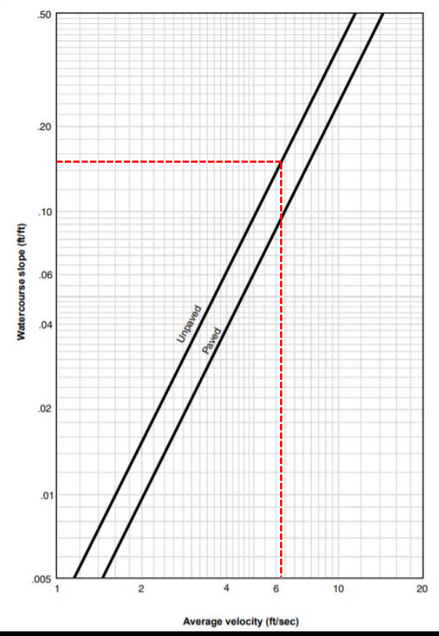
Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

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After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

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Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Peak Flow	
q_u	400
A_m	0.0087
Q	4.87
F_p	1
q_p	17.01

I_a/P	0.12
t_c (hour)	0.2

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is:

$$q_p = q_u A_m Q F_p \qquad \text{[eq. 4-1]}$$

where:

q_p = peak discharge (cfs)
q_u = unit peak discharge (csm/in)
A_m = drainage area (mi^2)
Q = runoff (in)
F_p = pond and swamp adjustment factor

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Exhibit 4-I Unit peak discharge (q_u) for NRCS (SCS) type I rainfall distribution

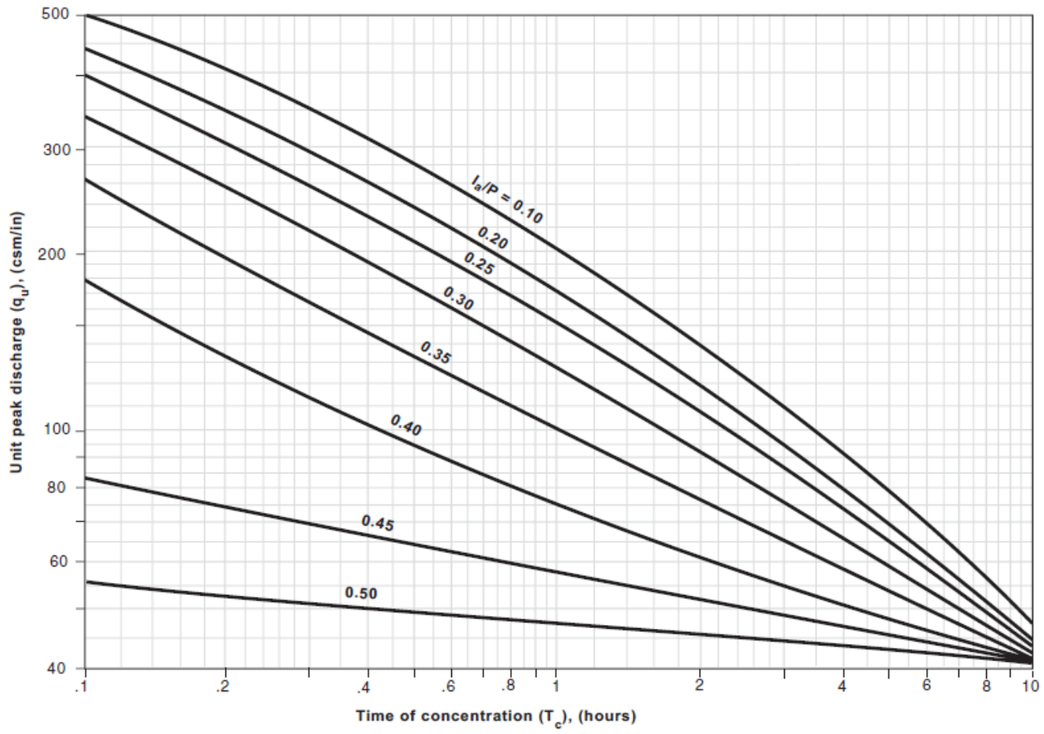


Table 4-2 Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Appendix B:

Water Budget Model:

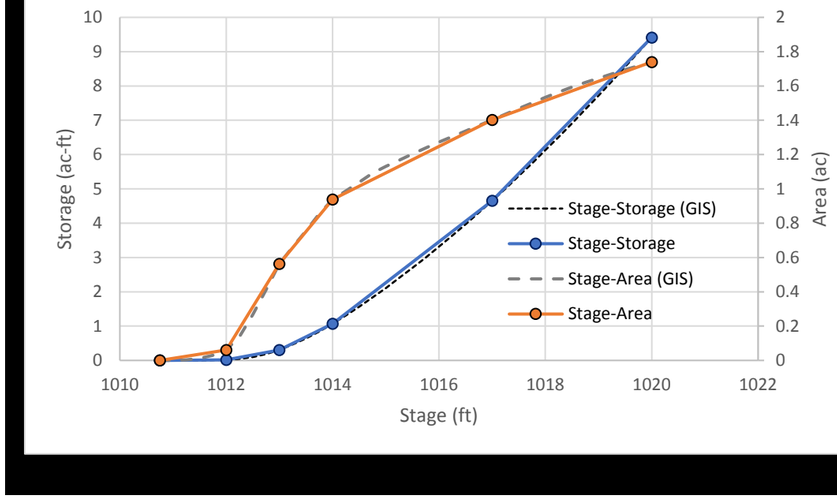
Parameter Entry and Example Calculation

Knuedler Lake

Hypsometry: eg

Hypsometry (ascending stage)		
Stage (ft)	Storage (ac-ft)	Area (ac)
1010.75	0	0
1012	0.019709166	0.06042
1013	0.30757791	0.56286
1014	1.069765123	0.93822
1017	4.655649535	1.40211
1020	9.414675161	1.73999

Hypsometry (descending stage)		
Stage (ft)	Storage (ac-ft)	Area (ac)
1020	9.414675161	1.73999
1017	4.655649535	1.40211
1014	1.069765123	0.93822
1013	0.30757791	0.56286
1012	0.019709166	0.06042
1010.75	0	0



	Factor	2.3E-05		

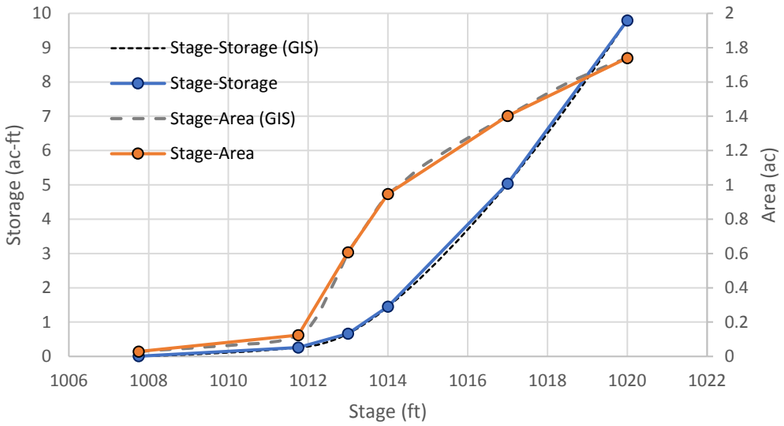
GIS Hypsometry				
Stage (ft)	Area (ft^2)	Vol (ft^3)	Area (ac)	Area (ac-ft)
1010.75	0	0	0	0
1011	10	0.375	0.00023	8.6088E-06
1011.25	176	23.09375	0.00404	0.00053016
1011.5	548	114.9688	0.01258	0.00263932
1011.75	1334	352.3438	0.030624	0.0080887
1012	2632	858.5313	0.060422	0.01970917
1012.25	6092	1925.531	0.139853	0.04420412
1012.5	11657	4187.219	0.267608	0.09612532
1012.75	18004	7978.313	0.413315	0.18315685
1013	24518	13398.09	0.562856	0.30757791
1013.25	28833	20162.63	0.661915	0.46287018
1013.5	32902	27935.28	0.755326	0.64130581
1013.75	37197	36752.41	0.853926	0.84371915
1014	40869	46598.97	0.938223	1.06976512
1014.25	43035	57130.72	0.987948	1.31154083
1014.5	45233	68185.53	1.038407	1.56532441
1014.75	47541	79832.81	1.091391	1.83270919
1015	49307	91968.94	1.131933	2.11131629
1015.25	50848	104513.1	1.167309	2.39928977
1015.5	52401	117446	1.202961	2.69618988
1015.75	53937	130760.5	1.238223	3.00184803
1016	55424	144453	1.27236	3.31618529
1016.25	56854	158512.7	1.305188	3.63894987
1016.5	58257	172926	1.337397	3.96983399
1016.75	59669	187685.8	1.369812	4.30867195
1017	61076	202800.1	1.402112	4.65564954
1017.25	62554	218273.7	1.436042	5.01087365
1017.5	63944	234110.5	1.467952	5.37443756
1017.75	65368	250293.9	1.500643	5.74595816
1018	66790	266837.1	1.533287	6.12573605
1018.25	68130	283725.7	1.56405	6.51344553
1018.5	69391	300938.8	1.592998	6.90860451
1018.75	70565	318452.3	1.619949	7.31065771
1019	71681	336252.1	1.645569	7.7192859
1019.25	72756	354325.7	1.670248	8.13419852
1019.5	73819	372664.8	1.694651	8.55520618
1019.75	74819	391261.1	1.717608	8.98211877
1020	75794	410103.3	1.739991	9.41467516

Warnings: NONE

Hypsometry: fg

Hypsometry (ascending stage)		
Stage (ft)	Storage (ac-ft)	Area (ac)
1007.75	0.006553461	0.02867
1011.75	0.257263688	0.12397
1013	0.662676481	0.60728
1014	1.449165662	0.94745
1017	5.037437586	1.40211
1020	9.796463212	1.73999

Hypsometry (descending stage)		
Stage (ft)	Storage (ac-ft)	Area (ac)
1020	9.796463212	1.73999
1017	5.037437586	1.40211
1014	1.449165662	0.94745
1013	0.662676481	0.60728
1011.75	0.257263688	0.12397
1007.75	0.006553461	0.02867



	Factor	2.3E-05		

GIS Hypsometry				
Stage (ft)	Area (ft^2)	Vol (ft^3)	Area (ac)	Area (ac-ft)
1007.75	1249	285.4688	0.028673	0.00655346
1008	1428	624	0.032782	0.01432507
1008.25	1600	1005.375	0.036731	0.02308023
1008.5	1763	1428.125	0.040473	0.03278524
1008.75	1931	1893.188	0.04433	0.0434616
1009	2098	2400	0.048163	0.05509642
1009.25	2275	2949.25	0.052227	0.06770546
1009.5	2442	3540.875	0.056061	0.0812873
1009.75	2615	4175.813	0.060032	0.09586346
1010	2787	4853.938	0.063981	0.11143107
1010.25	2971	5576.344	0.068205	0.12801524
1010.5	3144	6342.625	0.072176	0.14560663
1010.75	3321	7153.219	0.07624	0.16421531
1011	3517	8009.656	0.080739	0.18387641
1011.25	3863	8934.406	0.088682	0.20510574
1011.5	4419	9974.25	0.101446	0.22897727
1011.75	5400	11206.41	0.123967	0.25726369
1012	6906	12757.5	0.15854	0.2928719
1012.25	10511	14918.44	0.241299	0.3424802
1012.5	15647	18244.47	0.359206	0.41883537
1012.75	20849	22870.34	0.478627	0.52503085
1013	26453	28866.19	0.607277	0.66267648
1013.25	30245	36031.53	0.69433	0.82717014
1013.5	33975	44109.66	0.779959	1.01261837
1013.75	37915	53145.09	0.870409	1.22004347
1014	41271	63125.66	0.947452	1.44916566
1014.25	43216	73724.78	0.992103	1.69248809
1014.5	45294	84805.63	1.039807	1.94686926
1014.75	47559	96461.19	1.091804	2.21444416
1015	49310	108599.3	1.132002	2.49309788
1015.25	50848	121143.8	1.167309	2.78107782
1015.5	52401	134076.7	1.202961	3.07797793
1015.75	53937	147391.2	1.238223	3.38363608
1016	55424	161083.7	1.27236	3.69797334
1016.25	56854	175143.3	1.305188	4.02073792
1016.5	58257	189556.7	1.337397	4.35162204
1016.75	59669	204316.4	1.369812	4.69046
1017	61076	219430.8	1.402112	5.03743759
1017.25	62554	234904.3	1.436042	5.3926617
1017.5	63944	250741.2	1.467952	5.75622561
1017.75	65368	266924.6	1.500643	6.12774621
1018	66790	283467.8	1.533287	6.5075241

Warnings: NONE

Evapotranspiration

CIMIS Reference ET - Inches per Month													
Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.4	2.48	3.3	4.03	4.5	4.65	4.03	3.3	2.48	1.2	0.62	32.9
2	1.24	1.68	3.1	3.9	4.65	5.1	4.96	4.65	3.9	2.79	1.8	1.24	39.0
3	1.86	2.24	3.72	4.8	5.27	5.7	5.58	5.27	4.2	3.41	2.4	1.86	46.3
4	1.86	2.24	3.41	4.5	5.27	5.7	5.89	5.58	4.5	3.41	2.4	1.86	46.6
5	0.93	1.68	2.79	4.2	5.58	6.3	6.51	5.89	4.5	3.1	1.5	0.93	43.9
6	1.86	2.24	3.41	4.8	5.58	6.3	6.51	6.2	4.8	3.72	2.4	1.86	49.7
7	0.62	1.4	2.48	3.9	5.27	6.3	7.44	6.51	4.8	2.79	1.2	0.62	43.3
8	1.24	1.68	3.41	4.8	6.2	6.9	7.44	6.51	5.1	3.41	1.8	0.93	49.4
9	2.17	2.8	4.03	5.1	5.89	6.6	7.44	6.82	5.7	4.03	2.7	1.86	55.1
10	0.93	1.68	3.1	4.5	5.89	7.2	8.06	7.13	5.1	3.1	1.5	0.93	49.1
11	1.55	2.24	3.1	4.5	5.89	7.2	8.06	7.44	5.7	3.72	2.1	1.55	53.1
12	1.24	1.96	3.41	5.1	6.82	7.8	8.06	7.13	5.4	3.72	1.8	0.93	53.4
13	1.24	1.96	3.1	4.8	6.51	7.8	8.99	7.75	5.7	3.72	1.8	0.93	54.3
14	1.55	2.24	3.72	5.1	6.82	7.8	8.68	7.75	5.7	4.03	2.1	1.55	57.0
15	1.24	2.24	3.72	5.7	7.44	8.1	8.68	7.75	5.7	4.03	2.1	1.24	57.9
16	1.55	2.52	4.03	5.7	7.75	8.7	9.3	8.37	6.3	4.34	2.4	1.55	62.5
17	1.86	2.8	4.65	6	8.06	9	9.92	8.68	6.6	4.34	2.7	1.86	66.5
18	2.48	3.36	5.27	6.9	8.68	9.6	9.61	8.68	6.9	4.96	3	2.17	71.6

CIMIS Zone	3

Reference ET - Inches per Day		
Month	Month (numeric)	Daily Ref ET
Jan	1	0.06
Feb	2	0.08
Mar	3	0.12
Apr	4	0.16
May	5	0.17
Jun	6	0.19
Jul	7	0.18
Aug	8	0.17
Sep	9	0.14
Oct	10	0.11
Nov	11	0.08
Dec	12	0.06

Constant Pond Vegetation ET	
Pond Vegetative Area (ac)	1.06
Submergence stage (ft)	1016

Reference ET for Selected Zone (3)												
Monthly	1.86	2.24	3.72	4.8	5.27	5.7	5.58	5.27	4.2	3.41	2.4	1.86
Daily	0.06	0.08	0.12	0.16	0.17	0.19	0.18	0.17	0.14	0.11	0.08	0.06

https://cimis.water.ca.gov/Content/PDF/CimisRefEvapZones.pdf

Days Per Month												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
31	28	31	30	31	30	31	31	30	31	30	31	

Kc Values				
Month	Month (numeric)	Pond OW	Pond Veg.	Basin
Jan	1	1.05	0.9	0.25
Feb	2	1.05	0.9	0.25
Mar	3	1.05	0.9	0.25
Apr	4	1.05	1.2	0.25
May	5	1.05	1.2	0.25
Jun	6	1.05	1.2	0.25
Jul	7	1.05	0.7	0.25
Aug	8	1.05	0.7	0.25
Sep	9	1.05	0.7	0.25
Oct	10	1.05	0.7	0.25
Nov	11	1.05	0.7	0.25
Dec	12	1.05	0.7	0.25



Gage Data	
Date	Precip (in)
10/1/1990	0.04
10/2/1990	0
10/3/1990	0.16
10/4/1990	0.12
10/5/1990	0
10/6/1990	0
10/7/1990	0.12
10/8/1990	0.12
10/9/1990	0.28
10/10/1990	0.35
10/11/1990	0.31
10/12/1990	0.16
10/13/1990	0
10/14/1990	0.04
10/15/1990	0.04
10/16/1990	0
10/17/1990	0
10/18/1990	0.12
10/19/1990	0
10/20/1990	0
10/21/1990	0.04
10/22/1990	0
10/23/1990	0
10/24/1990	0
10/25/1990	0
10/26/1990	0
10/27/1990	0
10/28/1990	0
10/29/1990	0
10/30/1990	0
10/31/1990	2.95
11/1/1990	0
11/2/1990	0
11/3/1990	0
11/4/1990	0
11/5/1990	0
11/6/1990	0
11/7/1990	0
11/8/1990	0
11/9/1990	0
11/10/1990	0
11/11/1990	0.04
11/12/1990	0

PRISM MAP Scaling		
Location	mm	in
Precip Station	843	33.19
Site	900	35.43
Site / Precip		1.07

Precipitation

Month	Month (Numeric)	Spring Flow (cfs)
Jan	1	0.01
Feb	2	0.01
Mar	3	0.01
Apr	4	0.01
May	5	0.005
Jun	6	0.005
Jul	7	0.005
Aug	8	0.004
Sep	9	0.004
Oct	10	0.005
Nov	11	0.01
Dec	12	0.01

Spring Flows

Curve Number

TR-55 Parameters	
Area (ac)	11.73
CN	76
Initial Abstraction (I_a)	0.63
Storage (S)	3.16

Constrained CN's for continuous sim.	
CN min	76
CN max	90

Percolation	
Pond (in/day)	0.00

soil moisture accounting procedure (existing/previously developed) in SWAT and APEX overestimates runoff in shallow soils and soils with low storage. For better estimation of runoff under those situations, the present soil moisture accounting procedure is developed.

BACKGROUND

The CN runoff equation is given by

$$Q = \frac{(P - 0{\cdot}2S)^2}{P + 0{\cdot}8S} \quad (1)$$

where Q is the depth of runoff, P is the depth of rainfall and S is a retention parameter. The retention parameter is related to the CN as follows:

$$S = \frac{1000}{\mathrm{CN}} - 10 \quad (2)$$

The value of S in the CN method is related to watershed features and antecedent moisture conditions. To be used in continuous hydrologic modelling, the parameter S should be linked to a sound continuous soil moisture accounting procedure. Most of the existing models (e.g. SWAT, EPIC, APEX) use a procedure that links S with available soil water capacity of soil and use the CN methodology in continuous simulation. The model predictions of runoff will be more realistic if the parameter S is linked to soil moisture depletion, rather than to soil available water capacity. Williams and LaSeur (1976) were the first to incorporate this idea in the CN method (Equations (3)–(5)). The model has an upper limit (508 mm) for moisture storage in soil. This method avoids sudden jumps in CN from one moisture condition to another and yet allows CN values to vary widely from 33·3 to 100. The model calibration is based on the adjustment of depletion coefficient B (Equation (4)) until the predicted average annual surface runoff closely matches the observed value. One year of rainfall–runoff data is used to get a realistic initial estimate of soil moisture. Arbitrary fixing of a maximum value of moisture storage in the soil V and a loss of 1 year's rainfall–runoff information can be viewed as the limitations of this method (Mishra and Singh, 2004):

$$\mathrm{SM} = V - S \quad (3)$$

where SM is the soil moisture index.

$$\mathrm{SM}_t = \frac{\mathrm{SM}}{1{\cdot}0 + B \times \mathrm{SM} \sum_{t=1}^{T} \mathrm{PET}_t} \quad (4)$$

where SM_t is the soil moisture index at any time t, B is the moisture depletion coefficient and PET_t is the average monthly lake evaporation for day t.

Hawkins (1978) related evapotranspiration ET and CN and formulated a continuous soil moisture accounting procedure for the use of the CN methodology in continuous hydrologic simulation. The relationship is given by

$$\mathrm{CN}_t = \frac{1200}{\left(\frac{1200}{\mathrm{CN}_{t-1}}\right) + [\mathrm{ET} - (P - Q)]_t} \quad (5)$$

where CN_t is the CN at time t, CN_{t-1} is the CN at the previous time step, ET is evapotranspiration at time t, P is rainfall depth at time t and Q is runoff depth at time t.

Similar to the soil moisture accounting procedure developed by Williams and LaSeur (1976), the procedure developed by Hawkins (Equation (5)) avoids sudden jumps in CN value from one moisture condition to another. However, it allows an additional storage space of 20% of S available for water retention at every time interval, which in turn results in negative infiltration under no-rainfall conditions (Mishra and Singh, 2004).

Recently, Mishra and Singh (2004) proposed a model for the CN methodology involving four parameters (a parameter for the static portion of infiltration amount, a storage coefficient, a base flow storage coefficient, and a potential maximum retention parameter). The model parameters can be derived either physically or from rainfall–runoff data. The model was applied to the Hemavati watershed in India and found to give satisfactory results for monthly and annual runoff (Mishra and Singh, 2004).

Although the method proposed by Mishra and Singh (2004) is proved to work well, it requires estimation and calibration of four parameters, which might be difficult under most modelling situations. Considering the limitations of the previous methodologies, an alternate methodology is proposed (Williams *et al.*, 2000) and is given in Equation (6). Operation of the model, sensitivity of the model parameter and the behaviour of the proposed method with different evapotranspiration methods are discussed in this article:

$$S_t = S_{t-1} + \mathrm{PET}_t \exp\left(\frac{-BS_{t-1}}{S_{\max}}\right) - P + Q \quad (6)$$

where S_t is the retention parameter at the present time step, S_{t-1} is the retention parameter at the previous time step, B is the depletion coefficient (theoretically varies from 0 to 2), P is the rainfall depth at the previous time step, Q is the runoff depth at the previous time step, and $S_{\max}$ is the maximum value of the retention parameter.

MODEL OPERATION AND CALIBRATION

An initial estimate of S is obtained based on the existing value of CN_2 (condition II CN). The maximum value of the retention parameter $S_{\max}$ is obtained by substituting CN_1 (condition I CN, which can be derived from CN_2) in Equation (2). The initial estimate of runoff is obtained using the values of S and P in Equation (1). During a rainfall event, the retention parameter is calculated (using Equation (6)) as the sum of the initial estimate of S_{t-1}, potential evapotranspiration (PET) at the present

Gravity Flow through Outlet

TRUE TRUE

Warnings: NONE

Inc. (ft)	0.25
Min Stage	1013.5
Max Stage	1017

Outlet Attributes (Ascending Stage)

Stage (ft, NAVD88)	Weir Length (ft)	Weir Coeff
1013.5	8.85	0.03
1014	12.92	0.01
1015	22.23	0.0075
1016	40.99	0.005
1017	67.72	0.0032

Outlet Attributes (Descending Stage)

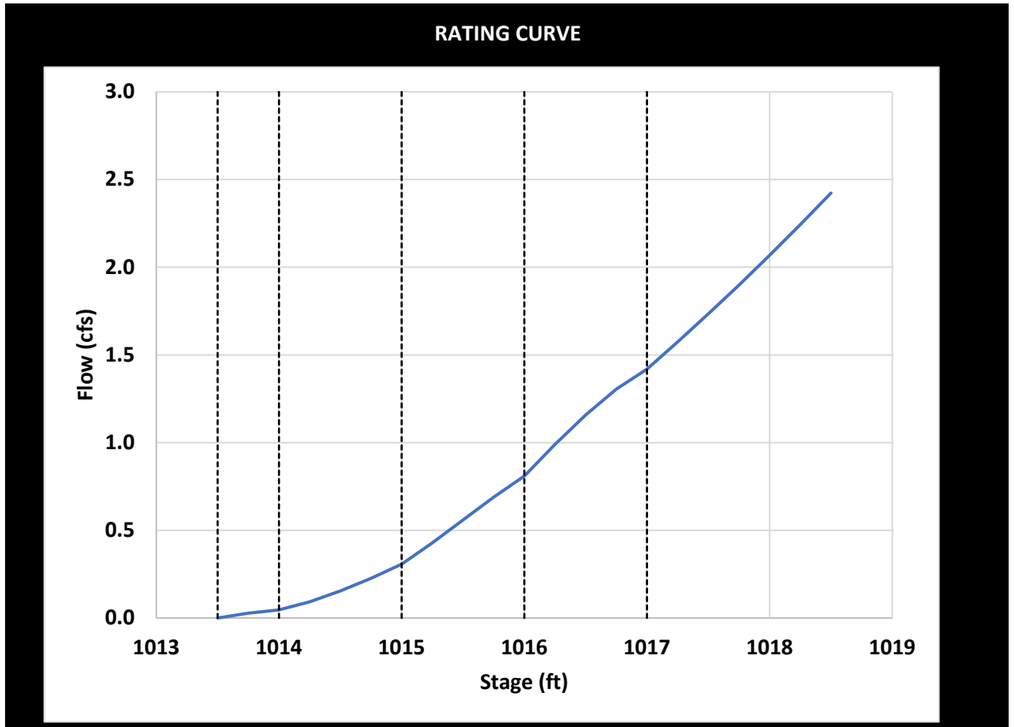
Stage (ft, NAVD88)	Weir Length (ft)	Weir Coeff
1017	67.72	0.0032
1016	40.99	0.005
1015	22.23	0.0075
1014	12.92	0.01
1013.5	8.85	0.03

Starting Pond Elevation	1011.75

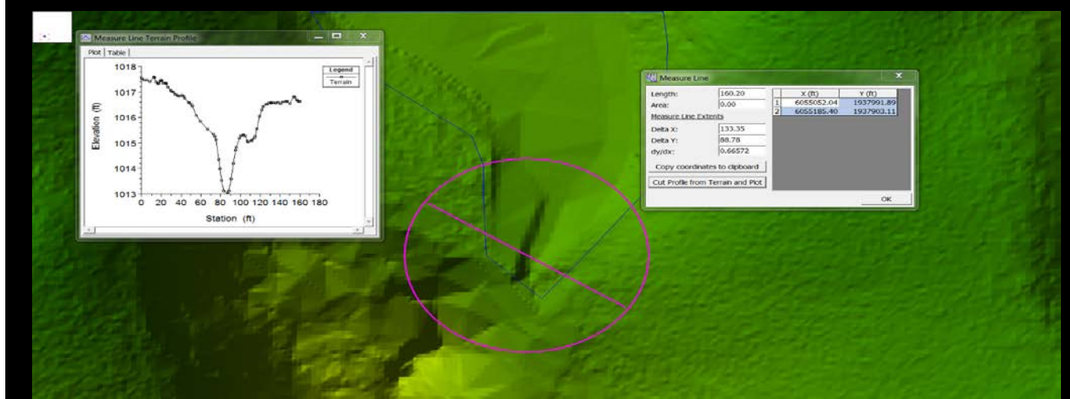
(MUST be >= 1010.95)

Rating Curve

Stage (ft)	Exact Val	Lin Fact.	Length	Coeff	Flow (cfs)
1013.5	TRUE	-	8.85	0.030	0.00
1013.75	FALSE	0.50	10.89	0.020	0.03
1014	TRUE	-	12.92	0.010	0.05
1014.25	FALSE	0.25	15.25	0.009	0.09
1014.5	FALSE	0.50	17.58	0.009	0.15
1014.75	FALSE	0.75	19.90	0.008	0.23
1015	TRUE	-	22.23	0.008	0.31
1015.25	FALSE	0.25	26.92	0.007	0.43
1015.5	FALSE	0.50	31.61	0.006	0.56
1015.75	FALSE	0.75	36.30	0.006	0.69
1016	TRUE	-	40.99	0.005	0.81
1016.25	FALSE	0.25	47.67	0.005	0.99
1016.5	FALSE	0.50	54.36	0.004	1.16
1016.75	FALSE	0.75	61.04	0.004	1.31
1017	TRUE	-	67.72	0.003	1.42
1017.25	FALSE	-	67.72	0.003	1.57
1017.5	FALSE	-	67.72	0.003	1.73
1017.75	FALSE	-	67.72	0.003	1.90
1018	FALSE	-	67.72	0.003	2.07
1018.25	FALSE	-	67.72	0.003	2.24
1018.5	FALSE	-	67.72	0.003	2.42



Screenshot: Outlet Cross Section (HEC-RAS)



Water Budget Calculation (page 1)

														1016		1.06								1013.5
			Inflows											Outflows										
Date	Month	Rainfall	Dir. Precip	TR-55								Springs Inflow		Total Inflow	Evapotranspiration								Pond Perc		Weir Length
				CN Parameters			Basin ET		Basin Area	Runoff					Open Water ET			Pond Veg ET			Total			
		(in)	(ac-ft)	CN	S (in)	I_a (in)	(in)	(ac-ft)	(ac)	(in)	(ac-ft)	(cfs)	(ac-ft)	(ac-ft)	OW Area (ac)	(in)	(ac-ft)	Veg Area (ac)	(in)	(ac-ft)	(ac-ft)	(in)	(ac-ft)	(ft)
				76.00	3.16	0.63				0.00														
10/1/1997	10	0.06	0.0006	76.18	3.13	0.63	0.028	0.03	11.62	0.00	0.0000	0.01	0.0099	0.0105	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/2/1997	10	0.21	0.0021	77.09	2.97	0.59	0.028	0.03	11.61	0.00	0.0000	0.01	0.0099	0.0121	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/3/1997	10	0.00	0.0000	76.95	3.00	0.6	0.028	0.03	11.59	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/4/1997	10	0.00	0.0000	76.82	3.02	0.6	0.028	0.03	11.58	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/5/1997	10	0.00	0.0000	76.68	3.04	0.61	0.028	0.03	11.57	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/6/1997	10	0.00	0.0000	76.55	3.06	0.61	0.028	0.03	11.56	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/7/1997	10	0.00	0.0000	76.41	3.09	0.62	0.028	0.03	11.55	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/8/1997	10	0.00	0.0000	76.28	3.11	0.62	0.028	0.03	11.54	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/9/1997	10	0.23	0.0038	77.30	2.94	0.59	0.028	0.03	11.54	0.00	0.0000	0.01	0.0099	0.0137	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/10/1997	10	0.03	0.0005	77.32	2.93	0.59	0.028	0.03	11.53	0.00	0.0000	0.01	0.0099	0.0105	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/11/1997	10	0.00	0.0000	77.18	2.96	0.59	0.028	0.03	11.52	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/12/1997	10	0.00	0.0000	77.05	2.98	0.6	0.028	0.03	11.52	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/13/1997	10	0.00	0.0000	76.91	3.00	0.6	0.028	0.03	11.52	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/14/1997	10	0.00	0.0000	76.78	3.02	0.6	0.028	0.03	11.51	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/15/1997	10	0.00	0.0000	76.64	3.05	0.61	0.028	0.03	11.51	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/16/1997	10	0.00	0.0000	76.51	3.07	0.61	0.028	0.03	11.51	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/17/1997	10	0.00	0.0000	76.37	3.09	0.62	0.028	0.03	11.50	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/18/1997	10	0.00	0.0000	76.24	3.12	0.62	0.028	0.03	11.50	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/19/1997	10	0.00	0.0000	76.11	3.14	0.63	0.028	0.03	11.49	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/20/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.49	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/21/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.49	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/22/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.48	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/23/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.48	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/24/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.47	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/25/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.47	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/26/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.47	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/27/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.46	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/28/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.46	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/29/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.46	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/30/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.45	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
10/31/1997	10	0.00	0.0000	76.00	3.16	0.63	0.028	0.03	11.45	0.00	0.0000	0.01	0.0099	0.0099	0.000	0.116	0.0000	1.060	0.077	0.0068	0.0068	0.00	0.0000	-
11/1/1997	11	0.00	0.0000	76.00	3.16	0.63	0.020	0.02	11.44	0.00	0.0000	0.01	0.0198	0.0198	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/2/1997	11	0.00	0.0000	76.00	3.16	0.63	0.020	0.02	11.43	0.00	0.0000	0.01	0.0198	0.0198	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/3/1997	11	0.00	0.0000	76.00	3.16	0.63	0.020	0.02	11.41	0.00	0.0000	0.01	0.0198	0.0198	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/4/1997	11	0.00	0.0000	76.00	3.16	0.63	0.020	0.02	11.39	0.00	0.0000	0.01	0.0198	0.0198	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/5/1997	11	0.00	0.0000	76.00	3.16	0.63	0.020	0.02	11.37	0.00	0.0000	0.01	0.0198	0.0198	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/6/1997	11	0.03	0.0010	76.06	3.15	0.63	0.020	0.02	11.35	0.00	0.0000	0.01	0.0198	0.0208	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-
11/7/1997	11	0.01	0.0004	76.01	3.16	0.63	0.020	0.02	11.33	0.00	0.0000	0.01	0.0198	0.0202	0.000	0.084	0.0000	1.060	0.056	0.0049	0.0049	0.00	0.0000	-

1017

Water Budget Calculation (page 2)

				Pond Water Budget					
Pond Outlet			Total Outflow	Stage ini	Storage ini	Area ini	Storage final	Stage final	Area final
Weir Coeff	Weir Flows								
[]	(cfs)	(ac-ft)	(ac-ft)	(ft)	(ac-ft)	(ac)	(ac-ft)	(ft)	(ac)
				1011.750	0.034	0.109	0.034	1011.750	0.109
-	0.000	0.0000	0.0068	1011.750	0.034	0.109	0.038	1011.836	0.120
-	0.000	0.0000	0.0068	1011.836	0.038	0.120	0.043	1011.959	0.137
-	0.000	0.0000	0.0068	1011.959	0.043	0.137	0.046	1012.032	0.147
-	0.000	0.0000	0.0068	1012.032	0.046	0.147	0.049	1012.104	0.157
-	0.000	0.0000	0.0068	1012.104	0.049	0.157	0.053	1012.177	0.167
-	0.000	0.0000	0.0068	1012.177	0.053	0.167	0.056	1012.250	0.176
-	0.000	0.0000	0.0068	1012.250	0.056	0.176	0.059	1012.322	0.186
-	0.000	0.0000	0.0068	1012.322	0.059	0.186	0.062	1012.354	0.192
-	0.000	0.0000	0.0068	1012.354	0.062	0.192	0.069	1012.370	0.201
-	0.000	0.0000	0.0068	1012.370	0.069	0.201	0.072	1012.379	0.205
-	0.000	0.0000	0.0068	1012.379	0.072	0.205	0.076	1012.386	0.209
-	0.000	0.0000	0.0068	1012.386	0.076	0.209	0.079	1012.393	0.213
-	0.000	0.0000	0.0068	1012.393	0.079	0.213	0.082	1012.400	0.217
-	0.000	0.0000	0.0068	1012.400	0.082	0.217	0.085	1012.407	0.221
-	0.000	0.0000	0.0068	1012.407	0.085	0.221	0.088	1012.414	0.225
-	0.000	0.0000	0.0068	1012.414	0.088	0.225	0.091	1012.421	0.229
-	0.000	0.0000	0.0068	1012.421	0.091	0.229	0.094	1012.428	0.232
-	0.000	0.0000	0.0068	1012.428	0.094	0.232	0.097	1012.436	0.236
-	0.000	0.0000	0.0068	1012.436	0.097	0.236	0.101	1012.443	0.240
-	0.000	0.0000	0.0068	1012.443	0.101	0.240	0.104	1012.450	0.244
-	0.000	0.0000	0.0068	1012.450	0.104	0.244	0.107	1012.457	0.248
-	0.000	0.0000	0.0068	1012.457	0.107	0.248	0.110	1012.464	0.252
-	0.000	0.0000	0.0068	1012.464	0.110	0.252	0.113	1012.471	0.256
-	0.000	0.0000	0.0068	1012.471	0.113	0.256	0.116	1012.478	0.259
-	0.000	0.0000	0.0068	1012.478	0.116	0.259	0.119	1012.486	0.263
-	0.000	0.0000	0.0068	1012.486	0.119	0.263	0.122	1012.493	0.267
-	0.000	0.0000	0.0068	1012.493	0.122	0.267	0.125	1012.500	0.271
-	0.000	0.0000	0.0068	1012.500	0.125	0.271	0.129	1012.507	0.275
-	0.000	0.0000	0.0068	1012.507	0.129	0.275	0.132	1012.514	0.279
-	0.000	0.0000	0.0068	1012.514	0.132	0.279	0.135	1012.521	0.282
-	0.000	0.0000	0.0068	1012.521	0.135	0.282	0.138	1012.528	0.286
-	0.000	0.0000	0.0049	1012.528	0.138	0.286	0.153	1012.562	0.305
-	0.000	0.0000	0.0049	1012.562	0.153	0.305	0.168	1012.597	0.323
-	0.000	0.0000	0.0049	1012.597	0.168	0.323	0.183	1012.631	0.342
-	0.000	0.0000	0.0049	1012.631	0.183	0.342	0.197	1012.665	0.360
-	0.000	0.0000	0.0049	1012.665	0.197	0.360	0.212	1012.699	0.378
-	0.000	0.0000	0.0049	1012.699	0.212	0.378	0.228	1012.735	0.398
-	0.000	0.0000	0.0049	1012.735	0.228	0.398	0.243	1012.770	0.417

Appendix C:

Water Year Selection

Years	28

CIMIS Download				
Stn Id	Stn Name	CIMIS Region	Date	Precip (in)
104	De Laveaga	Monterey Bay	10/1/1990	0.04
104	De Laveaga	Monterey Bay	10/2/1990	0
104	De Laveaga	Monterey Bay	10/3/1990	0.16
104	De Laveaga	Monterey Bay	10/4/1990	0.12
104	De Laveaga	Monterey Bay	10/5/1990	0
104	De Laveaga	Monterey Bay	10/6/1990	0
104	De Laveaga	Monterey Bay	10/7/1990	0.12
104	De Laveaga	Monterey Bay	10/8/1990	0.12
104	De Laveaga	Monterey Bay	10/9/1990	0.28
104	De Laveaga	Monterey Bay	10/10/1990	0.35
104	De Laveaga	Monterey Bay	10/11/1990	0.31
104	De Laveaga	Monterey Bay	10/12/1990	0.16
104	De Laveaga	Monterey Bay	10/13/1990	0
104	De Laveaga	Monterey Bay	10/14/1990	0.04
104	De Laveaga	Monterey Bay	10/15/1990	0.04
104	De Laveaga	Monterey Bay	10/16/1990	0
104	De Laveaga	Monterey Bay	10/17/1990	0
104	De Laveaga	Monterey Bay	10/18/1990	0.12
104	De Laveaga	Monterey Bay	10/19/1990	0
104	De Laveaga	Monterey Bay	10/20/1990	0
104	De Laveaga	Monterey Bay	10/21/1990	0.04
104	De Laveaga	Monterey Bay	10/22/1990	0
104	De Laveaga	Monterey Bay	10/23/1990	0
104	De Laveaga	Monterey Bay	10/24/1990	0
104	De Laveaga	Monterey Bay	10/25/1990	0
104	De Laveaga	Monterey Bay	10/26/1990	0
104	De Laveaga	Monterey Bay	10/27/1990	0
104	De Laveaga	Monterey Bay	10/28/1990	0
104	De Laveaga	Monterey Bay	10/29/1990	0
104	De Laveaga	Monterey Bay	10/30/1990	0
104	De Laveaga	Monterey Bay	10/31/1990	2.95
104	De Laveaga	Monterey Bay	11/1/1990	0
104	De Laveaga	Monterey Bay	11/2/1990	0
104	De Laveaga	Monterey Bay	11/3/1990	0
104	De Laveaga	Monterey Bay	11/4/1990	0
104	De Laveaga	Monterey Bay	11/5/1990	0
104	De Laveaga	Monterey Bay	11/6/1990	0
104	De Laveaga	Monterey Bay	11/7/1990	0
104	De Laveaga	Monterey Bay	11/8/1990	0
104	De Laveaga	Monterey Bay	11/9/1990	0
104	De Laveaga	Monterey Bay	11/10/1990	0

Data Processing			
Date	WY	Precip	Precip No NA
10/1/1990	1991	0.04	0.04
10/2/1990	1991	0	0
10/3/1990	1991	0.16	0.16
10/4/1990	1991	0.12	0.12
10/5/1990	1991	0	0
10/6/1990	1991	0	0
10/7/1990	1991	0.12	0.12
10/8/1990	1991	0.12	0.12
10/9/1990	1991	0.28	0.28
10/10/1990	1991	0.35	0.35
10/11/1990	1991	0.31	0.31
10/12/1990	1991	0.16	0.16
10/13/1990	1991	0	0
10/14/1990	1991	0.04	0.04
10/15/1990	1991	0.04	0.04
10/16/1990	1991	0	0
10/17/1990	1991	0	0
10/18/1990	1991	0.12	0.12
10/19/1990	1991	0	0
10/20/1990	1991	0	0
10/21/1990	1991	0.04	0.04
10/22/1990	1991	0	0
10/23/1990	1991	0	0
10/24/1990	1991	0	0
10/25/1990	1991	0	0
10/26/1990	1991	0	0
10/27/1990	1991	0	0
10/28/1990	1991	0	0
10/29/1990	1991	0	0
10/30/1990	1991	0	0
10/31/1990	1991	2.95	2.95
11/1/1990	1991	0	0
11/2/1990	1991	0	0
11/3/1990	1991	0	0
11/4/1990	1991	0	0
11/5/1990	1991	0	0
11/6/1990	1991	0	0
11/7/1990	1991	0	0
11/8/1990	1991	0	0
11/9/1990	1991	0	0
11/10/1990	1991	0	0

Water Year Summary		
WY	Total Precip (in)	Missing Days
1991	25.7	0
1992	28.56	0
1993	42.35	0
1994	23.57	0
1995	47.48	0
1996	31.05	0
1997	37.92	0
1998	57.52	0
1999	33.34	0
2000	32.14	0
2001	25.09	0
2002	29.47	0
2003	17.18	0
2004	22.67	0
2005	41.55	0
2006	43.24	0
2007	16.49	0
2008	23.43	0
2009	23.53	0
2010	34.86	0
2011	43.48	0
2012	20.82	0
2013	19.22	0
2014	6.73	0
2015	15.12	0
2016	23.36	0
2017	55.49	0
2018	17.58	0

Sorted WY's			Stats	
WY	Total Precip (in)	Missing Days	Rank	Exceedance
1998	**57.52**	**0**	**1**	**0.03**
2017	55.49	0	2	0.07
1995	47.48	0	3	0.10
2011	43.48	0	4	0.14
2006	43.24	0	5	0.17
1993	42.35	0	6	0.21
2005	**41.55**	**0**	**7**	**0.24**
1997	37.92	0	8	0.28
2010	34.86	0	9	0.31
1999	33.34	0	10	0.34
2000	32.14	0	11	0.38
1996	31.05	0	12	0.41
2002	29.47	0	13	0.45
1992	28.56	0	14	0.48
1991	**25.7**	**0**	**15**	**0.52**
2001	25.09	0	16	0.55
1994	23.57	0	17	0.59
2009	23.53	0	18	0.62
2008	23.43	0	19	0.66
2016	23.36	0	20	0.69
2004	22.67	0	21	0.72
2012	**20.82**	**0**	**22**	**0.76**
2013	19.22	0	23	0.79
2018	17.58	0	24	0.83
2003	17.18	0	25	0.86
2007	16.49	0	26	0.90
2015	15.12	0	27	0.93
2014	**6.73**	**0**	**28**	**0.97**

APPENDIX E

PROPEX SUBMITTAL: KNUEDLER LAKE SPILLWAY PROTECTION

August 21, 2019

April Sawyer, M.S.
Ecohydrologist
cbec inc. eco engineering

RE: Knuedler Lake Spillway Protection

Dear April Sawyer,

We want to thank you for considering the use of Propex products and solutions for erosion control on the above referenced project. We understand the project to consist of the protection of the spillway on Knuedler Lake in San Mateo County, CA. The spillway has a channel bottom width of 5.6 ft, side slopes with a gradient of 2 Horizontal : 1 Vertical (2H:1V), a channel depth of approximately 2.5 ft, and a bed slope of approximately 8% (0.08 ft/ft). Plans currently show the spillway being protected with D_{50} = 12 inches rock riprap. Soil information was taken from the Geotechnical Investigation Design Phase report prepared by Butano Geotechnical Engineering, Inc. Boring B-3 was performed in close proximity to the spillway and identified grey silt as the surficial soil.

Propex Engineered Earth Solutions have been protecting and stabilizing channels, slopes, levees, and stream banks for over 20 years. With over 35 million square yards of successful installations, Propex can provide solutions such as LANDLOK®, PYRAMAT®, and ARMORMAX® to design for the most challenging of environments. We would like to submit the following information in order to utilize our ***ARMORMAX® 75*** *Engineered Earth Armoring Solution™* as an alternative to the rock riprap for erosion protection.

ARMORMAX® 75 VS ROCK RIPRAP HYDRAULIC ANALYSIS

Propex's erosion potential analysis was completed on the channel using EC Design® software which utilizes Federal Highway Administration (FHWA) Hydraulic Engineering Circular (HEC) 15 for channel lining analysis and design to determine the erosion potential for the given project conditions based on the hydraulic shear stress. A 100-yr flow rate of 40 cfs was provided by cbec inc. eco engineering for use in the analysis. The permissible shear stress of rock riprap is dependent upon the mean size of the rock, D_{50}. Additionally, the erosion resistance reduces as the slope gradient on which the rock riprap is place increases. The analysis for the spillway can be found in Appendix A. A performance summary of rock riprap showing shear stress, based on Hydraulic Engineering Circular 15 (HEC-15), is shown in Table 1.

Table 1 – Channel Analysis Summary

Armoring Solution	Calculated Shear Stress (lb/ft^2)	Permissible Shear Stress (lb/ft^2)	Factory of Safety
Rock Riprap (D_{50} = 12 inches) [1]	3.49	4.10	1.17
ARMORMAX® 75 [2]	**3.49**	**4.55**	**1.30**

Notes:
1. Permissible Shear Stress for Riprap determined through HEC-15.
2. Soil type assumed to be Silt with 50% vegetation establishment. Additional vegetation establishment will increase permissible shear stress.

ARMORMAX 75 is an Engineered Earth Armoring Solution used for erosion control and surficial slope stability applications. It is composed of two components: *PYRAMAT 75 HPTRM* and Engineered Earth Anchors. The *PYRAMAT 75* component provides resistance to erosion and distributes the load amongst the anchors. The anchor component is specifically designed and tested for compatibility and performance with *HPTRM* and works to permanently secure the *PYRAMAT 75 HPTRM* as well as increase slope stability. Propex offers several anchor options to provide the *ARMORMAX 75* system designed for specific challenges and needs. We recommend that ARMORMAX 75 is installed using 3 ft long B1 anchors spaced at 4 ft horizontally and 5 ft vertically. Should any of the above assumptions be inaccurate, please notify Propex immediately so that the design and report can be amended accordingly.

MANUFACTURING QUALITY AND TESTING

Over the past 20 years, Propex has utilized a Manufacturing Quality Control (MQC) program to establish internal testing frequencies, set property requirements, and rectify any deficient test results in order to successfully provide over 10 million square yards of HPTRM. Propex proudly manufactures *PYRAMAT® 75* in Ringgold, GA, controlling the entire process from pellets of resin to the packaging of the HPTRM. *PYRAMAT® 75* is subjected to internal and external testing per ASTM D-4355 on an annual basis for 3,000 and 6,000 hours of exposure (Table 2).

Table 2 - Independent and Internal Test Results

Property	Test Method	*PYRAMAT® 75*
Tensile Strength (Published)	ASTM D-6818	4,000 x 3,000 lb/ft
UV Resistance @ 500 Hours	ASTM D-4355	> 95%
UV Resistance @ 1,000 Hours	ASTM D-4355	> 95%
UV Resistance @ 3,000 Hours	ASTM D-4355	> 90%
UV Resistance @ 6,000 Hours	ASTM D-4355	> 90%

ANTIOXIDANT PERFORMANCE

HPTRMs are very stable materials, but their susceptibility to UV degradation is dependent upon the type, quality, and amount of the Ultraviolet (UV) inhibitor utilized during manufacturing. HPTRMs are typically composed of polymer resin and an additive package. The additive package, such as Carbon Black or Hindered Amine Light Stabilizers (HALS), can be a combination of colorant and antioxidant that work in concert to protect the polymer against degradation. While UV radiation is the main source of degradation to the polymer, visible light and infrared (IR) light can degrade the colorant or antioxidant, causing the additive package to be ineffective and the polymer to degrade prematurely. The rate of degradation must be fully understood in order to have confidence in long term performance.

ASTM D-4355

The durability and long term performance of the HPTRM is tested per ASTM D-4355 in order to quantify the rate of degradation after an established amount of exposure. D-4355 utilizes a xenon arc in order to reproduce the entire spectrum of sunlight, from 250 nm to 800 nm including UV light, visible light, and IR light. Other test methods, such as ASTM D-7238, only reproduce UV light, from 295 to 400 nm. This results in the total radiation exposure for each test to be very different, with D-7238 only producing 68.3 W/m^2 and D-4355 producing 517.8 W/m^2. While D-7238 focuses the radiation on only the polymer, D-4355 exposes the entire material to radiation in order to simulate real world conditions.

By definition, an HPTRM is a synthetic textile utilized within the soil surface like a geotextile, however the function and required durability of an HPTRM is greatly different from that of a standard geotextile. Due to their lack of exposure, geotextiles only require a testing duration per ASTM D-4355 of 500 hours. HPTRMs, while intended to be vegetated, are also designed to be exposed. Whether seed or sod is used, no project can be guaranteed to maintain 100% vegetative coverage over the entire design life. It has also been found that even if the vegetative coverage is maintained, the thermal fluctuation in the HPTRM caused by regional temperature change can induce oxidation and reduce the durability of the material. Therefore, HPTRM designs should require more durability than standard geotextiles, having the test duration per ASTM D-4355 increased to a minimum of 3,000 hours and provided by a third party independent testing agency. ASTM D-4355 has been used by all of the permanent erosion control product manufacturers for over 20 years to specify the durability of HPTRMs and over 40 years to specify the durability of geotextiles.

FIELD PERFORMANCE

In addition to laboratory testing, field samples of Propex HPTRMs are evaluated in order to correlate results from ASTM D-4355 to real world exposure for a better understanding of the material's design life. In 2015, samples of *PYRAMAT® 75* were taken from the Bell Road Channel in Scottsdale, Arizona to determine the retained tensile strength after 13 years of exposure. With minimal vegetation established, the majority of the HPTRM was exposed in a severe environment having the highest solar radiation in North America of 21.70 MJ/m^2-day. The results showed an average retained tensile strength of 79% when compared to independent third party test results. Using this field retained tensile strength and both our independent and internal test results for UV resistance we can begin to anticipate the functional longevity of *PYRAMAT® 75* as shown in Figure 1.

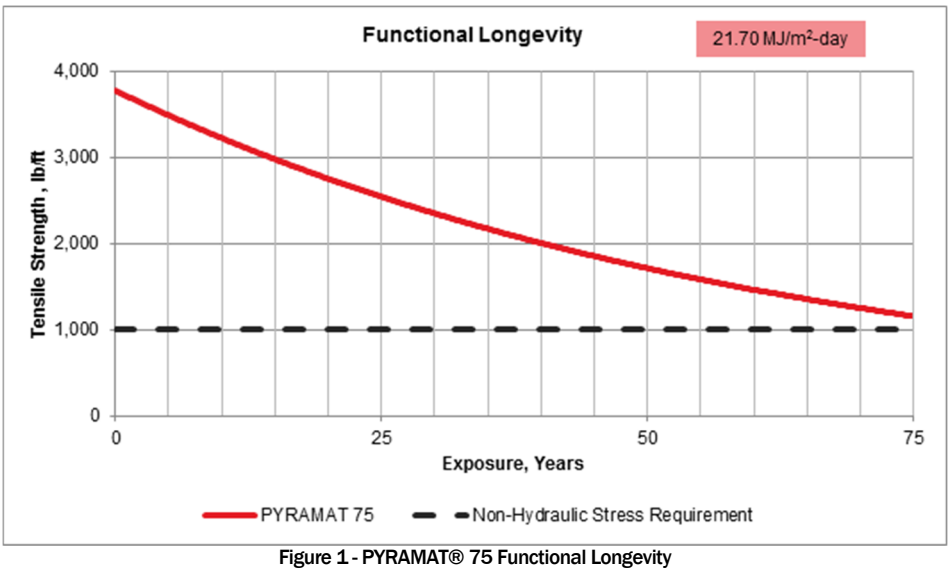


Figure 1 - PYRAMAT® 75 Functional Longevity

VEGETATION ESTABLISHMENT

For vegetation establishment, we are proposing our Vegetation Option No. 3 be used. Option 3 consists of the PYRAMAT 75 HPTRM in-filled with 1-2 inches of amended topsoil, seeded and covered with Propex Landlok S2 double net straw erosion control blanket. Figure 2 provides guidance demonstrating the vegetation establishment proposed for this project.

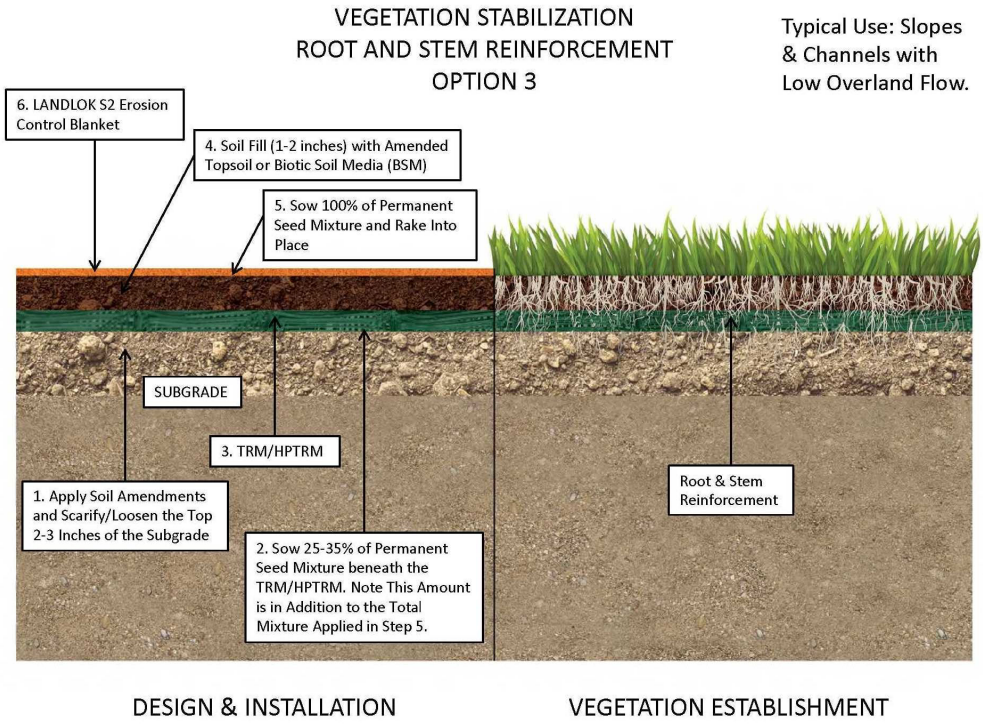


Figure 2 – Vegetation Stabilization

OPTION NO. 3 - SLOPES & CHANNELS WITH LOW OVERLAND FLOW

1. After conducting a site specific soil test, select and apply recommended soil amendments to the soil surface and then loosen/scarify the top 2 to 3 inches (50 to 75 mm) of the soil surface.
2. Sow 25%-35% of the total permanent seed mixture to prepared seedbed. Note this seed amount is in addition to the 100% total seed mixture being applied in Step 5.
3. Install the *ARMORMAX 75*.
4. Soil-fill the PYRAMAT *75* with 1-2 inches (25-50 mm) of amended topsoil or fill with a biotic soil media. Do not place excessive soil above the *PYRAMAT 75* material.
5. Sow 100% of the permanent seed mixture and rake into place to ensure good contact between seed and soil.
6. Install surficial protection with *LANDLOK S2* Erosion Control Blanket (ECB).

ENVIRONMENTAL BENEFITS

ARMORMAX® 75 provides significant environmental benefits when compared to traditional technologies, such as rock riprap. Utilizing *ARMORMAX® 75* provides an opportunity to remove pollutants from overland flow with the use of vegetation, deter burrowing animals, and can reduce traffic and emissions by improving shipping efficiencies. While often overlooked, these topics are crucial for the long term success of erosion control projects.

Hard armor, such as rock riprap is a conventional solution to prevent soil erosion. However, the EPA states in "Storm Water Technology Fact Sheet - Turf Reinforcement Mats" that while "these permanent measures can withstand great hydraulic forces, they are costly, and they do not provide the pollutant removal capabilities of vegetative systems". The EPA has established the use of vegetation as a best management practice (BMP). Vegetation acts to slow water velocities, increasing sedimentation and filtration of heavy metals, and encouraging infiltration of water back into the ground water table. Turf Reinforcement Mats (TRMs) and High Performance Turf Reinforcement Mats (HPTRMs), such as the *PYRAMAT® 75* component of *ARMORMAX® 75*, are also set as standard BMPs by the EPA to allow for the use of vegetated solutions where the hydraulic limits of unreinforced vegetation has been reached.

LIMITATIONS

The analysis presented herein are valid for Propex materials only and any alternate material should be evaluated separately. Please note that the information presented herein is general information only. It is for conceptual use only and not intended to be used for construction. While every effort has been made to ensure its accuracy, this information should not be used for a specific application without independent professional examination and verification of its suitability, applicability, and accuracy. This engineering document is protected by the Copyright Act, 17 U.S.C. §101 et seq. and may be used ONLY with the express written permission of Propex in connection with Propex products.

Enclosed please find supporting information on *ARMORMAX 75* in APPENDIX B. Should you have any questions or concerns regarding the analysis or the contents herein, please do not hesitate to contact me by phone at (423) 553-2200 or by email at jared.hill@propexglobal.com.

Sincerely,





Jared Hill, PE
Applications Engineer, GeoSolutions
Registered P.E. in TN
Propex Operating Company, LLC

Drew Loizeaux, PE
Engineering Services Manager, GeoSolutions
Registered P.E. in TN
Propex Operating Company, LLC

APPENDIX A

Channel Analysis

Project Information

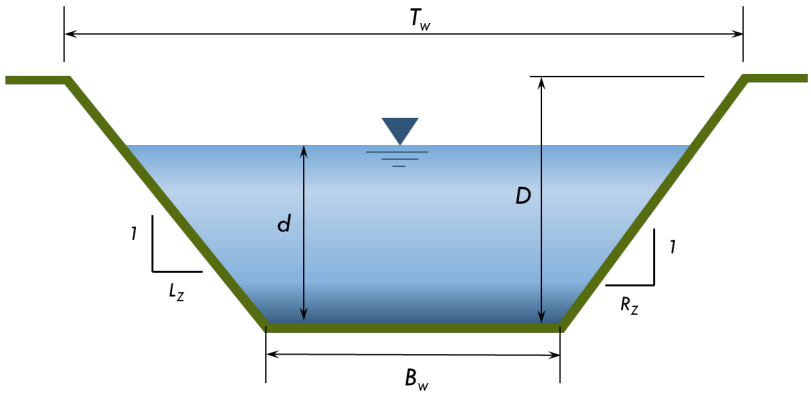
Project Name:	Knuedler Lake Spillway Protection	Designer:	Jared Hill
Location:	San Mateo County, CA; USA	Company:	Propex
Units:	English	Project Date:	8/21/2019

Channel Design Inputs

Channel Name: Typical Spillway

Input Criteria: Flow Rate

B_w =	5.6 ft
R_z =	2H:1V
L_z =	2H:1V
D =	2.5 ft
T_w =	15.6 ft
L =	23 ft
S_0 =	0.08 ft/ft
Q =	40 ft³/s
Radius of Curvature =	N/A
Channel Bend Ratio =	N/A
Required FS =	1.3



Channel Lining Analysis

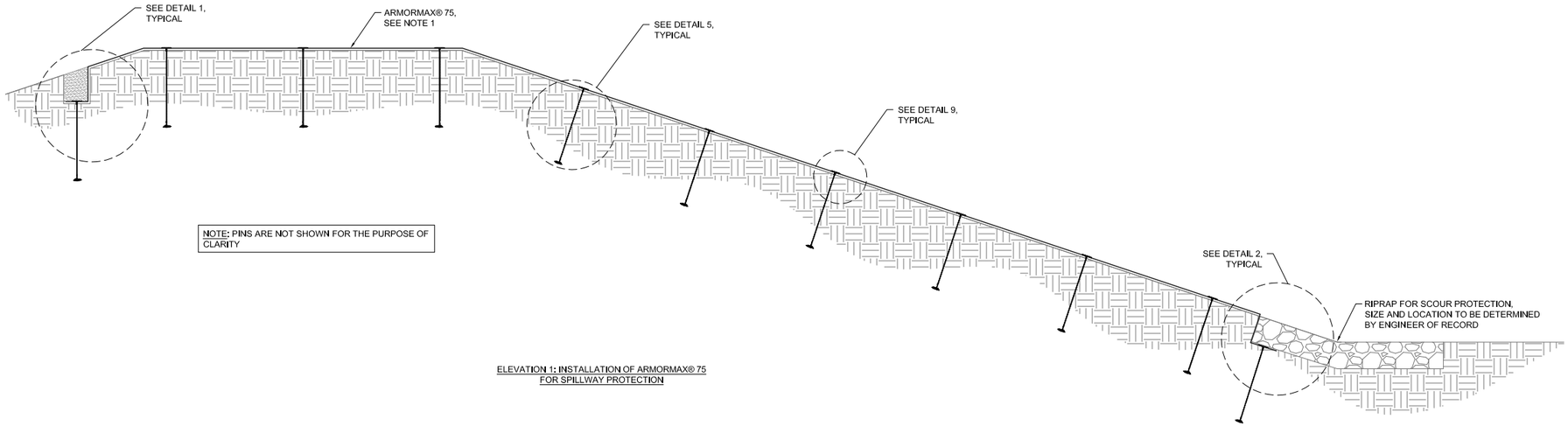
Channel Name:	Typical Spillway	Soil Type:	Silt
Anticipated Maintenance:	Light Maintenance (Mowers)	Vegetation Class:	User Defined
Anticipated Wildlife Impacts:	None	Manning's n:	0.035
Anticipated Debris Loading:	Low Potential	Grass Roughness Coefficient (C_n):	0
Required Design Life:	Up to 25 Years	Grass Cover Factor (C_f):	0.5

Channel Lining Result

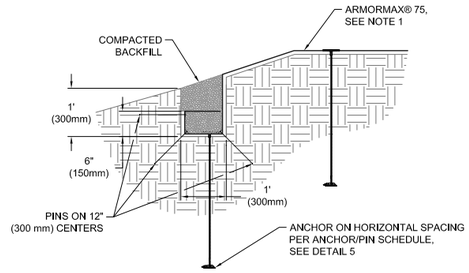
Lining Type	Flow Depth ft	Flow Rate ft³/s	Velocity ft/s	Calculated Shear Stress lb/ft²	Permissible Shear Stress lb/ft²	Factor of Safety
Bare Soil	0.45	40.16	13.85	2.25	0.03	0.01
Unreinforced Vegetation	0.7	40.19	8.2	3.49	0.29	0.08
PYRAMAT® 25	0.7	40.19	8.2	3.49	2.07	0.59
PYRAMAT® 75	0.7	40.19	8.2	3.49	2.68	0.77
ARMORMAX® 75	0.7	40.19	8.2	3.49	4.55	>1.3

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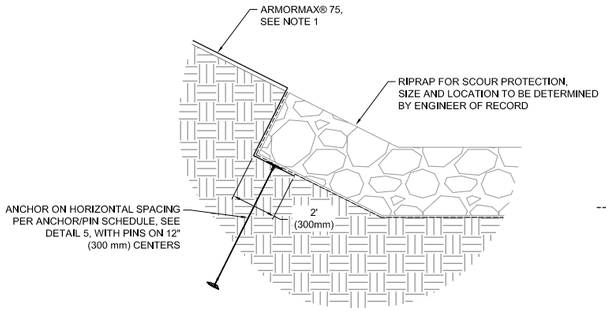
APPENDIX B



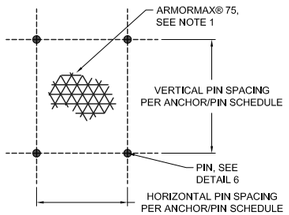
ELEVATION 1: INSTALLATION OF ARMORMAX® 75 FOR SPILLWAY PROTECTION



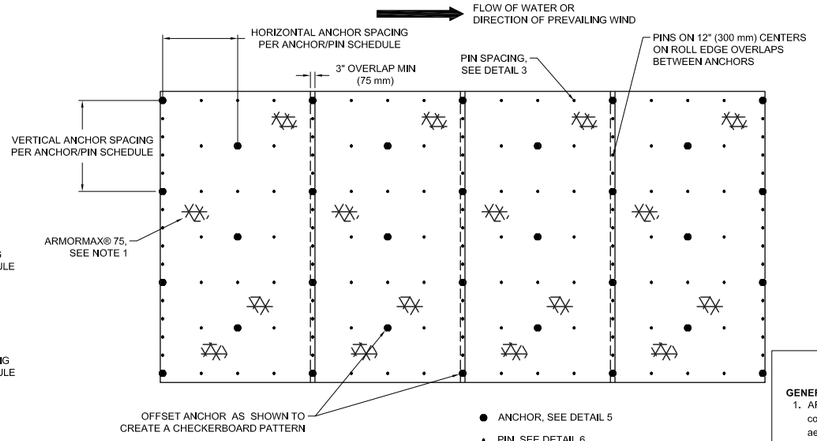
DETAIL 1: CREST OF SPILLWAY (COS) TRENCH



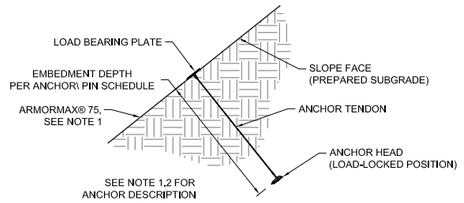
DETAIL 2: ARMORMAX® 75 CONNECTION TO ROCK RIPRAP



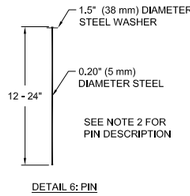
DETAIL 3: PIN PATTERN



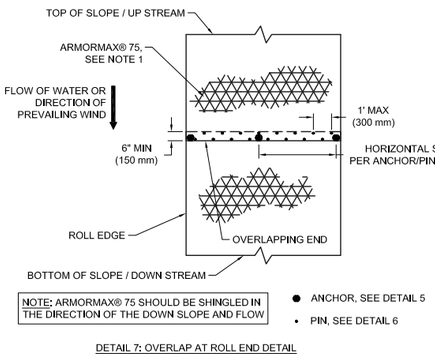
DETAIL 4: ANCHOR / PIN PATTERN



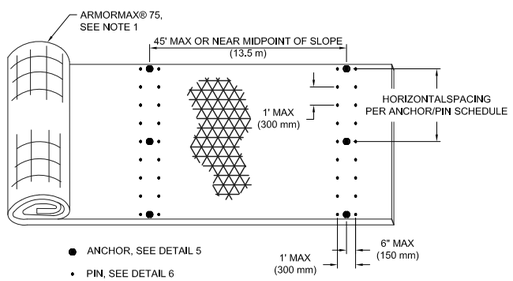
DETAIL 5: ENGINEERED EARTH ANCHOR



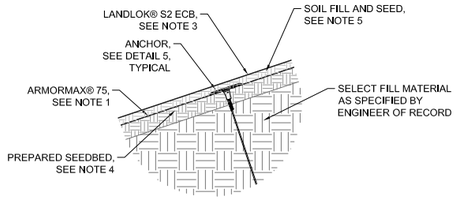
DETAIL 6: PIN



DETAIL 7: OVERLAP AT ROLL END DETAIL



DETAIL 8: SIMULATED CHECK SLOT DETAIL



DETAIL 9: VEGETATION ESTABLISHMENT

EROSION CONTROL INSTALLATION DETAILS

Please note that the information presented herein is general information only. It is for conceptual use only and not intended to be used for construction. While every effort has been made to ensure its accuracy, this information should not be used for a specific application without independent professional examination and verification of its suitability, applicability, and accuracy. This engineering drawing is protected by the Copyright Act, 17 U.S.C. §101 et seq. and may be used ONLY with the express written permission of Propex in connection with Propex products. Any copying, distributing, and/or creation of a derivative work without permission of Propex is prohibited and is subject of actual damages, statutory damages and attorney's fees under the Copyright Act.

Propex GEOSOLUTIONS

ARMORMAX®

ARMORMAX® 75 INSTALLATION DETAILS FOR SPILLWAYS

△	1 of 1				
△					
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Rev		08/21/2019	J. HILL	NTS	

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ANCHOR/PIN SCHEDULE		
SECURING DEVICE	ANCHOR	PIN
HORIZONTAL ANCHOR SPACING	4' (1.20 m)	2' (0.60 m)
VERTICAL ANCHOR SPACING	5' (1.50 m)	2.5' (0.75 m)
EMBEDMENT DEPTH	3' (0.90 m)	1.5' (300 mm)

ARMORMAX® 75 IN A CHANNEL FOR EROSION CONTROL GENERAL INSTALLATION GUIDELINES

GENERAL NOTES

1. ARMORMAX® 75 is an engineered solution used for permanent erosion protection or surficial slope stability in vegetated and unvegetated applications. It is composed of two components: PYRAMAT® 75 High Performance Turf Reinforcement Mat (HPTRM) and Engineered Earth Anchors. ARMORMAX® 75 is available in green or tan to provide for an aesthetically pleasing solution with proven performance.
   1.1. PYRAMAT® 75 HPTRM is a three-dimensional, lofty, woven polypropylene geotextile that is available in green or tan which is specially designed for erosion control applications on steep slopes and vegetated waterways. The matrix is composed of polypropylene monofilament yarns featuring X3® technology woven into a uniform configuration of resilient pyramid-like projections. The material exhibits very high interlock and reinforcement capacity with both soil and root systems, demonstrates superior UV resistance, and enhances seedling emergence.
   1.2. The Type B1 anchor model is used for permanent erosion protection applications and has a working load of up to 800 lbs. The Type B1 anchor consists a die cast aluminum anchor head, zinc-aluminum coated carbon steel cable, a die cast zinc load-locking mechanism with a ceramic roller, and two aluminum ferrules. The bullet nose design of the anchor head allows the anchor to penetrate HPTRM resulting in minimal installation damage. The Type B1 anchor is also designed with a recessed cavity so the top of the cable can be cut below the surface being protected.
2. The 12", 18", and 24" Securing Pins are composed of a wire, mushroomed at the top. A washer is then placed on the wire and the wire is crimped or swedged about 3-1/2" below the top so the washer will not slide off. The end of the wire is cut at a 45 degree angle for easy penetration of the soil. These Pins with washers conform to Industry standards for erosion control pins with washers.
3. LANDLOK® S2 Erosion Control Blankets consist of 100% wheat straw mechanically bound and covered on both sides by netting. The straw is homogeneously blended and evenly distributed throughout the blanket. The netting is photodegradable polypropylene with mesh openings of approximately 3/8 in. by 3/8 in. (11 mm by 11 mm). The blanket is sewn on approximately 2 in. (51 mm) centers with photodegradable polypropylene thread. This product is NTPEP approved for AASHTO standards.

VEGETATION ESTABLISHMENT

4. Prepare seedbed by loosening 50 to 75 mm (2 to 3 in) of soil above final grade. Apply seed in an amount equivalent to 60% of the total mixture required to be installed on the soil surface, to scarified surface prior to installation of the ARMORMAX® 75. Select and apply soil amendments and fertilizer, to scarified surface prior to installation of the ARMORMAX® 75. A site specific soil test should be performed to help determine what soil amendments, such as lime and fertilizer, need to be incorporated into the soil to promote healthy vegetation.
5. The installed ARMORMAX® 75 shall be soil filled and seeded with the remaining 40% of the seed mixture. Do not place excessive soil above material. Once soil fill and additional seed is in place, surficial protection should be accomplished by installing LANDLOK® S2 Erosion Control Blanket (ECB) atop the seed layer. LANDLOK® S2 ECB is to be secured using 6" U-shaped staples with a frequency of 2.0 staples per square meter (1.7 staples per square yard).
6. Irrigate as necessary to establish and maintain vegetation until 75% of vegetation has established and has reached a height of 2 inches. Frequent, light irrigation will need to be applied to seeded areas if natural rain events have not occurred within two weeks of seeding.

BEFORE INSTALLATION BEGINS

7. Coordinate with a Propex Representative: A pre-construction meeting is suggested with the construction team and a representative from Propex. This meeting should be scheduled by the contractor with at least a two week notice.
8. Gather the Tools Needed: Tools that you will need to install ARMORMAX® 75 include a pair of industrial shears to cut PYRAMAT® 75, tape measure, percussion hammer (sized appropriately for the anchors), ground rod driver compatible with the percussion hammer, drive steel compatible with the anchor, setting tool to set and load-lock the anchor, and wire cutters to cut the cable tendon of the anchor. If anchors will be load tested during construction, additional testing equipment may be necessary. Consult the "Anchor Load Test Manual" from Propex for further guidance. Available for purchase from Propex are drive steel, setting tools, and wire cutters.
9. Determine how to Establish Vegetation: The method of vegetation establishment should be determined prior to the start of installation. Different vegetation establishment methods require different orders of installation. Refer to Establish Vegetation for further guidance.
10. Please consult the Propex Website for the most up to date installation guidelines.

ARMORMAX®

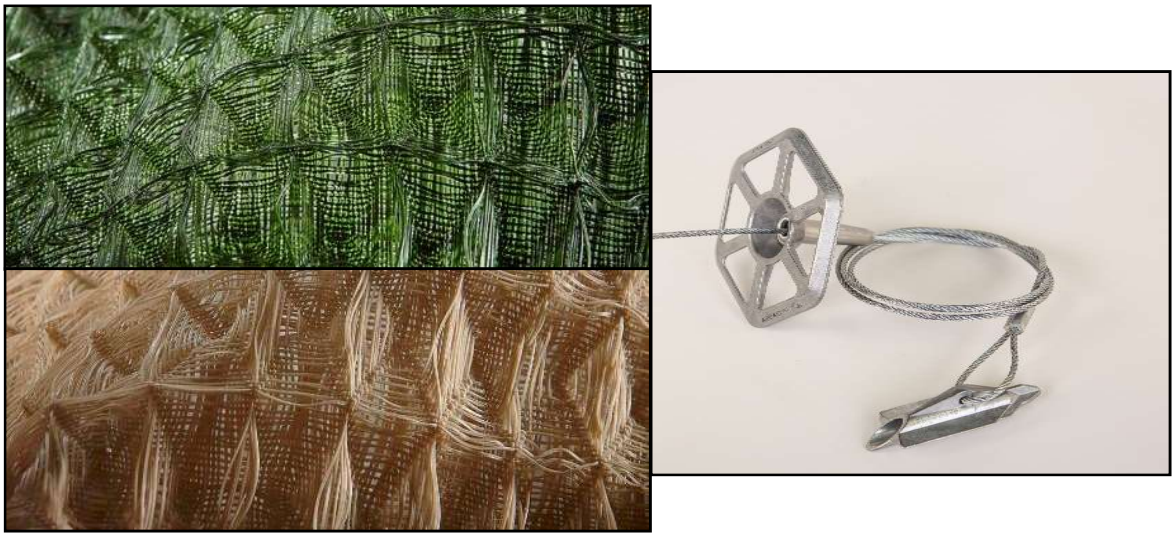
Engineered Earth Armoring System

Product Data

ARMORMAX® 75

For Erosicon Control

The ARMORMAX® 75 for Erosion Control is an Engineered Earth Armoring Solution™ used for permanent erosion protection in vegetated and unvegetated applications. It is composed of two components: PYRAMAT® 75 High Performance Turf Reinforcement Mat (HPTRM) and Type B1 Enginnered Earth Anchors. ARMORMAX® 75 is available in green or tan to provide for an aesthetically pleasing solution with proven performance. The anchor component is specifically designed and tested for compatibility and performance with PYRAMAT® 75 HPTRM to provide a system solution. Propex offers several anchor options to provide the ARMORMAX® 75 system designed for specific challenges and needs. The expected design life of ARMORMAX® 75 is up to 75 years because of its superior UV resistance, resistance to corrosion, strength, and durability in the most demanding environments.



The PYRAMAT® 75 HPTRM component of ARMORMAX® 75 values listed below[1] while manufactured at a Propex facility having achieved ISO 9001:2015 certification. Propex also performs internal Manufacturing Quality Control (MQC) tests that have been accredited by the Geosynthetic Accreditation Institute – Laboratory Accreditation Program (GAI-LAP).

The Type B1 Anchor model is used for permanent erosion protection applications and has a working load of up to 500 lbs. The Type B1 Anchor consists of an aluminum anchor head, galvanized steel cable, aluminum ferrules, aluminum load-locking mechanism, and an aluminum top plate. The bullet nose design of the anchor head allows the anchor to penetrate PYRAMAT® 75 HPTRM resulting in minimal installation damage. The Type B1 Anchor is also designed with a recessed cavity so the top of the cable can be cut below the surface being protected.

Propex GEOSOLUTIONS

ENGINEERED EARTH ARMORING SOLUTIONS™

www.propexglobal.com

Propex Operating Company, LLC · 4019 Industry Drive · Chattanooga, TN 37416 · ph 800 621 1273 · ph 423 855 1466

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ARMORMAX®

Engineered Earth Armoring System

Product Data

ARMORMAX® 75

For Erosion Control

PYRAMAT® 75 HPTRM PROPERTIES

PROPERTY	TEST METHOD	ENGLISH	METRIC
ORIGIN OF MATERIALS			
% U.S. Manufactured		100%	100%
PHYSICAL			
Thickness [2]	ASTM D-6525	0.40 in	10.2 mm
Light Penetration (% Passing) [3]	ASTM D-6567	10%	10%
Color	Visual	Green or Tan	
MECHANICAL			
Tensile Strength [2]	ASTM D-6818	4000 x 3000 lbs/ft	58.4 x 43.8 kN/m
Elongation [2]	ASTM D-6818	40 x 35 %	40 x 35 %
Resiliency [2]	ASTM D-6524	80%	80%
Flexibility [4]	ASTM D-6575	0.534 in-lb	616,154 mg-cm
ENDURANCE			
UV Resistance % Retained at 3,000 hrs [4]	ASTM D-4355	90%	90%
UV Resistance % Retained at 6,000 hrs [4]	ASTM D-4355	90%	90%
PERFORMANCE			
Velocity (Vegetated) [4, 5]	Large Scale	25 ft/sec	7.6 m/sec
Shear Stress (Vegetated) [4, 5]	Large Scale	16 lb/ft²	766 Pa
Manning's n (Unvegetated) [4, 6]	Calculated	0.028	0.028
USACE / CSU Wave Overtopping	Large Scale	USACE Approved	
Seedling Emergence [4]	ASTM D-7322	296%	296%
ROLL SIZES		8.5 ft x 120 ft 15.0 ft x 120 ft	2.6 m x 36.6 m 4.6 m x 36.6 m

TYPE B1 ANCHOR PROPERTIES

Component Materials	Material Composition	Physical Properties
Anchor Head	Aluminum	3.57 in x 1.26 in x 0.91 in (90.7 mm x 32 mm x 23.1 mm) Bearing Area: 3.44 in² (22.2 mm²)
Cable Tendon	Galvanized Steel	Diameter: 0.109 in (2.8 mm)
Lower Termination	Aluminum	Length: 0.63 in (16 mm), Wall Thickness: 0.09 in (2.3 mm)
Load Bearing Plate	Aluminum Alloy	3.97 in x 4.4 in x 0.25 in (100.8 mm x 111.8 mm x 6.4 mm) Bearing Area: 8.07 in² (52.1 mm²)
Top Termination	Aluminum	Circumferential Tripple Wedge Grip Assembly to Eliminate Cable Pinch Points Grip to Cable Contact Surface Area: 0.242 in² (156.1 mm²) Grip to Cable Contact Ratio: 83% of Cable Diameter

Performance Properties			
Ultimate Assembly Strength	1300 lb (5.78 kN)	Typical Working Load	500 lb (2.22 kN)
Ultimate Cable Strength	1600 lb (7.12 kN)	Embedment Depth	3-5 ft (0.91-1.52 m)

NOTES:

1. The property values listed above are effective 01/01/2019 and are subject to change without notice. Values represent testing at time of manufacture.
2. Minimum average roll values (MARV) are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.
3. Maximum Average Roll Value (MaxARV), calculated as the typical plus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will meet to the value reported.
4. Typical Value.
5. Maximum permissible velocity and shear stress has been obtained through vegetated testing programs featuring specific soil types, vegetation classes, flow conditions, and failure criteria. These conditions may not be relevant to every project nor are they replicated by other manufacturers. Please contact Propex for further information.
6. Calculated as typical values from large-scale flexible channel lining test programs with a flow depth of 6 to 12 inches.

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ARMORMAX®
Engineered Earth Armoring System

CHANNEL INSTALLATION AND MAINTENANCE GUIDELINES

Thank you for purchasing the ARMORMAX® by Propex Operating Company, LLC (Propex). This document provides installation and maintenance guidelines for ARMORMAX used as channel armoring to increase channel resiliency towards forces created by high velocities and shear stresses. ARMORMAX provides permanent erosion protection of an earthen channel, promotes vegetation and consists of two components:

- PYRAMAT® - High Performance Turf Reinforcement Mat (HPTRM)
- Engineered Earth Anchor (Anchor)

Temporary securing pins (pins) are used during installation to hold ARMORMAX in place while installing anchors. Pins also promote vegetation establishment keeping ARMORMAX in intimate contact with the soil.

ARMORMAX is an Engineered Earth Armoring Solution ™ with a unique design for each specific project. While Propex has made every effort to ensure general validity, this information should not be used for a specific application without independent professional examination and verification of its suitability, applicability, and accuracy. The documentation provided herein is for general information only, and is intended to present installation guidance only. Project specific contract documents take precedence when pin and anchor placements are different than what is represented in this document. Depending upon the critical nature of the structure to be armored, work restrictions may be in place such as limiting installation based on growing seasons, weather patterns, etc. Work should be performed under the provisions set forth for the specific project. Propex Engineering Services is available for support during installation to consult for solving constructability issues encountered in specific applications. Please feel free to contact our Engineering Serivces team at GeoEngineering@propexglobal.com.

BEFORE INSTALLATION BEGINS

- *Coordinate with a Propex Representative:* A pre-construction meeting with the construction team and a representative from Propex is recommended prior to installation. This meeting should be scheduled by the contractor with at least a two week notice prior to construction.
- *Gather the Tools Needed:* Tools that you will need to install ARMORMAX include a pair of industrial shears, tape measure, percussion hammer (sized appropriately for the anchors), ground rod driver compatible with the percussion hammer, drive steel compatible with the anchor, setting tool to set and load-lock the anchor, and wire cutters to cut the cable tendon of the anchor. If anchors will be load tested during construction, additional testing equipment may be necessary. Consult the "Anchor Load Test Manual" from Propex for further guidance. Available for purchase from Propex are drive steel, JackJaw® setting tools, wire cutters, and a gas powered anchor driver.
- *Determine Vegetation Establishment Strategy:* The method of vegetation establishment should be determined prior to the start of installation. Different vegetation establishment methods require different orders of installation. Refer to *VEGETATION ESTABLISHMENT* for further guidance.

INSTALLATION OF ARMORMAX FOR CHANNELS

PREPARE THE SITE

It is recommended during all stages of site preparation that disturbed soils remain unprotected for not more than a single day. Depending on project size this may require progressive site preparation during installation.

1. Grade and compact the area in the channel where ARMORMAX will be installed. The channel surface should be uniform and smooth, having all rocks, clods, vegetation or other objects removed so that during *ARMORMAX LAYDOWN*, ARMORMAX comes in direct, intimate contact with the channel surface.
2. Prepare the area to be armored with ARMORMAX by loosening the topsoil to promote better vegetation establishment. This may be accomplished with a rotary tiller on slopes 3:1 or flatter. For slopes greater than 3:1, prepare topsoil in a safe manner.

3. Excavate an Initial Channel (IC) trench a minimum of 12 in x 12 in (300 mm x 300 mm) across the channel at the downstream end of the project (Figure 1). Deeper IC trench and/or hard armoring may be required for channels that have the potential for scour.

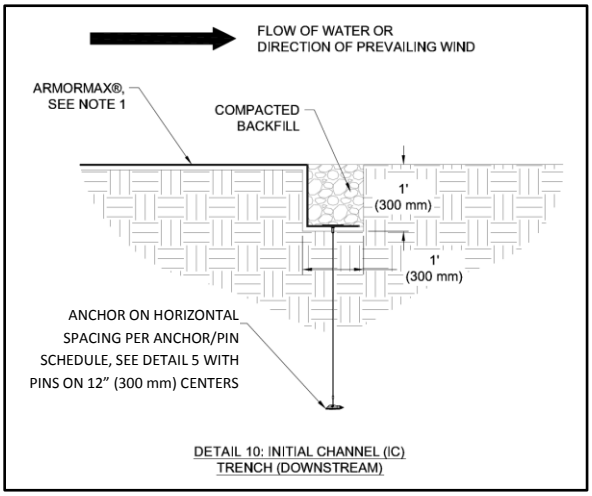


Figure 1: Initial Channel (IC) Trench

4. Excavate a Crest of Slope (COS) trench a minimum of 12 in x 12 in (300 mm x 300 mm) along both sides of the installation. Each COS trench must be a minimum of 3 ft (900mm) over the crest of the bank (Figure 2), preferably on a relatively flat surface.

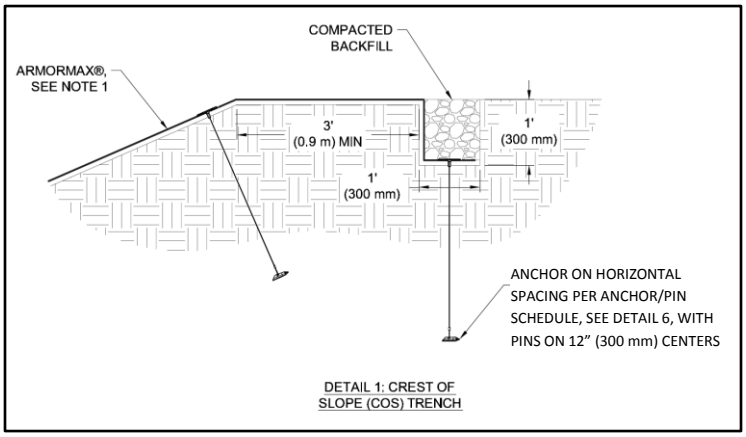
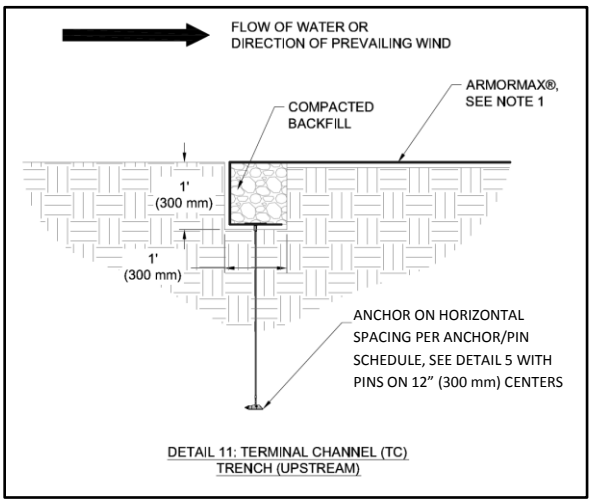


Figure 2: Crest of Slope (COS) Trench

5. Excavate a Terminal Channel (TC) trench a minimum of 12 in x 12 in (300 mm x 300 mm) across the channel at the upstream end of the project (3). Deeper TC trench and/or hard armoring may be required for channels that have the potential for scour.



3: Terminal Channel (TC) Figure Trench

6. If seeding, refer to *VEGETATION ESTABLISHMENT* for additional considerations during site preparation.

ARMORMAX LAYDOWN

1. Starting with the downstream end of the site select one of the COS trenches to begin the *ARMORMAX LAYDOWN* process. To ensure proper anchoring of the overlapped areas the proceeding roll width must be laid out before the current roll width can be anchored with exception to the final roll width at the TC trench.

2. For straight sections of a channel, ARMORMAX panel lengths should be long enough to construct both COS trenches while also covering the surface of the channel being armored. (Figure 20) Panel edges should rest perpendicular to the channel center line. For best results, panels of ARMORMAX should be continuous and free from seams or roll end overlaps that are parallel to the centerline of the channel. Panel edge overlapping should follow a pattern of placing each proceeding panel's edge overtop the previous panel edge, shingling the panels in the direction of the water flow.

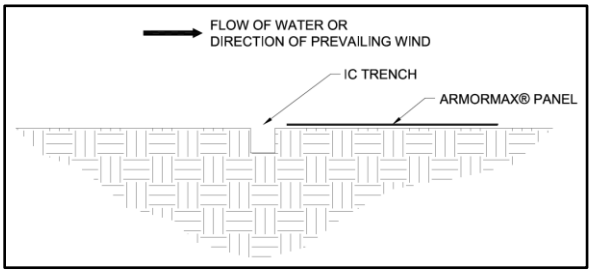


Figure 4: Initial Channel (IC) Trench Alignment

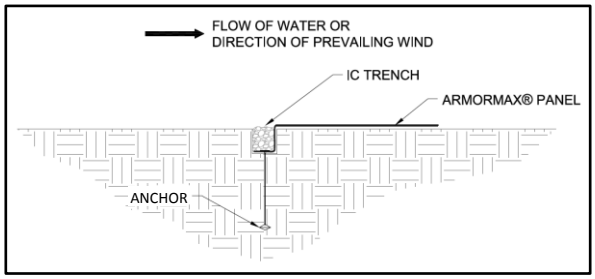


Figure 5: Initial Channel (IC) Trench Placement

3. Lay the ARMORMAX panel on the downstream side of the IC trench (Figure 4). Place the panel edge in the IC trench, ensuring full coverage along the bottom of the entire IC trench with the ARMORMAX (Figure 5). Secure ARMORMAX with pins and anchors in the IC trench (Figure 5). Pins should be made of steel with a 0.20 in (5 mm) minimum diameter, having a 1.5 in (38mm) diameter washer at the head, and a length between 12 and 24 in (300-600 mm) with sufficient ground penetration to resist pullout.

4. Longer pins may be required for looser soils. Heaver metal stakes may be required in rocky soils. Suggested placement of pins and anchors for the IC trench is along the bottom of the trench with pins on 12 in (300 mm) centers in between anchors on 5 ft (1.5 m) centers.

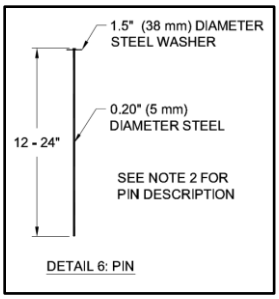


Figure 6 - Securing Pin

5. Backfill and compact the IC trench (Figure 5).

6. Fold the ARMORMAX panel over the top of the compacted IC trench (Figure 7) and place each panel end into the respective COS trenches.

7. Place the next ARMORMAX panel by laying the ARMORMAX roll so that the roll end points towards the COS trench (Figure 8), with a 3 inch (75 mm) overlap created at adjacent panel edge locations. Ensure that adjacent panel edges maintain a minimum 3 inch (75 mm) overlap during *ARMORMAX LAYDOWN* (Figure 12).

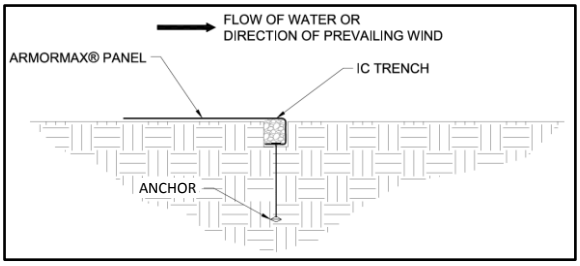


Figure 7 - Initial Channel (IC) Trench Complete

8. Secure ARMORMAX with pins and anchors in the COS trench. Suggested placement of pins and anchors for the COS trench is along the bottom of the trench with pins on 12 in (300 mm) centers in between anchors on 4 ft (1.2 m) centers. Anchors should also be installed on panel edge overlaps in the COS trench.

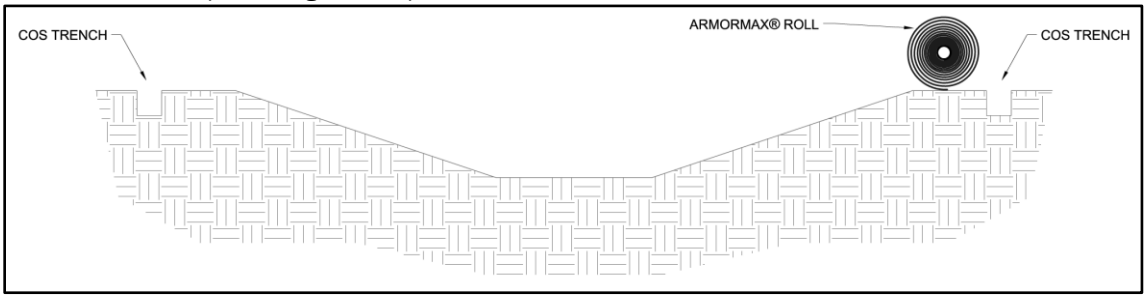


Figure 8: Crest of Slope (COS) Trench Alignment

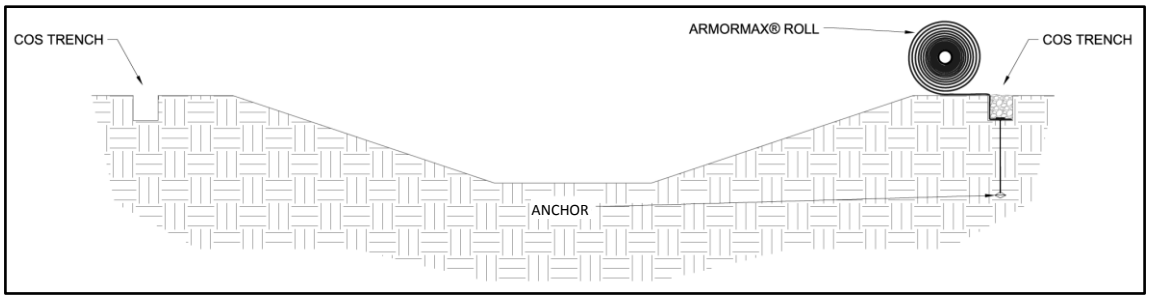


Figure 9: Crest of Slope (COS) Trench Placement

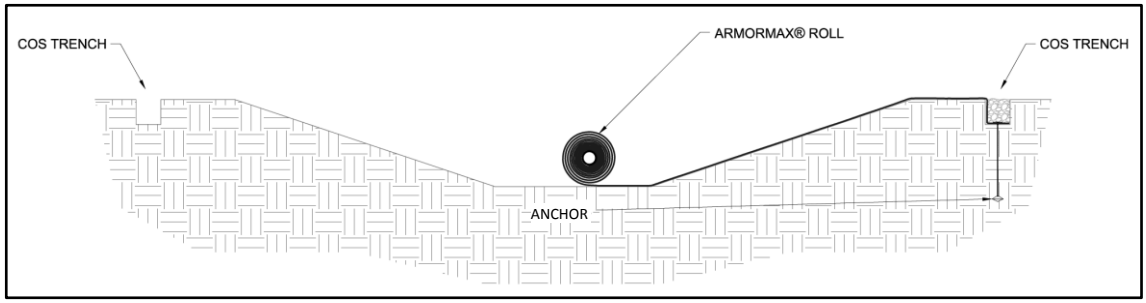


Figure 10: Perpendicular Placement of ARMORMAX across Channel

9. Backfill and compact the COS trench in the location of the first ARMORMAX panel only (Figure 9).

10. Unroll the ARMORMAX roll on the channel surface in the area to be armored. (Figure 10) Ensure that ARMORMAX has intimate contact with the ground and all irregular surfaces beneath ARMORMAX are removed.

11. Secure ARMORMAX panels in place using pins and anchors across the channel surface according to the project's engineered design. Pin and anchor placement should reflect a staggered checkerboard pattern across the channel surface for best results (Figure 11 and Figure 12).

    - Roll edges shall be overlapped a minimum of 3 in (75 mm) with pins placed on 12 in (300 mm) centers in between anchors on 4 ft (1.2 m) centers (Figure 12).

    - Roll ends shall be overlapped a minimum of 6 in (150 mm) with upstream panel on top. Secure roll end overlaps with two rows of pins staggered 6 in (150 mm) apart on 12 in (300 mm) centers and with one row of anchors on 4 ft (1.2 m) centers (Figure 13)

    - For channel bank heights or channel bottom widths greater than 45 ft (13.7 m), install simulated check slots. This method includes placing two rows of pins 12 in (300 mm) apart on 12 in (300 mm) centers and one row of anchors between the rows of pins on 4 ft (1.2 m) centers at 45 ft (13.7 m) maximum intervals or across the midpoint of the slope for slope lengths less than 60 ft (18.2 m) (Figure 14).

    - At the break in slope interface towards the channel bed, it is suggested that anchors be installed on 4 ft (1.2 m) centers (Figure 15).

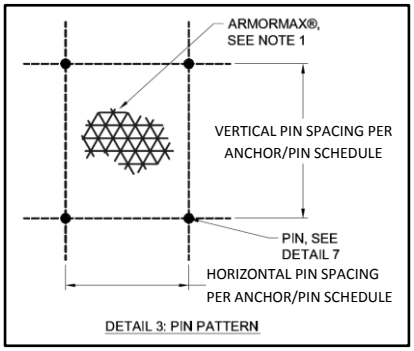


Figure 11: Example Pin Pattern

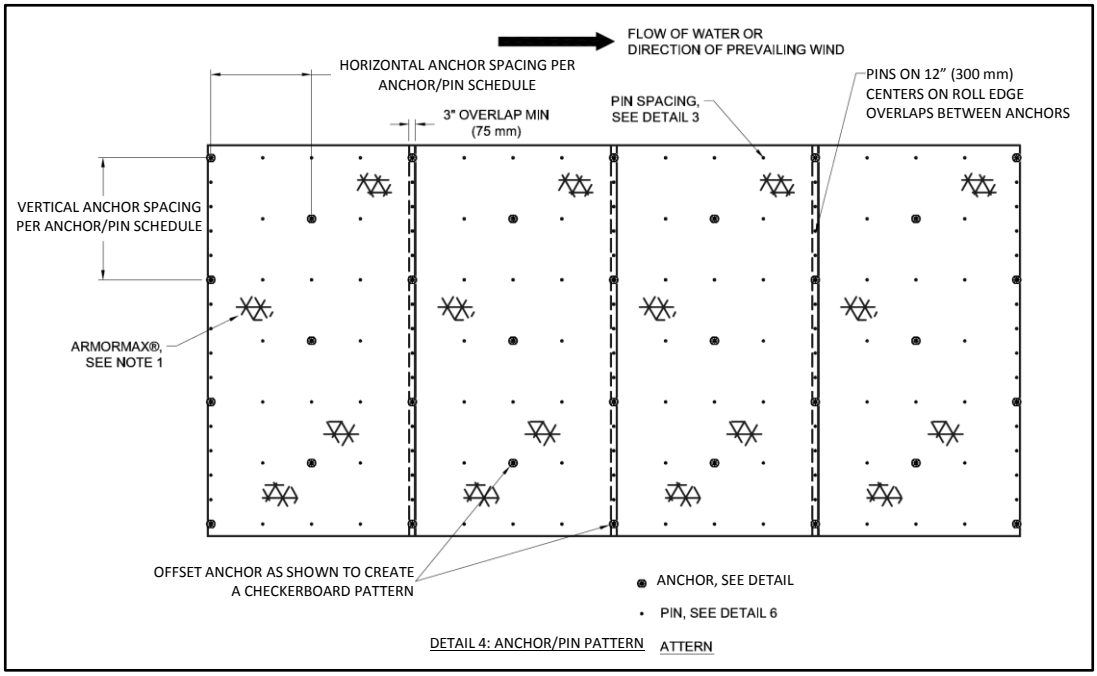


Figure 12: Example Anchor Pattern - 0.5 Anchors/ Yd2

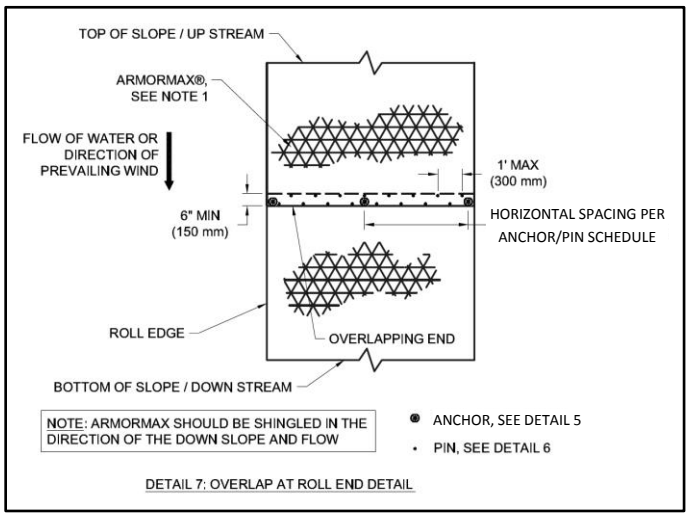


Figure 13: Roll End Overlap

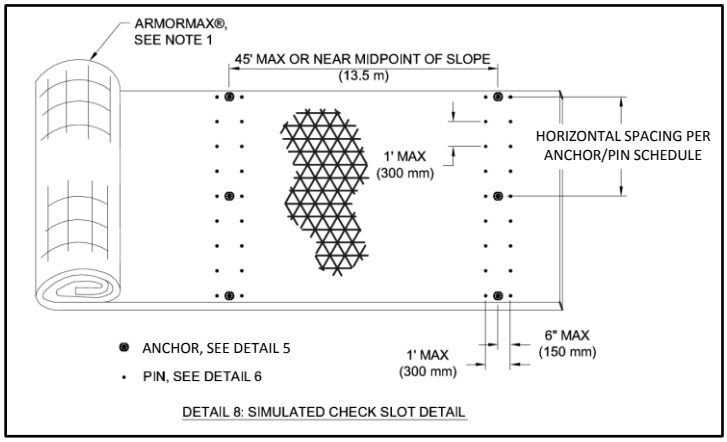


Figure 14: Simulated Check Slot

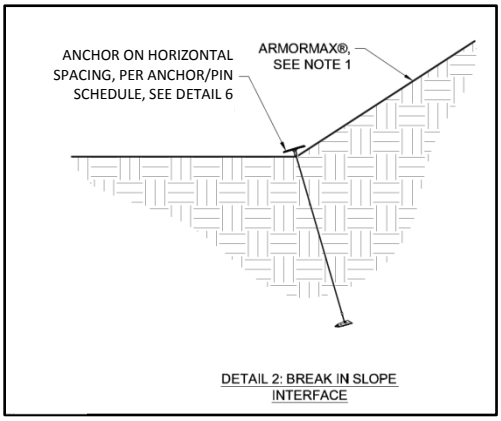


Figure 15: Break in Slope Interface

12. Secure ARMORMAX with pins and anchors in the opposite COS trench. Suggested placement of pins and anchors for the opposite COS trench is along the bottom of the trench with pins on 12 in (300 mm) centers in between anchors on 4 ft (1.2 m) centers (Figure 16).

13. Backfill and compact the opposite COS trench in the location of the first ARMORMAX panel only (Figure 16).

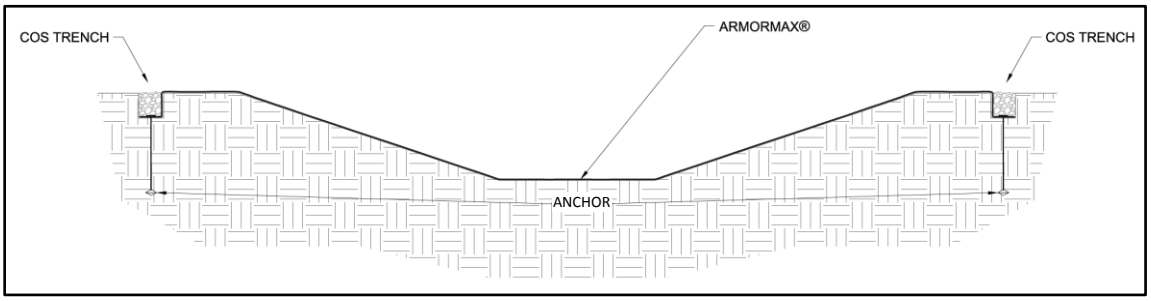


Figure 16: Crest of Slope (COS) Trenches Complete

14. Continue to work down the length of the channel by repeating steps 6 through 9 overlapping each adjacent ARMORMAX panel by 3 inches (75 mm) (Figure 20).The last ARMORMAX panel should terminate on the Terminal Channel (TC) trench with pins on 12 in (300 mm) centers in between anchors on 5 ft (1.5 m) centers.

15. Lay the ARMORMAX panel on the upstream side of the TC trench (Figure 17). Place the panel edge in the TC trench, ensuring full coverage along the bottom of the entire TC trench with the ARMORMAX (Figure 18).

16. Secure ARMORMAX with pins and ANCHORs in the TC trench. Suggested placement of pins and anchors for the TC trench is along the bottom of the trench with pins on 12 in (300 mm) centers in between anchors on 5 ft (1.5 m) centers (Figure 18).

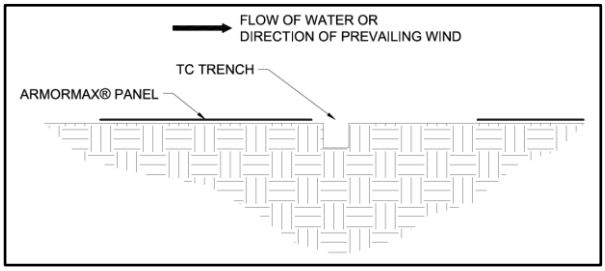


Figure 17: Terminal Channel (TC) Trench Alignment

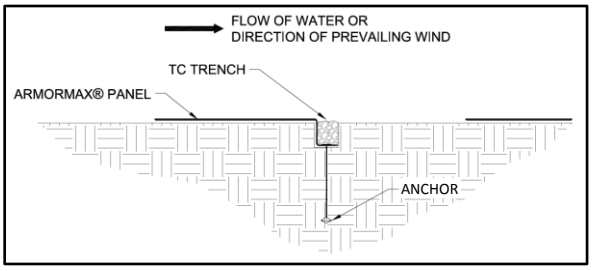


Figure 18: Terminal Channel (TC) Trench Placement

17. Backfill and compact the TC trench (Figure 19).

18. Fold the ARMORMAX panel over the top of the compacted TC trench ensuring a minimum 3 inch (75 mm) overlap and place each panel end into the respective COS trenches (Figure 19).

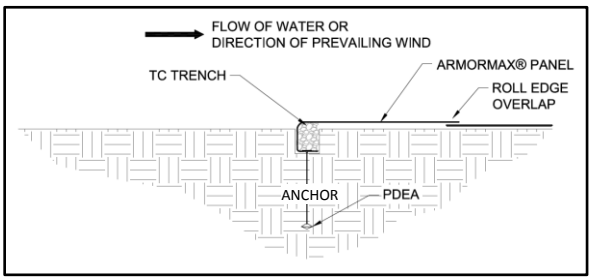


Figure 19: Terminal Channel (TC) Trench Complete

19. At a minimum, ARMORMAX panels should be pinned entirely across the channel surface, pins and earth s should be installed in the trenches, and the trenches should be backfilled and compacted at the end of each day to minimize rework in the case of a major rain event. Specific project conditions may warrant further evaluation of installation order for ease. An example elevation view (Figure 20) of a channel armored with ARMORMAX can be seen below for overall reference. Consult Propex Engineering Services at (423) 553-2450 with any questions that you may have.

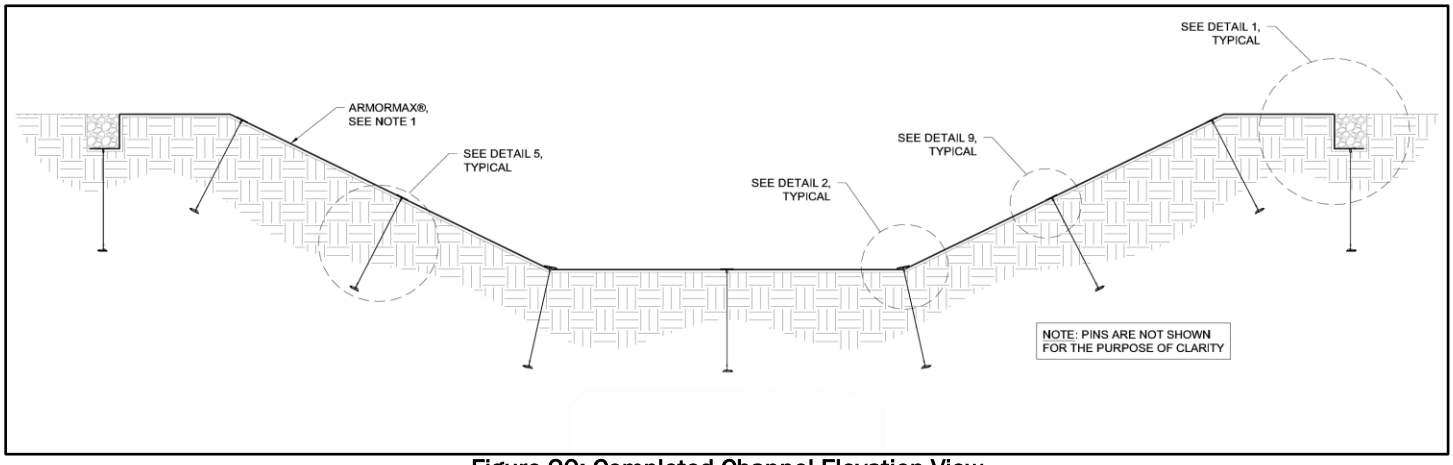


Figure 20: Completed Channel Elevation View

INSTALL ANCHORS

The ARMORMAX anchor typically consists of an anchor head, a flexible cable tendon, and a load bearing plate. For quality control purposes and warranty claims, anchors should be delivered to the jobsite fully assembled and ready for installation.

Anchors are to be installed in locations specified for the project, and are typically installed in conjunction with *ARMORMAX LAYDOWN*. There are several options available from Propex for different types of anchors. For optimal performance with the greatest risk reduction, it is important to select the proper anchor and perform the installation in accordance with the pattern designed for required resiliency and long term durability of the slope. Understanding the mechanics behind installing the anchor component of ARMORMAX will result in a quality ARMORMAX installation.

TYPE B1 & B2 ANCHOR

The installation of either Type B1 or Type B2 Anchor (Figure 21) is described below. The tools that you will need are a percussion hammer, a ground rod driver and drive steel compatible with the anchor and percussion hammer, a JackJaw setting tool, and wire cutters.

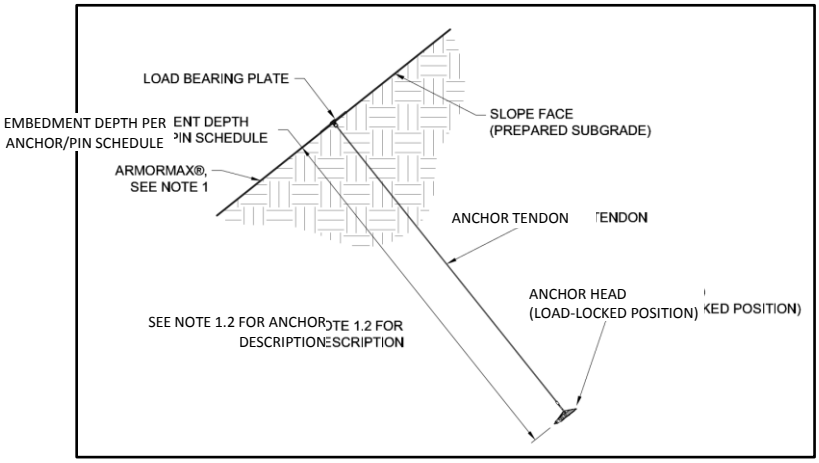


Figure 21: Anchor Detail

1. Use one piece drive steel or assemble segmental drive steel to the appropriate length in order to drive the anchor to the specified embedment depth.

2. Insert the tapered end of the drive steel into the hollow cavity of the anchor head. Position the anchor head/ drive steel tip above the ground at the drive location (Figure 22 and Figure 23).

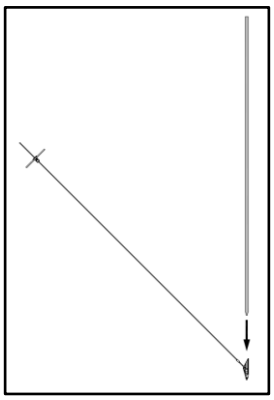


Figure 22: Insert Drive Steel into Anchor

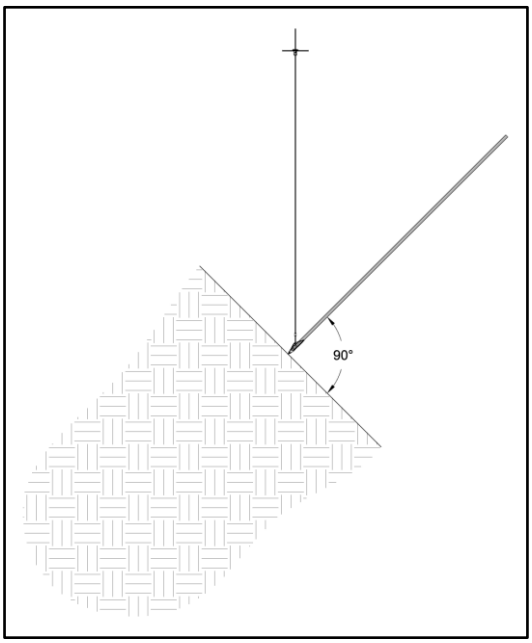


Figure 23: Position Anchor Head / Drive Steel Tip

3. Using a percussion hammer, guide the drive steel into the ground perpendicular to the slope surface at a smooth pace. Continue driving until the desired embedment depth is reached (Figure 24).

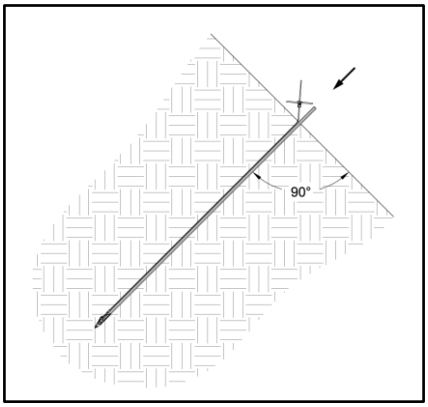


Figure 24: Drive Steel to Drive the Anchor into the Ground

4. Remove the drive steel from the ground. (Figure 25) Depending on soil conditions, this may require the use of a setting tool or leverage device.

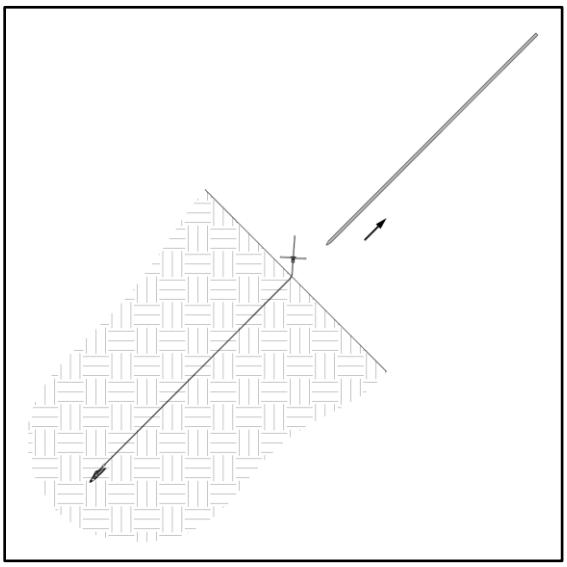


Figure 25: Remove Drive Steel from Ground

5. Slide the load bearing plate down the anchor tendon towards the slope surface using your hands (Figure 26).

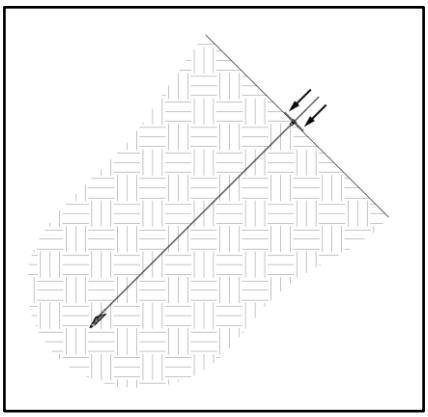


Figure 26: Slide Plate

6. Once the plate is close to the slope surface, place the JackJaw Setting Tool on the anchor plate and place the top of the anchor tendon into the grips, keeping the anchor tendon perpendicular to the slope surface (Figure 27). With gentle force, slowly start to press down on the JackJaw lever – towards the slope surface - causing the anchor tendon to start to move out of the ground (displace). During this step, the anchor head will turn in the ground – a process known as "anchor setting". The change in embedment depth to set a Type B1 Anchor can be up to 6 inches and up to 8 inches for Type B2 depending on soil conditions. When the anchor is set, there will be a noticeable change in the amount of force needed to displace the anchor any further. This is a good indication that the anchor head is now perpendicular to the anchor tendon and the anchor is ready to be load-locked.

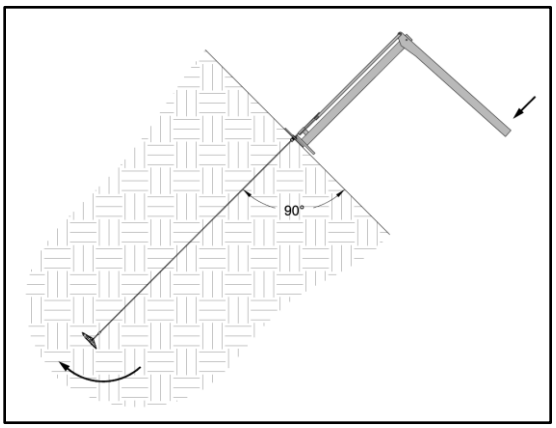


Figure 27: Use JackJaw Setting Tool to Set Anchor

7. To load-lock an anchor, continue to apply tension to the anchor tendon using the JackJaw Setting Tool creating a slight depression on the slope surface. Visually, anchors across ARMORMAX will look similar to buttons across a mattress top when anchors have been properly load-locked.

8. Conduct anchor load tests when required for quality assurance during installation. Refer to the document entitled "Anchor Load Test Manual" by Propex for further details.

9. Once anchors have been load-locked, cut off the excess anchor tendon flush to the plate at the slope surface using wire cutters (Figure 28 and Figure 29).

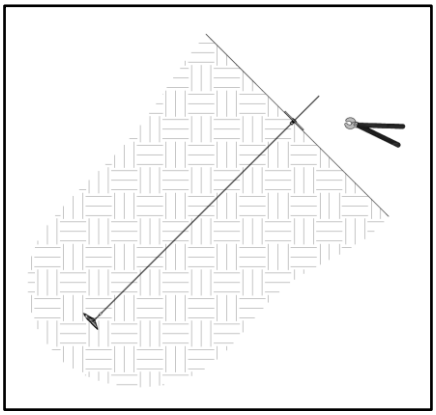


Figure 28: Trim Extra Cable Flush to Plate

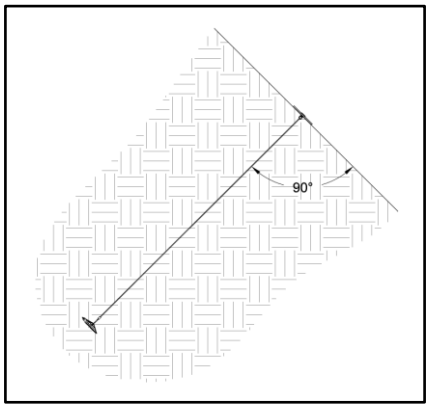


Figure 29: Complete Anchor Installation

VEGETATION ESTABLISHMENT

Vegetation can be established with ARMORMAX by broadcast seeding, hydraulic seed application (hydroseeding), or sodding. Seed application rate, seed type, sod type, and irrigation rate should be selected based on local or site specific knowledge and time of year. For best results, consider having a site specific soil test performed to help determine what soil amendments, such as lime and fertilizer, need to be incorporated into the soil to promote healthy vegetation.

WITH SEED

1. Determine the seed location. Seed can be placed entirely on top of soil filled ARMORMAX, or alternatively 50% below ARMORMAX prior to pinning and anchoring, with the remainder placed on top of soil filled ARMORMAX. If a rain event occurs prior to vegetation establishment, having 50% of the seed below ARMORMAX ensures that some seed remains in place. Seed placed entirely on top of soil filled ARMORMAX will allow for faster vegetation establishment.

2. If seeding below ARMORMAX, ensure 50% of the seed is placed prior to the installation of ARMORMAX.

3. Once ARMORMAX is in place, distribute soil on top by filling the pyramid like projections of ARMORMAX. The proper amount can be visually measured by making the top ridges of the pyramid projections barely visible, or is approximately 1 inch thick when measured. Soil filling can be accomplished manually or by using a small piece of equipment. Do not place excessive soil above ARMORMAX. See *PROJECT SPECIFIC CONSIDERATIONS* for guidance on driving equipment across ARMORMAX.

4. After seed has been placed, for added protection, install a Landlok® Erosion Control Blanket (ECB) above the soil-filled ARMORMAX.

5. Irrigate as necessary to establish and maintain vegetation until 75% of vegetation has established and has reached a height of 2 inches. Frequent, light irrigation will need to be applied to seeded areas if natural rain events have not occurred within two weeks of seeding. When watering seeded areas, use a fine spray to prevent erosion of seeds or soil. Do not over irrigate. Proper irrigation guidance is provided under the Maintenance portion of this document.

WITH SOD

1. Sod will be always placed on top of ARMORMAX.

2. Sod staples should be used to secure the sod against ARMORMAX. During the placement of the sod, ensure that ARMORMAX is 100% covered by tightly adjoining rolls or squares of sod along edges. Any voids in between sod pieces should be filled with clean loose soil.

3. Irrigate as necessary. Proper irrigation guidance is provided under the Maintenance portion of this document.

4. Monitor to identify areas where browned/dead sod emerges. These areas may need to be addressed to ensure proper sod establishment.

PROJECT SPECIFIC CONSIDERATIONS

1. For applications that require special transitions (i.e. connections to riprap, concrete, T-walls, etc.), refer to the project specific drawings or consult with Propex Engineering Services at (800) 621-1273.

2. A deeper trench and/or hard armoring may be required when channels have severe scour potential at IC and TC trenches.

3. For installing ARMORMAX panels around curved sections of a channel, trim panels at an angle so that no more than two layers of ARMORMAX overlap at any point in time. Additional pins and anchors may be needed to secure panel edges towards the break in slope interface depending upon the radius of the curved channel. Install pins or anchors as necessary to securely fasten ARMORMAX to the ground.

4. Allowable Vehicle Traffic:

   A. If using equipment on ARMORMAX, it should be of the rubber-tired type and should avoid sharp turns. Tracked equipment is not permitted to drive over the ARMORMAX without vegetation at any time.

   B. Avoid any traffic over ARMORMAX if loose or wet soil conditions exist.

5. Disturbed areas should be reseeded. If ruts or depressions develop for any reason, rework soil until smooth and reseed or sod such areas.

SHORT-TERM AND LONG-TERM MAINTENANCE OF ARMORMAX

The purpose of this section is to provide some general guidelines for performing short-term and long-term maintenance of ARMORMAX with respect to maintaining vegetation reinforced with ARMORMAX, and patching of ARMORMAX (in the event it needs to be removed or replaced). These procedures are to be considered minimum guidelines for proper maintenance, and further maintenance techniques may be appropriate considering local practices and procedures.

ARMORMAX PROTECTED CHANNEL

For ARMORMAX to be most effective, it is important to ensure that it is properly maintained both during construction and after construction. Identifying trouble areas is easy with ARMORMAX, and it can make identifying potential threats much simpler and manageable. Look for areas with sparse, dying, or no vegetation as these are obvious signs that ARMORMAX is losing intimate contact with the channel surface. If loss of ground surface occurs, ARMORMAX will need to be removed and reinstalled as described in *PATCHING AND REPAIRS* Section after the eroded area is backfilled with compacted soil that is similar to material of the slope. After ARMORMAX is reinstalled, re-establish vegetation on the newly installed ARMORMAX and disturbed areas. Monitor the sites to determine if frequent watering may be required to establish vegetation.

To minimize exposure to unwanted maintenance and repair, ARMORMAX armored channels should be free of unauthorized vehicular traffic. Routine maintenance and slope inspections should be performed with rubber tired vehicles. Tracked equipment such as skid steers, excavators, or dozers should only be allowed to traffic over ARMORMAX in times of emergency after vegetation establishment is complete. Failure to control unauthorized traffic can result in ARMORMAX being damaged resulting in erosion below ARMORMAX during storm events. In addition, routine mowing maintenance should be used to keep the protected area free of unwanted brush, saplings, and trees. Selective herbicides that target only the unwanted plants can be used as long as the vegetation established with ARMORMAX is not impaired. Failure to control the sapling and tree growth can result in the trees being uprooted during a flood.

MAINTAINING VEGETATION

Good vegetative cover will ensure maximum performance of ARMORMAX. Vegetative cover care starts before a project is complete and is ongoing until all ARMORMAX is installed. Vegetative cover should be given every opportunity to grow and establish well. This will require that a contractor periodically fertilize, water, and mow the grasses as needed until a project is complete in the short-term, with the owner of the channel fulfilling the maintenance of the channel in a similar fashion for the long-term. For the entire lifecycle of ARMORMAX, every effort must be made to prevent unauthorized encroachments, grazing, vehicle traffic, the misuse of chemicals, or burning during inappropriate seasons.

1. After the installation of vegetation is complete, immediately water and soak the entire area using a fine spray to prevent erosion and loss of seeds. A suggested amount of water is identified below. Prior to installation if using sod, the sod pads in storage should be kept moist at all times and not stored for more than 24 hours from site arrival to installation. Warmer weather will necessitate more frequent applications than listed below.

   A. For each reach/segment of installed vegetation, watering shall be conducted immediately after each installation or the day's work.

   B. For initial vegetation establishment, water vegetation in a manner consistent with best practices for vegetation type and location.

C. Establish a watering schedule and follow until vegetation is well established and will thrive in the absence of manual watering.

D. Avoid excessive application of water, so that surface runoff does not occur. Runoff should be prohibited. However, additional watering may be required for repaired or damaged areas.

2. Fertilizer should be applied as needed to address any nutrient deficiencies revealed in soil testing.

3. Implement best practices for mowing over ARMORMAX. While ARMORMAX is designed to withstand non-hydraulic stresses such as mowing, there are procedures to minimize exposure to unwanted damage.

   A. Immediately after installation, signage and post shall be installed stating that "Vehicles and Pedestrians are Prohibited from Access" on the slopes and the newly installed vegetation. Signage shall be posted every 1,500 lineal feet.

   B. Vegetated areas should be mowed to a height no less than 6 inches and no greater than 12 inches from natural ground after a period of 60 days of growth. The excessive grass clippings created from mowing shall be evenly spread on the slope section outside of the armored area. Periodic and final grass mowing should be performed until final inspection and acceptance of slope work. Monitor the vegetated areas throughout winter months and generate reports as needed, noting any issues that should be addressed. Minimum mowing heights will depend on the vegetation density and should be as follows:

      i. 6" with 0 – 30% vegetation establishment
      ii. 4" with 30 – 70% vegetation establishment
      iii. 3" with 70 – 100% vegetation establishment

   C. To prevent damage to the newly established vegetation, the mowing tractor should be fitted with 3-rib agriculture tires. Note that tractors with 8-foot flail mowers provide best results. Tractors with 15-foot brush hogs should avoid sharp turns up the slope to prevent damage to vegetation.

   D. Mowing should not take place for a minimum of 48 hours after a rainfall event of 2 inches or more to minimize the potential for rutting and/or damage to the slope surface. Maintenance mowing of the slope should be done on a consistent basis to prevent vegetation growing to more than 3 feet in height. This will minimize thatch thickness and potential damage to ARMORMAX. If turn-around pads are present, operate mowing equipment utilizing the turn-around pads to the fullest extent. The mowing blade height over ARMORMAX should be a minimum of 8 inches. However, should vegetation grow to more than 3 feet in height, the mowing blade height for the condition should be a minimum of 12 inches.

4. Some special circumstances may exist. When mowing the crown of a slope with a crown or crest equal to or exceeding 20%, it should be mowed with an articulating arm mower to minimize the potential for the mower blades to catch ARMORMAX at the channel surface. The articulating arm mower should be level on the surface with the articulating arm extending over the crown. **Pay close attention to areas where the slope changes.** The mower blades should be set at a minimum height of 8 inches. If ARMORMAX is damaged by the mowing blades at any time, mowing should stop immediately and further direction should be obtained to continue activity. Repair the damaged area as described in the *Patching and Repairs* section below.

5. ARMORMAX protected channels are not as susceptible to animal burrowing due the tenacity of the ARMORMAX; however, inspections to detect the presence of burrowing animal activity are generally most effective immediately after the slope has been mowed. Animal burrows that are identified should be thoroughly excavated and inspected, backfilled with compacted soil that is similar to material of the slope, and vegetation re-established. This will avoid the possibility of water piping through unfilled portions of the burrows. Should ARMORMAX be damaged, it is to be repaired as described *Patching and Repairs* section below.

PATCHING AND REPAIRS

ARMORMAX may require localized repair at times. For emergency repairs, an adequate supply of ARMORMAX should be maintained in inventory with the necessary tools to install. This will allow for a timely, initial repair of the system.

1. In order to identify areas in need of repair, the site should be patrolled immediately after mowing and after rain events of 2 inches or more. When patrolling look for areas of sparse vegetation, exposed edges of ARMORMAX, and areas where direct contact between ARMORMAX and the channel surface is compromised. ARMORMAX should be rated as *Acceptable, Minimally Acceptable*, or *Unacceptable* during inspection.

   A. *Acceptable* (A) - The rated area is in satisfactory, acceptable condition, and will function as designed and intended during the rain event. ARMORMAX has no exposed edges, is installed tightly by maintaining direct contact to the channel surface with no rilling beneath, and has over 90% vegetation cover. There is no noticeable damage present.

   B. *Minimally Acceptable* (M) - The rated area has a minor deficiency that needs to be corrected. The minor deficiency will not seriously impair the functioning of the area during the next rain event; however, the overall reliability of the project will be lowered because of the minor deficiency. ARMORMAX has 75% vegetation cover with un-vegetated patches as large as one square yard. Edges of ARMORMAX are exposed with noticeable damage. Minimal erosion has occurred underneath ARMORMAX.

   C. *Unacceptable* (U) - The rated area is unsatisfactory. The deficiency is so serious that the area will not adequately function in the next rain event. ARMORMAX has been physically torn, ripped, or lifted from the channel surface. Less than 75% vegetation cover is present with un-vegetated patches being greater than 1 square yard, and there is evidence that erosion is occurring beneath ARMORMAX.

2. Repair any raised or exposed edges of ARMORMAX by driving existing and additional pins or anchors along the edges as necessary to securely fasten to the ground. Inspect areas where the vegetation is not growing on top of ARMORMAX. Many times this is an indicator that ARMORMAX has lost contact with the ground beneath. Check for voids beneath ARMORMAX and fill any holes, gullies, etc. with compacted fill material if possible. Replace ARMORMAX as described below.

3. To repair ARMORMAX, cut out and remove damaged areas in a square configuration a minimum size of 2 ft by 2 ft. Remove all vegetation and debris atop of ARMORMAX. Loosen the top 1 to 2 in of soil in the patch area then seed. The subgrade of area to be patched shall be prepared to be smooth and uniform and transition smoothly into the in-situ area. Cut a square ARMORMAX patch a minimum of 12 in greater than the damaged area for all four sides of the patch. Overlap the patch area in all directions a minimum of 12 in. The patch overlaps shall be tucked under the existing damaged ARMORMAX material (Figure 30 and Figure 31).

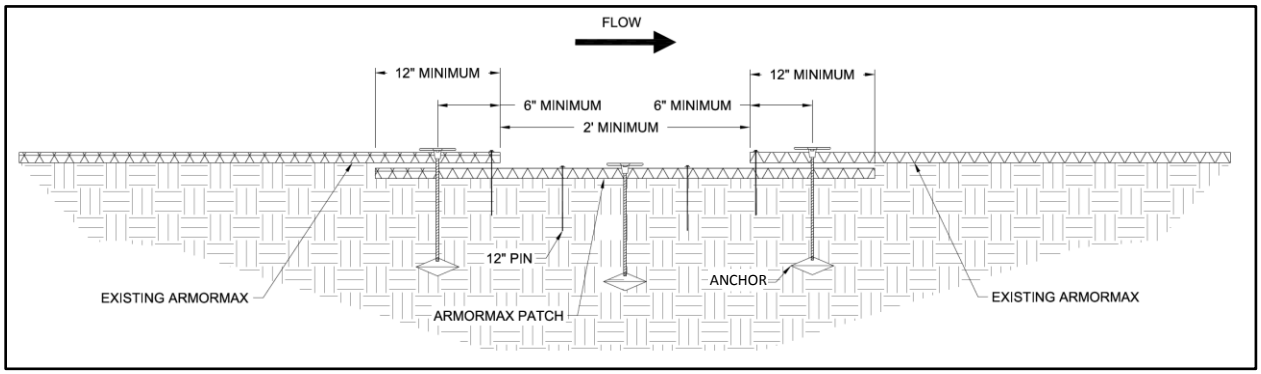


Figure 30: ARMORMAX Patch Cross Section

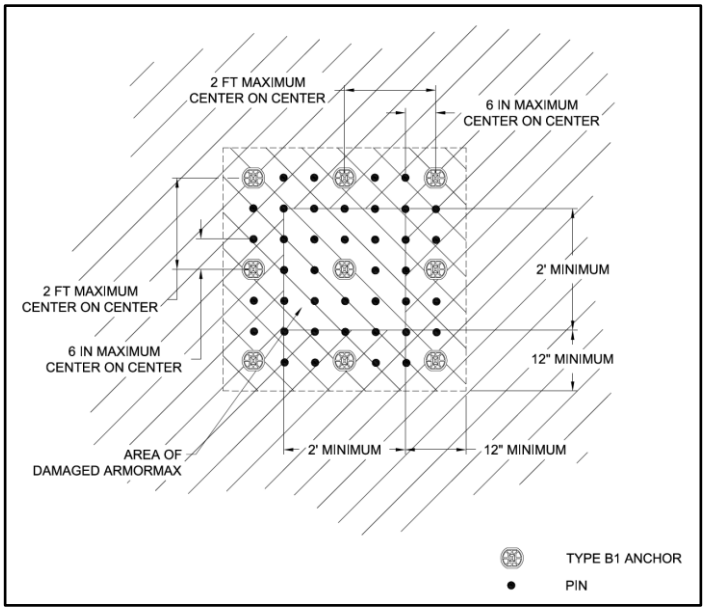


Figure 31: ARMORMAX Patch Plan View

4. Install Type B1 anchors on 2 ft (600 mm) (max) centers, and pins on 6 in (150 mm) (max) centers. For larger areas of damage, anchors should be installed to match existing anchor pattern. Once ARMORMAX is in place, vegetate per project specifications.

SUMMARY

Maintenance should consist of watering and weeding, repair of all erosion, and any re-seeding as necessary to establish a uniform stand of vegetation during construction and beyond. A minimum of 70% of the armored area should be covered with no bare or dead spots greater than 10 ft^2 (1 m^2). Establishing vegetation should not be mowed prior to 70% vegetative density and a minimum grass growth of 4 in (100 mm). Throughout the duration of the project, the contractor should be responsible for mowing to facilitate growth and should not let the vegetation in the armored areas exceed 18 in (450 mm). In addition, the Contractor should water all grassed areas as often as necessary to establish satisfactory growth and to maintain its growth throughout the duration of the project. After the project is complete, it is the responsibility of the Owner to maintain and upkeep all ARMORMAX installed areas for long term performance and best results as described herein for superior channel armoring.

APPENDIX F

REVEGETATION PLAN

Knuedler Lake and Upper Spring Revegetation Plan
Mindego Ranch Ponds Enhancement Project

Prepared for

Midpeninsula Regional Open Space District

Prepared by

Kittleson Environmental Consulting
3283 Malibu Drive
Santa Cruz, California 95062
(831) 251-0215
kittlesonenvironmental@gmail.com

October 16, 2019

I. Summary

The Knuedler Lake and Upper Spring Revegetation Plan element of the Mindego Ranch Ponds Enhancement Project provides the goals, design, maintenance, monitoring and reporting requirements for installing plants and erosion control for proposed vegetation and sediment removal activities at Knuedler Lake and Upper Spring. Knuedler Lake covers approximately 1.15 acres (49,909 sq. ft.), with the majority of the lake composed of a dense cover of emergent wetland vegetation dominated by broad-fruited bur-reed (*Sparganium eurycarpum*), common knotweed (*Persicaria lapthifolia*), California bulrush (*Schoenoplectus californicus*), and cattail (*Typha sp*.). The periphery of the lake is dominated by a mixture of native and non-native herbaceous wetland species including spikerush (*Eleocharis macrostachya*), water cress (*Nasturtium officinale*), tall flatsedge (*Cyperus eragrostis*), soft rush (*Juncus effusis*) and rabbits-foot grass (Polypogon monspeliensis). Figure 1.

Figure 1. Knuedler Lake with location of proposed habitat conversion to open water. 9/2018



The primary objective of the Knuedler Lake enhancement effort is to create more open water habitat within a densely vegetated seasonal lake. The proposed grading and deepening of the lake is limited to only about 10% of the lake surface (0.11 acres or 4,920 sq. ft.) on the District's side of the lake (APN: 080-340-010). The area to be cleared of vegetation will be deepened by approximately 4 feet and will have a 1:1 slope on the edge of cut in the lake center and a gradual slope of 4:1 to the lake shoreline.

Due to the normal seasonal dry-out conditions, it can be assumed that the existing burreed will gradually re-colonize the deeper water areas from the cut bank during the dry season while existing,

remaining knotweed will expand in shallow water while seed stock from sedges and rushes will be brought in by wind, water and waterfowl. As a result, the Knuedler Lake Revegetation Plan is limited in scope to the relatively small area of construction disturbance within the lake and it proposes to use a small number of low stature sedges and rushes species which will be collected on site, held in 5-gallon buckets during grading, and replanted immediately after grading. No nursery stock is proposed.

The Upper Spring restoration effort will also be focused on sediment and vegetation removal to increase pond capacity and available aquatic habitat for amphibian breeding. Revegetation plans at Upper Spring are limited to hand-broadcasted erosion control seeding in the spoils disposal area and in the reinforced spillway.

II. Policy Guidance

The District's Resource Management Policies (December 2014) include an overall Vegetation Management Goal and specific policies that address revegetation. The Knuedler Lake Enhancement Project and the attached Revegetation Plan are consistent with the District's Goals and Policies, even though general nature of the work is the creation of open water habitat in a well-vegetated seasonal lake. The relevant District goals and policies are highlighted below:

Goal VM- Sustain and promote viable and diverse native plant communities characteristic of the region

Policy VM-1 Maintain the diversity of native plant communities.

♦ *Identify appropriate areas for restoring lost or altered native plant communities and restore them to a natural condition. This is often best done by restoring natural processes and controlling invasive plants, rather than by planting.*

♦ *Manage native grassland sites to encourage reestablishment and perpetuation of California native grasses.*

Policy VM-2 Use native species occurring naturally on similar sites in ecological restoration projects.

♦ *Use seed and cuttings collected from the same geographic area to revegetate or enhance degraded areas. One source of native seed is topsoil or mulch taken from adjacent intact habitat and applied thinly.*

♦ *Use fill, mulch, and seed mixtures that are as free as possible of non-native plants in ecological restoration projects. Know where such materials come from. (See GS-2 for possible exception.)*

♦ *Use plant material that is biologically and visually appropriate to the surrounding wild landscape and appropriate to the stage of plant community development at the site.*

III. Project Background

Knuedler Lake is habitat for three special status species: the San Francisco garter snake ("SFGS"), the California red-legged frog ("CRLF"), and the western pond turtle. The San Francisco Garter Snake Habitat Management Plan, dated September 5, 2012, was prepared for the District's Mindego Ranch Property and identified site-specific management strategies for enhancing SFGS habitat within the Preserve, including recommendations for Knuedler Lake. The primary objective of the Knuedler Lake Enhancement Project is to improve the habitat for these sensitive species, with emphasis on habitat needs for the SFGS and its prey base (CRLF, Pacific tree frogs *(Pseudacris regilla)*, and other amphibians).

The 2012 SFGS Management Plan states that Knuedler Lake may have been a more productive CRLF breeding location in the past, when regular cattle grazing created open water habitat. Under current conditions, only a small, shallow residual pool of open water remains in the lake center during the late summer and fall. CRLF and western pond turtles were observed using this habitat during the September 2018 field surveys conducted by KEC.

Figure 2. CRLF observed on edge of in shallow open area in center of Knuedler Lake. 9/17/2018



Enhancement of the pond in the proposed plan will be accomplished by removal of the dense accumulations broad fruited burred, knotweed and underlying sediment. The additional areas of open water will contribute to the recovery of the species by providing breeding habitat for CRLF and other amphibian species. This is expected to benefit SFGS by providing a more robust population of native prey species. The larger area of open water will also provide additional foraging habitat for western pond turtles in all life history stages.

IV. Revegetation Design

At Knuedler Lake, approximately 0.11 acres or 4,920 sq. ft. of open water habitat will be created and planted with 10 planting groups, consisting each of groups of 3 salvaged or locally collected spikerush and tall flatsedge clumps. A total of 30 healthy plants will be salvaged from the project impact area or collected on site for replanting.

Hand broadcasted native grass seed with crimped sterile straw will be used for erosion control on the 8,550 sq. ft. spoils disposal area located on the adjacent grassland habitat at Knuedler Lake. Spoils will be a mix of wet, fine sediment and wetland plants. It is anticipated that abundant seeds within the spoils, combined with the uprooted wetland plants, will result in a mix of upland grasses and wetland plants in the spoils disposal area during the 3 year plant establishment period.

No grading will be done for access routes and staging, to limit soil disturbance. It is anticipated that the existing primary access road will be used and hauling and staging will be done on dry grass-covered locations and routes. A District-approved sunny native grass seed mix will be used and is listed in Table 1. An overall revegetation plan view for Knuedler Lake is shown in Figure 3.

At Upper Spring, hand broadcasted Sunny Seed Mix will be used for erosion control on the spoils disposal area located on the adjacent grassland habitat. Like Knuedler Lake, spoils will be a mix of wet, fine sediment and wetland plants. The erosion control plan for Upper Spring calls for the District's Shade Seed mix in the spillway fabric installation area. The District's approved shade see mix is listed in Table 2.

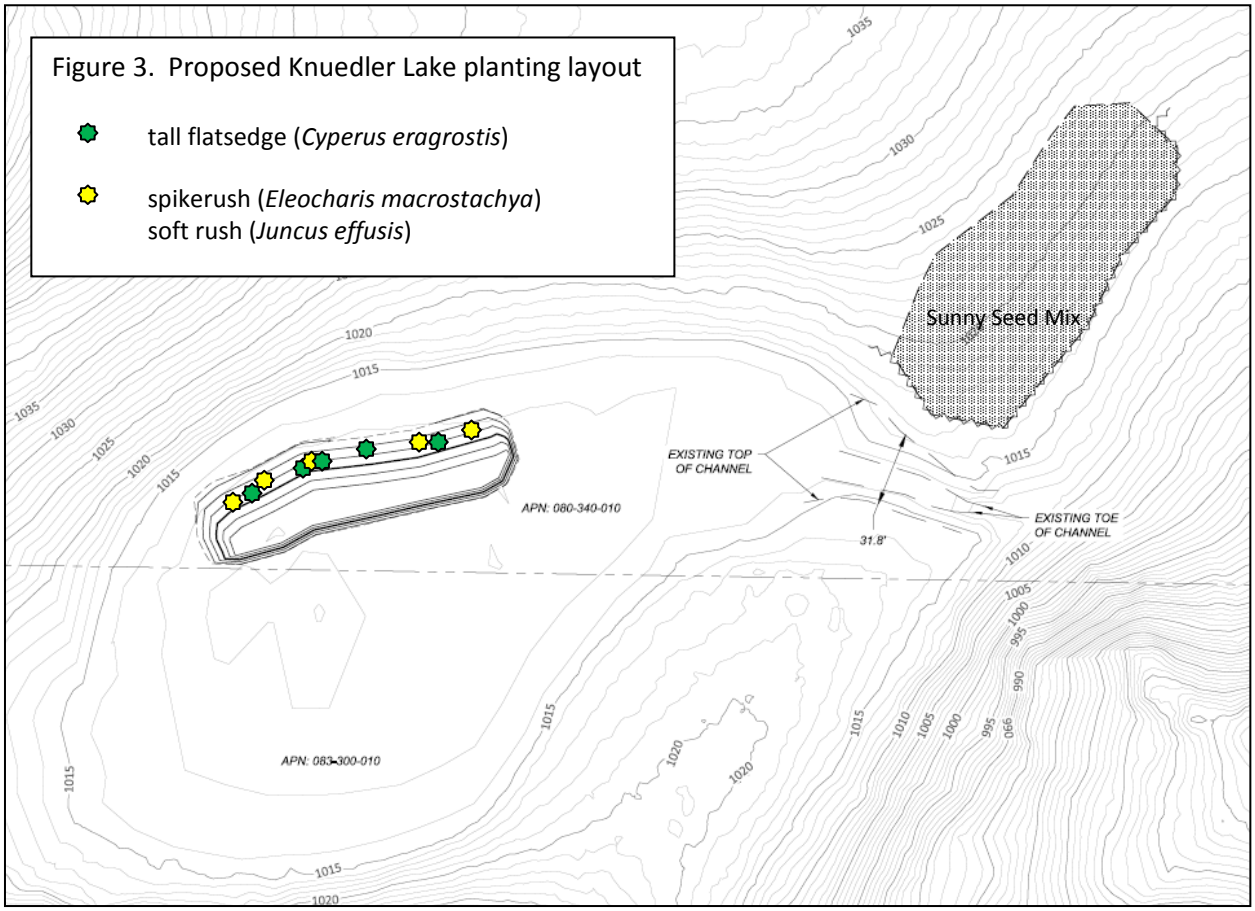


Figure 3. Proposed Knuedler Lake planting layout

Table 1. Sunny Seed Mix

Species Name	Common Name	Percent in 40 lb. bag
Stipa pulchra	purple needle grass	20%
Bromus carinatus	California brome	40%
Elymus glaucus	blue wild rye	40%

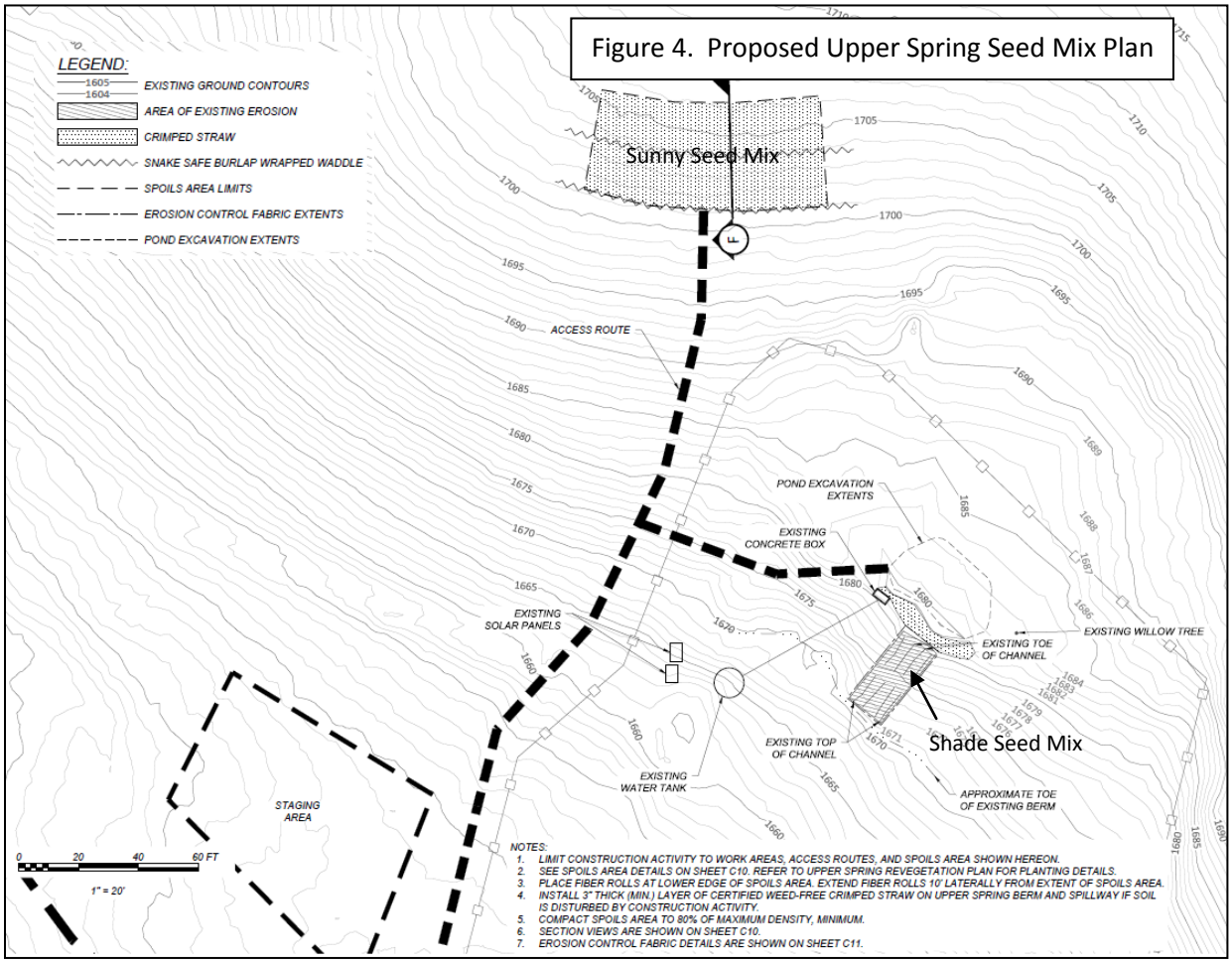


Figure 4. Proposed Upper Spring Seed Mix Plan

Table 2. Shade Seed Mix

Species Name	Common Name	Percent in 40 lb. bag
Bromus carinatus	California brome	37.5%
Regreen™	sterile wheatgrass seed	62.5%

V. Maintenance

Maintenance is expected to belimited due to the small size of the project and the over-arching goal of the project to create open-water habitat at both ponds. Maintenance may be necessary at regular intervals for the first 3 years. Maintenance includes the removal of invasive, non-native vegetation and replacement of dead plants (only if survivorship drops below accepted thresholds). Monitoring data will be used to evaluate the need to adjust maintenance activities to ensure the success of the revegetation project.

The plantings at Knuedler Lake will not require watering during the proposed 3-year plant establishment period. Seasonal inundation and annual dry-out will dictate plant success for the replanted material. Natural recruitment of other emergent wetland species is anticipated and will be documented. Maintenance may include vegetation thinning if the burreed, cattail, and knotweed aggressively re-colonize the newly created open water habitat.

Weeds within the revegetation sites will be controlled throughout the plant establishment period. Weed control methods in the aquatic habitat shall be by pulling by hand or mowing and will be consistent with the District's Integrated Pest Management Program.

Following Year 3, the conditions the installed plants will be evaluated and dead plants will be replaced if the average plant survival for all installed species combined falls below the 80% plant survival criterion outlined in the next section. An adaptive management approach towards plant replacement will be instituted and plant species chosen for replacement will be based upon the availability of similarly suitable native plant material on the District's property.

VI. Monitoring and Reporting

Monitoring of the mitigation site by a qualified biologist will be conducted throughout the 3 year plant establishment period, and monitoring reports will be prepared annually. Field monitoring will take place annually, with the first monitoring to occur during the summer following site installation. By the final year of monitoring, the plantings should be sufficiently well established to determine if the site will eventually achieve the long-term goals of sustaining a mix of open water, native emergent plant cover, and less than 10% cover of invasive species.

Survival will be assessed by a full plant count, recording survivorship by species. Each planting group will be inspected to determine whether the plants therein are alive or dead. Vigor (overall plant health) shall be monitored each year. A survival criterion of 80% is proposed for the installed rushes and sedges. In addition, a qualitative assessment of the installed plants shall be made and a visual estimate of percent cover across the enhancement site should be done to characterize the ecological succession in the open water-emergent marsh habitat.

The annual report will include: a summary of the year's monitoring observations, a summary of invasive plant control efforts, an assessment of progress towards success survivorship requirements, and any

recommendations, including vegetation thinning recommendations should the burreed and knotweed re-colonize the open water habitats. The annual report will be finalized and submitted to regulatory agencies as required by January 31 of each reporting year.

VII. References

Biosearch Associates and Coast Range Biological. 2011 (November). *Biotic Assessment for Mindego Gateway Study Area, San Mateo County, CA.* Santa Cruz, CA.

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Guidelines for Minimizing *Phytophthora* Contamination at Midpeninsula Regional Open Space District Preserves

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The goal of these guidelines is to minimize the contamination of Midpeninsula Regional Open Space District (MROSD) preserves with *Phytophthora*, a soil pathogen that kills plants. Once a site is contaminated, this soil pathogen can spread farther into wildland areas and can be difficult to eradicate. Prevention is the lowest cost and easiest method to manage contamination.

The best way to prevent the spread of this disease is to not move soil from one location to another by cleaning tools, equipment, and footwear.

Part of the District's mission is to protect and restore the natural environment. Within the last few years, planted restoration sites have unintentionally exposed preserves to soil pathogens brought in by nursery plants that were later found to be contaminated. Testing of former restoration sites on District preserves is now underway to determine which sites are contaminated and the necessary remedial actions.

Who should use these guidelines?
These guidelines are intended for use by field staff and Natural Resource (NR) staff who pose the highest chance of spreading soil *Phytophthora* via equipment and footwear. Several methods are provided on how and when to decontaminate tools and equipment depending on the site conditions (contaminated versus clean site) and staff activities (planting, other). Guidelines for contractors, consultants, volunteers and preserve visitors are under development. Consult NR staff (Amanda Mills, amills@openspace.org or x558, or Coty Sifuentes-Winter, csifuentes@openspace.org or x560) on which guidelines are best for your project.

When to use these guidelines?
Use these guidelines for any activity that contacts soil, water or plants on a known Phytophthora-contaminated site, on a formerly planted site, on a site with rare plants, or when preparing or planting a new restoration site.

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1. Overview

Remember to **Arrive Clean and Leave Clean**. The best way to prevent the spread of *Phytophthora* is to leave soil at its original location in the field. Equipment and footwear should be clean and sanitized before entering a site, especially for planting events where extra precautionary steps will be taken. Before leaving a site, especially at contaminated sites, it's crucial to clean and sanitize footwear and equipment.

Definitions:

Clean - remove soil and organic debris from tools and footwear

Sanitize - Use disinfecting agent such as alcohol or chlorine bleach.

Phytosanitary- control of plant pests and diseases especially in agricultural crops

1.1 What is Phytophthora?

1.1.1 *Phytophthora* (Fie-tof-thora) is a group of water molds that infect plants. There are many species, mostly notably *P. ramorm* (Sudden Oak Death), *P. infestans* (potato blight/ Irish potato famine) and *P. tentaculata* (nursery root rot).

1.1.2 Symptoms are similar to drought, making diagnosis difficult without testing.

1.1.3 Symptoms include leaf spots, branch die-back, cankers, trunk bleeding and death of whole plant.

1.1.4 Hosts include many native and nursery plants including oaks, bay laurel, madrones, sticky monkeyflower.

1.1.5 Brought to California through imported camellia and rhododendron nursery plants.

1.1.6 Mainly spreads from contaminated nursery stock, pots and soil. Can spread by foot traffic from contaminated footwear.

1.2 General Steps:

1.2.1 **What -** Items to be cleaned: Anything that comes into contact with soil, water or plants. This includes tools (shovels, hand trowels, hori-horis, rakes, tree cages, plant protection tubes etc.), footwear, equipment, wheeled equipment and vehicles.

1.2.2 **When -** Prior to the project day, field staff will be notified what items need to be cleaned and by which method. In general, tools and equipment should be cleaned at the field office before bringing them to the field site, and soil should be removed from footwear beforehand and more thoroughly cleaned at the entrance to the field site.

1.2.3 **Transportation** - Cleaned equipment should be transported in a truckbed from which all soil has been washed out, or cleaned equipment can be wrapped in a clean tarp before placed in a dirty truck.

1.3 Proper Disinfectants

All recommended disinfectants are considered pesticides. Personal protective equipment required by the State of California for anyone using disinfectants is eye protection with wrap-around and brow protection and 14 mil chemical resistant gloves. You can use smaller mil gloves if handling chemicals for 15 minutes or less.

1.3.1 The disinfectants listed in Table 1 are recommended by standard phytosanitary guidelines.

1.3.2 Other disinfecting agents or methods, such as Lysol or heat treatments, must be reviewed and approved by NR staff before use.

1.3.3 Disinfectants are most effective when surfaces are clean of soil and user follows label instructions.

Disinfecting Agent	**Active ingredient**	**Contact time**	**Product shelf life**	**Proper Disposal**	**Health Risk**	**Personal Protective Equipment**
Granular Chlorine Bleach (Leslies Chlor Brite, EZ Chlor)	Sodium dichloroisocyanurate dihydrate	2 min	Long if undiluted	Neutralizer (Vita-D-Chlor)	High	Eyewear, gloves; do not inhale
Liquid Bleach (Clorox)*	Sodium chloride	2 min	3-5 months	TBD	High	Eyewear, gloves; do not inhale
Rubbing Alcohol	Ethanol or Isopropyl Alcohol	1 min	Long	TBD	Med	Eyewear, gloves; flammable
Quaternary ammonium compounds (Quat 128 or Physan 20)	Dodecyl dimethyl ammonium chloride	10 min	Long if undiluted	TBD	Med	Eyewear, gloves; toxic to fish

Table 1: List of approved disinfecting agents. Always follow chemical label instructions.
*Liquid bleaches are generally not recommended as a disinfectant because they lose potency in storage.

2. Cleaning at the Field Office

Clean equipment, tools and footwear at the field office **before** arriving to the project site. This is the easiest way to prevent soil contamination. For those occasions where equipment and footwear must be cleaned at a field site, see Cleaning at Field Site (page 7).

2.1 Remove Soil from Equipment and Footwear

2.1.1 At the field office, scrape, brush, and wash off any soil or organic material. Take care to remove soil trapped in treads or cracks.

2.1.2 Pathogens can survive inside soil clods even after soaking because disinfectants may not completely penetrate large or clayey masses. Therefore, it is important to remove large clods of soil before soaking or otherwise treating with disinfectants.

2.2 Disinfect Tools With Bleach

Several disinfecting agents are available for treating Phytophthoras (Table 1). When many tools need treatment, use granular chlorine bleach at the field office. Spraying with rubbing alcohol is more appropriate for spot treatment at remote field locations.

NEVER MIX DIFFERENT DISINFECTING AGENTS.

ALWAYS FOLLOW LABEL DIRECTIONS.

FOLLOW REQUIREMENTS FOR PERSONAL PROTECTIVE EQUIPMENT WHEN USING DISINFECTING AGENTS.

List of Equipment for Disinfecting Tools:

- **Disinfectant** – most frequently, we expect to be using granular chlorine bleach such as EZ Chlor or Leslie's Chlor Brite when cleaning multiple tools at the field office. Carefully follow the directions below when using any [?] of the bleach disinfectants.
- **Vita-D-Chlor (chlorine neutralizer) -** This neutralizing product is only required if you used chlorine bleach as a disinfectant.
- **Waterproof container -** A large [minimum size?] plastic trashcan or waterproof pop-up garden trimming container in which to mix the water-based disinfectant and soak the tools.
- **Hard bristled scrub brushes and paint scrapers** - Grill brushes with scrapper attachment are handy tools to loosen soil from both flat surfaces and narrow cracks.
- **Personal Protective Equipment** Close-toed shoes, apron or coveralls, protective eyewear, 14 mil chemical resistant gloves (not leather or cloth).
- **Clean water source** - should not be cloudy or with a lot of organic material in it**.** Pressure washers or nozzles are helpful to remove soil quickly and get into small cracks.

2.2.1 Before using the disinfectant, remove soil as described in above section.

2.2.2 Fill waterproof container with 10 gallons of water. Use label instructions to add the right amount of disinfecting agent. For granular bleach, use one teaspoon in 10 gallons to get the desired 0.525% dilution.

2.2.3 Dunk tools in solution for required soaking time (see Table 1). For granular bleach, this is 2-minutes. Just getting tools wet does not mean they will be disinfected. Think of it as chemical cooking.

2.2.4 If you used chlorine bleach as a disinfectant, it needs to be neutralized after soaking. This 'rinse cycle" will deactivate the bleach so it does not corrode metal and so that it is safer to dispose of the soak water. Equipment sprayed with alcohol does not require this neutralization step.

2.2.5 In addition to tools, remember to disinfect the sanitation kit, gloves, tarps, or other miscellaneous items that have come into contact with soil.

2.2.6 Let tools dry. The hose lay is great for drying tarps.

2.3 Disinfect Wheeled Equipment/ Vehicles

Anything with wheels, including wheel barrels, ATV's, motorized carts that will be used at the field site needs to be cleaned and this is best done at the field office before the project. Vehicles that stay at the staging area do not have to be cleaned and sanitized. However, it is good phytosanitary practice to remove soil from wheels every time you leave a site.

2.3.1 Scrub down tires either by hand scrubbing or using a pressure spray wash.

2.3.2 Sanitize using disinfecting spray such as bleach (must be made weekly) or rubbing alcohol.

3. Cleaning at Field Site

Remember to **Arrive Clean and Leave Clean**. If equipment was cleaned and treated with a disinfectant at the field office and delivered in a clean truck, then on-site cleaning of equipment will only be required when leaving at the end of a work day. We recommend that everyone be encouraged to thoroughly clean their footwear of soil before arrival at the site, and then footwear be treated with alcohol upon arrival. Volunteers may not always be aware of this recommendation and may arrive with boots that need to be cleaned of foreign soil at the field site. Scraping all soil off equipment and footwear is required before leaving site, and sanitation of all footwear is usually recommended when leaving a site, especially for known contaminated sites. Rubbing alcohol is usually the preferred disinfectant in the field. Bleach products can be used in the field, but it is harder to mix and dispose of them properly in the field. See details below.

3.1 Cleaning at Start of Field Day

Tools:

Portable sanitation kits include the following items in a bin: 2 tarps, boot brush with scraper, 2 spray bottles of 70% isopropyl alcohol, 2 long-handled brushes, 2 paint scrapers, and instructions. On muddy days, also bring a basin and 2 jugs of water.

Alcohol 70% Ethyl alcohol (Ethanol) or 90% Isopropyl alcohol is fine. Called rubbing alcohol at drug stores.

Spray bottle - we take the nozzles from chemical resistant spray bottles and screw them directly into the rubbing alcohol bottle. Sometimes the stem needs to be trimmed. This allows you to have a spray bottle that is properly labeled with rubbing alcohol information and precautions.

3.1.1 Any equipment or footwear not cleaned and sanitized at the field office must be cleaned and sanitized before entering the site. Off-site soil should be considered contaminated.

3.1.2 Using the items in the portable sanitation kit, set up a staging area where equipment and footwear will be cleaned and sanitized. A paved parking lot or surface near the entrance to the work site is preferred.

3.1.3 Lay out 2 tarps, one labeled 'dirty' and one labeled 'clean'.
Remove any off-site soil from footwear and equipment onto the 'dirty' tarp. Try not to use water. If water is used, DO NOT dump potentially contaminated water onto on-site soil. Water can be dumped onto non-permeable pavement such as a road or parking lot in a low traffic area. This will UV-sterilize the dirty water (24 hr daylight cycle) as long as no clumps exist. Potentially contaminated soil in the 'dirty' tarp should be bagged in a trash bag and thrown away. DO NOT dispose of off-site soil at the new site.

3.1.4 Use the 'clean' tarp to sanitize soil-free footwear and equipment. Standing on the tarp, spray cleaned footwear and tools with 70% isopropyl alcohol, thoroughly wetting the surface. If the surface of your footwear or tools is already wet, spray extra alcohol to displace the water and allow the alcohol to soak the surface. Spray the footwear from the top down to avoid contamination.

3.1.5 Allow alcohol to evaporate (approx. 1 min) before starting work. You can stand on the tarp until your shoes are dry.

3.1.6 Footbath Alternative - we are investigating sanitizing mats where sanitizing only requires stepping on the mat. Gemplers.com, sanistride.com, and nelsonjameson.com sell both sponge mats and footbath mats for disinfecting shoes. Either chlorine bleach or non-evaporating disinfectants are used in these footbaths and the solution is changed weekly or as needed. Chemical strips are available to test if disinfectants are still effective. Caution should be taken if footbaths and solutions are transported to avoid spills.

3.1.7 Bleach alternative in the field. We are currently recommending that the bleach alternative be used at the field office and alcohol be used in the field. Bleach may be a better alternative in the field under some circumstances (large amounts of tools that must be disinfected in field), but will require special processes for safety and to properly dispose of the chlorine treatment water. Consult with the NR Department to determine best methods under these conditions.

3.2 Cleaning at End of Field Day

Tools:

Portable sanitation kits include the following items in a bin: 2 tarps, boot brush withscraper, 2 spray bottles of 70% isopropyl alcohol, 2 long-handled brushes, 2 paint scrapers, and instructions. On muddy days, also bring a basin & 2 jugs of water.

3.2.1 Sanitation of equipment and shoes is important for known or suspected contaminated sites. More leniency can be given for 'clean' sites.

3.2.2 Remove all soil and organic material from footwear and equipment. Leave soil onsite. Use the boot scraper, paint scraper and a stiff brush to remove any soil and plant material on both the top and bottom of footwear and from tools including the digging ends and handles. Make sure to clean out crevices. On muddy days, fill the basin with water to assist in rinsing off excess soil once the majority of debris has been removed.

3.2.3 Water helps in removing dried clods of soil. This water can be dumped on-site only if the soil originates from on-site.

3.2.4 Standing on the 'clean' tarp, spray cleaned footwear and tools with 70% isopropyl alcohol, thoroughly wetting the surface and allowing it to dry (approx. 1 min). If the surface of your footwear or tools is already wet, spray extra alcohol to displace the water and allow the alcohol to soak the surface.

3.2.5 Before leaving the site, shake soil off the scrapers, brushes and tarp.

3.2.6 At the field office, thoroughly clean the portable sanitation kit by washing out, spraying with alcohol and drying the container and all contents before storage. The portable sanitation kit must be clean before moving to a new site.

4. FAQ

Q. What do we do with left over soil?
A. Depends on the soil. Soil from off-site should be disposed of in a trash bag and thrown away--there's no knowing if off-site soil is contaminated or not. On site soil can be disposed of on-site back where it came from.

Q. What do we do with dirty water?
A. Pouring on pavement or another non-porous surface should disperse the contaminated soil enough to UV (sun) sterilize the water. If using bleach, use neutralizer and the water can be considered clean and safe enough to pour out anywhere. Don't pollute! Other disinfectants need proper disposal that isn't safe for dumping on the ground. Contact Natural Resources Department (Amanda Mills/Coty Sifuentes-Winter) or EH&S for safe disposal procedures.

Q. How do we use the tarps?
A. Two tarps, two purposes. Dirty tarp: use as a containment area to clean off soil clogs, especially offsite soil, for later disposal. Clean tarp: provides users a clean surface to sterilize (with alcohol or other sanitation liquid) shoes and equipment not cleaned at the Field offices.

Q. When will we need to sanitize or use the kits?

A. 1. Contaminated sites (list TBD) 2. Planting events-NR staff lead 3. When NR Staff recommend sanitation. Most of these will be NR staff lead, otherwise a leading crew member will advise on Phytosanitary BMP.

Q. Can we use hot water to sterilize?
A. Hot water can be used only if equipment bathes in 120-125° water for 30 minutes in order to be effective at killing both surface contaminants and internal infections.

Q. What about large equipment and Ranger lead projects?
A. TBD. Field staff will be trained on phytosanitary measures. For field crew lead projects, a crew member should be in charge of facilitating phytosanitary compliance.

Q. Why does this take so much time?
A. It's best to prevent rather than respond to contamination by *Phytophthora*. Once a natural area has been exposed to this soil disease, it can slowly spread and kill other plants. It is very difficult and expensive to kill all the pathogens in the soil of a natural area.

5. Sources

CalPhytos.org. "Guidelines to minimize *Phytophthora* Pathogens in Restoration Nurseries". Suddenoakdeath.org. http://www.suddenoakdeath.org/wp-content/uploads/2016/04/Restoration.Nsy_.Guidelines.final_.092216.pdf

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Cornell University Institutional Animal Care and Use Committee "Cleaning and sanitizing equipment used in the transport of animals." https://ras.research.cornell.edu/care/documents/ACUPs/ACUP532.pdf

http://agriculture.mo.gov/animals/pdf/animalag_guide4.pdf

6. Future Methods

Let us know how these guidelines worked for your project! We may adjust guidelines based on feedback.

Midpeninsula Regional
Open Space District

Techniques for Grass Seeding by Hand

1. It is ideal to seed one day before the first substantial rain in October. Starting in November, the days get shorter and the soil and air become colder, which means germination will take longer.
2. Prepare the soil surface for planting using heavy equipment or hand tools to loosen the topsoil and smooth out the soil surface. If using hand tools, use a rake to create a swath measuring 3 feet in width. Make sure the lines are drawn perpendicular to the slope to ensure that seeds do not drain down the slope during the rainy season.
3. Spread handfuls of seed evenly in an organized pattern over the site. Note: the exact amount of seed will depend on the seeding rate (pounds per acre) and the size of the seeds. It is best to sow seed in two passes over the entire site, with the first pass only using 1/3 of the mix. This will help ensure a more even seed distribution.
4. Lightly rake soil over seed to cover (not necessary if covering seed with erosion control blanket or certified weed-free straw). Soil depth covering the seed should be no more than ¼-inch deep.
5. Cover with approximately 2-inches of certified weed-free straw.