APPENDIX A

PERMITS

San Francisco Bay Regional Water Quality Control Board

CLEAN WATER ACT SECTION 401 WATER QUALITY CERTIFICATION AND ORDER for:

First and F Street Bridge Replacement Project, Sonoma County

Sent via electronic mail: No hard copy to follow

Effective Date: **May 10, 2021**

Place ID 872888
WDID# 2 CW442594

Applicant: City of Petaluma Public Works Department
Attn.: Ken Eichstaedt
P.O. Box 61
Petaluma, CA 94953
Phone: (707) 776-3672
Email: keichstaedt@cityofpetaluma.org

Applicant's Agent: Questa Engineering
Jeff Peters
1220 Brickyard Cove Road, Suite 206
Point Richmond, CA 94801
Phone: (510) 236-6114 Ext. 206
Email: jpeters@questaec.com

Water Board Staff: Nicole Fairley
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Oakland, CA 94612
Phone: (510) 622-2424
Email: nicole.fairley@waterboards.ca.gov

Table of Contents

Order

This Clean Water Act (CWA) section 401 Water Quality Certification and Order (Order) is issued at the request of the City of Petaluma Public Works Department (Permittee) for the First and F Street Bridge Replacement Project (Project). We received the application for certification (Application) on March 15, 2021.

The Permittee has also applied to the U.S. Army Corps of Engineers (Corps), Regulatory Branch for coverage under Nationwide Permit 3 (Maintenance), pursuant to CWA Section 404 (33 USC 1344).

I. Project

The Project is located on Thompson Creek, a tributary to the Petaluma River, at the intersection of First and F streets in Petaluma (38.232941, -122.633691). The Project purpose is to replace a failing wooden bridge structure with a bottomless arch culvert. The existing wooden bridge structure is made up of degraded timber piles, broken support beams, and decking, all of which is either pressure-treated or creosote-treated wood, and has reach the end of its design life. The bridge is approximately 20 feet wide and 30 feet long, spanning a tidal portion of Thompson Creek, approximately 225 feet upstream from the confluence with the Petaluma River. On the upstream end, the bridge ties into an existing concrete oval storm drain culvert pipe that discharges stream flow below the bridge.

To avoid catastrophic failure of the bridge and roadway, the old bridge structure will be demolished and replaced with a new 24-foot-wide, 30-foot-long, pre-cast bottomless concrete arch culvert. Demolition of the existing bridge will take place from the roadway with existing bridge piers and lagging left in place help isolate and stabilize the trenching area from the main channel. To isolate the construction work area from tidal water, a temporary sheet pile coffer dam will be installed across the channel at the downstream side of the existing bridge for up to three weeks. Behind the wood lagging and within the existing roadway fill on each side of the channel, a trench will be excavated and 8 steel displacement piles, also called torque down piles, will be installed in a row approximately two feet landward from the previous bridge's piers and wood lagging supports. Concrete will be poured to fortify the hollow steel piles and concrete grade beams will be installed in the trenches to cap and tie together the drilled piles. This will be the structural foundation for the pre-cast concrete arch culvert, which will rest on top of the grade beams. The trenching and concrete work will take place outside of waters of the State within the existing road prism and concrete pouring will be contained and prevented from entering the tidal channel in accordance with the BMPs included in the application. Groundwater seepage into the trench will be dewatered and discharged to a nearby sanitary sewer drain in accordance with the dewatering plan included in the Application. The wood lagging isolation structure will remain in place until freshly poured concrete has set and a water safe sealant shall be used to ensure complete curing after the form boards are removed. Then the treated timber piles and wood lagging from the previous bridge structure will be removed in full, if possible, or cut at or below the mudline. A pre-cast concrete headwall and wingwalls will be installed at the downstream end of the bridge behind the existing timber headwall and wingwalls, which will then be demolished and removed from the channel.

II. Impacts to Waters of the State

If effective best management practices (BMPs) are not implemented during construction, waters of the state may be impacted by increased erosion and sedimentation, and/or discharging debris and other waste materials. The project will temporarily disturb approximately 0.013 acres (40 linear feet) of tidal channel.

III. Mitigation

During construction, the Permittee will avoid and minimize impacts to waters of the State by implementing appropriate and effectives BMPs as described in the Application. These include, but are not limited to, dewatering the channel during construction to ensure no construction related discharges to waters of the State, tidal marsh vegetation disturbed during construction will be salvaged and replaced to promote efficient revegetation, and all treated wood material associated with the bridge will be removed and disposed of off-site.

The Project will result in a net benefit to water quality and aquatic habitat through the removal of copper-arsenic-treated wood wingwalls and 22 creosote-treated timber piles and the installation of a wider arch culvert. All of this will result in the restoration of approximately 148 square feet (32 linear feet) of tidal channel through the removal of the wooden bridge structure and eliminate the treated wood as a source of pollutants.

IV. California EcoAtlas

Regional, state, and national studies have determined that tracking of mitigation and restoration projects must be improved to better assess the performance of these projects, following monitoring periods that last several years. To effectively carry out the State's Wetlands Conservation Policy of no net loss to wetlands, the State needs to closely track both losses and successes of mitigation and restoration projects affecting wetlands and other waters of the State. The Water Board must also track project performance in Bay Area creeks subject to routine repair and maintenance activities, such as recurring instabilities. Therefore, we adopted the digital interactive mapping tool called *EcoAtlas*.[1] *EcoAtlas* is a web-based tool that integrates maps, project plans, site conditions, restoration efforts, and other elements on a project-by-project basis based on data inputs. Accordingly, we require the Permittee to upload their Project information to *EcoAtlas* with the *Project Tracker* tool at https://ptrack.ecoatlas.org. The California Wetlands Monitoring Workgroup developed *EcoAtlas* and maintains detailed instructions for *Project Tracker* on its website at https://ptrack.ecoatlas.org/instructions.

V. California Environmental Quality Act (CEQA)

The City of Petaluma determined that the project is categorically exempt from review under CEQA pursuant to CEQA Guidelines Section 15302, Replacement or Reconstruction. The City of Petaluma filed a Notice of Exemption with the State Clearinghouse on January 29, 2021. The Water Board concurs with this determination.

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[1] Source: California Wetlands Monitoring Workgroup (CWMW), 2019. *EcoAtlas*. Accessed May 14, 2019. https://www.ecoatlas.org. The California Wetland Monitoring Workgroup (CWMW) provides technical oversight on the development of content and functionality of EcoAtlas. As a member of CWMW, San Francisco Estuary Institute provides day-to-day support and management of EcoAtlas, and can be contacted by email at ptrackadmin@sfei.org.

VI. Conditions

The Water Board independently reviewed the Project record to analyze impacts to water quality and the environment and designated beneficial uses within the Project's watershed. In accordance with this Order, the Permittee may proceed with the Project under the following terms and conditions:

General Conditions

1. The Project shall be constructed in conformance with the Project description provided in the Application. The Permittee shall fully comply with engineering plans, specifications, and technical reports submitted in the Application or required as part of this Order. Any changes to information provided in the Application must be submitted to the Water Board and receive Executive Officer approval before the changes may be implemented.

   ***Rationale**: This condition is necessary to ensure compliance with the permit and applicable conditions and to ensure that the proposed work and final restoration work has been conducted in accordance with the permit and all applicable conditions. (California Water Code (CWC) Section 13264).*

2. Disturbance or removal of vegetation shall be minimized. The site shall be stabilized through incorporation of appropriate BMPs, including the successful reestablishment of native vegetation to enhance wildlife habitat values, and to prevent and control erosion.

   ***Rationale:** This condition is necessary to ensure minimization of impacts to waters of the State and to ensure successful restoration of all temporary impacts authorized (State Board Resolution No. 68-16; 40 CFR Part 131.12 (a)(1); CWC sections 13264 and 13369; Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) Chs. 3 and 4).*

3. No equipment shall be operated in stream channels or other waters where there is flowing or standing water. Fueling, cleaning, or maintenance of vehicles or equipment during construction shall not take place within any areas where an accidental discharge to waters of the State may occur.

   ***Rationale:** This condition is necessary to minimize adverse impacts to water quality from construction activities to the maximum extent practicable (State Board Resolution No. 68-16; 40 CFR Part 131.12 (a)(1); CWC section 13369; Basin Plan Section 2.1.14).*

4. No unauthorized construction related materials or wastes shall be allowed to enter into or be placed where they may be washed by rainfall or runoff into waters of the State. When construction is completed, any excess material shall be removed from the work area and any areas adjacent to the work area where such material may be discharged to waters of the State.

   ***Rationale:** This condition is necessary to ensure that contaminated material is not placed within waters of the State (Basin Plan Sections 3.3.12, 3.3.19, and 4.19).*

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Mitigation

5. To mitigate for 0.013 acres of temporary impacts to tidal channel, the Permittee shall restore all areas of temporary impacts to waters of the State and all upland areas temporarily impacted that could result in a discharge to waters of the State in accordance with the Application.

6. If restoration of temporary impacts to waters of the State is not completed within one year of the impacts, additional compensatory mitigation shall be required to offset temporal loss of waters of the State.

   Rationale: *Conditions 5 and 6 are necessary to ensure avoidance and minimization of impacts to waters of the State, as well as ensure successful compensatory mitigation and replacement of the functions of the aquatic environment that would be lost as a result from the construction of the proposed project (Title 23, California Code of Regulations (23 CCR) section 3013, section 3861(d), Dredge of Fill Procedures section IV. A.2(d) & B.4)*.

Monitoring and Reporting

7. The Permittee shall input Project information to *EcoAtlas* within 14 days from the date of this Order, consistent with Certification Section **IV**. The Project information shall be added to the *Project Tracker* tool in *EcoAtlas* online at https://ptrack.ecoatlas.org. Instructions for adding information to *EcoAtlas* are available at https://ptrack.ecoatlas.org/instructions, or by contacting the San Francisco Estuary Institute by email at ptrackadmin@sfei.org, or the Water Board case manager listed on the cover page of this Order. The Executive Officer may grant an extension to the 14-day deadline if the Permittee submits a request in writing to the Water Board case manager listed on the cover page of this Order. The extension request may be submitted via electronic mail.

   Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC section 13267)*.

8. The Permittee shall submit a Commencement of Construction Report at least seven days prior to start of initial ground disturbance activities.

   Rationale: *This condition is necessary to assist in scheduling compliance inspections to ensure compliance with the permit and applicable conditions* (*CWC section 13267).*

9. No later than 30 days after completing Project construction activities, the Permittee shall submit, acceptable to the Executive Officer, a Notice of Project Construction Completion. The Notice shall include the date Project construction activities (defined as construction of both the Project and any compensatory mitigation) were completed and reference Place ID 872888. The Notice shall be sent via email to RB2-401Reports@waterboards.ca.gov, or by mail to the attention of 401 Certifications Reports (see address on the letterhead).

10. To verify that temporarily impacted areas are restored and that the Project is preforming as intended, vegetation and geomorphic monitoring shall be conducted. Percent cover of tidal marsh vegetation on the banks was estimated and pre-construction photographs were provided in the Application. The temporarily disturbed bank vegetation shall be salvaged and replaced post-construction, then photo monitored annually until percent cover is restored to pre-construction conditions.

Geomorphic monitoring shall be conducted annually for 5 years and shall consist of visual inspections and photographs of any signs of significant erosion or sedimentation threatening Project stability and/or aquatic habitat. Photographs shall be taken at the culvert outlet and at least two photographs, looking upstream and downstream, every 25 feet for 100 feet downstream. The performance criterion shall be no significant erosion or sedimentation threatening Project stability and/or aquatic habitat.

11. The Permittee shall submit annual monitoring reports, acceptable to the Executive Officer, by January 31 following each monitoring year with the first monitoring year commencing the calendar year after completing the Project. Each annual report shall summarize each year's monitoring results, including the need for, and implementation of, any remedial actions to help meet the performance criteria. The annual reports shall compare data to previous monitoring years and describe progress towards meeting final performance criteria.

12. The final monitoring report shall document if the site meets the final performance criteria. If the final criteria are not met, the Permittee shall, in consultation with the Water Board and appropriate agencies, identify remedial measures to be undertaken, including extension of the monitoring and reporting period until the criteria are met. The Permittee shall implement all remedial measures identified upon receiving written acceptance by the Executive Officer. Success of the mitigation program shall be determined by, and acceptable to, the Water Board Executive Officer.

13. Annual monitoring reports shall reference Place ID 872888 and shall be submitted via email to RB2-401Reports@waterboards.ca.gov, or by mail to the attention of 401 Certifications Reports (see the address on the letterhead).

14. Within 30 days of successfully establishing the Project's compensatory mitigation, the Permittee shall submit, acceptable to the Executive Officer, a Notice of Mitigation Monitoring Completion notifying the Water Board that mitigation has been completed. The Notice shall be submitted via email to RB2-401Reports@waterboards.ca.gov, or by mail to the attention of 401 Certifications Reports. This notification shall include the date compensatory mitigation was completed, the Project Name, and Place ID 872888.

***Rationale**: Conditions 9-14 are necessary to ensure compliance with the permit and applicable conditions and to ensure that the proposed work and restoration work has been conducted in accordance with the permit and all applicable conditions* (*23 CCR section 3013; CWC section 13267*).

Administrative

15. The Permittee shall grant Water Board staff or an authorized representative, upon presentation of credentials and other documents as may be required by law, permission to: (1) enter upon the Project site or compensatory mitigation site(s) where a regulated facility or activity is located or conducted, or where records are kept; (2) have access to and copy any records that are kept and are relevant to the Project or the requirements of this Order; (3) inspect any facilities, equipment, practices, or operations regulated or required under this Order; and (4) sample or monitor for the purposes of assuring Order compliance.

***Rationale:** This condition is necessary to assist in scheduling compliance inspections and to ensure compliance with the permit and applicable conditions* (*CWC section 13267*).

16. A copy of this Order shall be provided to any consultants, contractors, and subcontractors working on the Project. Copies of this Order shall remain at the Project site for the duration of this Order. The Permittee shall be responsible for work conducted by its consultants, contractors, and any subcontractors.

    Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC sections 13170 and 13245).*

17. The Permittee shall provide a signed and dated notification to the Water Board of any change in ownership or interest in ownership of the Project area at least 10 days prior to the transfer of ownership. The purchaser shall also submit a written request to the Water Board to be named as the permittee in an amended order. Until such time as this Order has been modified to name the purchaser as the permittee, the Permittee shall continue to be responsible for all requirements set forth in this Order.

    Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC section 13264).*

18. The Permittee may transfer responsibility for long-term management of compensatory mitigation after final performance criteria are met. The Permittee shall submit documentation to the Water Board if responsibility for long-term management of compensatory mitigation is legally transferred at least 30 days prior to the transfer of long-term management responsibility.

    Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC section 13264).*

19. The Permittee shall submit documentation to the Water Board if maintenance responsibility for post-construction BMPs is legally transferred at least 10 days prior to the transfer of BMP maintenance responsibility. The Permittee shall provide the transferee with a copy of a long-term BMP maintenance plan that complies with manufacturer or designer specifications.

    Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC section 13264).*

General Compliance

20. The Permittee shall notify the Water Board of any event causing a violation of compliance with water quality standards as soon as practicable (ideally within 24 hours). Notification may be via telephone, email, delivered written notice, or other verifiable means.

    Rationale: *This condition is necessary to minimize adverse impacts to water quality* (*CWC sections 13385 and 13267*).

21. Failure to implement the Project as proposed is a violation of this Order. Violation of this Order is a violation of state law and is subject to administrative civil liability pursuant to California Water Code (CWC) sections 13350, 13385, or 13399.2. Failure to meet any condition of this Order shall constitute a violation of the Porter-Cologne Water Quality Control Act and the Clean Water Act and may subject you to civil liability imposed by the Water Board to a maximum of $5,000 per day of violation or $10 for each gallon of waste discharged in violation of this Order.

22. In response to a suspected violation of any condition of this Order, the Water Board may require the Permittee to furnish, under penalty of perjury, any technical or monitoring reports the Water Board deems appropriate, provided that the burden, including costs, of the reports shall bear a reasonable relationship to the need for the reports and the benefits to be obtained from the reports.

    Rationale: *This condition is necessary to minimize adverse impacts to water quality* (*CWC sections 13267 and 13383).*

23. Should new information come to our attention that indicates a water quality problem with this Project, the Water Board may issue Waste Discharge Requirements pursuant to 23 CCR section 3857.

24. This Order shall continue to have full force and effect regardless of the expiration or revocation of any federal license or permit issued for the Project.

    Rationale: *This condition is necessary to ensure compliance with the permit and applicable conditions* (*CWC sections 13170 and 13245).*

Standard Conditions

25. This Order is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to CWC section 13330 and 23 CCR 3867.

26. This Order is not intended and shall not be construed to apply to any activity involving a hydroelectric facility and requiring a FERC license or an amendment to a FERC license unless the pertinent certification application was filed pursuant to 23 CCR Subsection 3855(b) and that application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.

    Rationale: *Conditions 25 and 26 are standard conditions that "shall be included as conditions of all water quality certification actions." (23 CCR Section 3860(a)).*

Fees

27. This Order is conditioned upon total payment of the full fees, including annual fees, required in State regulations (23 CCR sections 2200(a)(3) and 3833(b)(3)) and owed by the Permittee. The Application fee for this Project, $2,060, was paid in full on March 9, 2021, and was calculated as Category E – *Low Impact Discharges* with the dredge and fill fee calculator.

    Rationale: *This is a standard condition that "shall be included as conditions of all water quality certification actions." (23 CCR Section 3860(a)).*

28. In accordance with 23 CCR section 2200, the Permittee shall pay an annual fee to the Water Board each fiscal year (July 1 – June 30) until Project construction activities are completed and an acceptable Notice of Project Construction Completion is received by the Water Board. If monitoring is required, the Permittee shall pay an annual fee to the Water Board until monitoring activities are completed and an acceptable Notice of Mitigation Monitoring Completion is received by the Water Board. Annual fees will be automatically invoiced to the Permittee. **The Permittee must notify the Water Board at Project and/or mitigation completion with a final report in order to request to terminate annual invoicing. Notification should be sent to**

the staff listed at the bottom of this Order and to RB2-401Reports@waterboards.ca.gov. Water Board staff will verify conditions of the Certification have been met and may request a site visit at that time to confirm the Project's status and compliance with this Certification.

Rationale: *This condition is a requirement of 23 CCR sections 3833(b)(3) and 2200(a)(3).*

I, Michael Montgomery, Executive Officer, do hereby issue this Order certifying that any discharge from the proposed Project will comply with the applicable provisions of sections 301 (Effluent Limitations), 302 (Water Quality Related Effluent Limitations), 303 (Water Quality Standards and Implementation Plans), 306 (National Standards of Performance), and 307 (Toxic and Pretreatment Effluent Standards) of the Clean Water Act, and with other applicable requirements of State law. This discharge is also regulated under State Water Resources Control Board Order No. 2003-0017-DWQ, "General Waste Discharge Requirements for Dredge and Fill Discharges That Have Received State Water Quality Certification," which requires compliance with all conditions of this Order.

If you have any questions concerning this Order, please contact Nicole Fairley of my staff at (510) 622-2424 or nicole.fairley@waterboards.ca.gov.

Digitally signed by Keith H. Lichten, Division Chief
Date: 2021.05.10 17:21:41 -07'00'

Water Boards

for Michael Montgomery
Executive Officer

Cc: SWRCB, DWQ, Stateboard401@waterboards.ca.gov
Water Board, Victor Aelion, victor.aelion@waterboards.ca.gov
U.S. EPA, Region IX, Jennifer Siu, siu.jennifer@epa.gov
U.S. Army Corps, SF Regulatory, Kendra Spicher, kendra.a.spicher@usace.army.mil
CDFW, James Hansen, james.hansen@wildlife.ca.gov
Questa Engineering
Tom Hawbaker, thawbaker@questaec.com
Margaret Henderson, mhenderson@questaec.com

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, U.S. ARMY CORPS OF ENGINEERS
450 GOLDEN GATE AVENUE
SAN FRANCISCO, CALIFORNIA 94102

June 11, 2021

Regulatory Division

Subject: First and F Street Bridge Replacement File Number 2020-00442

Ken Eichstaedt, Senior Traffic Engineer
City of Petaluma Public Works Department
P.O. Box 61 Petaluma, Ca 94953
KEichstaedt@cityofpetaluma.org

Dear Mr. Eichstaedt:

This correspondence is in reference to your submittal of November 9, 2020 concerning Department of the Army (DA) authorization to replace the First and F Street Bridge, which is a wooden bridge built over a small tidal cut tributary to the Petaluma River located at the intersection of First and F Street in downtown Petaluma. The overall project site is approximately 0.06 acres and is located in the City of Petaluma, Sonoma County, California; Latitude 38.23302°, Longitude -122.63367°.

Work within U.S. Army Corps of Engineers' (Corps) jurisdiction will include the old bridge structure being replaced with a new pre-cast bottomless concrete arch culvert. The arch culvert would rest on concrete grade beams that cap and tie together a series of drilled displacement piles, located in a row behind the preserved wood lagging bridge walls. The plan would be for all work requiring construction equipment and new bridge replacement material to be completed and installed above high tide line and from behind the wood lagging wall. This construction method is sometimes called "top down" construction, as most of the work is from street grade. There is the possibility that depending on the condition of the bridge walls, that temporary sheet piling, or a temporary sheet pile cofferdam might be required during construction. Work will require placement of 182 cubic yards of temporary and permanent fill within 0.013 acre(s) of Thompson Creek. All work shall be completed in accordance with the plans and drawings titled "USACE File #2020-00442, First and F Street Bridge Replacement" provided as enclosure 1.

Section 404 of the Clean Water Act (CWA) generally regulates the discharge of dredged or fill material below the plane of ordinary high water in non-tidal waters of the United States, below the high tide line in tidal waters of the United States, and within the lateral extent of wetlands adjacent to these waters. Section 10 of the Rivers and Harbors Act (RHA) generally regulates construction of structures and work, including excavation, dredging, and discharges of dredged or fill material occurring below the plane of mean high water in tidal waters of the United States; in former diked baylands currently below mean high water; outside the limits of mean high water but affecting the navigable capacity of tidal waters; or below the plane of ordinary high water in non-tidal waters designated as navigable waters of the United States. Navigable waters of the United States generally include all waters subject to the ebb and flow of the tide; and/or all waters presently used, or have been used in the past, or may be susceptible for future use to transport interstate or foreign commerce.

Based on a review of the information in your submittal, the project qualifies for authorization under Department of the Army Nationwide Permits (NWPs) 3 for Maintenance and 33 for Temporary Construction, Access, and Dewatering (82 Fed. Reg. 1860, January 6, 2017), pursuant to Section 404 of the CWA of 1972, as amended (33 U.S.C. § 1344 *et seq*.), and Section 10 of the RHA of 1899, as amended (33 U.S.C. § 403 *et seq*.). The project must be in compliance with the terms of the NWP cited on our website (www.spn.usace.army.mil/Portals/68/docs/regulatory/NWP/NWP17_03.pdf) andwww.spn.usace.army.mil/Portals/68/docs/regulatory/NWP/NWP17_33.pdf) , the general conditions of the Nationwide Permit Program (www.spn.usace.army.mil/Portals/68/docs/regulatory/NWP/NWP17_GC.pdf), and the San Francisco District regional conditions (www.spn.usace.army.mil/Portals/68/docs/regulatory/NWP/NWP17_RC.pdf). You must also be in compliance with any special conditions specified in this letter for the NWP authorization to remain valid. Non-compliance with any term or condition could result in the revocation of the NWP authorization for your project, thereby requiring you to obtain an Individual Permit from the Corps. This NWP authorization does not obviate the need to obtain other State or local approvals required by law.

This verification will remain valid until March 18, 2022, unless the NWP authorization is modified, suspended, or revoked. Activities which have commenced (i.e., are under construction) or are under contract to commence in reliance upon a NWP will remain authorized provided the activity is completed within 12 months of the date of a NWP's expiration, modification, or revocation, unless discretionary authority has been exercised on a case-by-case basis to modify, suspend, or revoke the authorization in accordance with 33 C.F.R. § 330.4(e) and 33 C.F.R. § 330.5(c) or (d). This verification will remain valid if, during the time period between now and March 18, 2022, the activity complies with any subsequent modification of the NWP authorization. The Chief of Engineers will periodically review NWPs and their conditions and will decide to modify, reissue, or revoke the permits. If a NWP is not modified or reissued within five years of its effective date, it automatically expires and becomes null and void. It is incumbent upon you to remain informed of any changes to the NWPs. Changes to the NWPs would be announced by Public Notice posted on our website (www.spn.usace.army.mil/Missions/Regulatory/Public-Notices.aspx). Upon completion of the project and all associated mitigation requirements, you shall sign and return the Certification of Compliance, enclosure 2, verifying that you have complied with the terms and conditions of the permit.

You shall comply with all terms and conditions set forth by the "WQC for the First and F Street Bridge Replacement Project," issued by the San Francisco Bay Regional Water Quality

Control Board on May 11, 2021 (enclosure 3). You shall consider such conditions to be an integral part of the NWP authorization for your project.

General Condition 18 stipulates that project authorization under a NWP does not allow for the incidental take of any federally-listed species in the absence of a biological opinion with incidental take provisions. As the principal federal lead agency for this project, the Corps initiated consultation with the National Marine Fisheries Service (NMFS) to address project related impacts to listed species, pursuant to Section 7(a) of the Endangered Species Act of 1973, as amended, 16 U.S.C. § 1531 *et seq*. By letter of April 7, 2021, cited in enclosure 4, NMFS concurred with the determination that the project was not likely to adversely affect CCC Steelhead or North American Green Sturgeon and designated critical habitat for these species.

General Condition 20 stipulates that any project affecting a historic property may not commence construction until the provisions of 33 C.F.R. § 325, Appendix C, have been satisfied. As the Federal lead agency for this project, the Corps initiated consultation with the State Historic Preservation Officer (SHPO) to address project related impacts to the First and F Street Bridge, and was determined to not be eligible for the National Register of Historic Places in a letter dated April 22, 2021. The letter is included as enclosure 5.

In order to ensure compliance with this NWP authorization, the following special conditions shall be implemented:

1. Incidents where any individuals of fish listed by NOAA Fisheries under the Endangered Species Act appear to be injured or killed as a result of discharges of dredged or fill material into waters of the United States or structures or work in navigable waters of the United States authorized by this NWP shall be reported to NOAA Fisheries, Office of Protected Resources, at (301) 713-1401 and the Regulatory Office of the San Francisco District of the U.S. Army Corps of Engineers at (415) 503-6795. The finder should leave the plant or animal alone, make note of any circumstances likely causing the death or injury, note the location and number of individuals involved, and, if possible, take photographs. Adult animals should not be disturbed unless circumstances arise where they are obviously injured or killed by discharge exposure or some unnatural cause. The finder may be asked to carry out instructions provided by NOAA Fisheries, Office of Protected Resources, to collect specimens or take other measures to ensure that evidence intrinsic to the specimen is preserved.

2. The NMFS concurred with the determination that the project was not likely to adversely affect CCC Steelhead or North American Green Sturgeon and designated critical habitat for this species. This concurrence was premised, in part, on project work restrictions and the description of the proposed action outlined in enclosure 4.

These work restrictions are incorporated as special conditions to the NWP authorization for your project to ensure unauthorized incidental take of species and loss of critical habitat does not occur.

You may refer any questions on this matter to Kendra Spicher of my Regulatory staff by e-mail at kendra.a.spicher@usace.army.mil. All correspondence should be addressed to the Regulatory Division, North Branch, referencing the file number at the head of this letter.

The San Francisco District is committed to improving service to our customers. My Regulatory staff seeks to achieve the goals of the Regulatory Program in an efficient and cooperative manner while preserving and protecting our nation's aquatic resources. If you would like to provide comments on our Regulatory Program, please complete the Customer Service Survey Form available on our website: http://www.spn.usace.army.mil/Missions/Regulatory.aspx

Sincerely,

William Connor
Acting North Branch Chief, Regulatory Division

Enclosures:

Jeffery Peters, JPeters@questaec.com

cc (w/ encl):

CA RWQCB, Nicole Fairley, nicole.fairley@waterboards.ca.gov

Enclosure 2

Permittee: Ken Eichstaedt, Senior Traffic Engineer
City of Petaluma Public Works Department

File Number: 2020-00442

Certification of Compliance
for
Nationwide Permit

"I hereby certify that the work authorized by the above referenced File Number and all required mitigation have been completed in accordance with the terms and conditions of this Nationwide Permit authorization."

______________________________ __________________________
(Permittee) (Date)

Return to:

Kendra Spicher
U.S. Army, Corps of Engineers
San Francisco District
Regulatory Division, CESPN-R-N
450 Golden Gate Ave., 4th Floor
San Francisco, CA 94102-3404

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
BAY DELTA REGION
2825 CORDELIA ROAD, SUITE 100
FAIRFIELD, CA 94534

STREAMBED ALTERATION AGREEMENT
EPIMS-SON-18195-R3
THOMPSON CREEK

CITY OF PETALUMA
FIRST AND F STREET BRIDGE REPLACEMENT

This Streambed Alteration Agreement (Agreement) is entered into between the California Department of Fish and Wildlife (CDFW) and the City of Petaluma (Permittee) as represented by Kenneth Eichstaedt.

RECITALS

WHEREAS, pursuant to Fish and Game Code section 1602, Permittee notified CDFW on April 12, 2021 that Permittee intends to complete the project described herein.

WHEREAS, pursuant to Fish and Game Code section 1603, CDFW has determined that the project could substantially adversely affect existing fish or wildlife resources and has included measures in the Agreement necessary to protect those resources.

WHEREAS, Permittee has reviewed the Agreement and accepts its terms and conditions, including the measures to protect fish and wildlife resources.

NOW THEREFORE, Permittee agrees to complete the project in accordance with the Agreement.

PROJECT LOCATION

The project is located at Thompson Creek, in the City of Petaluma, County of Sonoma, State of California; Latitude 38.232937°, Longitude -122.633704°. It is located at the intersection of First Street and F Street.

PROJECT DESCRIPTION

The project is limited to the demolition and removal of the existing wooden bridge built over a small tidal cut where Thompson Creek enters the Petaluma River, and replacement with an arch culvert. The existing bridge has approximate dimensions of 20-feet in width spanning the tidal cut, with the bridge deck extending upstream along First Street approximately 30 feet, where it ties into a concrete storm drainpipe culvert. The existing bridge will be replaced with a pre-cast bottomless concrete arch culvert of the same dimensions as the existing bridge. The immediate work area will be dewatered with sheet piles, a cofferdam and a bypass pipe conveying any flow from the upstream storm drain culvert. The majority of work will be performed within the existing bridge footprint, except for temporary impacts to the downstream channel and banks during installation of the coffer dam and sheet piles, as well as permanent impacts from the installation of new concrete wing walls. The project will involve drilling 12-14 steel piers into the native substrate underneath the existing road to support the grade beams, which the new pre-cast concrete arch culvert will be placed on. Each pier will be approximately 36 inches wide and at least 22 feet deep in order to reach bedrock. Piers will be installed by drilling a hole and inserting steel piles in a manner that does not utilize drilling muds or fluids and will not displace groundwater. The project also involves the removal of all 22 existing 10-inch creosote wood piers in the channel that support the existing bridge.

The installation and removal of sheet piles for dewatering will temporarily impact approximately 480 square feet of stream habitat. The installation of new concrete wing walls will permanently impact approximately 144 square feet of stream habitat. Removal of the existing creosote piles from underneath the existing bridge after it is demolished will restore approximately 250 square feet of channel habitat and improve water quality in an immediate tributary to the Petaluma River. No trees will be removed as part of this project.

PROJECT IMPACTS

Existing fish or wildlife resources the project could substantially adversely affect include:

- Steelhead trout, Central California Coast Distinct Population Segment (*Oncorhynchus mykiss irideus*), Federal Threatened
- Sonoma spineflower (*Choizanthe valida*), State Endangered and Federal Endangered
- Pitkin Marsh Lily (*Lilium pardalinum* ssp. *pitkinense*), State Endangered and Federal Endangered
- Sacramento splittail (*Pgonichthys macrolepidotus*), California Species of Special Concern (SSC)
- Townsend's big-eared bat (*Corynorhinus townsendii*), SSC
- San Pablo song sparrow (*Melospiza melodia samuelis*), SSC
- Waterfowl
- Nesting birds

The adverse effects the project could have on the fish or wildlife resources identified above include:

- disruption to the species listed above
- disruption of aquatic and riparian habitat
- loss of riparian and/or emergent marsh habitat
- colonization by exotic plant species
- loss of aquatic and terrestrial wildlife species
- temporary impediment to migration of aquatic and terrestrial species
- disruption to nesting birds and other wildlife

- change in contour of bed, channel, or bank
- change in gradient of bed, channel, or bank
- short term release of contaminates
- change in flow depth, width, or velocity
- change in composition of channel materials
- accelerated channel scour
- loss of bank stability during construction
- increase of bank erosion during construction
- soil compaction or other disturbance to soil layer
- increased turbidity

MEASURES TO PROTECT FISH AND WILDLIFE RESOURCES

1. Administrative Measures

Permittee shall meet each administrative requirement described below.

1.1 Documentation at Project Site. Permittee shall make the Agreement, any extensions and amendments to the Agreement, and all related notification materials and California Environmental Quality Act (CEQA) documents, readily available at the project site at all times and shall be presented to CDFW personnel, or personnel from another state, federal, or local agency upon request.

1.2 Providing Agreement to Persons at Project Site. Permittee shall provide copies of the Agreement and any extensions and amendments to the Agreement to all persons who will be working on the project at the project site on behalf of Permittee, including but not limited to contractors, subcontractors, inspectors, and monitors.

1.3 Notification of Conflicting Provisions. Permittee shall notify CDFW if Permittee determines or learns that a provision in the Agreement might conflict with a provision imposed on the project by another local, state, or federal agency. In that event, CDFW shall contact Permittee to resolve any conflict.

1.4 Project Site Entry. Permittee agrees that CDFW personnel may enter the project site at any time to verify compliance with the Agreement.

1.5 Notify CDFW Prior to Work. The Permittee shall notify CDFW by email at least five working days prior to commencement of covered activities. See contact information below.

1.6 No Trespass. To the extent that any provisions of this Agreement provide for activities that require the Permittee to traverse another owner's property, such provisions are agreed to with the understanding that the Permittee possesses the legal right to so traverse. In the absence of such right, any such provision is void.

1.7 Unauthorized Take. The Permittee is required to comply with all applicable State and Federal laws, including the California Endangered Species Act (CESA) and Federal Endangered Species Act. This Agreement does not authorize the take of any State or Federal endangered or threatened species. Liability for any take or incidental take of such listed species remains the responsibility of the Permittee for the duration of the project. Any unauthorized take of such listed species may result in prosecution and nullification of the Agreement.

1.8 Fish Passage. The project shall be in compliance with Fish and Game Code section 5901 and shall not install or maintain any device or contrivance that prevents, impedes, or tends to prevent or impede, the passing of fish up and down stream.

1.9 Designated Representative. Before initiating ground-disturbing project activities, Permittee shall designate a representative (Designated Representative) responsible for communications with CDFW and overseeing compliance with this Agreement. The Permittee shall notify CDFW in writing 5 days prior to commencement of project activities of the Designated Representative's name, business address, and contact information. Permittee shall notify CDFW in writing if a substitute Designated Representative is selected or identified at any time during the term of this Agreement.

2. Avoidance and Minimization Measures

To avoid or minimize adverse impacts to fish and wildlife resources identified above, Permittee shall implement each measure listed below.

2.1 Work Period. All work shall begin on or after June 15 and all work shall be completed by October 15. Revegetation work is not limited to this work window but must be completed within the same season as project activities. If more time is needed to complete Project activities, the work period may be modified in writing on a week-by-week basis by a CDFW representative. Requests for a work period extension shall: 1) describe the extent of work already completed; 2) detail the activities that remain to be completed; 3) detail the time required to complete each of the remaining activities; 4) provide photographs of both the current work completed and the proposed site for continued work; and 5) include an assessment of additional biological impacts as a result of the work extension.

2.2 Conduct Work During Daylight Hours. Work is restricted to daylight hours (one hour after sunrise to sunset).

2.3 Work According to Documents. Except as they are contradicted by measures required by this Agreement, all work shall be conducted in conformance with the project description above and the avoidance, minimization, and mitigation measures provided in the notification package.

2.4 Work according to plans. All work shall be completed according to the plans, and all associated appendices and attachments, submitted to CDFW entitled *First and F Street Bridge Replacement Project*, prepared by Questa Engineering Corp, dated March 2021 (Exhibit A) and *First and F Street Bridge Replacement Project*, prepared by ZFA Structural Engineers, dated August 2020 (Exhibit B). If the Permittee finds it necessary to update project plans prior to construction, the updated plans will be submitted to CDFW at least 30 days prior to beginning project activities to determine if an Amendment to this Agreement is required. Project activities shall not proceed until CDFW has accepted the updated plans in writing. At the discretion of CDFW, minor plan modifications may require an amendment to this Agreement. At the discretion of the CDFW, if substantial changes are made to the original plans this Agreement becomes void and the Permittee shall submit a new notification.

2.5 Best Management Practices. All Best Management Practices (BMPs) and other conditions as submitted in the Notification shall be implemented as part of this project, unless otherwise conditioned herein.

2.6 No Equipment in Stream. No equipment shall be operated within the live stream.

2.7 No Work in Stream. No work shall occur, except dewatering activities, in the portion of the stream bed where surface water is present or anticipated during the term of this Agreement.

Weather Restrictions

2.8 Work Period in Dry Weather Only. Project work shall be restricted to dry weather as allowed during the work period specified in Measure 2.1. Construction shall be timed with awareness of precipitation forecasts and potential increases in stream flow. Construction activities shall cease when the National Weather Service (NWS) 72-hour weather forecast indicates a 30 percent chance or higher of precipitation. All necessary erosion control measures shall be implemented prior to the onset of precipitation. Construction equipment and materials shall be removed if inundation is likely. Construction activities halted due to precipitation may resume when precipitation ceases and the NWS 72-hour weather forecast indicates less than a 30 percent chance of precipitation. No work shall occur during a dry-out period of 24 hours after the above referenced wet weather. Weather forecasts shall be documented upon request by CDFW.

Wildlife Protection and Prevention

2.9 CDFW Approved Qualified Biologist On-site. A Qualified Biologist shall be on site daily to monitor compliance with all conditions of this Agreement unless otherwise approved in writing by CDFW. The Qualified Biologist shall have the authority to halt project activities, through communication with the Project Manager or their on-site designee, in order to comply with the terms of this Agreement and otherwise avoid impacts to species and or habitats. If the on-site Qualified Biologist has requested a work stop due to failure to implement any of the conditions CDFW shall be contacted within 24 hours.

2.10 Biologist Approval. No later than 30 days prior to project activities covered by this Agreement, the Permittee shall submit to CDFW, for review and approval, the qualifications for the biologist(s) that shall oversee the implementation of the conditions in this Agreement and conduct surveys or monitoring work. Project activities covered by this Agreement may not commence unless CDFW has approved the proposed biologist(s) in writing. At minimum the CDFW approved biologist(s) shall have a minimum of five years of academic training and professional experience in biological sciences and related resource management activities with a minimum of two years conducting surveys for each species that may be present within the project area.

2.11 Training Session for Personnel. Permittee shall ensure that a CDFW-approved Qualified Biologist conducts an education program for all persons employed on the project prior to performing covered activities. Instruction shall consist of a presentation by the designated qualified biologist that includes a discussion of the biology and general behavior of any sensitive species that may be in the area, how they may be encountered within the work area, and procedures to follow when they are encountered. The status of CESA and ESA listed species including legal protection, penalties for violations and project-specific protective management measures provided in this Agreement shall be discussed. Interpretation shall be provided for non-English speaking workers, and the same instruction shall be provided for any new workers prior to on-site project activity. Copies of the Agreement for this project shall be maintained at the worksite with the project supervisor. Permittee or designated biologist shall prepare and distribute wallet-sized cards or a factsheet handout containing this information for workers to carry on-site. Upon completion of the program, employees shall sign an affidavit stating they attended the program and understand all protection measures. These forms shall be filed at the Permittee's office and be available to CDFW upon request.

2.12 Pre-Project Special-Status Plant Surveys. A Qualified Biologist shall conduct botanical surveys during the appropriate blooming period for all special-status plants that have the potential to occur in or near the Project site including the access route prior to the start of construction. Surveys shall be conducted following CDFW's 2018 *Protocol for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities* (https://wildlife.ca.gov/Conservation/Survey-Protocols#377281280-plants). More than one year of surveys may be required to establish that plants are absent. Surveys shall be submitted to CDFW for written approval prior to the start of construction. If Pitkin Marsh lily, Sonoma spineflower, or other special status plants are observed, the Project shall: 1) avoid all direct and indirect impacts to the special status plants, and 2) prepare and implement an avoidance plan that is approved in writing by CDFW prior to project start. If avoidance of Pitkin Marsh lily or Sonoma spineflower is not possible, Project activities shall not commence until the Permittee has consulted with CDFW and obtained a CESA Incidental Take Permit. Authorization from the U.S. Fish and Wildlife Service (USFWS) may also be required for impacts to plant species listed under the Federal Endangered Species Act.

2.13 Bat Habitat Assessment. A Qualified Biologist shall perform a habitat assessment of all structures proposed for removal at least 120 days prior to starting work. If any of the structures contain suitable bat roosting habitat, then bat roost surveys shall be conducted pursuant to Measure 2.14.

2.14 Bat Roost Survey and Exclusion Plan. Any roost habitat, including bridges and other structures, shall be surveyed for bats by a Qualified Bat Biologist at least 90 days prior to the beginning of Project-related activities. If roosting bats are detected in bridges or structures, an associated bat exclusion plan shall be submitted to CDFW for written approval and implemented. The plan shall recognize that both the maternity and winter roosting seasons are vulnerable times for bats and require exclusion outside of these times, generally between March 1 and April 15 or September 1 and October 15 when temperatures are sufficiently warm. Survey and exclusion plan implementation results shall be submitted to CDFW for written acceptance prior to Project construction activities.

2.15 Bat Habitat Removal. Removal of bridges or structures shall not start until the CDFW-approved Qualified Bat Biologist confirms that bats have left the site pursuant to the bat exclusion plan. Bat habitat shall be removed during seasonal periods of bat activity from approximately March 1 through April 15 and September 1 through October 15. If any injured or killed bats are observed while removing habitat, all removal activities shall cease immediately, and Permittee shall contact CDFW within 24 hours. In this event, habitat removal activities shall not resume until CDFW has provided written permission.

2.16 Nesting Bird Surveys. If construction, grading, vegetation removal, or other project-related improvements are scheduled during the nesting season of protected raptors and migratory birds February 1 to August 31, a focused survey for active nests of such birds shall be conducted by a qualified biologist within 7 days prior to the beginning of project-related activities. The results of the survey shall be sent to James Hansen, Environmental Scientist by email (James.Hansen@Wildlife.ca.gov) prior to the start of project activities, and uploaded to EPIMS. Refer to Notification Number EPIMS-SON-18195-R3 when submitting the survey to CDFW. If an active nest is found, Permittee shall consult with CDFW and (USFWS regarding appropriate action to comply with Fish and Game Code and the Migratory Bird Treaty Act of 1918. If a lapse in project-related work of 7 days or longer occurs, another focused survey and if required, consultation with CDFW and USFWS, shall be required before project work is reinitiated.

2.17 Breeding Bird Nest Take Prohibition. Permittee shall avoid active nests occurring near the project site. Permittee is responsible to comply with Fish and Game Code, section 3503 et seq. and the Migratory Bird Treaty Act of 1918.

2.18 Active Nest Buffers. Active bird nest sites shall be designated as "Ecologically Sensitive Areas" (ESA) and protected (while occupied) during project work by demarking a "No Work Zone" buffer around each nest site.

- Buffer distances for bird nests shall be site specific and an appropriate distance, as determined by a qualified biologist. The buffer distances shall be specified to protect the bird's normal behavior thereby preventing nesting failure or abandonment. The buffer distance recommendation shall be developed after field investigations that evaluate the bird(s) apparent distress in the presence of people or equipment at various distances. Abnormal nesting behaviors which may cause reproductive harm include, but are not limited to, defensive flights/vocalizations directed towards project personnel, standing up from a brooding position, and flying away from the nest. The qualified biologist shall have authority to order the cessation of all nearby project activities if the nesting birds exhibit abnormal behavior which may cause reproductive failure (nest abandonment and loss of eggs and/or young) until an appropriate buffer is established.

- The qualified biologist shall monitor the behavior of the birds (adults and young, when present) at the nest site to ensure that they are not disturbed by project work. Nest monitoring shall continue during project work until the young have fully fledged (have completely left the nest site and are no longer being fed by the parents), as determined by the qualified biologist.

2.19 Nesting Habitat Removal or Modification. No habitat removal or modification shall occur within the ESA-fenced nest zone until the young have fully fledged and will no longer be adversely affected by the project. Any trees or shrubs that are removed shall be "downed" in such a manner as to minimize disturbance to stable soil conditions.

2.20 Trenching. At the end of each workday all trenches and holes greater than one foot deep shall be covered to prevent wildlife from entering. When trenches cannot be fully covered, an escape ramp shall be placed at each end of any constructed open trench to allow any wildlife that may have become entrapped in the trench to climb out overnight. The ramp may be constructed of either dirt fill or wood planking or other suitable material that is placed at an angle no greater than 30 degrees.

2.21 Pipes, Hoses, and Similar Structures. All pipes, hoses, or similar structures less than 12 inches in diameter shall be closed or covered to prevent animal entry. All construction pipes or similar structures greater than 2 inches in diameter stored at the project site overnight shall be inspected thoroughly for wildlife before the pipe or similar structure is buried, capped, used, or moved.

2.22 Special Status Species Encountered During Work. If Permittee encounters special status species during project activities, work shall be suspended, CDFW notified, and avoidance and minimization measures shall be developed in agreement with CDFW prior to re-initiating the activity.

2.23 Daily Inspections. At the beginning of each workday, a Biological Monitor shall inspect the project area unless otherwise approved in writing by CDFW. If special status species are encountered during project activities, all work shall cease and CDFW shall immediately be notified. Work shall not proceed without written approval from CDFW.

2.24 Refueling of Equipment. Refueling of construction equipment and vehicles may not occur within 175 feet of any water body, or anywhere that spilled fuel could drain to a water body. Tarps or similar material shall be placed underneath the construction equipment and vehicles, when refueling, to capture incidental spillage of fuels. Equipment and vehicles operating in the project area shall be checked and maintained daily to prevent leaks of fuels, lubricants, or other liquids.

Culvert Design and Construction

2.25 Culvert Design. The culvert shall be:

- Adequately sized to carry the 100-year storm flow for the tributary;
- Properly aligned within the channel and otherwise engineered, installed, and maintained, to resist washout and erosion of the stream bed, stream banks and/or fill; and
- Passable to fish as required under Fish and Game Code section 5901.

2.26 Culverts Shall be Kept Open. Permanent culverts shall be maintained and kept open year round. The Permittee is responsible for such maintenance as long as the culvert remains in the stream. Substantial changes to the bed, channel or bank necessary for maintenance may require separate notification under Fish and Game Code section 1602, subdivision (a).

2.27 Concrete – Primary Containment. The Permittee shall install the necessary containment structures to control the placement of wet concrete and to prevent it from entering into the channel outside of those structures. No concrete shall be poured within the high flow line if the 15 day weather forecast indicates any chance of rain greater than 20 percent.

2.28 Cement Based Products. All cement based products (concrete, mortar, etc.) poured or applied wet onsite shall be excluded from the wetted channel or areas where they may come into contact with water for a period of 15 days after application. During that time the product shall be kept moist and runoff from the product shall not be allowed to enter the stream. Commercial sealants may be applied to the product surface or mixture where difficulty in excluding flow for a long period may occur. If sealant is used, water shall be excluded from the site until the sealant is cured.

2.29 Concrete – Designated Monitor. At all times when the Permittee is pouring or working with wet concrete there shall be a designated monitor to inspect the containment structures and ensure that no concrete or other debris enters into the channel outside of those structures

Dewatering

2.30 Divert Water Around Work Areas. Work shall be performed in isolation from the creek. All dewatering activities shall be completed according to the dewatering plans on Sheet C-6 of Exhibit A.

2.31 Fish Relocation Plan. Permittee shall submit a fish relocation plan to CDFW for review and written approval at least 15 days prior to commencement of project activities.

2.32 Cofferdam Work Period. Cofferdams shall be constructed after June 15th.

2.33 Dewater Work Site. Once water has been diverted around the work area, the site shall be dewatered to provide an adequately dry work area. Any muddy or otherwise contaminated water shall be pumped to a settling tank, dewatering filter bag, upland area, or other CDFW-approved location prior to re-entering the creek.

2.34 Maintain Aquatic Life. When any dam or other artificial obstruction is being constructed, maintained, or placed in operation, Permittee shall allow sufficient water at all times to pass downstream to maintain aquatic life below the dam pursuant to Fish and Game Code section 5937.

2.35 Screen According to Existing Standards. The inlets of the dewatering pump structure shall be fitted with fish screens meeting the “fry-size” criteria of CDFW and the National Marine Fisheries Service before water is pumped from within the coffer dams (see screening criteria at: https://www.noaa.gov/sites/default/files/atoms/files/07354626823.pdf).

2.36 Stranded Aquatic Life. The Permittee shall check daily for stranded aquatic life as the water level in the dewatering area drops. All reasonable efforts shall be made to capture and move all stranded native aquatic life observed in the dewatered areas. This condition does not allow for the take or disturbance of any State or federally listed species.

2.37 Clean Obstruction Only. Any temporary dam or other artificial obstruction constructed by Permittee shall only be built from materials that will cause little or no siltation, such as clean gravels.

2.38 Maintain Water Quality. Permittee shall divert flow in a manner that prevents turbidity, siltation, or pollution and provides flows to downstream reaches. Flows to downstream reaches shall be provided during all times that the natural flow would have supported aquatic life. Said flows shall be sufficient quality and quantity, and of appropriate temperature to support fish and other aquatic life both above and below the diversion.

2.39 Restore Normal Flows. Permittee shall restore normal flows to the effected stream immediately upon completion of work at that location.

2.40 Groundwater Encountered. Nuisance groundwater encountered during excavation within the streambed shall be discharged at a location where it will infiltrate into the soil, resulting in no overland flow. Turbid water shall not be allowed to flow downstream.

Vegetation Protection, Prevention, and Restoration

2.41 Restoration Plan. At least 30 days prior to the commencement of project actives, Permittee shall submit to CDFW for review and approval a restoration plan for the restoration of all bank areas disturbed during construction of culvert and from dewatering activities.

2.42 Enhancement Plan. At least 30 days prior to commencement of project activities, the Permittee shall submit to CDFW for review and approval an enhancement plan to enhance 200 square feet of riparian habitat on-site or near the site to off-set permanent impacts.

2.43 Habitat Protection. Disturbance or removal of vegetation shall not exceed the minimum necessary to complete the project. Vegetation outside the construction corridor shall not be removed or damaged without prior consultation and approval of a CDFW representative.

2.44 Vegetation Marked for Protection. Prior to project activities, the Permittee shall clearly mark all vegetation within the project area that shall be avoided during project activities.

2.45 Tree Removal. No trees shall be removed as part of this project. If the removal of more trees is required, the Permittee must receive approval from CDFW in writing before construction activities begin.

2.46 Vegetation Success. To ensure a successful revegetation effort, all plants shall be monitored and maintained as necessary for five years. All planting shall have a minimum of 85% survival at the end of five years.

2.47 Irrigation. When supplemental watering is used to establish and maintain plant growth in order to meet success criteria, irrigation shall be done in the most water efficient manner possible, such as using hand watering, drip/microirrigation or through the use of a time release system.

2.48 Revegetation Remediation. If revegetation survival and/or cover requirements do not meet established goals, Permittee is responsible for replacement planting, additional watering, weeding, invasive exotic eradication, or any other practice, to achieve these requirements. Replacement plants shall be monitored with the same survival and growth requirements for five years after planting.

2.49 Native Plant Materials Required. Revegetation shall include only local plant materials native to the project area, unless otherwise approved by CDFW in writing.

2.50 Prohibited Plant Species. Permittee shall not plant, seed or otherwise introduce invasive exotic plant species. Prohibited exotic plant species include those identified in the California Exotic Pest Plant Council's database, which is accessible at: www.cal-ipc.org/paf/.

2.51 Phytophthora. Permittee shall implement measures to avoid using plant stock that may be infected with the plant pathogen Phytophthora sp. Measures to avoid contamination with Phytophthora sp. may include, but are not limited to, avoiding collection of propagules from 1) known or likely infected areas; 2) during wet conditions; 3) when soil is muddy; or 4) from within 0.5 meters of the soil surface. Measures may also include implementing heat or chemical treatments to collected seeds prior to installation.

2.52 Treat Exposed Areas. All exposed/disturbed areas and access points within the riparian zone left barren of vegetation as a result of the construction activities shall be restored by seeding with a blend of native erosion control grass seed. Seeded areas shall be mulched. Landscape fabric shall not be used. Revegetation shall be completed as soon as possible after construction activities in those areas cease. Seeding placed after October 15 must be covered with broadcast straw, jute netting, coconut fiber blanket or similar erosion control blanket.

2.53 Control Invasive Species. Permittee is responsible for monitoring and if needed, eradication of invasive exotic species that may occur within the project area for a minimum of two years following construction. All revegetation efforts shall include local plant materials native to the project area.

Erosion and Sediment Control

2.54 Erosion Control. At no time shall silt-laden runoff be allowed to enter a river, stream, or lake or directed to where it may enter a river, stream, or lake. Erosion control measures shall be utilized throughout all phases of operation where sediment runoff from exposed slopes threatens to enter a river, stream, or lake. Erosion control measures, such as, silt fences, straw hay bales, gravel or rock lined ditches, water check bars, and broadcasted straw shall be used wherever sediment has the potential to leave the work site and enter the river, stream, or lake.

2.55 Monofilament. Permittee shall not use erosion control materials containing plastic monofilament netting (erosion control matting) or similar material containing netting within the project area due to documented evidence of amphibians and reptiles becoming entangled or trapped in such material. Acceptable substitutes include coconut coir matting or similar.

2.56 Erosion Control Monitoring. Permittee shall monitor erosion control measures during and after each storm event and repair and/or replace ineffective measures immediately.

2.57 Excavation. No spoil from the excavation shall be placed on the stream side. Excavated spoil shall be removed to an area where the sediment will not deliver to a watercourse.

2.58 Groundwater Encountered. Nuisance groundwater encountered during excavation within the streambed or floodplain shall be discharged at a location where it will infiltrate into the soil, resulting in no overland flow. Turbid water shall not be allowed to flow downstream.

Material Handling, Debris, and Waste

2.59 Stockpiled Materials. Building materials and/or construction equipment shall not be stockpiled or stored where they may be washed into the water or cover aquatic or riparian vegetation. Stockpiles shall be covered when measurable rain is forecasted.

2.60 No Dumping. Permittee and all contractors, subcontractors, and employees shall not dump any litter or construction debris within the stream, or where it may pass into the stream.

2.61 Pick Up Debris. Permittee shall pick up all debris and waste daily.

2.62 Wash water. Water containing mud, silt, or other pollutants from equipment washing or other activities, shall not be allowed to enter a lake or flowing stream or placed in locations that may be subjected to high storm flows.

2.63 Disposal and Removal of Materials. All removed spoils and construction debris shall be moved outside the work area prior to inundation by water. Spoil sites shall not be located within the stream channel or areas that may be subjected to stream flows, where spoil may be washed back into a stream, or where it may impact streambed habitat, aquatic or riparian vegetation. All removed material shall be disposed of according to State and local laws and ordinances.

Toxic and Hazardous Material

2.64 Toxic Materials. Any hazardous or toxic materials that could be deleterious to aquatic life that could be washed into the stream or its tributaries shall be contained in water tight containers or removed from the project site.

2.65 Hazardous Materials. Debris, soil, silt, bark, slash, sawdust, rubbish, creosote-treated wood, raw cement/concrete or washings thereof, asphalt, paint or other coating material, oil or other petroleum products, or any other substances which could be hazardous to aquatic life, wildlife, or riparian habitat resulting from the project related activities shall be prevented from contaminating the soil and/or entering the Waters of the State.

Spills and Emergencies

2.66 Spill Kits. Prior to entering the work site, all field personnel shall know the location of spill kits and trained in their appropriate use.

2.67 Spill of Material Deleterious to Fish and Wildlife. In the event of a hazardous materials spill into a stream (e.g., concrete or bentonite), Permittee shall immediately notify the California Office of Emergency Services State Warning Center by calling 1-800-852-7550 and immediately provide written notification to CDFW by email at AskBDR@wildlife.ca.gov. Permittee shall take all reasonable measures to document the extent of the impacts and affected areas including photographic documentation of affected areas, injured fish and wildlife. If dead fish or wildlife are found in the affected area, Permittee shall collect carcasses and immediately deliver them to CDFW. Permittee shall meet with CDFW within ten days of the reported spill in order to develop a resolution including: site clean-up, site remediation and compensatory mitigation for the harm caused to fish, wildlife and the habitats on which they depend as a result of the spill. The Permittee shall be responsible for all spill clean-up, site remediation and compensatory mitigation costs. Spill of materials to waters of the state that are deleterious to fish and wildlife are in violation of Fish and Game Code section 5650 et. seq. and are subject to civil penalties for each person responsible. CDFW reserves the right to refer the matter to the District Attorney's Office if a resolution cannot be agreed upon and achieved within a specified timeframe, generally six months from the date of the incident.

2.68 Spill Containment. All activities performed in or near a river, stream, or lake shall have absorbent materials designated for spill containment and cleanup activities on-site for use in an accidental spill. The Permittee shall immediately notify the California Emergency Management Agency at 1-800-852-7550 and immediately initiate the cleanup activities. CDFW shall be notified by the Permittee and consulted regarding clean-up procedures

3. Reporting Measures

Permittee shall meet each reporting requirement described below.

3.1 Notification Prior to Work. As per Measure 1.5, at least 5 days prior to the start of Project activities, Permittee shall notify CDFW that work will commence.

3.2 Notification of Designated Representative. As per Measure 1.9, at least 5 days prior to the start of Project activities, Permittee shall submit to CDFW the name, business address, and contact information of the Designated Representative.

3.3 Biologist Approval. As per Measure 2.10, no later than 30 days prior to project activities covered by this Agreement, the Permittee shall submit to CDFW, for review and approval, the qualifications for the biologist(s) that shall oversee the implementation of the conditions in this Agreement and conduct surveys or monitoring work.

3.4 Fish Relocation Plan. As per Measure 2.31, Permittee shall submit a fish relocation plan to CDFW for review and approval at least 15 days prior to commencement of project activities.

3.5 Special-Status Plant Survey Results. Survey results for special-status plants shall be submitted to CDFW prior to the start of work.

3.6 Roosting Bat Survey Reports. Survey results for roosting bats shall be submitted to CDFW prior to the start of work.

3.7 Nesting Bird Survey Reports. Survey results for nesting birds shall be submitted to CDFW prior to the start of work.

3.8 Restoration Plan. At least 30 days prior to the commencement of project actives, Permittee shall submit to CDFW for review and approval a restoration plan for the restoration of bank areas disturbed during construction of culvert and from dewatering activities.

3.9 Enhancement Plan. At least 30 days prior to commencement of project activities, the Permittee shall submit to CDFW for review and approval an enhancement plan to enhance 200 square feet of riparian habitat on-site to off-set permanent impacts

3.10 Re-vegetation Annual Report. The Permittee shall submit an annual status report on the monitoring of planting to CDFW by January 31st of each year for five (5) years. This report shall include the survival, percent cover, and height of both tree and shrub species. The number by species of plants replaced, an overview of the revegetation effort, and the method used to assess these parameters shall also be included. Photos from designated photo stations shall be included.

3.11 Photographic Documentation of Work. Prior to commencement of work a minimum of four (4) vantage points that offer representative views of the project site and work areas shall be identified. The Permittee shall photograph the project area from each of the vantage points, noting the direction and magnification of each photo. Upon completion of work, the Permittee shall photograph post-project conditions from the vantage points using the same direction and magnification as pre-project photos. A reference key shall be submitted with the photos describing the location of the photo, the direction of the view, and whether the photo is pre- or post-construction. All photos shall be submitted within 30 days of project conclusion.

3.12 Notification to the California Natural Diversity Database. If any listed, rare, or special status species are detected during project surveys or on or around the project site during project activities, the Permittee shall submit CNDDB Field Survey Forms to CDFW in the manner described at the CNDDB website (https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data) within five working days of the sightings. Copies of such submittals shall also be submitted to the CDFW regional office as specified below.

CONTACT INFORMATION

Any communication that Permittee or CDFW submits to the other shall be submitted through EPIMS as instructed by CDFW.

To Permittee:

Kenneth Eichstaedt
City of Petaluma
EPIMS-SON-18195-R3
First and F Street Bridge Replacement
keichstaedt@cityofpetaluma.org

To CDFW:

Department of Fish and Wildlife
Bay Delta Region
EPIMS-SON-18195-R3
First and F Street Bridge Replacement
EPIMS.R3@wildlife.ca.gov

LIABILITY

Permittee shall be solely liable for any violations of the Agreement, whether committed by Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents or contractors and subcontractors, to complete the project or any activity related to it that the Agreement authorizes.

This Agreement does not constitute CDFW's endorsement of, or require Permittee to proceed with the project. The decision to proceed with the project is Permittee's alone.

SUSPENSION AND REVOCATION

CDFW may suspend or revoke in its entirety the Agreement if it determines that Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, is not in compliance with the Agreement.

Before CDFW suspends or revokes the Agreement, it shall provide Permittee written notice by certified or registered mail that it intends to suspend or revoke. The notice shall state the reason(s) for the proposed suspension or revocation, provide Permittee an opportunity to correct any deficiency before CDFW suspends or revokes the Agreement, and include instructions to Permittee, if necessary, including but not limited to a directive to immediately cease the specific activity or activities that caused CDFW to issue the notice.

ENFORCEMENT

Nothing in the Agreement precludes CDFW from pursuing an enforcement action against Permittee instead of, or in addition to, suspending or revoking the Agreement.

Nothing in the Agreement limits or otherwise affects CDFW's enforcement authority or that of its enforcement personnel.

OTHER LEGAL OBLIGATIONS

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from complying with, or obtaining any other permits or authorizations that might be required under, other federal, state, or local laws or regulations before beginning the project or an activity related to it. For example, if the project causes take of a species listed as threatened or endangered under the Endangered Species Act (ESA), such take will be unlawful under the ESA absent a permit or other form of authorization from the U.S. Fish and Wildlife Service or National Marine Fisheries Service.

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from complying with other applicable statutes in the Fish and Game Code including, but not limited to, Fish and Game Code sections 2050 *et seq*. (threatened and endangered species), section 3503 (bird nests and eggs), section 3503.5 (birds of prey), section 5650 (water pollution), section 5652 (refuse disposal into water), section 5901 (fish passage), section 5937 (sufficient water for fish), and section 5948 (obstruction of stream).

Nothing in the Agreement authorizes Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, to trespass.

AMENDMENT

CDFW may amend the Agreement at any time during its term if CDFW determines the amendment is necessary to protect an existing fish or wildlife resource.

Permittee may amend the Agreement at any time during its term, provided the amendment is mutually agreed to in writing by CDFW and Permittee. To request an amendment, Permittee shall log into EPIMS and submit to CDFW a completed CDFW "Amendment & Extension" form. Permittee shall include with the completed form, payment of the corresponding amendment fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

TRANSFER AND ASSIGNMENT

This Agreement may not be transferred or assigned to another entity, and any purported transfer or assignment of the Agreement to another entity shall not be valid or effective, unless the transfer or assignment is requested by Permittee in writing, as specified below, and thereafter CDFW approves the transfer or assignment in writing.

The transfer or assignment of the Agreement to another entity shall constitute a minor amendment, and therefore to request a transfer or assignment, Permittee shall log into EPIMS and submit to CDFW a completed CDFW "Amendment & Extension" form. Permittee shall include with the completed form, payment of the minor amendment fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

EXTENSIONS

In accordance with Fish and Game Code section 1605, subdivision (b), Permittee may request one extension of the Agreement, provided the request is made prior to the expiration of the Agreement's term. To request an extension, Permittee shall log into EPIMS and submit to CDFW a completed CDFW "Amendment & Extension' form. Permittee shall include with the completed form, payment of the extension fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5). CDFW shall process the extension request in accordance with Fish and Game Code section 1605, subdivisions (b) through (e).

If Permittee fails to submit a request to extend the Agreement prior to its expiration, Permittee must submit a new notification and notification fee before beginning or continuing the project the Agreement covers (Fish & G. Code § 1605, subd. (f)).

EFFECTIVE DATE

The Agreement becomes effective on the date of CDFW's signature, which shall be: 1) after Permittee's signature; 2) after CDFW complies with all applicable requirements under the California Environmental Quality Act (CEQA); and 3) after payment of the applicable Fish and Game Code section 711.4 filing fee listed at https://www.wildlife.ca.gov/Conservation/CEQA/Fees.

TERM

This Agreement shall expire on December 31, 2025, unless it is terminated or extended before then. All provisions in the Agreement shall remain in force throughout its term. Permittee shall remain responsible for implementing any provisions specified herein to protect fish and wildlife resources after the Agreement expires or is terminated, as Fish and Game Code section 1605, subdivision (a)(2) requires.

EXHIBITS

The documents listed below are included as exhibits to the Agreement and incorporated herein by reference.

A. *First and F Street Bridge*, prepared by Questa Engineering Corp, dated March 2021
B. *First and F Street Bridge Replacement Project*, prepared by ZFA Structural Engineers, dated August 2020

AUTHORITY

If the person signing the Agreement (signatory) is doing so as a representative of Permittee, the signatory hereby acknowledges that he or she is doing so on Permittee's behalf and represents and warrants that he or she has the authority to legally bind Permittee to the provisions herein.

AUTHORIZATION

This Agreement authorizes only the project described herein. If Permittee begins or completes a project different from the project the Agreement authorizes, Permittee may be subject to civil or criminal prosecution for failing to notify CDFW in accordance with Fish and Game Code section 1602.

CONCURRENCE

Through the electronic signature by the permittee or permittee's representative as evidenced by the attached concurrence from CDFW's Environmental Permit Information Management System (EPIMS), the permittee accepts and agrees to comply with all provisions contained herein.

The EPIMS concurrence page containing electronic signatures must be attached to this agreement to be valid.

APPENDIX B

GEOTECHNICAL REPORT

RGH CONSULTANTS
Experience is the difference

Santa Rosa Office
1305 North Dutton Ave
Santa Rosa, CA 95401
707-544-1072

Napa Office
1041 Jefferson St, Suite 4
Napa, CA 94559
707-252-8105

December 4, 2019 (Revised December 23, 2019)

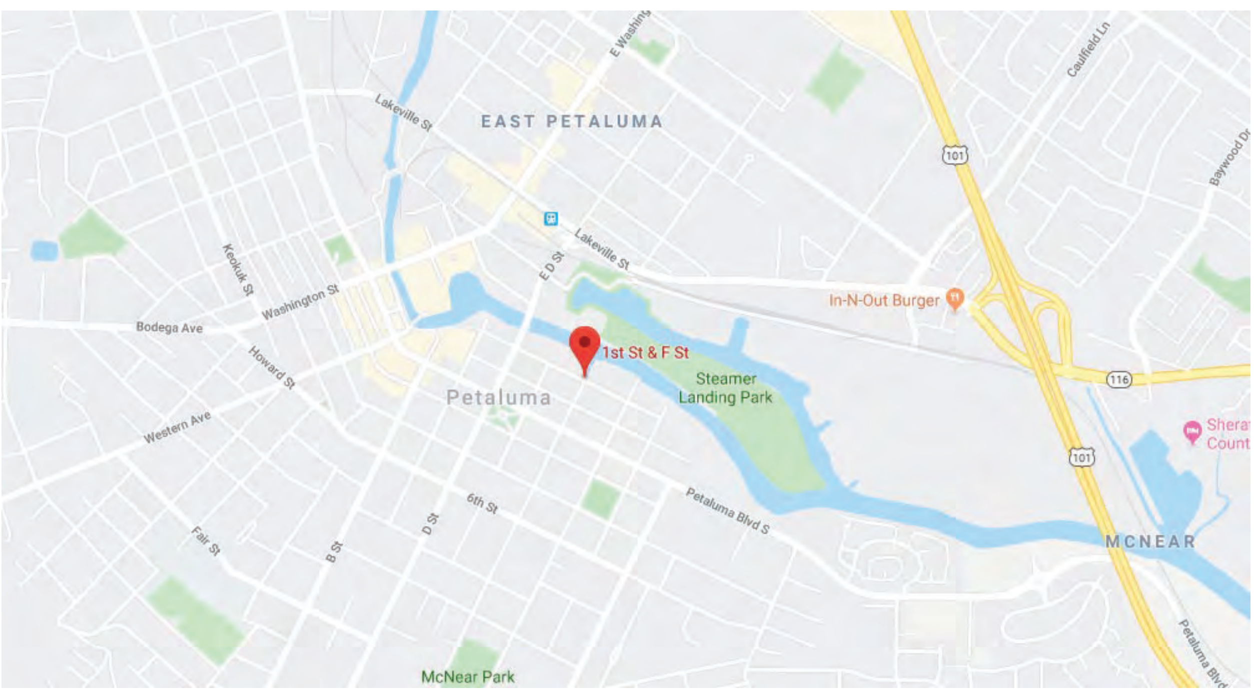
City of Petaluma
Attention: Ken Eichstaedt, PE, TE
P.O. Box 61
Petaluma, CA 94953
KEichstaedt@cityofpetaluma.org

Geotechnical Study Report
First Street Wooden Deck
First Street
Petaluma, California

Project Number: 2553.10.PW.1

INTRODUCTION

This report presents the results of our geotechnical study for the replacement of the wooden deck located at First and F Streets in Petaluma, California. The deck extends the outlet of an underground culvert that runs under F street. From the deck area, water flows in a channel to the Petaluma River. We understand that the wooden deck will be replaced with a concrete box culvert. The site location is shown below.



SCOPE

The purpose of our study, as outlined in our Professional Service Agreement dated October 10, 2019, was to generate geotechnical information for the design and construction of the project. Our scope of services included reviewing selected published geologic data pertinent to the site; evaluating the subsurface conditions with borings; analyzing the field data; and presenting this report with the following geotechnical information:

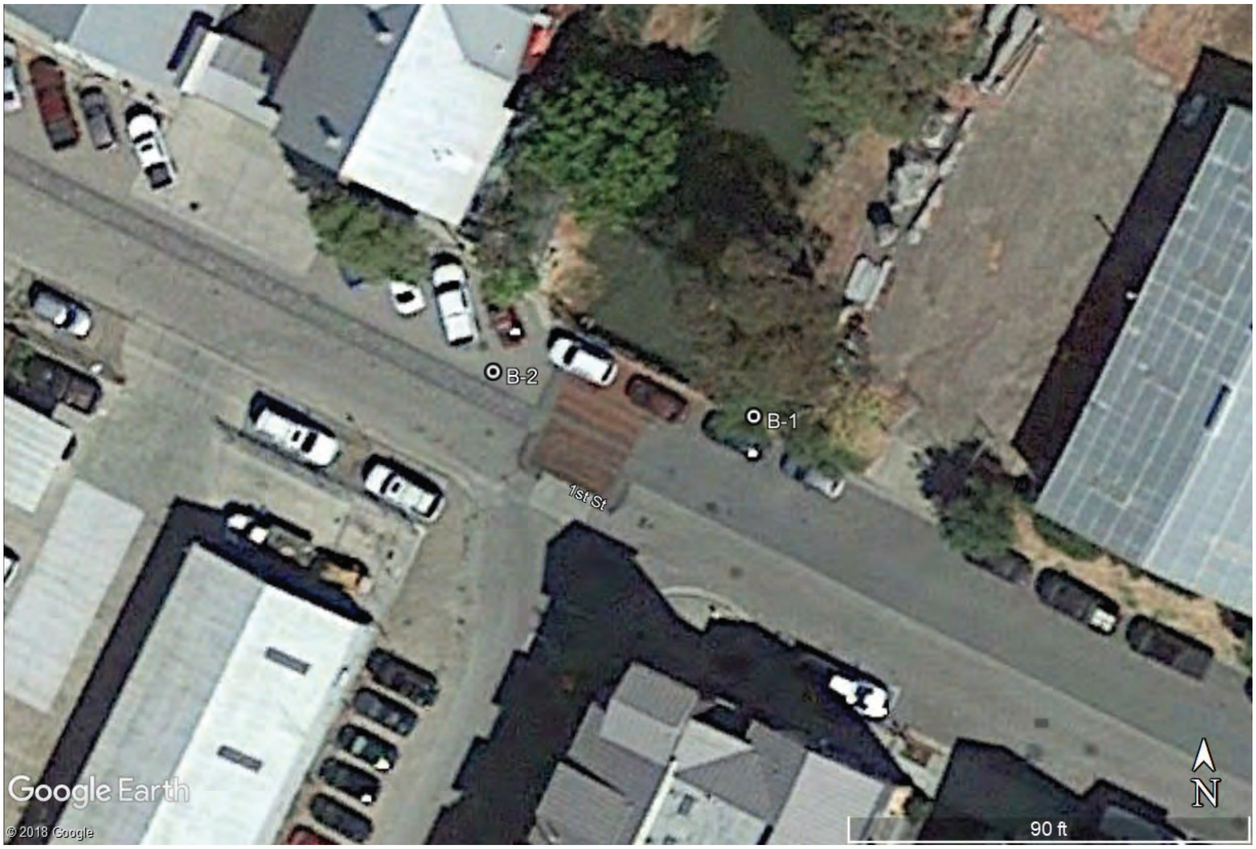
1. A brief description of soil and groundwater conditions observed during our study;
2. A discussion of seismic hazards that may affect the proposed improvements, including seismic design criteria per guidelines in the 2019 California Building Code;
3. Specific conclusions and recommendations concerning:
    a. Primary geotechnical engineering concerns and mitigating measures, as applicable;
    b. Alternative foundation types, design criteria, and settlement behavior for new foundation elements;
    c. Lateral forces for wall design, if required;
    d. Geotechnical engineering drainage improvements; and
    e. Supplemental geotechnical engineering services.

STUDY

Site Exploration

On May 10, 2013, we performed a geotechnical reconnaissance of the site and explored the subsurface conditions by drilling two borings to depths ranging from 26½ to 36½ feet. The borings were drilled with a truck-mounted drill rig using 8-inch diameter, hollow stem augers at the approximate locations shown below. The boring locations were determined approximately by pacing their distance from features shown on the image below and should be considered accurate only to the degree implied by the method used. Our personnel located and logged the boring and obtained samples of the materials encountered for visual examination, classification, and laboratory testing.

Relatively undisturbed samples were obtained from the borings at selected intervals by driving a 2.43-inch inside diameter, split spoon sampler, containing 6-inch long brass liners, using a 140-pound hammer dropping approximately 30 inches. The sampler was driven 12 to 18 inches. The blows required to drive each 6-inch increment were recorded and the blows required to drive the last 12 inches, or portion thereof, were converted to equivalent Standard Penetration Test (SPT) blow counts for correlation with empirical data. Disturbed samples were also obtained at selected depths by driving a 1.375-inch inside diameter (2-inch outside diameter) SPT sampler, without liners or rings, using a 140-pound hammer dropping approximately 30 inches. The sampler was driven 12 to 18 inches, the blows to drive each 6-inch increment were recorded, and the blows required to drive the final 12 inches, or portion thereof, are provided on the boring logs.



The logs of the borings showing the materials encountered, groundwater conditions, converted blow counts and sample depths are presented on Plates 1 and 2. The soil is described in accordance with the Unified Soil Classification System, outlined on Plate 3. The boring logs show our interpretation of the subsurface soil and groundwater conditions on the date and at the locations indicated. Subsurface conditions may vary at other locations and times. Our interpretation is based on visual inspection of soil samples, laboratory test results, and interpretation of drilling and sampling resistance. The location of the soil boundaries should be considered approximate. The transition between soil types may be gradual.

Laboratory Testing

The samples obtained from the borings were transported to our office and re-examined to verify soil classifications, evaluate characteristics, and assign tests pertinent to our analysis. Selected samples were laboratory tested to determine their consolidation characteristics. The test results are presented below:

Pre-Consolidation Pressure (P_C) – 1100 pounds per square foot (psf)
Compression Index (C_C) – 0.97
Recompression Index (C_R) – 0.18

SITE CONDITIONS

General

Sonoma County is located within the California Coast Range geomorphic province. This province is a geologically complex and seismically active region characterized by sub-parallel northwest-trending faults, mountain ranges and valleys. The oldest bedrock units are the Jurassic-Cretaceous Franciscan Complex and Great Valley sequence sediments originally deposited in a marine environment. Subsequently, younger rocks such as the Tertiary-age Sonoma Volcanics group, the Plio-Pleistocene-age Clear Lake Volcanics and sedimentary rocks such as the Guinda, Domengine, Petaluma, Wilson Grove, Cache, Huichica and Glen Ellen formations were deposited throughout the province. Extensive folding and thrust faulting during late Cretaceous through early Tertiary geologic time created complex geologic conditions that underlie the highly varied topography of today. In valleys, the bedrock is covered by thick alluvial soil.

Surface

The project site extends over essentially level roadway terrain. The exposed surface is generally asphalt or what appears to be grout set cobbles. The wooden deck is exposed at the surface. Railroad tracks extend down the road. Natural drainage consists of sheet flow over the ground surface that concentrates in man-made drainages such as roadside gutters, and natural drainages such as the Petaluma River.

Subsurface

Our borings indicate that the portion of the site we studied is blanketed by asphalt and aggregate base that extend to about 18 inches. These materials are underlain by very soft to medium stiff clay and silt soil that extends to depth of 17½ to 20 feet below the ground surface. The silt soil is referred to locally as Bay Mud. Bay Mud and the clay soils encountered are compressible under fill and new foundation loads. The clay soil is underlain by medium dense sand that extends to depths of about 21½ to 22½ feet. The sand is underlain by stiff clay to the maximum depth explored (36½ feet in boring B-2). A summary of the subsurface conditions found in our borings is provided on Plates 1 and 2. Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-16, titled “Minimum Design Loads and Associated Criteria for Buildings and Other Structures” (2017), we have determined a Site Class of E should be used for the site.

Corrosion Potential

Mapping by the Natural Resources Conservation Service (www.websoilsurvey.sc.egov.usda.gov) indicates that the corrosion potential of the near surface soil is low for uncoated steel and low for concrete. Performing corrosivity tests to verify these values was not part of our requested and/or proposed scope of work. Should the need arise, we would be pleased to provide a proposal to evaluate these characteristics.

Groundwater

Groundwater was observed at a depth of 8 feet below the ground surface in our borings. Fluctuation in the groundwater level typically occurs because of a variation in rainfall intensity, duration and other factors such as flooding and stream flow depth.

DISCUSSION AND CONCLUSIONS

Seismic Hazards

Faulting and Seismicity

We did not observe landforms within the area that would indicate the presence of active faults and the site is not within a current Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007). Therefore, we believe the risk of fault rupture at the site is low. However, the site is within an area affected by strong seismic activity and future seismic shaking should be anticipated at the site. It will be necessary to design and construct the proposed improvements in strict adherence with current standards for earthquake-resistant construction.

Liquefaction

Liquefaction is a rapid loss of shear strength experienced in saturated, predominantly granular soil below the groundwater level during strong earthquake ground shaking due to an increase in pore water pressure. The occurrence of this phenomenon is dependent on many complex factors including the intensity and duration of ground shaking, particle size distribution and density of the soil.

Granular soil was encountered at the site below the groundwater table. Therefore, we performed an analysis of the blow count data from our borings using the methods of Seed and Idriss (1982), Seed and others (1985), Youd and Idriss (2001), Idriss and Boulanger (2004) and Idriss and Boulanger (2008). These procedures normalize the blow counts to account for overburden pressure, rod length, hammer energy, and fines (percent of silt and clay) content. Once the blow counts are normalized and adjusted to a clean sand blow count, the cyclic resistance ratio (CRR) for each blow count is then determined using the same procedures referenced above. The CRR is compared to the cyclic stress ratio (CSR) induced by the earthquake. Calculating the CSR requires a peak ground acceleration and design earthquake magnitude.

Peak ground acceleration (PGA) was determined using the methods in the 2019 California Building Code (CBC) and the site-specific ground motion methods in Chapter 21 of ASCE Standard 7-16 (2017). Using the site's latitude and longitude of 38.2329°N and -122.6337°W, respectively, and a site soil Class of E, the PGA for the site is 0.55g. Using this information, the CSR for a M_M 7.5 earthquake at the site ranges from 0.52 to 0.79. The Rogers Creek fault is most likely controlling the ground motions at the site. According to Petersen (1996), the Rogers Creek fault is capable of a M_M 7.0 earthquake. Therefore, the CRR values at the site must be scaled to account for the difference between M_M 7.0 and M_M 7.5. When the scaling factor for magnitude and confining stress corrections presented in Idriss and Boulanger (2004) are applied, the CRR values at the site do not exceed the CSR values. Therefore, we judge that there is potential for liquefaction at the site.

There are three potential consequences of liquefaction: bearing capacity failure, lateral spreading toward a free face (e.g. riverbank) and settlement. Bearing capacity failure is sudden and extreme settlement of foundations that typically occurs when the liquefied layer is relatively close (typically within two times the footing width, depending on the loads) to the bottom of the foundation. The upper portion of the liquefiable layer is about 17½ to 20 feet below the ground surface. Given the potential depth of the culvert, we judge that there is the potential for bearing capacity of the culvert.

Lateral spreading can occur where continuous layers of liquefiable soil extend to a free face, such as a channel or a riverbank. The potentially liquefiable layers are located at depths ranging from 17½ to 20 feet. The layer is below the adjacent free face. Therefore, we judge the potential for liquefaction-induced lateral spreading at the site is low.

The third potential consequence of liquefaction is settlement due to densification of the liquefied soil. Potential settlements based on the blow count data and cyclic stress ratio were calculated using the methods of Ishihara and Yoshimine (1992). For the layers encountered between approximately 17½ and 20 feet below the surface, we calculated total settlement ranging from about ¾ inch to 1¼ inches. Differential settlement could range up to ½ inch across the culvert.

Geotechnical Issues

General

Based on our study, we judge the proposed culvert can be built as planned, provided the recommendations presented in this report are incorporated into its design and construction. The primary geotechnical concerns during design and construction of the project are:

1. The presence of compressible soil to depths of approximately 17½ to 20 feet;
2. The presence of potentially liquefiable soil below the compressible soil;
3. The detrimental effects of uncontrolled surface runoff and groundwater seepage on long-term satisfactory performance; and
4. The strong ground shaking predicted to impact the site during the life of the project.

Compressible Soil

Our borings encountered soils that are susceptible to settlement under new loading such as that from the proposed culvert. Based on the size of the culvert, the culvert will be bearing directly on the compressible soil. Settlement calculations indicate that the culvert may settle on the order of 4 to 6 inches. This settlement will be seen at the surface within the roadway. This amount of settlement is unacceptable in a roadway. Therefore, the culvert needs to be supported on a deep foundation system that gains support below the compressible soil.

Liquefiable Soil

As discussed previously, there are liquefiable soils below the compressible soil. The potential consequences of liquefaction are bearing capacity failure and settlement. Settlement was calculated to range between ¾ to 1¼ inches. Based on these potential consequences, the culvert needs to be supported on a deep foundation system that gains support below the liquefiable soil.

Foundation - Satisfactory support for the culvert can be obtained from a deep foundation system gaining support below the compressible and liquefiable soils. Deep foundation systems typically include driven piles, drilled piers, torque-down piles, and auger-cast piles.

On-Site Soil Quality

All culvert backfill materials must be select, as subsequently described in “Recommendations.” We anticipate that, with the exception of organic matter and of rocks or lumps larger than 6 inches in diameter, the excavated material will be suitable for re-use as general fill but will not be suitable for use as select fill for culvert backfill.

Select Culvert Backfill

The select culvert backfill can consist of approved import materials with a low expansion potential. The geotechnical engineer must approve the use of import soil as select fill during grading.

Settlement

Provided the culvert is supported on a deep foundation system that gains support below the compressible soil and liquefiable soil, we estimate that post-construction differential settlements across the culvert should be about ½ inch.

RECOMMENDATIONS

Seismic Design

Seismic design parameters presented below are based on Section 1613 titled “Earthquake Loads” of the 2019 California Building Code (CBC). Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-16, titled “Minimum Design Loads and Associated Criteria for Buildings and Other Structures” (2017), we have determined a Site Class of E should be used for the site. Using a site latitude and longitude of 38.2329°N and 122.6337°W, respectively, the Site Class of E, and the site-specific ground motion procedures of Chapter 21 of ASCE 7-16, we recommend that the following seismic design criteria be used for applicable structures at the site.

2019 CBC Seismic Criteria	
Spectral Response Parameter	**Acceleration (g)**
S_S (0.2 second period)	1.500
S_1 (1 second period)	0.600
S_{MS} (0.2 second period)	1.671
S_{M1} (1 second period)	1.956
S_{DS} (0.2 second period)	1.114
S_{D1} (1 second period)	1.304

Foundation Support

Because of the great depth to supporting soil, the culvert should be supported on a deep foundation system. Deep foundation systems that could be used for this project include driven piles, drilled piers, torque-down piles, and auger cast piles. Vibrations created by pile driving could have an adverse impact on the adjacent buildings, which include a condominium complex and older buildings along the waterfront. In addition, drilled pier foundations will create soil cuttings and groundwater that will need to be disposed of. The cost of disposing of these materials could be prohibitive depending on whether contaminants are present within them. Based on the above information, we understand that the City of Petaluma wants to focus on torque-down piles or auger cast piles as a foundation system for the culvert. Recommendations for these options are presented below.

Torque-Down Piles

Torque-down piles (also referred to as screw piles) are advanced into the ground by a sacrificial screw-head that is attached to the end of a tubex pile. This type of pile system is designed for skin friction with no end bearing. The piles should gain support in the clay soil below a depth of 22 feet. The diameter of the pile should be set by the design. Piles should be spaced no closer than 3 pile diameters, center to center.

Skin Friction - The portion of the piles extending below a depth of 22 feet from the ground surface may be designed using an allowable skin friction of 350 pounds per square foot (psf) for dead load plus long-term live loads. This value can be increased by ⅓ for total loads, including downward vertical wind or seismic forces. A skin friction value of 230 psf should be used to resist uplift forces.

Lateral Forces - Lateral loads on piles will be resisted by passive pressure on the soil. An equivalent fluid pressure of 100 pounds per cubic foot (pcf) acting on two pile diameters. Confinement for passive pressure may be assumed from the base of the culvert. Passive resistance can be increased to 350 pcf below a depth of 22 feet.

Auger Cast Piles

Drilled, auger-cast or continuous flight auger (CFA) reinforced concrete piles can be used for foundation support. The piles should be a minimum of 12 inches in diameter, spaced no closer than 3 pier diameters, center to center, and gain support in the clay soil below a depth of 22 feet. Larger piers may be needed to resist the lateral forces imposed by earthquakes per the California Building Code.

Skin Friction - The portion of the piles extending below a depth of 22 feet from the ground surface may be designed using an allowable skin friction of 375 pounds per square foot (psf) for dead load plus long-term live loads. This value can be increased by ⅓ for total loads, including downward vertical wind or seismic forces. A skin friction value of 250 psf should be used to resist uplift forces.

Lateral Forces - Lateral loads on piles will be resisted by passive pressure on the soil. An equivalent fluid pressure of 100 pounds per cubic foot (pcf) acting on two pile diameters. Confinement for passive pressure may be assumed from the base of the culvert. Passive resistance can be increased to 350 pcf below a depth of 22 feet.

Culvert and Wing Walls

Culvert walls and wing walls must be designed to resist lateral earth pressures plus additional lateral pressures that may be caused by surcharge loads applied at the ground surface behind the walls. Walls free to rotate (yielding greater than 0.1 percent of the wall height at the top of the backfill) should be designed for active lateral earth pressures. If walls are restrained by rigid elements to prevent rotation, they should be designed for “at rest” lateral earth pressures. In the absence of backdrains, the walls should be designed to resist full hydrostatic pressure.

Retaining walls should be designed to resist the following earth equivalent fluid pressures (triangular distribution):

EARTH EQUIVALENT FLUID PRESSURES	
Loading Condition	**Pressure (pcf)**
Active - Level Backfill	42
At Rest - Level Backfill	63
Active Full Hydrostatic	84
At Rest Full Hydrostatic	94

* If required

These pressures do not consider additional loads resulting from adjacent foundations or other loads. If these additional surcharge loadings are anticipated, we can assist in evaluating their effects. Where wall backfill is subject to vehicular traffic, the walls should be designed to resist an additional surcharge pressure equivalent to two feet of additional backfill.

Walls will yield slightly during backfilling. Therefore, walls should be backfilled prior to building on, or adjacent to, the walls. Backfill against the walls should be compacted to at least 90 and not more than 95 percent relative compaction. Over-compaction or the use of large compaction equipment should be avoided because increased compactive effort can result in lateral pressures higher than those recommended above.

Walls should be backdrained as shown on Plate 4. The backdrains should consist of 4-inch diameter, rigid perforated pipe embedded in Class 2 permeable material. The pipe should be PVC Schedule 40 or ABS with SDR 35 or better, and the pipe should be sloped to drain to outlets by gravity. The top of the pipe should be at least 8 inches below lowest adjacent grade. The Class 2 permeable material should extend to within 1½ feet of the surface. The upper 1½ feet should be backfilled with compacted soil to exclude surface water. Retaining walls designed to resist full hydrostatic pressure do not need to be backdrained. Expansive soil should not be used for wall backfill. Where expansive soil is present in the excavation made to install the retaining wall, the excavation should be sloped back 1:1 from the back of the footing or grade beam. The ground surface behind walls should be sloped to drain. Where migration of moisture through walls would be detrimental, walls should be waterproofed.

Utility Trenches

The shoring and safety of culvert and trench excavations is solely the responsibility of the contractor. Attention is drawn to the State of California Safety Orders dealing with "Excavations and Trenches."

Unless otherwise specified by the City of Petaluma, utility trench backfill should consist of aggregate baserock. The baserock should comply with the minimum requirements in Caltrans Standard Specifications, Section 26 for Class 2 Aggregate Base. Trench backfill should be moisture-conditioned as necessary, and placed in horizontal layers not exceeding 8 inches in thickness, before compaction. Each layer should be compacted to at least 90 percent relative compaction as determined by ASTM Test Method D-1557. The top 6 inches of trench backfill below vehicle pavement subgrades should be moisture-conditioned as necessary and compacted to at least 95 percent relative compaction. Jetting or ponding of trench backfill to aid in achieving the recommended degree of compaction should not be attempted.

Maintenance

Periodic land maintenance will be required. Surface and subsurface drainage facilities should be checked frequently and cleaned and maintained as necessary or at least annually. Sloughing and erosion that occurs must be repaired promptly before it can enlarge.

Supplemental Services

Pre-Bid Meeting

It has been our experience that contractors bidding on the project often contact us to discuss the geotechnical aspects. Informal contacts between RGH Consultants (RGH) and an individual contractor could result in incomplete or misinterpreted information being provided to the contractor. Therefore, we recommend a pre-bid meeting be held to answer any questions about the report prior to submittal of bids. If this is not possible, questions or clarifications regarding this report should be directed to the project owner or their designated representative. After consultation with RGH, the project owner or their representative should provide clarifications or additional information to all contractors bidding the job.

Plan and Specifications Review

Coordination between the design team and the geotechnical engineer is recommended to assure that the design is compatible with the soil, geologic and groundwater conditions encountered during our study. RGH recommends that we be retained to review the project plans and specifications to determine if they are consistent with our recommendations. In the event we are not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

Construction Observation and Testing

Prior to construction, a meeting should be held at the site that includes, but is not limited to, the owner or owner's representative, the general contractor, the grading contractor, the foundation contractor, the underground contractor, any specialty contractors, the project civil engineer, other members of the project design team and RGH. This meeting should serve as a time to discuss and answer questions regarding the recommendations presented herein and to establish the coordination procedure between the contractors and RGH.

In addition, we should be retained to monitor all soil related work during construction, including:

- Site stripping, over-excavation, grading, and compaction of near surface soil;
- Placement of all engineered fill and trench backfill with verification field and laboratory testing;
- Observation of all foundation excavations; and
- Observation of foundation and subdrain installations.

If, during construction, we observe subsurface conditions different from those encountered during the explorations, we should be allowed to amend our recommendations accordingly. If different conditions are observed by others, or appear to be present beneath excavations, RGH should be advised at once so that these conditions may be evaluated and our recommendations reviewed and updated, if warranted. The validity of recommendations made in this report is contingent upon our being notified and retained to review the changed conditions.

If more than 18 months have elapsed between the submission of this report and the start of work at the site, or if conditions have changed because of natural causes or construction operations at, or adjacent to, the site, the recommendations made in this report may no longer be valid or appropriate. In such case, we recommend that we be retained to review this report and verify the applicability of the conclusions and recommendations or modify the same considering the time lapsed or changed conditions. The validity of recommendations made in this report is contingent upon such review.

These supplemental services are performed on an as-requested basis and are in addition to this geotechnical study. We cannot accept responsibility for items that we are not notified to observe or for changed conditions we are not allowed to review.

LIMITATIONS

This report has been prepared by RGH for the exclusive use of the City of Petaluma and their consultants as an aid in the design and construction of the proposed improvements described in this report.

The validity of the recommendations contained in this report depends upon an adequate testing and monitoring program during the construction phase. Unless the construction monitoring and testing program is provided by our firm, we will not be held responsible for compliance with design recommendations presented in this report and other addendum submitted as part of this report.

Our services consist of professional opinions and conclusions developed in accordance with generally accepted geotechnical engineering principles and practices. We provide no warranty, either expressed or implied. Our conclusions and recommendations are based on the information provided to us regarding the proposed construction, the results of our field exploration, laboratory testing program, and professional judgment. Verification of our conclusions and recommendations is subject to our review of the project plans and specifications, and our observation of construction.

The boring logs represent the subsurface conditions at the locations and on the date indicated. It is not warranted that they are representative of such conditions elsewhere or at other times. Site conditions and cultural features described in the text of this report are those existing at the time of our field exploration and may not necessarily be the same or comparable at other times.

The scope of our services did not include an environmental assessment or a study of the presence or absence of toxic mold and/or hazardous, toxic or corrosive materials in the soil, surface water, groundwater or air (on, below or around this site), nor did it include an evaluation or study for the presence or absence of wetlands. These studies should be conducted under separate cover, scope and fee and should be provided by a qualified expert in those fields.

We trust this provides the information you require at this time. If you have questions, please contact the undersigned.

Very truly yours,
RGH Consultants

Eric G. Chase
Principal Geotechnical Engineer

cc: christianb@zfa.com

EGC:TAW:lfc:nvd
Electronically submitted

s:\project files\2501-2750\2553\2553.10.pw.1 first street wooden deck\gs letter report.doc

Attachments: References
Plate 1 – Log of Boring B-1
Plate 2 – Log of Boring B-2
Plate 3 – Soil Classification and Key to Test Data
Plate 4 – Culvert and Wing Wall Backdrain Illustration

Date(s) Drilled **May 10, 2013**	Logged By **TAW**	Checked By **TAW**
Drilling Method **Hollow Stem Auger**	Drill Bit Size/Type **8"**	Total Depth of Borehole **26 1/2 feet**
Drill Rig Type **Mobile B-53**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **8 feet**	Sampling Method(s) **Modified California, SPT**	Hammer Data **140lb auto hammer**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
	0				Asphalt								
					Aggregate Base								
					BLACK SILT WITH CLAY AND ORGANICS (MH), very soft to soft, wet (Bay Mud)								
	5		1										
	10		4										
					DARK GRAY CLAY (CL), medium stiff, wet								
	15		4										
					BROWN SAND WITH CLAY AND GRAVEL (SP-SC), medium dense, wet								
	20												
					BROWN CLAY WITH SAND (CH), stiff, wet								

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Job No: 2553.10.PW.1 | Date: NOV 2019

LOG OF BORING B-1
First Street Wooden Deck
1st Street and F Street
Petaluma, California

PLATE
1

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
	25		9		BROWN CLAY WITH SAND (CH), stiff, wet								
					Boring terminated at 26 1/2 feet Groundwater encountered at 8 feet								
	30												
	35												
	40												
	45												

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Job No: 2553.10.PW.1 | Date: NOV 2019

LOG OF BORING B-1 CONTINUED
First Street Wooden Deck
1st Street and F Street
Petaluma, California

PLATE
1 Cont.

Date(s) Drilled **May 10, 2013**	Logged By **TAW**	Checked By **TAW**
Drilling Method **Hollow Stem Auger**	Drill Bit Size/Type **8"**	Total Depth of Borehole **36 1/2 feet**
Drill Rig Type **Mobile B-53**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing Ground Surface**
Groundwater Level **8 feet**	Sampling Method(s) **SPT**	Hammer Data **140 lb auto hammer**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
	0				Asphalt								
					Aggregate Base								
					BROWN SANDY CLAY (CL), soft, wet								
					BLACK SILT WITH CLAY AND ORGANICS (MH), soft, wet (Bay Mud)								
	5												
	10												
					BROWN CLAY WITH SAND (CH), stiff, wet								
	15												
	20	SPT	13		GRAY SAND WITH GRAVEL (SP), medium dense, wet								
					BROWN CLAY WITH SAND (CH), stiff, wet								

RGH CONSULTANTS

Job No: 2553.10.PW.1 | Date: NOV 2019

LOG OF BORING B-2
First Street Wooden Deck
1st Street and F Street
Petaluma, California

PLATE
2

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
	25		10		BROWN CLAY WITH SAND (CH), stiff, wet								
	30												
	35		9										
					Boring terminated at 36 1/2 feet Groundwater encountered at 8 feet								
	40												
	45												

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Job No: 2553.10.PW.1 | Date: NOV 2019

LOG OF BORING B-2 CONTINUED

First Street Wooden Deck
1st Street and F Street
Petaluma, California

PLATE

2 Cont.

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, ksf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14

COLUMN DESCRIPTIONS

1. Elevation (feet): Elevation (MSL, feet).
2. Depth (feet): Depth in feet below the ground surface.
3. Sample Type: Type of soil sample collected at the depth interval shown.
4. Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
5. Graphic Log: Graphic depiction of the subsurface material encountered.
6. MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
7. Dry Density (pcf): Dry density, in pcf.
8. Water Content (%): Water content, percent.
9. % <#200 Sieve: % <#200 Sieve
10. PI, %: Plasticity Index, expressed as a water content.
11. LL, %: Liquid Limit, expressed as a water content.
12. Expansion Index (EI): Expansion Index (EI)
13. UC, ksf: Unconfined compressive strength, in kips per square foot.
14. REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in ksf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

- Asphaltic Concrete (AC)
- Boulders
- Fat CLAY, CLAY w/SAND, SANDY CLAY (CH)
- Lean CLAY, CLAY w/SAND, SANDY CLAY (CL)
- SILT, SILT w/SAND, SANDY SILT (MH)
- Poorly graded SAND (SP)
- Poorly graded SAND with Clay (SP-SC)

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk Sample
- 2.5-inch-ID Modified California w/ brass liners
- 2-inch-OD unlined split spoon (SPT)

OTHER GRAPHIC SYMBOLS

- Water level (at time of drilling, ATD)
- Water level (after waiting)
- Minor change in material properties within a stratum
- Inferred/gradational contact between strata
- Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

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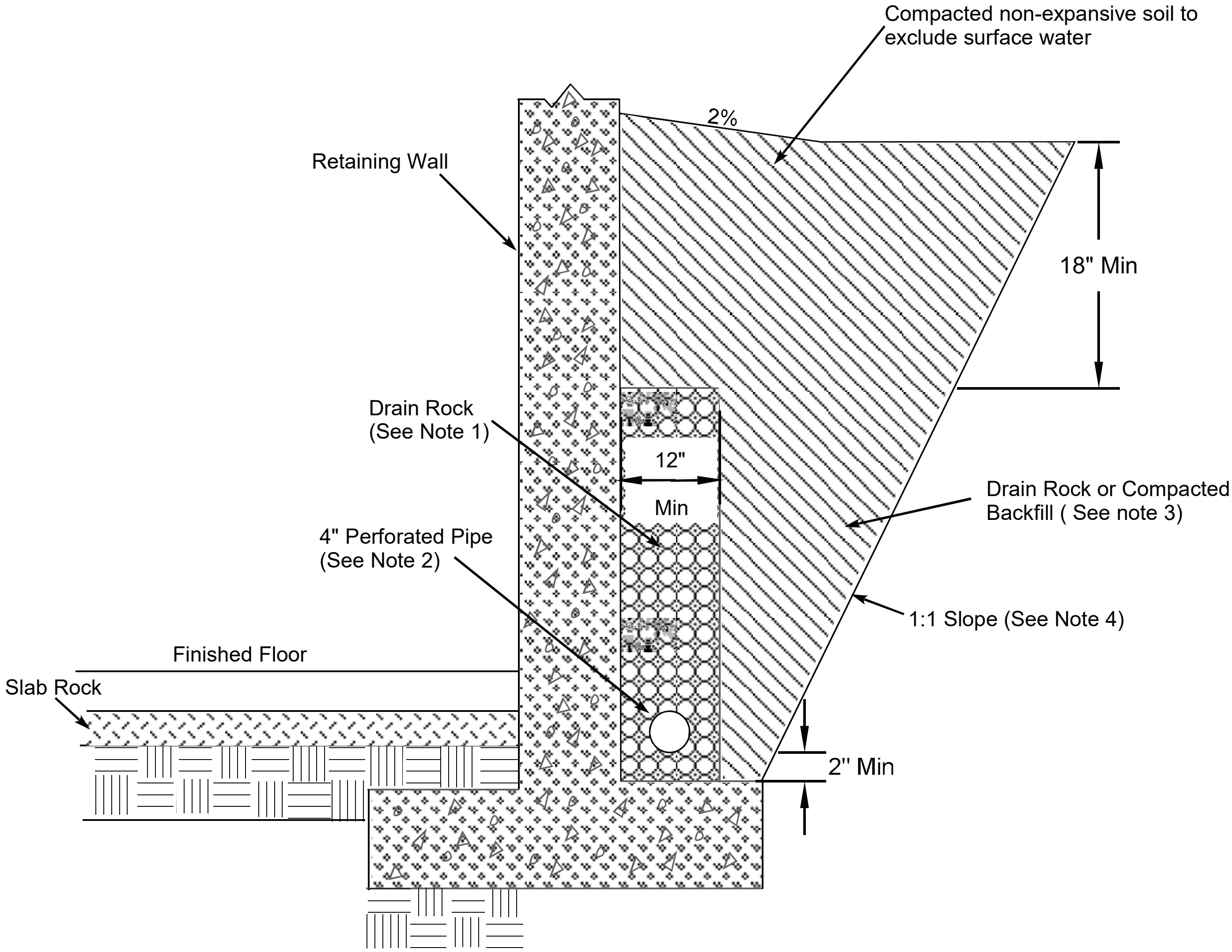
Job No: 2553.10.PW.1 | Date: NOV 2019

SOIL CLASSIFICATION AND KEY TO TEST DATA
First Street Wooden Deck
1st Street and F Street
Petaluma, California

PLATE
3



Notes:

1. Drain rock should meet the requirements for Class 2 Permeable Material, Section 68, State of California "Caltrans" Standard Specification, latest edition. Drain rock should be placed to approximately three-quarters the height of the retaining wall.

2. Pipe should conform to the requirements of Section 68 of State of California "Caltrans" Standards, perforations placed down, sloped at 1% for gravity flow to outlet or sump with automatic pump. The pipe invert should be located at least 8 inches below the lowest adjacent finished surface.

3. During construction the contractor should use appropriate methods such as temporary bracing and/or light compaction equipment to avoid overstressing the walls. Non-expansive soils to be used as backfill.

4. Slope excavation back at a 1:1 gradient from the back of footing where expansive materials are exposed.

Not to Scale

RGH CONSULTANTS	**CULVERT & WING WALL BACKDRAIN ILLUSTRATION** First Street Wooden Deck 1st Street and F Street Petaluma, California	PLATE **4**
Job No: 2553.10.PW.1 · Date: NOV 2019		

APPENDIX A – REFERENCES

American Society of Civil Engineers, 2017, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, ASCE Standard ASCE/SEI 7-16.

Bryant, W.A., and Hart, E.W., Interim Revision 2007, Fault-Rupture Zones in California; California Geological Survey, Special Publication 42, p. 21 with Appendices A through F.

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Idriss, I.M. and Boulanger, R.W., 2014, CPT and SPT Based Liquefaction Triggering Procedures.

Ishihara, K., and Yoshimine, M., 1992, Evaluation of settlements in sand deposits following liquefaction during earthquakes, *Soils and Foundations* 32(1), 173-88.

Petersen, et al., 1996, Probabilistic Seismic Hazard Assessment for the State of California, California Department of Conservation, Division of Mines and Geology, Open File Report 96-08.

Seed, H.B. and Idriss, I.M., 1982, Ground Motion and Soil Liquefaction During Earthquakes: Earthquake Engineering Research Institute, Berkeley, California.

Seed, H.B., Tokimatsu, K., Harder, L.F., and Chung, R.M., 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations: Journal of Geotechnical Engineering Division, American Society of Civil Engineers, v. III, no. 12, December, p. 1425-1445.

Youd, T.L., and Idriss, I.M., and 19 others, 2001, Liquefaction Resistance of Soils: summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils: ASCE Geotechnical and Geoenvironmental Journal, v. 127, no. 10, p. 817-833.

APPENDIX C

STRUCTURAL CALCULATIONS

ZFA STRUCTURAL ENGINEERS

san francisco
silicon valley
sacramento
santa rosa
napa

First and F Street Bridge Replacement
Structural Calculations

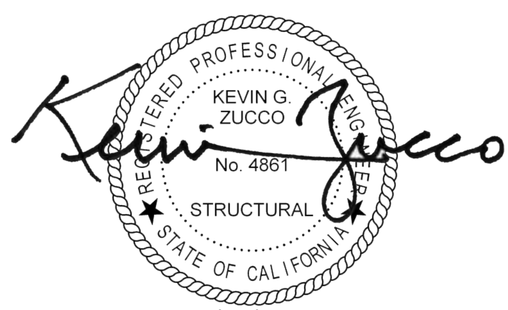
Petaluma, California
ZFA Project Number: 13415

Permit Submittal

June 17, 2021

Prepared For:
City of Petaluma Public Works & Utilities Department
Petaluma, California

Prepared By:
Matthew Ramos, PE, Engineer
Christian S. Botto, SE, Associate
Kevin Zucco, SE, Principal-in-Charge
Santa Rosa, California



06/17/2021

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ZFA STRUCTURAL ENGINEERS
Job #16XXX
Design Criteria Sheet

Engineer: ABC
7/13/2016

Proj Name

DESIGN CRITERIA

Material (unless noted otherwise)

Concrete: f'c = 5000 psi @ 28 days (Foundation)
f'c = 5000 psi @ 28 days (Beams and Columns)
f'c = 5000 psi @ 28 days (Walls)
Reinf. Steel: fy = 60 ksi, ASTM A615, Grade 60

Structural Steel:	WF Shapes	fy = 50 ksi	ASTM A992 or A572 Grade 50
	C and L Shapes, and Plates	fy = 36 ksi	ASTM A36 or A572 Grade 50
	Pipes	fy = 35 ksi	ASTM A53, Grade B

Design Code: **2019 California Building Code** Risk Category = **II**

Wind Exposure =	**C**	Basic Wind Speed (3sec. gust) =			**91 mph**		
Design Category =	**D**	$R_{(N-S)}$ =	**6.50**	$\Omega_{0\ (N-S)}$ =	**2.50**	$I_{SEISMIC}$ =	**1.00**
Soil Site Class =	**E**	$R_{(E-W)}$ =	**6.50**	$\Omega_{0\ (E-W)}$ =	**2.50**		
		S_s =	**1.500 g**	S_1 =	**0.600 g**		

Seismic Coefficients:

F_a =	**0.900**
F_v =	**2.400**
S_{MS} =	**1.350**
S_{M1} =	**1.440**
S_{DS} =	**0.900**
S_{D1} =	**0.960**

Foundation:
Design Dead + Live Bearing = **1500** **psf**
Design Dead + Wind/Seismic Bearing = **2000** **psf**

Geotechnical Report by:
RGH Consultants
2553.10.PW.1
December 4, 2019 (Revised December 23, 2019)

STRUCTURAL NARRATIVE

AASHTO LRFD Load combinations are used to determine strength demands on the piers and pier caps. CBC/ASCE7 ASD load combinations are used for soil failure modes. CBC/ASCE7 is used to design the misc. site walls

Since the structure is below grade wind, seismic, temperature, and dynamic vehicle loading does not apply per AASHTO 12.6.1. Strength design will be governed by LRFD combos Strength 1.

Trolley Loading is the same as that used for a trestle rehabilitation on the same trolley line approximately 0.25 miles north of this site and is based on the "Petaluma Trestle Rehabilitation Structural Calculations" report dated March 2013. Trolley loading is treated as a vehicle live load similar to a design truck.

From Geo Report

Torque-Down Piles

Torque-down piles (also referred to as screw piles) are advanced into the ground by a sacrificial screw-head that is attached to the end of a tubex pile. This type of pile system is designed for skin friction with no end bearing. The piles should gain support in the clay soil below a depth of 22 feet. The diameter of the pile should be set by the design. Piles should be spaced no closer than 3 pile diameters, center to center.

Skin Friction - The portion of the piles extending below a depth of 22 feet from the ground surface may be designed using an allowable skin friction of 350 pounds per square foot (psf) for dead load plus long-term live loads. This value can be increased by ⅓ for total loads, including downward vertical wind or seismic forces. A skin friction value of 230 psf should be used to resist uplift forces.

Lateral Forces - Lateral loads on piles will be resisted by passive pressure on the soil. An equivalent fluid pressure of 100 pounds per cubic foot (pcf) acting on two pile diameters. Confinement for passive pressure may be assumed from the base of the culvert. Passive resistance can be increased to 350 pcf below a depth of 22 feet.

From AASHTO 12.6.1

12.6—GENERAL DESIGN FEATURES

12.6.1—Loading

Buried structures shall be designed for force effects resulting from horizontal and vertical earth pressure, pavement load, live load, and vehicular dynamic load allowance. Earth surcharge, live load surcharge, downdrag loads, and external hydrostatic pressure shall be evaluated where construction or site conditions warrant. Water buoyancy loads shall be evaluated for buried structures with inverts below the water table to control flotation, as indicated in Article 3.7.2. Earthquake loads should be considered only where buried structures cross active faults.

For vertical earth pressure, the maximum load factor from Table 3.4.1-2 shall apply.

Wheel loads shall be distributed through earth fills according to the provisions of Article 3.6.1.2.6.

C12.6.1

Buried structures benefit from both earth shelter and support that reduce or eliminate from concern many of the loads and load combinations of Article 3.4. Wind, temperature, vehicle braking, and centrifugal forces typically have little effect due to earth protection. Structure dead load, pedestrian live load, and ice loads are insignificant in comparison with force effects due to earth fill loading. External hydrostatic pressure, if present, can add significantly to the total thrust in a buried pipe.

Vehicular collision forces are applicable to appurtenances such as headwalls and railings only. Water, other than buoyancy and vessel collision loads, can act only in the noncritical longitudinal direction of the culvert.

From Petaluma Trestle Rehabilitation Structural Calculations

Live Loads (Trestle Deck):

Uniform Load:	100 psf
Trolley Load:	Total Load = 94,000 lbs, 4 axles @ 23,500 lbs

Corrosion Resistance

Per Geo report soils are LOW corrosion potential for steel and concrete

Corrosion Potential

Mapping by the Natural Resources Conservation Service (www.websoilsurvey.sc.egov.usda.gov) indicates that the corrosion potential of the near surface soil is low for uncoated steel and low for concrete. Performing corrosivity tests to verify these values was not part of our requested and/or proposed scope of work. Should the need arise, we would be pleased to provide a proposal to evaluate these characteristics.

Per correspondence with Civil engineer river water and tidal water may be **brackish**

Requirements for concrete:

Exposure S1-C2 per ACI318-14 T19.3.1.1
w/cm reduced and f'c increased for all concrete per ACI318 T19.3.2.1

Requirements for steel:

Steel above the high water line is not exposed to brackish water or spray therefore paint or galvanization will be sufficient

For steel cased piers (torque-down piers) consider sacrificial steel
Steel corrosion rates are based on:

Washington DOT Design Memo "Corrosion of Steel Foundations and Buried Structures" dated Jan 6, 2020
CALTRANS Corrosion Guideline v3.0 dated March 2018

Location	Marine or Non-Marine: Corrosive	Non-Marine: Non-Corrosive
Soil embedded zone (undisturbed soil)	0.001	0.0005
Soil embedded zone (fill or disturbed soils)	0.0015	0.00075
Immersed zone	0.003	0.0015
Tidal zone	0.004	—
Splash zone	0.006	—
Atmospheric	0.002	0.001

Table 1: Section Loss (inch per year)

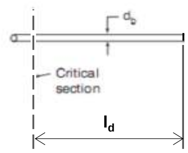
Design Life = 75 years
Corrosion Rate = 0.001 in/year
Section reduction = **0.075** in

CALCULATION PER ACI 318-14 section 25.4.2.3 and 25.5.2.1:

$l_d = d_b(3)f_y\psi_t\psi_e\psi_s$ / [$40\lambda(f'_c)^{0.5}((c_b+K_{tr})/d_b)$] [section 25.4.2.3 EQ (25.4.2.3a)]

K_{tr} = 0

Conc.Wt. Factor λ = 1.0 Location factor, ψ_t = 1.3 Coating factor, ψ_e = 1.0 $\psi_t\psi_e$ = 1.3

Development Length	Lap Splice
	

Minimum Splices for f'_c= 5000 psi

Bar	f_y (ksi)	d_b (in)	Min. Cover	Size Factor ψ_s	c_b = clear cover + d_b / 2	Min Spacing = 2 d_b (in)	$(c_b+K_{tr})/d_b$ 2.50 Max	l_d	Ls (Class B) = 1.3 l_d, 12" min	Use (in)
#3	60	0.375	1.0	0.8	1.188	2.375	2.50	12.0	12.9	13
#4	60	0.500	1.0	0.8	1.250	2.500	2.50	13.2	17.2	18
#5	60	0.625	1.0	0.8	1.313	2.625	2.10	19.7	25.6	26
#5	60	0.625	1.5	0.8	1.813	3.625	2.50	16.5	21.5	22
#6	60	0.750	1.5	0.8	1.875	3.750	2.50	19.9	25.8	26
#7	60	0.875	1.5	1.0	1.938	3.875	2.21	32.7	42.5	43
#8	60	1.000	1.5	1.0	2.000	4.000	2.00	41.4	53.8	54
#9	60	1.128	1.5	1.0	2.064	4.128	1.83	51.0	66.3	67
#10	60	1.270	1.5	1.0	2.135	4.270	1.68	62.5	81.3	82
#11	60	1.410	1.5	1.0	2.205	4.410	1.56	74.6	97.0	97

CALCULATION PER ACI 318-14 section 25.4.3:

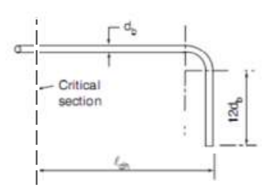
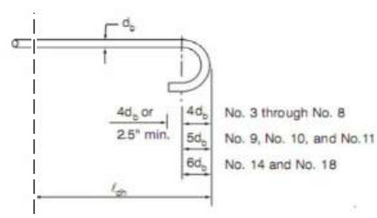
l_{dh} = MAX of d_b*[$fy\Psi_e\Psi_c\Psi_r/(50\ \lambda(f'_c)^{0.5})$] or $8d_b$ or 6in [section 25.4.3.1]

Conc.Wt. Factor λ = 1.0 Epoxy factor, ψ_e = 1.0 Factor

☑ Hooks with side cover (normal to plane of hook) > 2.5", and for 90d hook with cover on bar extension beyond hook > 2" 0.7 = ψ_c

☐ 90d hooks that are either enclosed within ties or stirrups perpendicular to the bar beind developed, spaced < 3db along ldh; or enclosed within ties or stirrups parallel to the bar being developed, spaced < 3db along the length of the tail extension of the hook plus bend 1 = ψ_r

☐ 180d hooks that are enclosed within ties or stirrups perpendicular to the bar being developed, < 3db along ldh 1 = ψ_r

90° Hook	180° Hook
	

Minimum Splices for f'_c= 5000 psi

Bar	f_y (ksi)	d_b (in)	r_{hook_inside}	L_{hook}	L_{hook}	l_{dh}	Use (in)
#3	60	0.375	1.125	4.500	5.63	4.5	6
#4	60	0.500	1.500	6.000	7.50	5.9	6
#5	60	0.625	1.875	7.500	9.38	7.4	8
#6	60	0.750	2.250	9.000	11.25	8.9	9
#7	60	0.875	2.625	10.500	13.13	10.4	11
#8	60	1.000	3.000	12.000	15.00	11.9	12
#9	60	1.128	3.384	13.536	16.92	13.4	14
#10	60	1.270	3.810	15.240	19.05	15.1	16
#11	60	1.410	4.230	16.920	21.15	16.7	17

Main Foundation Loading

Loading

Loading is enveloped for min and max expected

Span = 24.83 ft

ω_{vert} = vertical line load per side (+ is down)

ω_{horiz} = horizontal line load per side (thrust)

ω_{horiz} = 72% ω_{vert} (see arch thrust)

Dead Loads

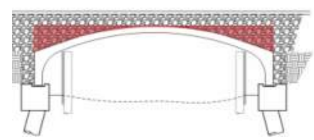
Asphalt Cover (DW)

Unit Weight = 140 pcf

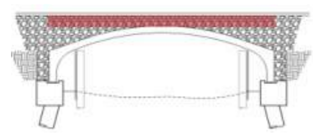
	Min	Max		
t =	4	8	in	
q =	47	93	psf	
ω_{vert} =	**0.58**	**1.16**	klf	
ω_{horiz} =	**0.41**	**0.83**	klf	

Aggregate Base (EV)

Unit Weight = 120 pcf



	Min	Max		
A =	27.3	27.3	ft^2	fill up to crest
ω_{vert} =	1.64	1.64	klf	A/2*unit weight
h_{crest} =	12	24	in	fill above crest
q =	120	240	psf	
ω_{vert} =	1.49	2.98	klf	
$\Sigma\omega_{vert}$ =	**3.13**	**4.62**	klf	
ω_{horiz} =	**2.24**	**3.31**	klf	



Concrete Arch (Contech B-Series 24'span 6'-10" Rise) (DC)

Unit Weight = 150 pcf

	Min	Max		
A =	29.2	29.2	ft^2	section area
ω_{vert} =	**2.19**	**2.19**	klf	A/2 * unit weight
ω_{horiz} =	**1.57**	**1.57**	klf	

Grade Beam (GB) (DC)

Unit Weight = 150 pcf

width = 36 in

depth = 30 in

	Min	Max		
ω_{vert} =	1.13	1.13	klf	
ω_{horiz} =	0	0	klf	(concentric with piers)

Live Loads (LL)

Per AASHTO 3.6.1.2 HL-93 Load = (HS20 Truck OR Design Tandem) + Lane Load
Per City of Petaluma Trolley Load = 200plf per track + 23.5k/axle x (4) axles @ 5'-0"oc

m = Multiple Presence Factor per AASHTO T3.6.1.1.2-1
To account for the probability of simultaneous occupancy
Does not apply to Lane Load or other distributed loads
1.0 for two lanes

IM = Dynamic Load Allowance per AASHTO 3.6.2
Need not be applied to buried structures/foundations
1.0

See Arch Thrust for distributions

HL-93 (Lane Load)

ω lane =	640	plf	AASHTO 3.6.1.2.4
Span/2 * ωlane=	7947	lbs	
Lane Width =	10	ft	
ω_{vert} =	0.79	klf	
ω_{horiz} =	0.57	klf	Uniform

HL-93 (HS-20)
Min truck length is 28'-0" (14' between axles)

P_{vert} =	46.6	k	See Arch Thrust
P_{horiz} =	23.3	k	
Lane Width =	8.5	ft	6' gauge + spread each side
ω_{vert} =	5.48	klf	
ω_{horiz} =	2.74	klf	

HL-93 (Design Tandem)
Min tandem length is 4'-0" (between axles)

P_{vert} =	45.6	k	See Arch Thrust
P_{horiz} =	27.9	k	
Lane Width =	8.5	ft	6' gauge + spread each side
ω_{vert} =	5.36	klf	
ω_{horiz} =	3.28	klf	

Trolley Load
Trolley length is 15'-0" (5' between axles)

P_{vert} =	64.7	k	See Arch Thrust
P_{horiz} =	43.2	k	
Lane Width =	8.5	ft	spread over ties
ω_{vert} =	7.61	klf	
ω_{horiz} =	5.08	klf	

Trolley Rail

ω lane =	400	plf	200plf per rail
Span/2 * ω=	4967	lbs	
Lane Width =	8.5	ft	spread over ties
ω_{vert} =	0.58	klf	
ω_{horiz} =	0.42	klf	Uniform

Provided by Contech

ω_{vert} =	6.1	klf
ω_{horiz} =	2.7	klf

Envelope

	Min (HL93)	Max (Trolley)	
ω_{vert} =	6.28	8.20	klf
ω_{horiz} =	3.85	5.50	klf

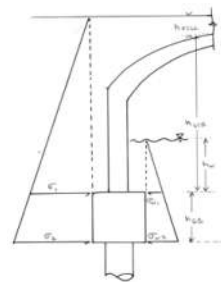
Lateral Soil Loads (EH)

Apply soil lateral loads to exterior faces of bridge and grade beam, similar to retaining wall

Equivalent fluid pressures are per geo report

Structure is rigid and thrust keeps structure from moving away from soil, therefore use passive case

h_{str} =	6.83	ft
h_{GB} =	2.5	ft
Vehicle Surcharge =	2.0	ft



Min Conditions

	Min		
Fluid Pressure =	63 pcf		free draining
h_{fill} =	2.0	ft	
h (str+fill) =	8.83	ft	
σ1 =	556.5	psf	
$\omega_{horiz,1}$ =	**2.46**	klf	$1/2\ h^2\ q$ (Top of GB)
h (GB+str+fill) =	11.33	ft	
σ2 =	714	psf	
$\omega_{horiz,2}$ =	**1.59**	klf	$h_{GB}\ (\sigma 1+\sigma 2)/2$ (On GB)

Max Conditions

	Max		
Fluid Pressure =	63 pcf		free draining
h_{fill} =	2.0	ft	
h (str+fill) =	8.83	ft	
σ1 =	557	psf	
$\omega_{horiz,1}$ =	2.46	klf	$1/2\ h^2\ q$ (Top of GB)
h (GB+str+fill) =	11.33	ft	
σ2 =	714	psf	
$\omega_{horiz,2}$ =	1.59	klf	$h_{GB}\ (\sigma 1+\sigma 2)/2$ (On GB)
$\sigma_{vehicle}$ =	126	psf	square distribution, wet condition max
$\omega_{horiz,1,vehichle}$ =	1.113	klf	σ h(str+fill)
$\omega_{horiz,2,vehichle}$ =	0.315	klf	$\sigma\ h_{GB}$
Σω1 =	**3.57**	klf	soil + vehicle
Σω2 =	**1.90**	klf	

Soil Load Summary

At Top of Grade Beam

	Min	Max	
ω_{horiz} =	2.46	3.57	klf

At Bot of Grade Beam

	Min	Max	
ω_{horiz} =	4.05	5.47	klf

Load Summary

At top of GB

	Vert Min	Vert Max	Horiz Min	Horiz Max	
DC	2.19	2.19	1.57	1.57	klf
DW	0.58	1.16	0.41	0.83	
EV	3.13	4.62	2.24	3.31	
EH			-3.57	-2.46	(max reaction results from min resisting EH)
LL (HL93)	6.28		3.85		
LL (Trolley)		8.20		5.50	
From Contech					
DC		10.8		4.5	
LL (HL93)	4.3		2		
LL (Trolley)		6.1		2.7	

At bot of GB

loads are those applied to GB, to be summed with above

	Vert Min	Vert Max	Horiz Min	Horiz Max
DC	1.13	1.13	0	0
EH	0	0	-1.90	-1.59

Load Combinations

Per AASHTO T3.4.1-1

Strength 1

Used for grade beam design

γ_p/factor

Load Type	Min	Max
DC	0.9	1.25
DW	0.65	1.5
EV	0.9	1.3
EH	0.9	1.5
LL (HL93)	0	1.75
LL (Trolley)	0	1.75

At Top of GB ω

	Vert Min	Vert Max	Horiz Min	Horiz Max	
DC	1.97	2.74	1.41	1.96	klf
DW	0.38	1.74	0.27	1.24	
EV	2.82	6.01	2.02	4.30	
EH			-5.36	-2.21	(max reaction results from min resisting EH)
LL (HL93)	0.00		0.00		
LL (Trolley)		14.34		9.63	
Σ	5.16	24.82	-1.66	14.91	
Contech Loading	9.33	24.88	3.89	10.64	
Envelope	**5.16**	**24.88**	**-1.66**	**14.91**	klf

Service 1
Used for Pier deflection control

	γ_p/factor	
Load Type	Min	Max
DC	1	1
DW	1	1
EV	1	1
EH	1	1
LL (HL93)	1	
LL (Trolley)		1

At Top of GB ω

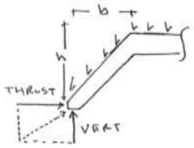
	Vert		Horiz		
	Min	Max	Min	Max	
DC	2.19	2.19	1.57	1.57	klf
DW	0.58	1.16	0.41	0.83	
EV	3.13	4.62	2.24	3.31	
EH			-3.57	-2.46	(max reaction results from min resisting EH)
Σ	5.90	7.97	0.65	3.24	
Contech Loading (DC)		10.80		4.50	
Envelope	**5.90**	**10.80**	**0.65**	**4.50**	
LL (HL93)	6.28		3.85		
LL (Trolley)		8.20		5.50	
Contech Loading (LL)					
LL (HL93)	4.30		2.00		
LL (Trolley)		6.10		2.70	
Envelope	**6.28**	**8.20**	**3.85**	**5.50**	
Σenvelope		**19.00**		**10.00**	

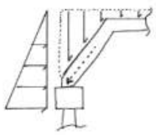
At bot of GB
loads are those applied to GB, to be summed with above

	Vert		Horiz		
		Max		Max	
DC	1.13	1.13	0.00	0.00	klf
EH	0.00	0.00	-1.90	-1.59	
Σ	1.13	1.13	-1.90	-1.59	
Σenvelope		**20.12**		**8.41**	

Arch Thrust

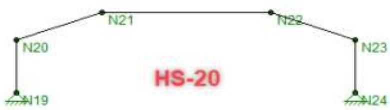
Shape of precast concrete arch results in horizontal thrust at each leg
Model arch shape in RISA to determine relationship between vertical loading and thrust
Arch is a constant material and thickness, same section may be used for all elements





Uniform Loads
All dead loads from arch self weight and material fill will be treated as uniform
The AASHTO Lane Load is uniform, the 200plf rail load is uniform

Moving Loads
HS20, Design Tandum, and Trolley loads will be applied as moving loads
The max reactions will be used



Vert = 46.6 k
Thrust = 23.3 k

Vert = 45.6 k
Thrust = 27.9 k

Vert = 64.7 k
Thrust = 43.2 k

Vert = 12.3 k
Thrust = 8.8 k
T/V = 72%

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC
1	N1	max	8.775	1-9	12.325	1-1
2		min	8.775	1-1	12.325	1-1
3	N6	max	-8.775	1-1	12.325	1-1
4		min	-8.775	1-9	12.325	1-1
5	N7	max	43.16	1-21	64.698	1-16
6		min	0	1-1	0	1-41
7	N12	max	0	1-1	62.033	1-25
8		min	-43.16	1-21	0	1-1
9	N13	max	27.9	1-15	45.632	1-5
10		min	0	1-1	0	1-30
11	N18	max	0	1-1	44.152	1-25
12		min	-27.9	1-15	0	1-1
13	N19	max	23.271	1-34	46.36	1-29
14		min	0	1-1	.913	1-53
15	N24	max	0	1-1	44.503	1-39
16		min	-23.271	1-34	0	1-1
17	Totals:	max	0	1-1	208.649	1-16
18		min	0	1-1	56.649	1-41

Company	:	ARCH THRUST	Jan 25, 2021
Designer	:		9:51 AM
Job Number	:		Checked By:_____
Model Name	:		

(Global) Model Settings

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation?	Yes
Increase Nailing Capacity for Wind?	Yes
Merge Tolerance (in)	0.12
P-Delta Analysis Tolerance	0.50%
Include P-Delta for Walls?	Yes
Automatically Iterate Stiffness for Walls?	Yes
Max Iterations for Wall Stiffness	3
Gravity Acceleration (ft/sec^2)	32.2
Wall Mesh Size (in)	12
Eigensolution Convergence Tol. (1.E-)	4
Dynamic Solver	Accelerated Solver

Hot Rolled Steel Code	AISC 15th (360-16): ASD
Adjust Stiffness?	Yes(Iterative)
Cold Formed Steel Code	AISI S100-16: ASD
Wood Code	AWC NDS-18: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-14
Masonry Code	TMS 402-16: ASD
Aluminum Code	AA ADM1-15: ASD - Building
Number of Shear Regions	4
Region Spacing Increment (in)	4
Concrete Stress Block	Rectangular
Use Cracked Sections?	Yes
Bad Framing Warnings?	No
Unused Force Warnings?	Yes
Min 1 Bar Diam. Spacing?	No
Concrete Rebar Set	REBAR_SET_ASTMA615
Min % Steel for Column	1
Max % Steel for Column	8

Member Distributed Loads (BLC 1 : Test Loads)

	Member Label	Direction	Start Magnitude[k...	End Magnitude[k/...	Start Location[ft,%]	End Location[ft,%]	Inactive
1	M2	Y	-1	-1	0	0	Active
2	M3	Y	-1	-1	0	0	Active
3	M4	Y	-1	-1	0	0	Active

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Joint	Point	Distributed
1	Test Loads	None					3

Moving Loads

	Tag	Pattern	Increme...	Both ...	1st Joint	2nd Joint	3rd Joint	4th Joint	5th Joint	6th Joint	7th Joint	8th Joint	9th Joint	10th Joint
1	M1	PET_TROLL...	1		N8	N9	N10	N11						
2	M2	DESIGN_TA...	1		N14	N15	N16	N17						

Moving Loads (Continued)

	Tag	Pattern	Increme...	Both ...	1st Joint	2nd Joint	3rd Joint	4th Joint	5th Joint	6th Joint	7th Joint	8th Joint	9th Joint	10th Joint
3	M3	H20_1	1		N20	N21	N22	N23						

Moving Load Patterns

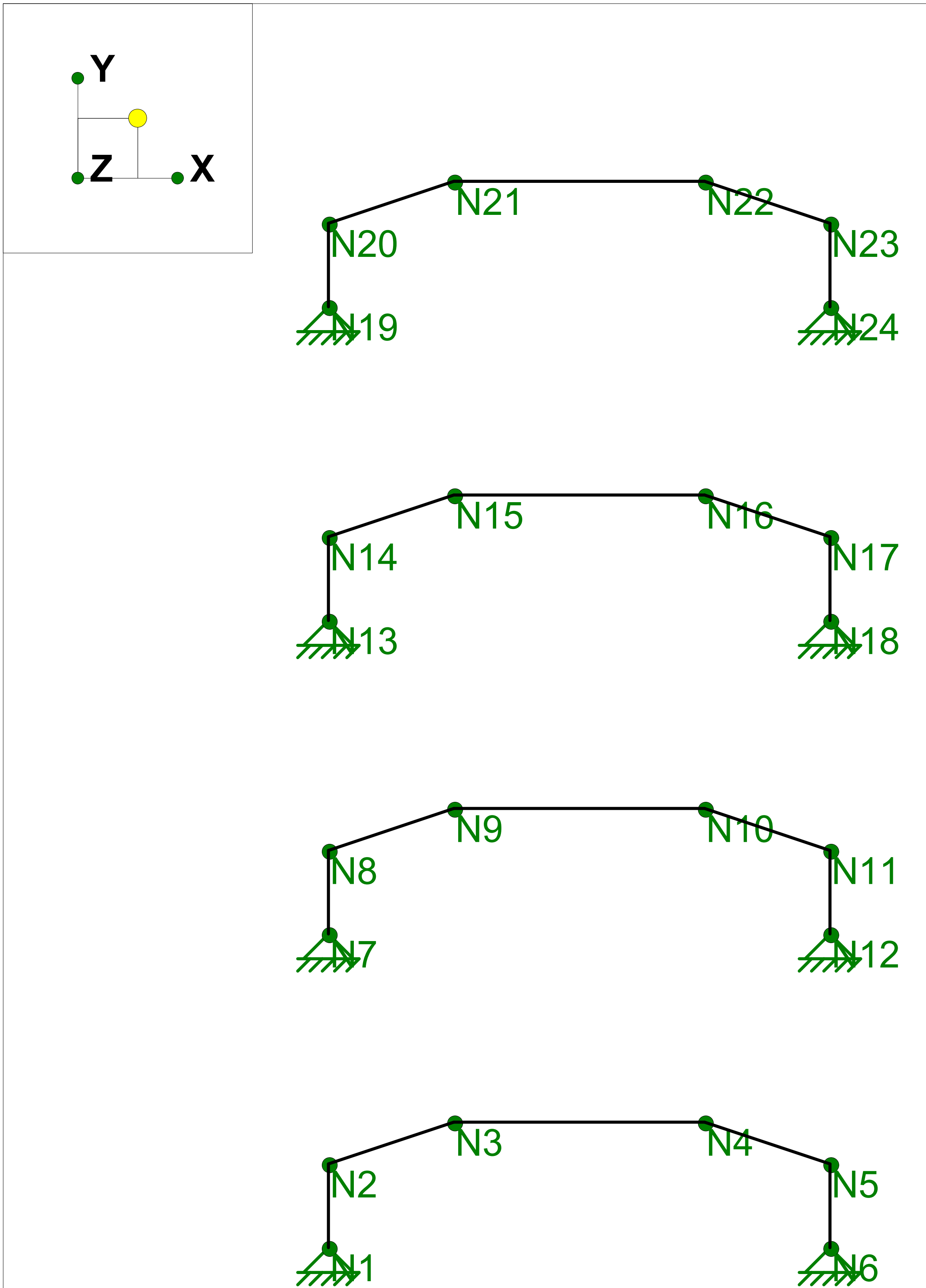
Pattern Label	Load (k)	Direction	Distance (ft)
PET_TROLLEY	-23.5	Y	0
	-23.5	Y	5
	-23.5	Y	5
	-23.5	Y	5
DESIGN_TANDEM	-25	Y	0
	-25	Y	4
H20_1	-8	Y	0
	-32	Y	14
	-32	Y	14

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...
1	Test Loads	Yes	Y		1	1	M1	1	M2	1	M3	1												

Envelope Node Reactions

	Node Label		X [k]	LC	Y [k]	LC	Moment [k-ft]	LC
1	N1	max	8.775	1-24	12.325	1-24	0	1-1
2		min	8.775	1-53	12.325	1-39	0	1-53
3	N6	max	-8.775	1-1	12.325	1-5	0	1-1
4		min	-8.775	1-25	12.325	1-29	0	1-53
5	N7	max	43.16	1-21	64.698	1-16	0	1-1
6		min	0	1-1	0	1-53	0	1-53
7	N12	max	0	1-1	62.033	1-25	0	1-1
8		min	-43.16	1-21	0	1-1	0	1-53
9	N13	max	27.9	1-15	45.632	1-5	0	1-1
10		min	0	1-1	0	1-53	0	1-53
11	N18	max	0	1-1	44.152	1-25	0	1-1
12		min	-27.9	1-15	0	1-1	0	1-53
13	N19	max	23.271	1-34	46.36	1-29	0	1-1
14		min	0	1-1	0.913	1-53	0	1-53
15	N24	max	0	1-1	44.503	1-39	0	1-1
16		min	-23.271	1-34	0	1-1	0	1-53
17	Totals:	max	0	1-10	208.649	1-21		
18		min	0	1-29	56.649	1-53		



Envelope Only Solution

		SK - 2
		Jan 25, 2021 at 9:54 AM
		B-Series_6-10.r2d

Contech Loading

Attached reactions were provided by Contech for their B-Series arch
Reactions are at top of grade beam

Dead Load (DC)

ω_{vert} = 10.8 klf
ω_{horiz} = 4.5 klf

HL-93 Load (LL)

ω_{vert} = 4.3 klf
ω_{horiz} = 2.0 klf

Trolley Load (LL)

ω_{vert} = 6.1 klf
ω_{horiz} = 2.7 klf

Load Combinations

Strength 1

Loading is provided as a lump sum
Load factors are a weighted avg based on load take off

	γ_p/factor	
Load Type	Min	Max
DC	0.86	1.32
LL	0	1.75
ω_{vert} =	9.33	24.88
ω_{horiz} =	3.89	10.64

Service 1

	γ_p/factor
Load Type	Max
DC	1
LL	1

	ω_{vert}	ω_{horiz}	
Dead Load (DC)	10.80	4.50	klf
HL-93 Load (LL)	4.30	2.00	
Trolley Load (LL)	6.10	2.70	

CON SPAN® BRIDGE SYSTEMS

BRIDGE REACTIONS

JOB #:
NAME: 1st and F Street
DATE: 09-Oct-20
BY: DM

LOADS: Loads are unfactored

includes self weight

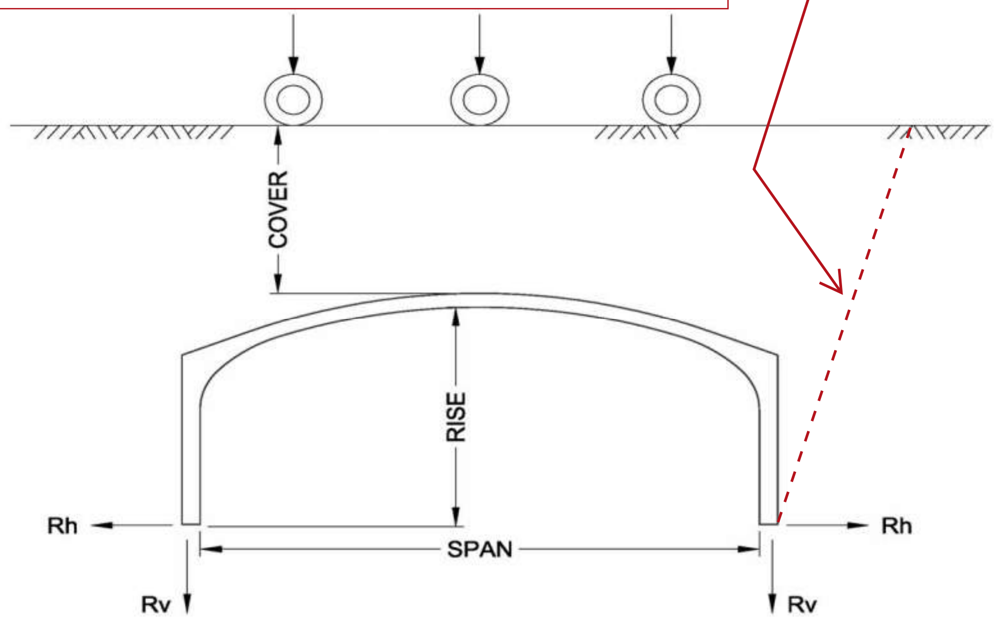
Cover at structure center:	2'-0"	Vertical load, per leg, R_v (DL Arch Only)	**2.4 k/f**
Shape ID:	B-Series	Horizontal load, per leg, R_h (DL Arch Only)	**1.3 k/f**
Bridge span:	24'-0"	Vertical load, per leg, R_v (DL Only)	**10.8 k/f**
Bridge rise:	6'-0"	Horizontal load, per leg, R_h (DL Only)	**4.5 k/f**
Design live load:	HL-93	Vertical load, per leg, R_v (DL + LL)	**15.1 k/f**
		Horizontal load, per leg, R_h (DL+LL)	**6.5 k/f**

Includes hz soil pressure

4.3 k/f
2.0k/f

LL only

DL includes "cone" of soil due to soil structure interaction in Contech's FEA program
Per call w/ Driss Majdoub 9/25/2020



Notes:

1) Axle load positions are varied to produce critical reactions shown here.
2) Reactions are unfactored loads.
3) Impact is not included.
4) Units are kips/ft.
5) Soil Weight = 120 pcf, Concrete Weight = 150 pcf, Asphalt Weight = 140 pcf.
6) Reactions are based on deep foundations.

Reactions provided by Contech (precast arch designer)

CON SPAN® BRIDGE SYSTEMS

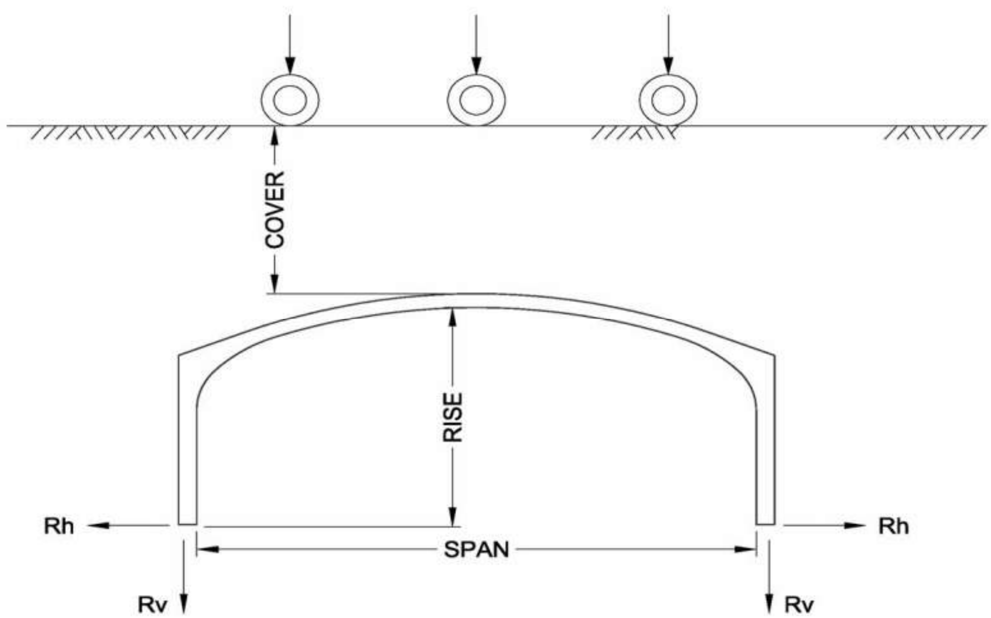
BRIDGE REACTIONS

JOB #:
NAME: 1st & F Street
DATE: 09-Oct-20
BY: DM

LOADS:

Cover at structure center:	2'-0"	Vertical load, per leg, R_v (DL Arch Only)	**2.4 k/f**	
Shape ID:	B-Series	Horizontal load, per leg, R_h (DL Arch Only)	**1.3 k/f**	
Bridge span:	24'-0"	Vertical load, per leg, R_v (DL Only)	**10.8 k/f**	
Bridge rise:	6'-0"	Horizontal load, per leg, R_h (DL Only)	**4.5 k/f**	
Design live load:	Trolley	Vertical load, per leg, R_v (DL + LL)	**16.9 k/f**	6.1 k/f
		Horizontal load, per leg, R_h (DL+LL)	**7.2 k/f**	2.7k/f

LL only

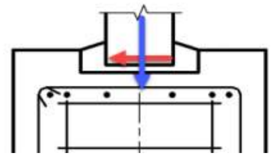


Notes:
1) Axle load positions are varied to produce critical reactions shown here.
2) Reactions are unfactored loads.
3) Impact is not included.
4) Units are kips/ft.
5) Soil Weight = 120 pcf, Concrete Weight = 150 pcf, Asphalt Weight = 140 pcf.
6) Reactions are based on deep foundations.

Grade Beam

Keyway

Precase arch legs are set in a grouted key way



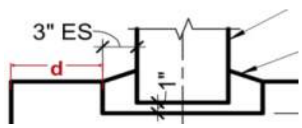
Friction resist the majority of leg sliding

Max horizontal load (H) =	14.91	klf
Corresponding vertical load (V) =	24.82	klf
H/V =	0.60	
Friction Factor =	0.6	(Per ACI318 22.9.4.2)

Concervatively check keyway for full horizontal load

Vc per ACI318 22.5.5.1

H =	14.91	klf
f'c =	5000	psi
λ =	1	
d =	14	
ϕ =	0.75	
ϕV_c =	17.82	klf
DCR =	**0.84**	



Check keyway for horizontal load reversal

H =	1.66	klf
f'c =	5000	psi
λ =	1	
d =	6	
ϕ =	0.75	
ϕV_c =	7.64	klf
DCR =	**0.22**	

Grade Beam

Requierments per CBC 1810.3.12 and ACI 318

1810.3.12 Grade beams. For structures assigned to Seismic Design Category D, E or F, grade beams shall comply with the provisions in Section 21.12.3 of ACI 318 for grade beams, except where they are designed to resist the seismic load effects including overstrength factor in accordance with Section 12.4.3 or 12.14.3.2 of ASCE 7.

21.12.3 — Grade beams and slabs-on-ground

21.12.3.1 — Grade beams designed to act as horizontal ties between pile caps or footings shall have continuous longitudinal reinforcement that shall be developed within or beyond the supported column or anchored within the pile cap or footing at all discontinuities.

Continuous longitudinal reinforcing

21.12.3.2 — Grade beams designed to act as horizontal ties between pile caps or footings shall be proportioned such that the smallest cross-sectional dimension shall be equal to or greater than the clear spacing between connected columns divided by 20, but need not be greater than 18 in. Closed ties shall be provided at a spacing not to exceed the lesser of one-half the smallest orthogonal cross-sectional dimension and 12 in.

Spacing =	6	ft
Min dim =	3.6	in

1810.3.13 Seismic ties. For structures assigned to Seismic Design Category C, D, E or F, individual deep foundations shall be interconnected by ties. Unless it can be demonstrated that equivalent restraint is provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade or confinement by competent rock, hard cohesive soils or very dense granular soils, ties shall be capable of carrying, in tension or compression, a force equal to the lesser of the product of the larger pile cap or column design gravity load times the seismic coefficient, S_{DS}, divided by 10, and 25 percent of the smaller pile or column design gravity load.

Spacing =	6	ft
Gravity load =	24.88	klf
Gravity load =	149.2843	k
SDS =	1.114	
factor =	0.25	
Axial Load =	**37.3**	k

Typical section between piers

Fixed-Fixed

Span =	6	ft	
Vertical load =	24.88	klf	(self weight added seperately)
Hz load =	14.91	klf	
Axial =	37.3	k	
			See Enercalc for analysis
fy =	60	ksi	
ϕ =	0.9		
Axial/ϕfy =	0.691	in^2	
n =	2		Provide (2) addl #6 or better
Ab =	0.44		for tension
As =	0.88		
DCR =	**0.79**		
Ac =	1080	in^2	
P/A =	35	psi	Ok for compression by inspection

Design for Torsion

bw =	36	in	
d =	30	in	
Torque =	224	k-in/ft	Hz load*d/2
Clear Span =	3.33	ft	face of support to face of support
T_U =	373	k-in	*clear span/2
A_{cp} =	1080	in^2	
p_{cp} =	132	in	
λ =	1		
f'c =	5000	psi	
T_{th} =	625	k-in	
ϕ =	0.75		
ϕT_{th} =	469	k-in	$T_{cr}/4$
DCR =	**0.80**		Design for torsion is NOT required

ZFA STRUCTURAL ENGINEERS
Job #
Concrete Beam Design

Engineer:
Date:

Project Name

DSA? NO

Beam: Grade Beam Vertical

Properties			Flexural Reinf.				Shear Reinf.		
f'_c =	5000	psi	4.0	#6	bars			4	Legs
f_y =	60	ksi	A_s =	1.76	in^2	NG	#5	@ 12	"oc
f_{yt} =	60	ksi	$A_{s,min\ T\&S}$ =	1.94	in^2				
			$A_{s,min\ Flexure}$ =	3.31	in^2		ϕ_v =	0.75	
Dimensions			$A_{s,min}$ =	3.31	in^2		V_{ult} =	156.0	k
Width =	36.0	in	a =	0.69	in		V_c =	132.4	k
Depth =	30.0	in	β_1 =	0.80			$V_{s,max}$ =	529.5	k
Cover =	3.0	in	c =	0.86	in		V_s =	161.2	k
d =	26.0	in	ε_s =	0.087			$V_{s,gov}$ =	161.2	k
A =	7.5	ft^2	Clear Spacing =	8.6	in oc		$\phi_v V_n$ =	220.2	k
q =	150	pcf					DCR =	0.71	OK
ω_{sw} =	1.125	klf	ϕ_b =	0.90					
ω =	24.88	klf	M_{ult} =	159.3	k-ft				
$\Sigma\omega$ =	26.01	klf	$\phi_b M_n$ =	203.2	k-ft				
			DCR =	0.78	OK				

Continuous Span

L =	6	ft	
M =	78.02	k-ft	$wL^2/12$
V =	78.02	k	$wL/2$

Cantilever Span

L =	3.5	ft	
M =	159.29	k-ft	$wL^2/2$
V =	156.03	k	wL

Mmax =	159.29	k-ft
Vmax =	156.03	k

DSA? NO

ZFA STRUCTURAL ENGINEERS

Job #
Concrete Beam Design

Engineer:
Date:

Project Name

Beam: Grade Beam Horizontal

Properties

f'_c =	5000	psi
f_y =	60	ksi
f_{yt} =	60	ksi

Dimensions

Width =	30.0	in
Depth =	36.0	in
Cover =	3.0	in
d =	32.0	in
A =	7.5	ft^2
q =		pcf
ω_{sw} =	0.000	klf
ω =	14.91	klf
$\Sigma\omega$ =	14.91	klf

Flexural Reinf.

2.0	#6	bars	
A_s =	0.88	in^2	NG
$A_{s,min\ T\&S}$ =	1.94	in^2	
$A_{s,min\ Flexure}$ =	1.94	in^2	
$A_{s,min}$ =	1.94	in^2	
a =	0.41	in	
β_1 =	0.80		
c =	0.52	in	
ε_s =	0.182		
Clear Spacing =	21.3	in oc	
ϕ_b =	0.90		
M_{ult} =	91.3	k-ft	
$\phi_b M_n$ =	125.9	k-ft	
DCR =	0.73		OK

Shear Reinf.

	2	Legs	
#5	@ 12	"oc	
ϕ_v =	0.75		
V_{ult} =	89.5	k	
V_c =	135.8	k	
$V_{s,max}$ =	543.1	k	
V_s =	99.2	k	
$V_{s,gov}$ =	99.2	k	
$\phi_v V_n$ =	176.2	k	
DCR =	0.51		OK

Continuous Span

L =	6	ft	
M =	44.74	k-ft	$wL^2/12$
V =	44.74	k	wL/2

Cantilever Span

L =	3.5	ft	
M =	91.34	k-ft	$wL^2/2$
V =	89.48	k	wL

Mmax =	91.34	k-ft
Vmax =	89.48	k

Piers

PIER DEMANDS:

See loading sheet for factored loads
Loads are distributed by the grade beam

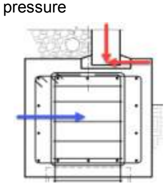
Vertical

Length =	32	ft	
Spacing =	6	ft	
Number of Piers =	6		L/s
ωd =	11.93	klf	included GB self weight
max ωd*L =	382	k	
$\omega_{trolley}$ =	8.20	klf	
trib =	8.50	ft	assume 1 lane filled with trolley
ω_{HL93} =	6.28	klf	
trib =	8.50	ft	assume 1 lane filled with traffic
PL =	123	k	
ΣP =	505	k	D&L
ΣP/n =	**84.1**	k	

Lateral

Thrust is partially resisted by soil pressure on the face of the structure and grade beam

Number of Piers =	6		
ωd =	4.50	klf	Thrust - earth pressure
$V_{dL,Thrust}$ =	144	k	at top of GB
$\omega_{trolley}$ =	5.50	klf	
trib =	8.50	ft	
ω_{HL93} =	3.85	klf	
trib =	8.50	ft	
$\Sigma V_{LL,Thrust}$ =	79	k	
$\Sigma V_{top\ of\ GB}$ =	223	k	at top of GB, D&L



Reaction at top of pier

ωd =	-1.59	klf	earth pressure on GB
$V_{soil\ on\ GB}$ =	-51	k	
ΣV =	173	k	D&L
ΣV/n =	**28.8**	k	

Moment due to thrust at top of GB

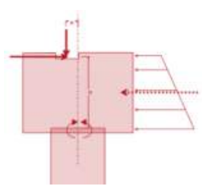
h_{GB} =	2.5	ft	
M =	559	k-ft	V at top of GB*h

Moment due to lateral pressure on GB

M =	-64	k-ft	V soil at GB*h/2

Moment due to vertical load eccentricity

e =	4	in	
M =	-168	k-ft	ΣPvert * e
ΣM =	327		
ΣM/n =	**54**	k-ft	
	653,966	in-lb	



PIER DEMANDS:

See loading sheet for factored loads
Loads are distributed by the grade beam

Vertical

Length =	32	ft	
Spacing =	5	ft	
Number of Piers =	6		L/s
ωd =	7.02	klf	included GB self weight
max ωd*L =	225	k	
$\omega_{trolley}$ =	0.00	klf	
trib =	8.50	ft	assume 1 lane filled with trolley
ω_{HL93} =	0.00	klf	
trib =	8.50	ft	assume 1 lane filled with traffic
PL =	0	k	
ΣP =	225	k	D&L
ΣP/n =	**37.5**	k	

Lateral
Thrust is partially resisted by soil pressure on the face of the structure and grade beam

Number of Piers =	6		
ωd =	0.65	klf	Thrust - earth pressure
$V_{dL,Thrust}$ =	21	k	at top of GB
$\omega_{trolley}$ =	0.00	klf	
trib =	8.50	ft	
ω_{HL93} =	0.00	klf	
trib =	8.50	ft	
$\Sigma V_{LL,Thrust}$ =	0	k	
$\Sigma V_{top\ of\ GB}$ =	21	k	at top of GB, D&L

Reaction at top of pier

ωd =	-1.90	klf	earth pressure on GB
$V_{soil\ on\ GB}$ =	-61	k	
ΣV =	-40	k	D&L
ΣV/n =	**-6.7**	k	

Moment due to thrust at top of GB

h_{GB} =	2.5	ft	
M =	52	k-ft	V at top of GB*h

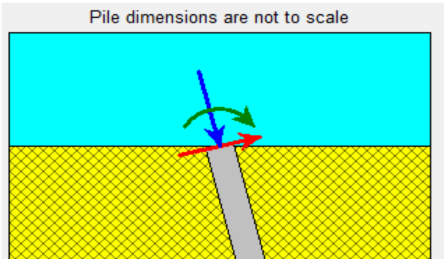
Moment due to lateral pressure on GB

M =	-76	k-ft	V soil at GB*h/2

Moment due to vertical load eccentricity

e =	4	in	
M =	-75	k-ft	ΣPvert * e
ΣM =	-99		
ΣM/n =	**-17**	k-ft	
	-198,126	in-lb	

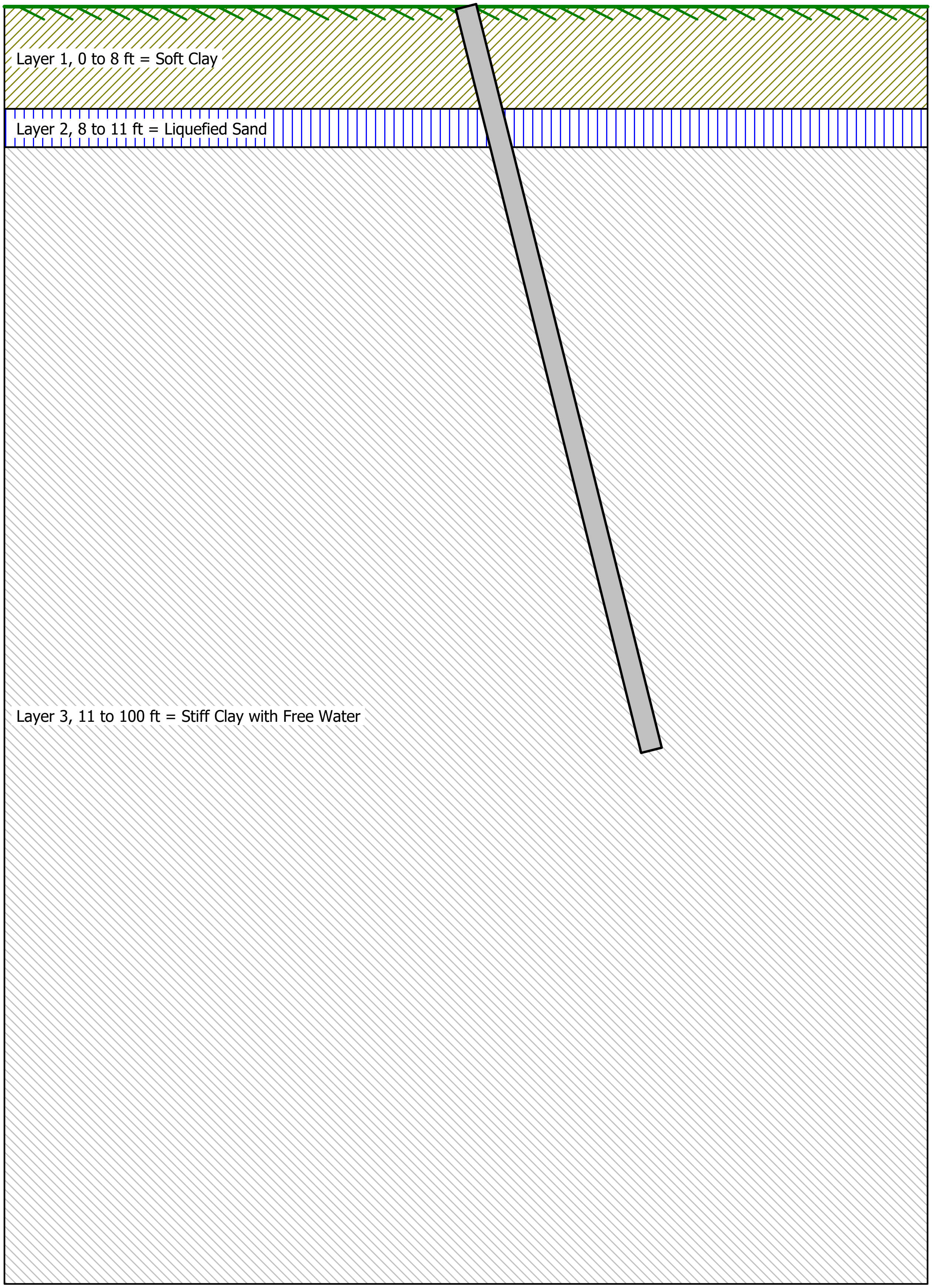
Battered Pier



Batter =	4	:1	V:H
α =	14.0		Batter angle

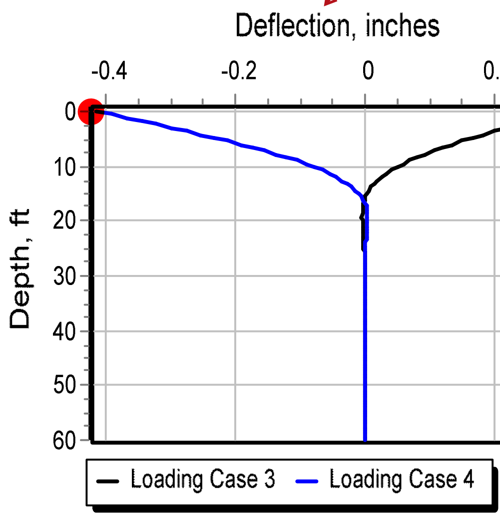
	Vert (k)	Horiz (k)	M (k-ft)	Axial	Shear	Moment
Max	84.1	28.8	54.5	**88.6**	**7.5**	**54.5**
Min	37.5	-6.7	-16.5	**34.7**	**-15.6**	**-16.5**

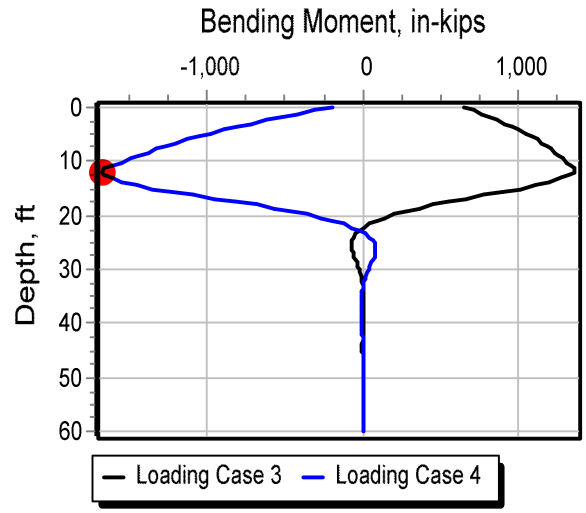
BRIDGE PILES

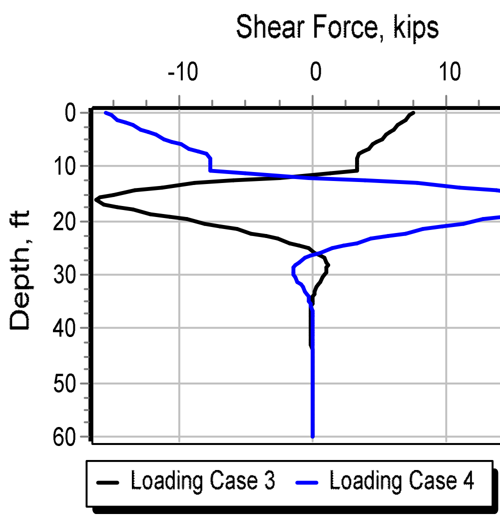


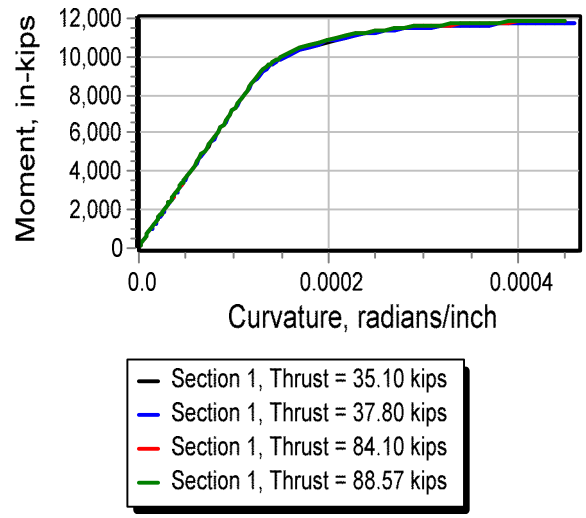
BRIDGE PILES

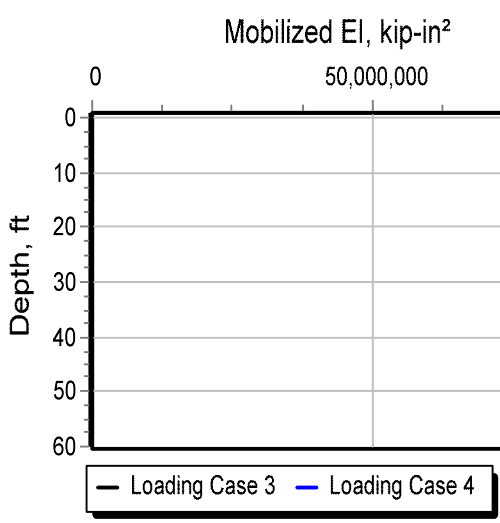
see analysis output for exact deflection
0.5" and less is acceptable per Contech specifications

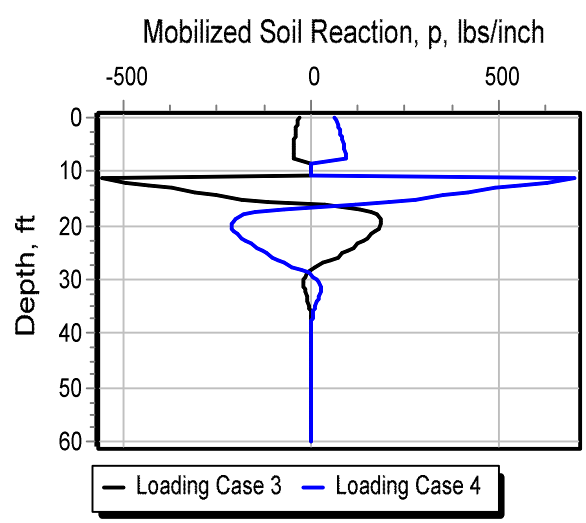












BRIDGE PILES

```
===============================================================================

                    LPile for Windows, Version 2019-11.005

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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-------------------------------------------------------------------------------
                             Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\\Zfa.com\sr\Projects\2010-2015\2013\13415 Evaluation of First and F Street bridge
in Petaluma\Calculations\

Name of input data file:
2020-10-22-LPile_AT BRIDGE_20in-shed80-batter.lp11d

Name of output report file:
2020-10-22-LPile_AT BRIDGE_20in-shed80-batter.lp11o

Name of plot output file:
2020-10-22-LPile_AT BRIDGE_20in-shed80-batter.lp11p

Name of runtime message file:
2020-10-22-LPile_AT BRIDGE_20in-shed80-batter.lp11r



-------------------------------------------------------------------------------
                            Date and Time of Analysis
-------------------------------------------------------------------------------
```

BRIDGE PILES

Date: January 25, 2021 Time: 11:11:11

Problem Title

Project Name: 1st and F Bridge

Job Number: 13415

Client:

Engineer: MJR

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 50.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
- Static loading specified

BRIDGE PILES

```
 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                            =            1
Total length of pile                                       =       60.000 ft
Depth of ground surface below top of pile                  =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----      -------------     -------------
  1            0.000           19.8500  <------------  20" - corrosion
  2           60.000           19.8500


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a drilled shaft with permanent casing
   Length of section                                       =    60.000000 ft
```

BRIDGE PILES

```
   Casing outside diameter                                =    19.850000 in
   Shear capacity of section                              =       0.0000 lbs



--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =      -14.000 degrees
                                                          =       -0.244 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers
```

soil properties as provided by Geo

```
Layer 1 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     8.000000 ft
   Effective unit weight at top of layer                  =    43.000000 pcf
   Effective unit weight at bottom of layer               =    43.000000 pcf
   Undrained cohesion at top of layer                     =   300.000000 psf
   Undrained cohesion at bottom of layer                  =   300.000000 psf
   Epsilon-50 at top of layer                             =       0.0000
   Epsilon-50 at bottom of layer                          =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 2 is liquefiable sand, by Rollins et al., 2004

   Distance from top of pile to top of layer              =     8.000000 ft
   Distance from top of pile to bottom of layer           =    11.000000 ft
   Effective unit weight at top of layer                  =    60.000000 pcf
   Effective unit weight at bottom of layer               =    60.000000 pcf


Layer 3 is stiff clay with water-induced erosion

   Distance from top of pile to top of layer              =    11.000000 ft
   Distance from top of pile to bottom of layer           =   100.000000 ft
   Effective unit weight at top of layer                  =    60.000000 pcf
```

BRIDGE PILES

Effective unit weight at bottom of layer	=	60.000000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.0000
Epsilon-50 at bottom of layer	=	0.0000
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 40.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	E50 or krm	kpy pci
1	Soft	0.00	43.0000	300.0000	default	--
	Clay	8.0000	43.0000	300.0000	default	--
2	Liquefied	8.0000	60.0000	--	--	--
	Sand	11.0000	60.0000	--	--	--
3	Stiff Clay	11.0000	60.0000	1500.	default	default
	with Free Water	100.0000	60.0000	1500.	default	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

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Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 4

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 28800. lbs	M = 654000. in-lbs	84100.	No	No
2	1	V = -6500. lbs	M = -192441. in-lbs	37800.	No	No
3	1	V = 7599. lbs	M = 654000. in-lbs	88569.	No	Yes
4	1	V = -15452. lbs	M = -192441. in-lbs	35105.	No	Yes

BRIDGE BATTERED PIER (MAX) (load 3)

BRIDGE BATTERED PIER (MIN) (load 4)

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:

Length of Section	=	60.000000 ft
Outer Diameter of Casing	=	19.850000 in
Concrete Cover Thickness Inside Casing	=	1.500000 in
Casing Wall Thickness	=	0.800000 in

BRIDGE PILES

```
Moment of Inertia of Steel Casing                         =       2176. in^4
Yield Stress of Casing                                    =      35000. psi
Elastic Modulus of Casing                                 =   29000000. psi
Number of Reinforcing Bars                                =           6 bars
Area of Single Reinforcing Bar                            =    0.440000 sq. in.
Edge-to-Edge Bar Spacing                                  =    6.500000 in
Maximum Concrete Aggregate Size                           =    0.750000 in
Ratio of Bar Spacing to Aggregate Size                    =        8.67
Offset of Center of Rebar Cage from Center of Pile        =      0.0000 in
Yield Stress of Reinforcing Bars                          =      60000. psi
Modulus of Elasticity of Reinforcing Bars                 =   29000000. psi
Gross Area of Pile                                        =  309.464548 sq. in.
Area of Concrete                                          =  258.946676 sq. in.
Cross-sectional Area of Steel Casing                      =   47.877872 sq. in.
Area of All Steel (Casing and Bars)                       =   50.517872 sq. in.
Area Ratio of All Steel to Gross Area of Pile             =       16.32 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As       =    2494.440 kips
Tensile Load for Cracking of Concrete                     =    -263.625 kips
Nominal Axial Tensile Capacity                            =   -1834.126 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X             Y
    Number         inches        sq. in.        inches        inches
  ----------    ----------    ----------    ----------    ----------
       1          0.750000      0.440000      7.250000       0.00000
       2          0.750000      0.440000      3.625000      6.278684
       3          0.750000      0.440000     -3.625000      6.278684
       4          0.750000      0.440000     -7.250000       0.00000
       5          0.750000      0.440000     -3.625000     -6.278684
       6          0.750000      0.440000      3.625000     -6.278684


NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero =  6.500 inches
between bars 5 and 6.

Ratio of bar spacing to maximum aggregate size = 8.67


Concrete Properties:
--------------------

Compressive Strength of Concrete                          =       3000. psi
```

BRIDGE PILES

Modulus of Elasticity of Concrete	=	3122019. psi
Modulus of Rupture of Concrete	=	-410.791918 psi
Compression Strain at Peak Stress	=	0.001634
Tensile Strain at Fracture of Concrete	=	-0.0001160
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 4

Number	Axial Thrust Force kips
1	35.105
2	37.800
3	84.100
4	88.569

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 35.105 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	105.8590633	84687251.	21.5720284	0.00002697	0.00000215	0.0977760	0.6632582	0.7783882	
0.00000250	211.7077750	84683110.	15.7530194	0.00003938	-0.00001024	0.1420175	0.9046383	1.1348983	
0.00000375	317.4802126	84661390.	13.8142910	0.00005180	-0.00002263				

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0.1859319	1.1461207	1.4915107			
0.00000500	423.1437392	84628748.	12.8451510	0.00006423	-0.00003502
0.2295101	1.3876357	1.8481557			
0.00000625	528.6926788	84590829.	12.2637451	0.00007665	-0.00004741
0.2727501	1.6291647	2.2048147			
0.00000750	634.1255603	84550075.	11.8761767	0.00008907	-0.00005980
0.3156508	1.8707016	2.5614816			
0.00000875	739.4418708	84507642.	11.5993617	0.0001015	-0.00007219
0.3582121	2.1122434	2.9181534			
0.00001000	844.6413922	84464139.	11.3917627	0.0001139	-0.00008458
0.4004337	2.3537887	3.2748287			
0.00001125	949.7240197	84419913.	11.2303052	0.0001263	-0.00009697
0.4423154	2.5953368	3.6315068			
0.00001250	949.7240197	75977922.	10.4431703	0.0001305	-0.0001176
0.4561155	2.5983711	3.7496711 C			
0.00001375	1037.	75413859.	10.3146113	0.0001418	-0.0001311
0.4937287	2.8069453	4.0733753 C			
0.00001500	1128.	75201066.	10.2074832	0.0001531	-0.0001446
0.5310620	3.0155215	4.3970815 C			
0.00001625	1219.	75017551.	10.1165373	0.0001644	-0.0001582
0.5680991	3.2239567	4.7206467 C			
0.00001750	1310.	74858139.	10.0387806	0.0001757	-0.0001717
0.6048676	3.4324918	5.0443118 C			
0.00001875	1401.	74717361.	9.9712386	0.0001870	-0.0001852
0.6413467	3.6409439	5.3678939 C			
0.00002000	1492.	74592175.	9.9122313	0.0001982	-0.0001988
0.6775518	-3.8642609	-5.7063409 C			
0.00002125	1583.	74479974.	9.8603293	0.0002095	-0.0002123
0.7134880	-4.1377617	-6.0949717 C			
0.00002250	1674.	74378480.	9.8142752	0.0002208	-0.0002258
0.7491498	-4.4112098	-6.4835498 C			
0.00002375	1764.	74285807.	9.7730167	0.0002321	-0.0002393
0.7845273	-4.6846937	-6.8721637 C			
0.00002500	1855.	74200916.	9.7360240	0.0002434	-0.0002528
0.8196357	-4.9580763	-7.2606763 C			
0.00002625	1946.	74122695.	9.7026879	0.0002547	-0.0002664
0.8544745	-5.2313572	-7.6490872 C			
0.00002750	2036.	74050232.	9.6725100	0.0002660	-0.0002799
0.8890435	-5.5045363	-8.0373963 C			
0.00002875	2127.	73982773.	9.6450786	0.0002773	-0.0002934
0.9233425	-5.7776135	-8.4256035 C			
0.00003000	2218.	73919638.	9.6200019	0.0002886	-0.0003069
0.9573668	-6.0506307	-8.8137507 C			
0.00003125	2308.	73860237.	9.5969342	0.0002999	-0.0003204
0.9911104	-6.3236455	-9.2018955 C			
0.00003250	2399.	73804256.	9.5757502	0.0003112	-0.0003339
1.0245835	-6.5965572	-9.5899372 C			
0.00003375	2489.	73751312.	9.5562408	0.0003225	-0.0003474
1.0577859	-6.8693658	-9.9778758 C			
0.00003500	2580.	73701080.	9.5382267	0.0003338	-0.0003609

BRIDGE PILES

1.0907174	-7.1420711	-10.3657111 C			
0.00003625	2670.	73653276.	9.5215534	0.0003452	-0.0003744
1.1233776	-7.4146728	-10.7534428 C			
0.00003750	2760.	73607657.	9.5060870	0.0003565	-0.0003879
1.1557664	-7.6871709	-11.1410709 C			
0.00003875	2851.	73564009.	9.4917109	0.0003678	-0.0004014
1.1878834	-7.9595651	-11.5285951 C			
0.00004000	2941.	73522146.	9.4783230	0.0003791	-0.0004149
1.2197285	-8.2318552	-11.9160152 C			
0.00004125	3031.	73481905.	9.4658337	0.0003905	-0.0004283
1.2513014	-8.5040411	-12.3033311 C			
0.00004250	3121.	73443141.	9.4541637	0.0004018	-0.0004418
1.2826018	-8.7761225	-12.6905425 C			
0.00004375	3212.	73405726.	9.4432430	0.0004131	-0.0004553
1.3136294	-9.0480994	-13.0776494 C			
0.00004500	3302.	73369546.	9.4330094	0.0004245	-0.0004688
1.3443841	-9.3199714	-13.4646514 C			
0.00004625	3392.	73334476.	9.4233690	0.0004358	-0.0004822
1.3748608	-9.5917897	-13.8515997 C			
0.00004750	3482.	73300432.	9.4142839	0.0004472	-0.0004957
1.4050604	-9.8635420	-14.2384820 C			
0.00004875	3572.	73267353.	9.4057397	0.0004585	-0.0005092
1.4349866	-10.1351882	-14.6252582 C			
0.00005125	3752.	73203802.	9.3901161	0.0004812	-0.0005361
1.4940171	-10.6781621	-15.3984921 C			
0.00005375	3931.	73143317.	9.3762193	0.0005040	-0.0005630
1.5519504	-11.2207096	-16.1712996 C			
0.00005625	4111.	73085479.	9.3638201	0.0005267	-0.0005898
1.6087843	-11.7628294	-16.9436794 C			
0.00005875	4291.	73029943.	9.3527281	0.0005495	-0.0006167
1.6645167	-12.3045197	-17.7156297 C			
0.00006125	4470.	72976419.	9.3427842	0.0005722	-0.0006436
1.7191455	-12.8457792	-18.4871492 C			
0.00006375	4649.	72924662.	9.3338542	0.0005950	-0.0006704
1.7726686	-13.3866061	-19.2582361 C			
0.00006625	4828.	72874466.	9.3258241	0.0006178	-0.0006972
1.8250839	-13.9269989	-20.0288889 C			
0.00006875	5007.	72825651.	9.3185965	0.0006407	-0.0007240
1.8763891	-14.4669560	-20.7991060 C			
0.00007125	5185.	72778067.	9.3120878	0.0006635	-0.0007508
1.9265821	-15.0064757	-21.5688857 C			
0.00007375	5364.	72731581.	9.3062256	0.0006863	-0.0007776
1.9756607	-15.5455565	-22.3382265 C			
0.00007625	5542.	72686078.	9.3009471	0.0007092	-0.0008044
2.0236228	-16.0841967	-23.1071267 C			
0.00007875	5721.	72641459.	9.2961974	0.0007321	-0.0008311
2.0704662	-16.6223946	-23.8755846 C			
0.00008125	5899.	72597635.	9.2919283	0.0007550	-0.0008578
2.1161885	-17.1601486	-24.6435986 C			
0.00008375	6076.	72554529.	9.2880976	0.0007779	-0.0008846

BRIDGE PILES

2.1607877	-17.6974571	-25.4111671 C			
0.00008625	6254.	72512073.	9.2846677	0.0008008	-0.0009113
2.2042614	-18.2343183	-26.1782883 C			
0.00008875	6432.	72470205.	9.2816055	0.0008237	-0.0009379
2.2466075	-18.7707306	-26.9449606 C			
0.00009125	6609.	72428873.	9.2788814	0.0008467	-0.0009646
2.2878236	-19.3066923	-27.7111823 C			
0.00009375	6786.	72388026.	9.2764690	0.0008697	-0.0009913
2.3279075	-19.8422016	-28.4769516 C			
0.00009625	6963.	72347623.	9.2743446	0.0008927	-0.0010179
2.3668568	-20.3772567	-29.2422667 C			
0.00009875	7140.	72307623.	9.2724869	0.0009157	-0.0010445
2.4046693	-20.9118561	-30.0071261 C			
0.0001013	7317.	72267992.	9.2708767	0.0009387	-0.0010711
2.4413427	-21.4459979	-30.7715279 C			
0.0001038	7494.	72228697.	9.2694969	0.0009617	-0.0010977
2.4768746	-21.9796803	-31.5354703 C			
0.0001063	7670.	72189710.	9.2683316	0.0009848	-0.0011243
2.5112628	-22.5129017	-32.2989517 C			
0.0001088	7846.	72151005.	9.2673667	0.0010078	-0.0011509
2.5445047	-23.0456601	-33.0619701 C			
0.0001113	8023.	72112558.	9.2665892	0.0010309	-0.0011774
2.5765981	-23.5779538	-33.8245238 C			
0.0001138	8198.	72074346.	9.2659873	0.0010540	-0.0012039
2.6075405	-24.1097810	-34.5866110 C			
0.0001163	8372.	72019731.	9.2646675	0.0010770	-0.0012305
2.6371986	-24.6441159	-35.0000000 CY			
0.0001188	8539.	71909886.	9.2605123	0.0010997	-0.0012575
2.6652705	-25.1884080	-35.0000000 CY			
0.0001213	8696.	71722527.	9.2522088	0.0011218	-0.0012850
2.6915958	-25.7478852	-35.0000000 CY			
0.0001238	8841.	71445248.	9.2389354	0.0011433	-0.0013131
2.7161017	-26.3264045	-35.0000000 CY			
0.0001263	8976.	71095046.	9.2214633	0.0011642	-0.0013419
2.7389474	-26.9222207	-35.0000000 CY			
0.0001288	9102.	70696196.	9.2010704	0.0011846	-0.0013710
2.7603541	-27.5314767	-35.0000000 CY			
0.0001313	9222.	70262533.	9.1785640	0.0012047	-0.0014006
2.7804684	-28.1517326	-35.0000000 CY			
0.0001338	9336.	69798939.	9.1547201	0.0012244	-0.0014305
2.7994245	-28.7804406	35.0000000 CY			
0.0001363	9443.	69302888.	9.1306637	0.0012441	-0.0014605
2.8173906	-29.4134459	35.0000000 CY			
0.0001388	9542.	68770315.	9.1075916	0.0012637	-0.0014905
2.8345279	-30.0459786	35.0000000 CY			
0.0001413	9635.	68213207.	9.0851544	0.0012833	-0.0015205
2.8507999	-30.6792572	35.0000000 CY			
0.0001438	9722.	67630430.	9.0640676	0.0013030	-0.0015505
2.8662935	-31.3101567	35.0000000 CY			
0.0001463	9801.	67018470.	9.0453162	0.0013229	-0.0015802

BRIDGE PILES

2.8811106	-31.9342108	35.0000000 CY			
0.0001488	9877.	66397716.	9.0272597	0.0013428	-0.0016099
2.8950644	-32.5579868	35.0000000 CY			
0.0001588	10132.	63821264.	8.9657570	0.0014233	-0.0017279
2.9425790	-35.0299028	35.0000000 CY			
0.0001688	10338.	61264494.	8.9132133	0.0015041	-0.0018456
2.9759697	-37.4936456	35.0000000 CY			
0.0001788	10512.	58808779.	8.8675395	0.0015851	-0.0019631
2.9950692	-39.9522532	35.0000000 CY			
0.0001888	10660.	56477585.	8.8272257	0.0016661	-0.0020805
2.9993728	-42.4080115	35.0000000 CY			
0.0001988	10789.	54282667.	8.7907011	0.0017472	-0.0021980
2.9993258	-44.8653110	35.0000000 CY			
0.0002088	10902.	52223710.	8.7584090	0.0018283	-0.0023154
2.9987651	-47.3181745	35.0000000 CY			
0.0002188	11002.	50295441.	8.7293768	0.0019096	-0.0024326
2.9999561	-49.7690857	35.0000000 CY			
0.0002288	11092.	48490690.	8.7036963	0.0019910	-0.0025497
2.9990839	-52.2146017	35.0000000 CY			
0.0002388	11173.	46798736.	8.6805747	0.0020725	-0.0026667
2.9998566	-54.6572952	35.0000000 CY			
0.0002488	11247.	45213738.	8.6601741	0.0021542	-0.0027835
2.9995425	-57.0937708	35.0000000 CY			
0.0002588	11314.	43727368.	8.6420900	0.0022361	-0.0029000
2.9982512	-59.5246968	35.0000000 CY			
0.0002688	11375.	42324593.	8.6244432	0.0023178	-0.0030169
2.9985493	-60.0000000	35.0000000 CY			
0.0002788	11423.	40980464.	8.6033682	0.0023982	-0.0031350
2.9984037	-60.0000000	35.0000000 CY			
0.0002888	11461.	39692583.	8.5803929	0.0024776	-0.0032541
2.9977856	-60.0000000	35.0000000 CY			
0.0002988	11495.	38477260.	8.5579579	0.0025567	-0.0033735
2.9991790	-60.0000000	35.0000000 CY			
0.0003088	11526.	37330085.	8.5365416	0.0026357	-0.0034930
2.9999062	-60.0000000	35.0000000 CY			
0.0003188	11554.	36246713.	8.5166883	0.0027147	-0.0036125
2.9992329	-60.0000000	35.0000000 CY			
0.0003288	11580.	35223689.	8.4980532	0.0027937	-0.0037320
2.9975086	-60.0000000	35.0000000 CY			
0.0003388	11604.	34254595.	8.4805994	0.0028728	-0.0038514
2.9999748	-60.0000000	35.0000000 CY			
0.0003488	11626.	33335692.	8.4639030	0.0029518	-0.0039709
2.9988705	-60.0000000	35.0000000 CY			
0.0003588	11647.	32465348.	8.4484665	0.0030309	-0.0040903
2.9981934	-60.0000000	35.0000000 CY			
0.0003688	11666.	31635932.	8.4335143	0.0031099	-0.0042098
2.9993396	-60.0000000	35.0000000 CY			
0.0003788	11684.	30849342.	8.4192966	0.0031888	-0.0043294
2.9970875	-60.0000000	35.0000000 CY			
0.0003888	11701.	30098395.	8.4053635	0.0032676	-0.0044491

BRIDGE PILES

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   2.9992939   -60.0000000    35.0000000 CY
    0.0003988        11717.     29383910.     8.3930750     0.0033467    -0.0045684
   2.9976290   -60.0000000    35.0000000 CY
    0.0004088        11731.     28700847.     8.3803228     0.0034255    -0.0046882
   2.9987247    60.0000000    35.0000000 CY
    0.0004188        11745.     28048517.     8.3693117     0.0035046    -0.0048075
   2.9998237    60.0000000    35.0000000 CY
    0.0004288        11757.     27422114.     8.3600802     0.0035844    -0.0049263
   2.9972803    60.0000000    35.0000000 CY
    0.0004388        11768.     26821494.     8.3515334     0.0036642    -0.0050450
   2.9997128    60.0000000    35.0000000 CY
    0.0004488        11777.     26245013.     8.3449506     0.0037448    -0.0051629
   2.9962754    60.0000000    35.0000000 CY
    0.0004588        11785.     25689494.     8.3399433     0.0038259    -0.0052802
   2.9983227    60.0000000    35.0000000 CY


Axial Thrust Force =     37.800 kips

    Bending        Bending        Bending      Depth to       Max Comp       Max Tens
  Max Conc       Max Steel     Max Casing  Run
   Curvature       Moment        Stiffness      N Axis        Strain         Strain
   Stress         Stress         Stress     Msg
    rad/in.        in-kip        kip-in2         in           in/in          in/in
     ksi            ksi            ksi
------------- ------------- ------------- ------------- ------------- -------------
------------- ------------- ------------- ---
   0.00000125   105.8422015     84673761.    22.4677354    0.00002808    0.00000327
   0.1018194     0.6957276     0.8108576
   0.00000250   211.6775593     84671024.    16.2009500    0.00004050   -0.00000912
   0.1460307     0.9371133     1.1673733
   0.00000375   317.4457087     84652189.    14.1131189    0.00005292   -0.00002151
   0.1899168     1.1786183     1.5240083
   0.00000500   423.1075870     84621517.    13.0694787    0.00006535   -0.00003390
   0.2334677     1.4201632     1.8806832
   0.00000625   528.6557009     84584912.    12.4433904    0.00007777   -0.00004629
   0.2766807     1.6617255     2.2373755
   0.00000750   634.0880891     84545079.    12.0260417    0.00009020   -0.00005868
   0.3195546     1.9032972     2.5940772
   0.00000875   739.4040648     84503322.    11.7279590     0.0001026   -0.00007107
   0.3620890     2.1448749     2.9507849
   0.00001000   844.6033358     84460334.    11.5044115     0.0001150   -0.00008346
   0.4042838     2.3864569     3.3074969
   0.00001125   949.6857648     84416512.    11.3305512     0.0001275   -0.00009584
   0.4461387     2.6280420     3.6642120
   0.00001250   949.6857648     75974861.    10.5530375     0.0001319    -0.0001162
   0.4607583     2.6381980     3.7894980 C
   0.00001375         1039.     75589456.    10.4152258     0.0001432    -0.0001297
   0.4983710     2.8470654     4.1134954 C
   0.00001500         1130.     75361768.    10.2998632     0.0001545    -0.0001433
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BRIDGE PILES

0.5356771	3.0557068	4.4372668 C			
0.00001625	1221.	75166519.	10.2023268	0.0001658	-0.0001568
0.5727071	3.2643850	4.7610750 C			
0.00001750	1312.	74996042.	10.1184864	0.0001771	-0.0001703
0.6094431	3.4729425	5.0847625 C			
0.00001875	1403.	74846318.	10.0460088	0.0001884	-0.0001838
0.6459103	3.6816002	5.4085502 C			
0.00002000	1494.	74712949.	9.9824984	0.0001996	-0.0001974
0.6820912	3.8902041	5.7322841 C			
0.00002125	1585.	74593291.	9.9265004	0.0002109	-0.0002109
0.7179946	4.0988331	6.0560431 C			
0.00002250	1676.	74485280.	9.8768789	0.0002222	-0.0002244
0.7536289	-4.3703608	-6.4427008 C			
0.00002375	1767.	74387074.	9.8326274	0.0002335	-0.0002379
0.7889937	-4.6436369	-6.8311069 C			
0.00002500	1857.	74296882.	9.7927288	0.0002448	-0.0002514
0.8240724	-4.9169653	-7.2195653 C			
0.00002625	1948.	74213802.	9.7567235	0.0002561	-0.0002649
0.8588781	-5.1902226	-7.6079526 C			
0.00002750	2039.	74136922.	9.7241191	0.0002674	-0.0002785
0.8934140	-5.4633780	-7.9962380 C			
0.00002875	2129.	74065430.	9.6944723	0.0002787	-0.0002920
0.9276798	-5.7364315	-8.3844215 C			
0.00003000	2220.	73998651.	9.6674135	0.0002900	-0.0003055
0.9616754	-6.0093827	-8.7725027 C			
0.00003125	2311.	73936018.	9.6426323	0.0003013	-0.0003190
0.9954003	-6.2822315	-9.1604815 C			
0.00003250	2401.	73876995.	9.6198164	0.0003126	-0.0003325
1.0288497	-6.5550249	-9.5484049 C			
0.00003375	2491.	73821130.	9.5986997	0.0003240	-0.0003460
1.0620186	-6.8278091	-9.9363191 C			
0.00003500	2582.	73768185.	9.5791933	0.0003353	-0.0003595
1.0949164	-7.1004900	-10.3241300 C			
0.00003625	2672.	73717854.	9.5611306	0.0003466	-0.0003730
1.1275430	-7.3730673	-10.7118373 C			
0.00003750	2763.	73669877.	9.5443675	0.0003579	-0.0003865
1.1598981	-7.6455409	-11.0994409 C			
0.00003875	2853.	73624022.	9.5287784	0.0003692	-0.0003999
1.1919814	-7.9179105	-11.4869405 C			
0.00004000	2943.	73580090.	9.5142533	0.0003806	-0.0004134
1.2237927	-8.1901761	-11.8743361 C			
0.00004125	3033.	73537905.	9.5006958	0.0003919	-0.0004269
1.2553317	-8.4623373	-12.2616273 C			
0.00004250	3124.	73497311.	9.4880205	0.0004032	-0.0004404
1.2865982	-8.7343940	-12.6488140 C			
0.00004375	3214.	73458170.	9.4761520	0.0004146	-0.0004539
1.3175919	-9.0063461	-13.0358961 C			
0.00004500	3304.	73420361.	9.4650232	0.0004259	-0.0004673
1.3483126	-9.2781933	-13.4228733 C			
0.00004625	3394.	73383773.	9.4545743	0.0004373	-0.0004808

BRIDGE PILES

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1.3787601    -9.5499355   -13.8097455 C
0.00004750         3484.    73348309.     9.4447518     0.0004486    -0.0004942
1.4089339    -9.8215725   -14.1965125 C
0.00004875         3574.    73313882.     9.4355075     0.0004600    -0.0005077
1.4388340   -10.0931040   -14.5831740 C
0.00005125         3754.    73247782.     9.4185121     0.0004827    -0.0005346
1.4978019   -10.6359585   -15.3562885 C
0.00005375         3934.    73184956.     9.4033274     0.0005054    -0.0005615
1.5556661   -11.1784549   -16.1290449 C
0.00005625         4113.    73124984.     9.3897548     0.0005282    -0.0005884
1.6124308   -11.7205233   -16.9013733 C
0.00005875         4293.    73067495.     9.3775895     0.0005509    -0.0006153
1.6680937   -12.2621621   -17.6732721 C
0.00006125         4472.    73012176.     9.3666600     0.0005737    -0.0006421
1.7226528   -12.8033698   -18.4447398 C
0.00006375         4651.    72958764.     9.3568218     0.0005965    -0.0006689
1.7761060   -13.3441447   -19.2157747 C
0.00006625         4830.    72907037.     9.3479522     0.0006193    -0.0006958
1.8284511   -13.8844853   -19.9863753 C
0.00006875         5009.    72856802.     9.3399462     0.0006421    -0.0007226
1.8796860   -14.4243900   -20.7565400 C
0.00007125         5188.    72807896.     9.3327139     0.0006650    -0.0007494
1.9298085   -14.9638570   -21.5262670 C
0.00007375         5366.    72760177.     9.3261773     0.0006878    -0.0007761
1.9788163   -15.5028849   -22.2955549 C
0.00007625         5544.    72713521.     9.3202686     0.0007107    -0.0008029
2.0267075   -16.0414720   -23.0644020 C
0.00007875         5723.    72667821.     9.3149288     0.0007336    -0.0008296
2.0734796   -16.5796166   -23.8328066 C
0.00008125         5901.    72622983.     9.3101061     0.0007564    -0.0008564
2.1191305   -17.1173171   -24.6007671 C
0.00008375         6078.    72578922.     9.3057549     0.0007794    -0.0008831
2.1636580   -17.6545718   -25.3682818 C
0.00008625         6256.    72535565.     9.3018349     0.0008023    -0.0009098
2.2070599   -18.1913790   -26.1353490 C
0.00008875         6434.    72492848.     9.2983102     0.0008252    -0.0009365
2.2493338   -18.7277370   -26.9019670 C
0.00009125         6611.    72450711.     9.2951490     0.0008482    -0.0009631
2.2904776   -19.2636442   -27.6681342 C
0.00009375         6788.    72409102.     9.2923229     0.0008712    -0.0009898
2.3304889   -19.7990987   -28.4338487 C
0.00009625         6965.    72367975.     9.2898064     0.0008941    -0.0010164
2.3693654   -20.3340989   -29.1991089 C
0.00009875         7142.    72327288.     9.2875765     0.0009171    -0.0010430
2.4071049   -20.8686431   -29.9639131 C
 0.0001013         7319.    72287003.     9.2856127     0.0009402    -0.0010696
2.4437051   -21.4027294   -30.7282594 C
 0.0001038         7496.    72247086.     9.2838963     0.0009632    -0.0010962
2.4791635   -21.9363562   -31.4921462 C
 0.0001063         7672.    72207505.     9.2824104     0.0009863    -0.0011228
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BRIDGE PILES

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  2.5134779   -22.4695215   -32.2555715 C
   0.0001088         7848.     72168232.     9.2811396     0.0010093    -0.0011494
  2.5466458   -23.0022238   -33.0185338 C
   0.0001113         8024.     72129241.     9.2800701     0.0010324    -0.0011759
  2.5786650   -23.5344610   -33.7810310 C
   0.0001138         8200.     72090510.     9.2791891     0.0010555    -0.0012024
  2.6095330   -24.0662315   -34.5430615 C
   0.0001163         8374.     72037480.     9.2777126     0.0010785    -0.0012290
  2.6391331   -24.6001374   -35.0000000 CY
   0.0001188         8542.     71930850.     9.2735011     0.0011012    -0.0012560
  2.6671602   -25.1436776   -35.0000000 CY
   0.0001213         8699.     71747719.     9.2652103     0.0011234    -0.0012834
  2.6934495   -25.7021686   -35.0000000 CY
   0.0001238         8845.     71475496.     9.2520097     0.0011449    -0.0013115
  2.7179269   -26.2794837   -35.0000000 CY
   0.0001263         8980.     71129254.     9.2346269     0.0011659    -0.0013402
  2.7407450   -26.8740254   -35.0000000 CY
   0.0001288         9107.     70733247.     9.2142376     0.0011863    -0.0013694
  2.7621107   -27.4823136   -35.0000000 CY
   0.0001313         9227.     70301843.     9.1916780     0.0012064    -0.0013989
  2.7821753   -28.1018172   -35.0000000 CY
   0.0001338         9341.     69838596.     9.1678991     0.0012262    -0.0014287
  2.8010951   -28.7293224    35.0000000 CY
   0.0001363         9448.     69344215.     9.1437724     0.0012458    -0.0014587
  2.8190055   -29.3616504    35.0000000 CY
   0.0001388         9547.     68810376.     9.1208724     0.0012655    -0.0014887
  2.8361136   -29.9925397    35.0000000 CY
   0.0001413         9640.     68251109.     9.0986944     0.0012852    -0.0015186
  2.8523623   -30.6237940    35.0000000 CY
   0.0001438         9728.     67669596.     9.0775342     0.0013049    -0.0015485
  2.8677903   -31.2540180    35.0000000 CY
   0.0001463         9807.     67054688.     9.0591310     0.0013249    -0.0015782
  2.8825833   -31.8756185    35.0000000 CY
   0.0001488         9882.     66431806.     9.0414088     0.0013449    -0.0016078
  2.8965052   -32.4969510    35.0000000 CY
   0.0001588        10137.     63852322.     8.9800956     0.0014256    -0.0017256
  2.9437298   -34.9638914    35.0000000 CY
   0.0001688        10343.     61293451.     8.9276403     0.0015065    -0.0018431
  2.9767633   -37.4230434    35.0000000 CY
   0.0001788        10517.     58835379.     8.8819918     0.0015877    -0.0019605
  2.9954464   -39.8773362    35.0000000 CY
   0.0001888        10665.     56503495.     8.8416049     0.0016689    -0.0020778
  2.9995087   -42.3293033    35.0000000 CY
   0.0001988        10793.     54306827.     8.8053167     0.0017501    -0.0021951
  2.9994763   -44.7810705    35.0000000 CY
   0.0002088        10907.     52247262.     8.7729791     0.0018314    -0.0023123
  2.9989813   -47.2299708    35.0000000 CY
   0.0002188        11007.     50317489.     8.7437739     0.0019127    -0.0024295
  2.9999892   -49.6777543    35.0000000 CY
   0.0002288        11097.     48512210.     8.7181412     0.0019943    -0.0025464
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BRIDGE PILES

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   2.9992837   -52.1187782   35.0000000 CY
    0.0002388        11178.    46818978.    8.6949225     0.0020759    -0.0026633
   2.9999304   -54.5579549   35.0000000 CY
    0.0002488        11252.    45232788.    8.6744649     0.0021578    -0.0027799
   2.9988041   -56.9906810   35.0000000 CY
    0.0002588        11319.    43745366.    8.6563479     0.0022398    -0.0028964
   2.9985630   -59.4177091   35.0000000 CY
    0.0002688        11380.    42342836.    8.6390891     0.0023218    -0.0030129
   2.9988498   -60.0000000   35.0000000 CY
    0.0002788        11428.    40998889.    8.6183316     0.0024024    -0.0031308
   2.9987375   -60.0000000   35.0000000 CY
    0.0002888        11467.    39711703.    8.5953397     0.0024819    -0.0032498
   2.9981953   -60.0000000   35.0000000 CY
    0.0002988        11500.    38495269.    8.5728832     0.0025611    -0.0033690
   2.9982529   -60.0000000   35.0000000 CY
    0.0003088        11531.    37347699.    8.5511934     0.0026402    -0.0034885
   2.9999761   -60.0000000   35.0000000 CY
    0.0003188        11559.    36263697.    8.5314879     0.0027194    -0.0036078
   2.9994849   -60.0000000   35.0000000 CY
    0.0003288        11585.    35240584.    8.5127412     0.0027986    -0.0037271
   2.9979935   -60.0000000   35.0000000 CY
    0.0003388        11609.    34270385.    8.4952203     0.0028778    -0.0038464
   2.9999537   -60.0000000   35.0000000 CY
    0.0003488        11631.    33351443.    8.4784458     0.0029569    -0.0039658
   2.9992031   -60.0000000   35.0000000 CY
    0.0003588        11652.    32480079.    8.4629876     0.0030361    -0.0040851
   2.9971114   -60.0000000   35.0000000 CY
    0.0003688        11671.    31650704.    8.4480488     0.0031152    -0.0042045
   2.9995994   -60.0000000   35.0000000 CY
    0.0003788        11690.    30863902.    8.4339691     0.0031944    -0.0043238
   2.9965243   -60.0000000   35.0000000 CY
    0.0003888        11706.    30112372.    8.4202170     0.0032734    -0.0044433
   2.9995818   -60.0000000   35.0000000 CY
    0.0003988        11722.    29397422.    8.4076481     0.0033525    -0.0045626
   2.9964219   -60.0000000   35.0000000 CY
    0.0004088        11737.    28714284.    8.3949692     0.0034314    -0.0046822
   2.9991377    60.0000000   35.0000000 CY
    0.0004188        11751.    28061154.    8.3840417     0.0035108    -0.0048014
   2.9985425    60.0000000   35.0000000 CY
    0.0004288        11762.    27434335.    8.3751169     0.0035908    -0.0049199
   2.9979465    60.0000000   35.0000000 CY
    0.0004388        11773.    26833366.    8.3663012     0.0036707    -0.0050385
   2.9998985    60.0000000   35.0000000 CY
    0.0004488        11782.    26255642.    8.3601296     0.0037516    -0.0051561
   2.9953470    60.0000000   35.0000000 CY
    0.0004588        11790.    25700182.    8.3552769     0.0038330    -0.0052732
   2.9988780    60.0000000   35.0000000 CY
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Axial Thrust Force =   84.100 kips

BRIDGE PILES

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	105.5518341	84441467.	37.8922085	0.00004737	0.00002255	0.1710062	1.2548647	1.3699947	
0.00000250	211.1015288	84440612.	23.9133242	0.00005978	0.00001016	0.2146858	1.4962604	1.7265204	
0.00000375	316.6505104	84440136.	19.2557986	0.00007221	-0.00000223	0.2580532	1.7378847	2.0832747	
0.00000500	422.1900174	84438003.	16.9285291	0.00008464	-0.00001461	0.3011064	1.9797255	2.4402455	
0.00000625	527.6734534	84427753.	15.5329620	0.00009708	-0.00002698	0.3438361	2.2217103	2.7973603	
0.00000750	633.0680106	84409068.	14.6029672	0.0001095	-0.00003935	0.3862346	2.4637785	3.1545585	
0.00000875	738.3596881	84383964.	13.9388875	0.0001220	-0.00005172	0.4282981	2.7058980	3.5118080	
0.00001000	843.5420896	84354209.	13.4409447	0.0001344	-0.00006409	0.4700243	2.9480515	3.8690915	
0.00001125	948.6120482	84321071.	13.0537291	0.0001469	-0.00007646	0.5114119	3.1902288	4.2263988	
0.00001250	1054.	84285428.	12.7440056	0.0001593	-0.00008882	0.5524603	3.4324239	4.5837239	
0.00001375	1158.	84247891.	12.4906298	0.0001717	-0.0001012	0.5931689	3.6746327	4.9410627	
0.00001500	1169.	77963206.	11.8484262	0.0001777	-0.0001200	0.6123964	3.7293317	5.1108917	C
0.00001625	1261.	77588996.	11.6397642	0.0001891	-0.0001334	0.6492656	3.9417774	5.4384674	C
0.00001750	1352.	77259984.	11.4599274	0.0002005	-0.0001468	0.6857924	4.1537238	5.7655438	C
0.00001875	1443.	76968695.	11.3033850	0.0002119	-0.0001602	0.7219922	4.3652985	6.0922485	C
0.00002000	1534.	76709312.	11.1659986	0.0002233	-0.0001737	0.7578804	4.5766337	6.4187137	C
0.00002125	1625.	76476479.	11.0444263	0.0002347	-0.0001871	0.7934604	4.7877546	6.7449646	C
0.00002250	1716.	76265774.	10.9359815	0.0002461	-0.0002006	0.8287291	4.9986271	7.0709671	C
0.00002375	1807.	76075012.	10.8389343	0.0002574	-0.0002140	0.8637123	5.2094874	7.3969574	C
0.00002500	1898.	75900272.	10.7512826	0.0002688	-0.0002275	0.8983876	5.4201236	7.7227236	C
0.00002625	1988.	75740293.	10.6719862	0.0002801	-0.0002409				

BRIDGE PILES

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0.9327798     5.6307654     8.0484954 C
0.00002750         2079.     75593069.     10.5998919     0.0002915    -0.0002544
0.9668877     5.8414019     8.3742619 C
0.00002875         2169.     75456348.     10.5338638     0.0003028    -0.0002678
1.0006944     6.0518693     8.6998593 C
0.00003000         2260.     75329753.     10.4734557     0.0003142    -0.0002813
1.0342282     6.2624390     9.0255590 C
0.00003125         2350.     75212006.     10.4179709     0.0003256    -0.0002948
1.0674867     6.4730909     9.3513409 C
0.00003250         2441.     75101287.     10.3665309     0.0003369    -0.0003082
1.1004402     6.6835324     9.6769124 C
0.00003375         2531.     74997640.     10.3190065     0.0003483    -0.0003217
1.1331207     6.8940767    10.0025867 C
0.00003500         2622.     74900308.     10.2749781     0.0003596    -0.0003351
1.1655278     7.1047241    10.3283641 C
0.00003625         2712.     74808633.     10.2340843     0.0003710    -0.0003486
1.1976612     7.3154747    10.6542447 C
0.00003750         2802.     74721664.     10.1958335     0.0003823    -0.0003620
1.2295019     7.5261347    10.9800347 C
0.00003875         2892.     74639166.     10.1600721     0.0003937    -0.0003755
1.2610612     7.7368189    11.3058489 C
0.00004000         2982.     74560868.     10.1266353     0.0004051    -0.0003889
1.2923467     7.9476070    11.6317670 C
0.00004125         3073.     74486388.     10.0953119     0.0004164    -0.0004024
1.3233579     8.1584992    11.9577892 C
0.00004250         3163.     74415385.     10.0659157     0.0004278    -0.0004158
1.3540948     8.3694956    12.2839156 C
0.00004375         3253.     74347563.     10.0382816     0.0004392    -0.0004293
1.3845571     8.5805964    12.6101464 C
0.00004500         3343.     74282516.     10.0121849     0.0004505    -0.0004427
1.4147350     8.7917002    12.9363802 C
0.00004625         3433.     74220004.      9.9874911     0.0004619    -0.0004561
1.4446275     9.0027935    13.2626035 C
0.00004750         3523.     74159971.      9.9641733     0.0004733    -0.0004696
1.4742450     9.2139920    13.5889320 C
0.00004875         3612.     74102227.      9.9421259     0.0004847    -0.0004830
1.5035871     9.4252960    13.9153660 C
0.00005125         3792.     73992928.      9.9014709     0.0005075    -0.0005099
1.5614446    -9.9181610   -14.6384910 C
0.00005375         3972.     73890915.      9.8648696     0.0005302    -0.0005367
1.6181979   -10.4590259   -15.4096159 C
0.00005625         4151.     73795207.      9.8317826     0.0005530    -0.0005635
1.6738449   -10.9994653   -16.1803153 C
0.00005875         4330.     73704786.      9.8016043     0.0005758    -0.0005903
1.7283612   -11.5397469   -16.9508569 C
0.00006125         4509.     73619151.      9.7740952     0.0005987    -0.0006171
1.7817629   -12.0796629   -17.7210329 C
0.00006375         4688.     73537779.      9.7489772     0.0006215    -0.0006439
1.8340532   -12.6191473   -18.4907773 C
0.00006625         4867.     73460178.      9.7259804     0.0006443    -0.0006707
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BRIDGE PILES

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   1.8852299   -13.1581984   -19.2600884 C
   0.00006875         5045.     73385930.       9.7048742       0.0006672      -0.0006975
   1.9352910   -13.6968147   -20.0289647 C
   0.00007125         5224.     73314676.       9.6854604       0.0006901      -0.0007242
   1.9842342   -14.2349945   -20.7974045 C
   0.00007375         5402.     73246104.       9.6675676       0.0007130      -0.0007510
   2.0320574   -14.7727362   -21.5654062 C
   0.00007625         5580.     73179943.       9.6510469       0.0007359      -0.0007777
   2.0787583   -15.3100383   -22.3329683 C
   0.00007875         5758.     73115958.       9.6357684       0.0007588      -0.0008044
   2.1243349   -15.8468991   -23.1000891 C
   0.00008125         5936.     73053908.       9.6215789       0.0007818      -0.0008311
   2.1687786   -16.3834091   -23.8668591 C
   0.00008375         6113.     72993603.       9.6083651       0.0008047      -0.0008577
   2.2120851   -16.9196071   -24.6333171 C
   0.00008625         6291.     72934929.       9.5960966       0.0008277      -0.0008844
   2.2542615   -17.4553565   -25.3993265 C
   0.00008875         6468.     72877743.       9.5846943       0.0008506      -0.0009110
   2.2953054   -17.9906556   -26.1648856 C
   0.00009125         6645.     72821917.       9.5740876       0.0008736      -0.0009377
   2.3352146   -18.5255026   -26.9299926 C
   0.00009375         6822.     72767336.       9.5642135       0.0008966      -0.0009643
   2.3739868   -19.0598959   -27.6946459 C
   0.00009625         6999.     72713897.       9.5550155       0.0009197      -0.0009909
   2.4116196   -19.5938338   -28.4588438 C
   0.00009875         7175.     72661510.       9.5464429       0.0009427      -0.0010175
   2.4481108   -20.1273143   -29.2225843 C
    0.0001013         7352.     72610089.       9.5384499       0.0009658      -0.0010440
   2.4834580   -20.6603360   -29.9858660 C
    0.0001038         7528.     72559561.       9.5309953       0.0009888      -0.0010706
   2.5176589   -21.1928968   -30.7486868 C
    0.0001063         7704.     72509856.       9.5240415       0.0010119      -0.0010971
   2.5507111   -21.7249952   -31.5110452 C
    0.0001088         7880.     72460913.       9.5175548       0.0010350      -0.0011237
   2.5826123   -22.2566292   -32.2729392 C
    0.0001113         8056.     72412676.       9.5115040       0.0010582      -0.0011502
   2.6133600   -22.7877971   -33.0343671 C
    0.0001138         8232.     72365093.       9.5058611       0.0010813      -0.0011766
   2.6429519   -23.3184971   -33.7953271 C
    0.0001163         8407.     72318117.       9.5006002       0.0011044      -0.0012031
   2.6713855   -23.8487273   -34.5558173 C
    0.0001188         8581.     72256981.       9.4949156       0.0011275      -0.0012297
   2.6985503   -24.3811796   -35.0000000 CY
    0.0001213         8748.     72144751.       9.4867849       0.0011503      -0.0012565
   2.7241815   -24.9230580   -35.0000000 CY
    0.0001238         8905.     71959868.       9.4749333       0.0011725      -0.0012839
   2.7481410   -25.4794682   -35.0000000 CY
    0.0001263         9051.     71690496.       9.4585709       0.0011941      -0.0013119
   2.7703737   -26.0541110   -35.0000000 CY
    0.0001288         9186.     71349548.       9.4383015       0.0012152      -0.0013405
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BRIDGE PILES

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  2.7910127   -26.6457141   -35.0000000 CY
   0.0001313         9312.     70945024.      9.4164027      0.0012359     -0.0013694
  2.8103889   -27.2464622    35.0000000 CY
   0.0001338         9428.     70487647.      9.3940630      0.0012565     -0.0013985
  2.8286749   -27.8520893    35.0000000 CY
   0.0001363         9536.     69986837.      9.3719118      0.0012769     -0.0014276
  2.8459623   -28.4602153    35.0000000 CY
   0.0001388         9635.     69437989.      9.3514150      0.0012975     -0.0014567
  2.8624240   -29.0648939    35.0000000 CY
   0.0001413         9725.     68851758.      9.3325700      0.0013182     -0.0014856
  2.8780526   -29.6657795    35.0000000 CY
   0.0001438         9810.     68243696.      9.3146299      0.0013390     -0.0015145
  2.8927640   -30.2656268    35.0000000 CY
   0.0001463         9888.     67611516.      9.2984397      0.0013599     -0.0015432
  2.9066379   -30.8606508    35.0000000 CY
   0.0001488         9961.     66965584.      9.2827875      0.0013808     -0.0015719
  2.9195505   -31.4557032    35.0000000 CY
   0.0001588        10215.     64343740.      9.2257953      0.0014646     -0.0016866
  2.9616401   -33.8327510    35.0000000 CY
   0.0001688        10421.     61755953.      9.1755080      0.0015484     -0.0018013
  2.9883174   -36.2100404    35.0000000 CY
   0.0001788        10594.     59269472.      9.1307002      0.0016321     -0.0019161
  2.9995861   -38.5880932    35.0000000 CY
   0.0001888        10743.     56915426.      9.0903108      0.0017158     -0.0020309
  2.9998531   -40.9679492    35.0000000 CY
   0.0001988        10871.     54697305.      9.0545556      0.0017996     -0.0021456
  2.9998513   -43.3445202    35.0000000 CY
   0.0002088        10984.     52618790.      9.0220946      0.0018834     -0.0022603
  2.9995709   -45.7218879    35.0000000 CY
   0.0002188        11084.     50669533.      8.9923094      0.0019671     -0.0023751
  2.9985771   -48.1011069    35.0000000 CY
   0.0002288        11173.     48844423.      8.9661989      0.0020510     -0.0024897
  2.9997826   -50.4732253    35.0000000 CY
   0.0002388        11254.     47136428.      8.9428895      0.0021351     -0.0026041
  2.9991813   -52.8410935    35.0000000 CY
   0.0002488        11327.     45534998.      8.9216436      0.0022193     -0.0027184
  2.9988837   -55.2075952    35.0000000 CY
   0.0002588        11393.     44032571.      8.9029883      0.0023036     -0.0028325
  2.9993899   -57.5669810    35.0000000 CY
   0.0002688        11455.     42622587.      8.8863856      0.0023882     -0.0029465
  2.9995996   -59.9211896    35.0000000 CY
   0.0002788        11509.     41288415.      8.8697195      0.0024724     -0.0030608
  2.9996040   -60.0000000    35.0000000 CY
   0.0002888        11553.     40010420.      8.8496369      0.0025553     -0.0031764
  2.9993549   -60.0000000    35.0000000 CY
   0.0002988        11587.     38786181.      8.8277649      0.0026373     -0.0032929
  2.9986968   -60.0000000    35.0000000 CY
   0.0003088        11618.     37630088.      8.8058396      0.0027188     -0.0034099
  2.9973570   -60.0000000    35.0000000 CY
   0.0003188        11647.     36538515.      8.7857408      0.0028005     -0.0035267
```

BRIDGE PILES

```
   2.9999852   -60.0000000    35.0000000 CY
    0.0003288        11673.    35506536.     8.7663946     0.0028820    -0.0036437
   2.9993462   -60.0000000    35.0000000 CY
    0.0003388        11697.    34528655.     8.7482424     0.0029635    -0.0037607
   2.9973501   -60.0000000    35.0000000 CY
    0.0003488        11719.    33603816.     8.7310451     0.0030450    -0.0038777
   2.9999323   -60.0000000    35.0000000 CY
    0.0003588        11740.    32723731.     8.7149965     0.0031265    -0.0039947
   2.9983673   -60.0000000    35.0000000 CY
    0.0003688        11759.    31889404.     8.6995567     0.0032080    -0.0041117
   2.9998608   -60.0000000    35.0000000 CY
    0.0003788        11777.    31094861.     8.6849895     0.0032894    -0.0042287
   2.9985663   -60.0000000    35.0000000 CY
    0.0003888        11794.    30337908.     8.6718298     0.0033712    -0.0043455
   2.9997174    60.0000000    35.0000000 CY
    0.0003988        11809.    29615811.     8.6588393     0.0034527    -0.0044625
   2.9981180    60.0000000    35.0000000 CY
    0.0004088        11822.    28923321.     8.6492568     0.0035354    -0.0045783
   2.9999731    60.0000000    35.0000000 CY
    0.0004188        11834.    28259366.     8.6402036     0.0036181    -0.0046941
   2.9969649    60.0000000    35.0000000 CY
    0.0004288        11843.    27622813.     8.6334371     0.0037016    -0.0048091
   2.9996716    60.0000000    35.0000000 CY
    0.0004388        11852.    27012060.     8.6275626     0.0037853    -0.0049238
   2.9962542    60.0000000    35.0000000 CY
    0.0004488        11858.    26424462.     8.6234877     0.0038698    -0.0050379
   2.9986048    60.0000000    35.0000000 CY


Axial Thrust Force =      88.569 kips

    Bending          Bending          Bending       Depth to        Max Comp        Max Tens
  Max Conc         Max Steel       Max Casing   Run
   Curvature         Moment         Stiffness      N Axis         Strain          Strain
   Stress           Stress          Stress     Msg
    rad/in.          in-kip          kip-in2          in            in/in           in/in
     ksi              ksi             ksi
------------- ------------- ------------- ------------- ------------- -------------
------------- ------------- ------------- ---
   0.00000125   105.5237337     84418987.    39.3849202    0.00004923    0.00002442
   0.1776575     1.3089756    1.4241056
   0.00000250   211.0452325     84418093.    24.6596822    0.00006165    0.00001202
   0.2212855     1.5503713    1.7806313
   0.00000375   316.5660179     84417605.    19.7533730    0.00007408  -3.62351E-07
   0.2646013     1.7919959    2.1373859
   0.00000500   422.0813796     84416276.    17.3017533    0.00008651   -0.00001274
   0.3076036     2.0338430    2.4943630
   0.00000625   527.5507457     84408119.    15.8316691    0.00009895   -0.00002511
   0.3502844     2.2758510    2.8515010
   0.00000750   632.9368273     84391577.    14.8520499     0.0001114   -0.00003748
```

BRIDGE PILES

0.3926353	2.5179540	3.2087340			
0.00000875	738.2230777	84368352.	14.1525547	0.0001238	-0.00004985
0.4346520	2.7601161	3.5660261			
0.00001000	843.4017636	84340176.	13.6280679	0.0001363	-0.00006222
0.4763320	3.0023172	3.9233572			
0.00001125	948.4690326	84308358.	13.2202180	0.0001487	-0.00007459
0.5176737	3.2445458	4.2807158			
0.00001250	1053.	84273823.	12.8939940	0.0001612	-0.00008695
0.5586763	3.4867948	4.6380948			
0.00001375	1158.	84237224.	12.6271229	0.0001736	-0.00009931
0.5993393	3.7290594	4.9954894			
0.00001500	1173.	78194430.	11.9941830	0.0001799	-0.0001178
0.6195550	3.7927359	5.1742959 C			
0.00001625	1264.	77806329.	11.7752352	0.0001913	-0.0001312
0.6564176	4.0056181	5.5023081 C			
0.00001750	1356.	77465162.	11.5865988	0.0002028	-0.0001446
0.6929380	4.2180096	5.8298296 C			
0.00001875	1447.	77162834.	11.4223889	0.0002142	-0.0001580
0.7291282	4.4300068	6.1569568 C			
0.00002000	1538.	76892295.	11.2779982	0.0002256	-0.0001714
0.7649875	4.6415940	6.4836740 C			
0.00002125	1629.	76649748.	11.1502835	0.0002369	-0.0001849
0.8005405	4.8529889	6.8101989 C			
0.00002250	1720.	76430898.	11.0365467	0.0002483	-0.0001983
0.8357937	5.0642457	7.1365857 C			
0.00002375	1810.	76231393.	10.9343825	0.0002597	-0.0002117
0.8707326	5.2752273	7.4626973 C			
0.00002500	1901.	76049857.	10.8424564	0.0002711	-0.0002252
0.9053889	5.4862245	7.7888245 C			
0.00002625	1992.	75882804.	10.7590212	0.0002824	-0.0002386
0.9397398	5.6970208	8.1147508 C			
0.00002750	2083.	75729046.	10.6831504	0.0002938	-0.0002521
0.9738049	5.9078005	8.4406605 C			
0.00002875	2173.	75587213.	10.6139606	0.0003052	-0.0002655
1.0075932	6.1186500	8.7666400 C			
0.00003000	2264.	75454743.	10.5502574	0.0003165	-0.0002790
1.0410726	6.3292564	9.0923764 C			
0.00003125	2354.	75331651.	10.4917636	0.0003279	-0.0002924
1.0742787	6.5399655	9.4182155 C			
0.00003250	2445.	75216851.	10.4378785	0.0003392	-0.0003059
1.1072113	6.7507774	9.7441574 C			
0.00003375	2535.	75108833.	10.3878608	0.0003506	-0.0003193
1.1398478	6.9614678	10.0699778 C			
0.00003500	2625.	75007165.	10.3414107	0.0003619	-0.0003328
1.1721999	7.1721532	10.3957932 C			
0.00003625	2716.	74911455.	10.2982624	0.0003733	-0.0003463
1.2042784	7.3829419	10.7217119 C			
0.00003750	2806.	74821105.	10.2580858	0.0003847	-0.0003597
1.2360829	7.5938340	11.0477340 C			
0.00003875	2896.	74735563.	10.2205790	0.0003960	-0.0003731

BRIDGE PILES

```
  1.2676116     7.8048136    11.3738436 C
  0.00004000        2986.     74653932.    10.1852851     0.0004074    -0.0003866
  1.2988415     8.0156408    11.6998008 C
  0.00004125        3076.     74576320.    10.1522172     0.0004188    -0.0004000
  1.3297972     8.2265721    12.0258621 C
  0.00004250        3166.     74502370.    10.1211792     0.0004302    -0.0004135
  1.3604784     8.4376078    12.3520278 C
  0.00004375        3256.     74431767.    10.0919971     0.0004415    -0.0004269
  1.3908849     8.6487480    12.6782980 C
  0.00004500        3346.     74364231.    10.0645164     0.0004529    -0.0004403
  1.4210164     8.8599928    13.0046728 C
  0.00004625        3436.     74299512.    10.0385994     0.0004643    -0.0004538
  1.4508726     9.0713426    13.3311526 C
  0.00004750        3526.     74237272.    10.0140568     0.0004757    -0.0004672
  1.4804452     9.2827066    13.6576466 C
  0.00004875        3616.     74177279.     9.9907590     0.0004870    -0.0004806
  1.5097310     9.4940510    13.9841210 C
  0.00005125        3796.     74063810.     9.9477862     0.0005098    -0.0005075
  1.5674755     9.9170570    14.6373870 C
  0.00005375        3975.     73958012.     9.9090830     0.0005326    -0.0005343
  1.6241155   -10.3901082   -15.3406982 C
  0.00005625        4155.     73858855.     9.8740812     0.0005554    -0.0005611
  1.6796489   -10.9304658   -16.1113158 C
  0.00005875        4334.     73765483.     9.8423090     0.0005782    -0.0005880
  1.7340734   -11.4703962   -16.8815062 C
  0.00006125        4513.     73677073.     9.8132903     0.0006011    -0.0006147
  1.7873754   -12.0100426   -17.6514126 C
  0.00006375        4692.     73593011.     9.7866809     0.0006239    -0.0006415
  1.8395504   -12.5494426   -18.4210726 C
  0.00006625        4870.     73512922.     9.7623054     0.0006468    -0.0006683
  1.8906116   -13.0884089   -19.1902989 C
  0.00006875        5049.     73436366.     9.7399210     0.0006696    -0.0006951
  1.9405567   -13.6269401   -19.9590901 C
  0.00007125        5227.     73362963.     9.7193189     0.0006925    -0.0007218
  1.9893836   -14.1650344   -20.7274444 C
  0.00007375        5405.     73292387.     9.7003184     0.0007154    -0.0007485
  2.0370901   -14.7026903   -21.4953603 C
  0.00007625        5583.     73224353.     9.6827630     0.0007383    -0.0007753
  2.0836740   -15.2399061   -22.2628361 C
  0.00007875        5761.     73158611.     9.6665155     0.0007612    -0.0008019
  2.1291331   -15.7766803   -23.0298703 C
  0.00008125        5939.     73094945.     9.6514560     0.0007842    -0.0008286
  2.1734652   -16.3130112   -23.7964612 C
  0.00008375        6117.     73033161.     9.6374788     0.0008071    -0.0008553
  2.2166681   -16.8488972   -24.5626072 C
  0.00008625        6294.     72973075.     9.6244712     0.0008301    -0.0008820
  2.2587364   -17.3843845   -25.3283545 C
  0.00008875        6471.     72914501.     9.6123044     0.0008531    -0.0009086
  2.2996607   -17.9195940   -26.0938240 C
  0.00009125        6648.     72857362.     9.6009753     0.0008761    -0.0009352
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BRIDGE PILES

```
 2.3394500   -18.4543510   -26.8588410 C
 0.00009375         6825.     72801537.     9.5904174     0.0008991    -0.0009618
 2.3781018   -18.9886539   -27.6234039 C
 0.00009625         7002.     72746918.     9.5805713     0.0009221    -0.0009884
 2.4156139   -19.5225009   -28.3875109 C
 0.00009875         7178.     72693408.     9.5713836     0.0009452    -0.0010150
 2.4519840   -20.0558903   -29.1511603 C
  0.0001013         7355.     72640920.     9.5628060     0.0009682    -0.0010416
 2.4872097   -20.5888203   -29.9143503 C
  0.0001038         7531.     72589374.     9.5547951     0.0009913    -0.0010681
 2.5212886   -21.1212892   -30.6770792 C
  0.0001063         7707.     72538699.     9.5473113     0.0010144    -0.0010947
 2.5542186   -21.6532951   -31.4393451 C
  0.0001088         7883.     72488829.     9.5403191     0.0010375    -0.0011212
 2.5859970   -22.1848363   -32.2011463 C
  0.0001113         8059.     72439706.     9.5337857     0.0010606    -0.0011477
 2.6166216   -22.7159109   -32.9624809 C
  0.0001138         8235.     72391274.     9.5276814     0.0010838    -0.0011742
 2.6460900   -23.2465172   -33.7233472 C
  0.0001163         8410.     72343486.     9.5219792     0.0011069    -0.0012006
 2.6743997   -23.7766533   -34.4837433 C
  0.0001188         8584.     72284936.     9.5160505     0.0011300    -0.0012272
 2.7014653   -24.3083963   -35.0000000 CY
  0.0001213         8752.     72177930.     9.5078374     0.0011528    -0.0012540
 2.7270170   -24.8490320   -35.0000000 CY
  0.0001238         8910.     71999913.     9.4960147     0.0011751    -0.0012813
 2.7509098   -25.4038120   -35.0000000 CY
  0.0001263         9057.     71738750.     9.4797783     0.0011968    -0.0013092
 2.7730864   -25.9764652   -35.0000000 CY
  0.0001288         9193.     71404069.     9.4595454     0.0012179    -0.0013378
 2.7936558   -26.5663950   -35.0000000 CY
  0.0001313         9319.     71001603.     9.4379048     0.0012387    -0.0013666
 2.8129859   -27.1646195    35.0000000 CY
  0.0001338         9435.     70543377.     9.4159565     0.0012594    -0.0013956
 2.8312356   -27.7671698    35.0000000 CY
  0.0001363         9543.     70039756.     9.3942441     0.0012800    -0.0014246
 2.8484843   -28.3719745    35.0000000 CY
  0.0001388         9642.     69493849.     9.3736513     0.0013006    -0.0014536
 2.8648400   -28.9754207    35.0000000 CY
  0.0001413         9733.     68903143.     9.3553730     0.0013214    -0.0014824
 2.8804261   -29.5723728    35.0000000 CY
  0.0001438         9817.     68291836.     9.3378998     0.0013423    -0.0015111
 2.8950743   -30.1686200    35.0000000 CY
  0.0001463         9895.     67661001.     9.3215341     0.0013633    -0.0015398
 2.9088135   -30.7627055    35.0000000 CY
  0.0001488         9968.     67010664.     9.3060573     0.0013843    -0.0015684
 2.9216190   -31.3553233    35.0000000 CY
  0.0001588        10221.     64387013.     9.2493303     0.0014683    -0.0016829
 2.9631762   -33.7244015    35.0000000 CY
  0.0001688        10428.     61798024.     9.1995037     0.0015524    -0.0017973
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BRIDGE PILES

```
  2.9892271   -36.0926113    35.0000000 CY
   0.0001788         10601.     59308212.      9.1547282      0.0016364     -0.0019118
  2.9997507   -38.4635381    35.0000000 CY
   0.0001888         10750.     56951354.      9.1144416      0.0017204     -0.0020263
  2.9999469   -40.8358631    35.0000000 CY
   0.0001988         10878.     54732506.      9.0785272      0.0018044     -0.0021408
  2.9999490   -43.2063539    35.0000000 CY
   0.0002088         10991.     52651647.      9.0458512      0.0018883     -0.0022554
  2.9997611   -45.5780711    35.0000000 CY
   0.0002188         11091.     50700364.      9.0166518      0.0019724     -0.0023698
  2.9989711   -47.9466851    35.0000000 CY
   0.0002288         11180.     48873302.      8.9903242      0.0020565     -0.0024842
  2.9999209   -50.3131840    35.0000000 CY
   0.0002388         11260.     47163488.      8.9668679      0.0021408     -0.0025983
  2.9984000   -52.6750732    35.0000000 CY
   0.0002488         11333.     45561655.      8.9458161      0.0022253     -0.0027124
  2.9992691   -55.0332214    35.0000000 CY
   0.0002588         11400.     44058962.      8.9267624      0.0023098     -0.0028264
  2.9996696   -57.3885865    35.0000000 CY
   0.0002688         11461.     42647428.      8.9101304      0.0023946     -0.0029401
  2.9998246   -59.7361281    35.0000000 CY
   0.0002788         11516.     41312794.      8.8935457      0.0024791     -0.0030541
  2.9998347   -60.0000000    35.0000000 CY
   0.0002888         11560.     40035222.      8.8738558      0.0025623     -0.0031694
  2.9996766   -60.0000000    35.0000000 CY
   0.0002988         11595.     38812308.      8.8521089      0.0026446     -0.0032856
  2.9991941   -60.0000000    35.0000000 CY
   0.0003088         11626.     37655410.      8.8308140      0.0027265     -0.0034022
  2.9981238   -60.0000000    35.0000000 CY
   0.0003188         11655.     36563803.      8.8105033      0.0028083     -0.0035188
  2.9991152   -60.0000000    35.0000000 CY
   0.0003288         11680.     35529993.      8.7910217      0.0028900     -0.0036356
  2.9997115   -60.0000000    35.0000000 CY
   0.0003388         11705.     34552127.      8.7727275      0.0029718     -0.0037524
  2.9981782   -60.0000000    35.0000000 CY
   0.0003488         11727.     33626268.      8.7557367      0.0030536     -0.0038691
  2.9998227   -60.0000000    35.0000000 CY
   0.0003588         11748.     32745647.      8.7393098      0.0031352     -0.0039860
  2.9990292   -60.0000000    35.0000000 CY
   0.0003688         11767.     31911373.      8.7238147      0.0032169     -0.0041028
  2.9980027   -60.0000000    35.0000000 CY
   0.0003788         11785.     31115426.      8.7092355      0.0032986     -0.0042196
  2.9992089   -60.0000000    35.0000000 CY
   0.0003888         11802.     30358310.      8.6961850      0.0033806     -0.0043360
  2.9977508    60.0000000    35.0000000 CY
   0.0003988         11817.     29634844.      8.6830290      0.0034624     -0.0044528
  2.9989007    60.0000000    35.0000000 CY
   0.0004088         11830.     28941263.      8.6738156      0.0035454     -0.0045683
  2.9989309    60.0000000    35.0000000 CY
   0.0004188         11841.     28276195.      8.6650961      0.0036285     -0.0046837
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   2.9980605    60.0000000    35.0000000 CY
    0.0004288        11850.     27639119.     8.6579228     0.0037121    -0.0047986
   2.9999511    60.0000000    35.0000000 CY
    0.0004388        11858.     27027125.     8.6534376     0.0037967    -0.0049125
   2.9962564    60.0000000    35.0000000 CY
    0.0004488        11865.     26439070.     8.6490712     0.0038813    -0.0050264
   2.9993660    60.0000000    35.0000000 CY
```

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	35.105	11638.696	0.00300000
2	37.800	11642.702	0.00300000
3	84.100	11706.781	0.00300000
4	88.569	11712.344	0.00300000

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	35.104686	11639.	22.818046	7565.	72212914.
2	0.65	37.800000	11643.	24.570000	7568.	72230904.

```
   3       0.65          84.100000        11707.     54.665000          7609.
72536601.
   4       0.65          88.569221        11712.     57.569994          7613.
72565811.

   1       0.75          35.104686        11639.     26.328515          8729.
71660058.
   2       0.75          37.800000        11643.     28.350000          8732.
71686773.
   3       0.75          84.100000        11707.     63.075000          8780.
72106555.
   4       0.75          88.569221        11712.     66.426916          8784.
72141202.

   1       0.90          35.104686        11639.     31.594218         10475.
59335346.
   2       0.90          37.800000        11643.     34.020000         10478.
59379136.
   3       0.90          84.100000        11707.     75.690000         10536.
60107130.
   4       0.90          88.569221        11712.     79.712299         10541.
60175455.
```

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	18986.
2	8.0000	8.0000	No	No	18986.	9156.
3	11.0000	29.3955	No	No	28142.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Lateral Loading Analysis for Load Case Number 1

Analysis was not performed.

Lateral Loading Analysis for Load Case Number 2

Analysis was not performed.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 7598.9 lbs
Applied moment at pile head = 654000.0 in-lbs
Axial thrust load on pile head = 88569.2 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3152	654000.	7599.	-0.00284	0.00	8.44E+10	-33.8747	386.9345	0.00
0.6000	0.2949	709627.	7347.	-0.00278	0.00	8.44E+10	-35.9983	878.8425	0.00
1.2000	0.2751	763350.	7081.	-0.00272	0.00	8.44E+10	-37.9730	993.8105	0.00
1.8000	0.2558	815062.	6801.	-0.00265	0.00	8.43E+10	-39.7936	1120.	0.00
2.4000	0.2369	864667.	6509.	-0.00258	0.00	8.43E+10	-41.4548	1260.	0.00
3.0000	0.2186	912076.	6205.	-0.00250	0.00	8.43E+10	-42.9512	1415.	0.00
3.6000	0.2009	957209.	5891.	-0.00242	0.00	8.43E+10	-44.2766	1587.	0.00
4.2000	0.1837	999995.	5568.	-0.00234	0.00	8.43E+10	-45.4249	1780.	0.00
4.8000	0.1672	1040371.	5237.	-0.00225	0.00	8.43E+10			

BRIDGE PILES

-46.3891	1998.	0.00				
5.4000	0.1513	1078285.	4900.	-0.00216	0.00	8.43E+10
-47.1619	2245.	0.00				
6.0000	0.1360	1113696.	4559.	-0.00207	0.00	8.43E+10
-47.7348	2527.	0.00				
6.6000	0.1215	1146572.	4214.	-0.00197	0.00	8.42E+10
-48.0988	2851.	0.00				
7.2000	0.1076	1176892.	3867.	-0.00187	0.00	7.82E+10
-48.2433	3228.	0.00				
7.8000	0.09453	1204641.	3520.	-0.00176	0.00	7.81E+10
-48.1657	3669.	0.00				
8.4000	0.08226	1229823.	3346.	-0.00165	0.00	7.79E+10
-0.07193	6.2955	0.00				
9.0000	0.07081	1254929.	3346.	-0.00153	0.00	7.78E+10
-0.07282	7.4047	0.00				
9.6000	0.06019	1279957.	3345.	-0.00142	0.00	7.77E+10
-0.07191	8.6016	0.00				
10.2000	0.05043	1304906.	3345.	-0.00130	0.00	7.76E+10
-0.06911	9.8683	0.00				
10.8000	0.04153	1329773.	3344.	-0.00117	0.00	7.76E+10
-0.06449	11.1793	0.00				
11.4000	0.03353	1354559.	1333.	-0.00105	0.00	7.75E+10
-558.6547	119962.	0.00				
12.0000	0.02643	1350304.	-2464.	-9.23E-04	0.00	7.75E+10
-496.0177	135111.	0.00				
12.6000	0.02024	1320255.	-5812.	-7.99E-04	0.00	7.76E+10
-434.0286	154408.	0.00				
13.2000	0.01493	1267629.	-8717.	-6.79E-04	0.00	7.78E+10
-372.7445	179795.	0.00				
13.8000	0.01046	1195604.	-11182.	-5.65E-04	0.00	7.81E+10
-312.0234	214785.	0.00				
14.4000	0.00679	1107334.	-13210.	-4.63E-04	0.00	8.43E+10
-251.3289	266657.	0.00				
15.0000	0.00379	1005974.	-14791.	-3.73E-04	0.00	8.43E+10
-187.9241	356633.	0.00				
15.6000	0.00142	894818.	-15882.	-2.91E-04	0.00	8.43E+10
-114.9937	582853.	0.00				
16.2000	-4.03E-04	777651.	-16159.	-2.20E-04	0.00	8.44E+10
37.9908	679052.	0.00				
16.8000	-0.00175	662412.	-15563.	-1.59E-04	0.00	8.44E+10
127.5594	525338.	0.00				
17.4000	-0.00269	553749.	-14534.	-1.07E-04	0.00	8.44E+10
158.1361	423773.	0.00				
18.0000	-0.00329	453254.	-13335.	-6.38E-05	0.00	8.44E+10
174.8627	383242.	0.00				
18.6000	-0.00361	361800.	-12047.	-2.90E-05	0.00	8.44E+10
183.1830	365837.	0.00				
19.2000	-0.00370	279822.	-10719.	-1.66E-06	0.00	8.44E+10
185.6530	360972.	0.00				
19.8000	-0.00363	207452.	-9389.	1.91E-05	0.00	8.44E+10

BRIDGE PILES

```
183.7896    364632.       0.00
   20.4000   -0.00343    144600.      -8084.    3.41E-05        0.00   8.44E+10
178.6181    375190.       0.00
   21.0000   -0.00314     90999.      -6826.    4.42E-05        0.00   8.44E+10
170.8910    392156.       0.00
   21.6000   -0.00279     46252.      -5630.    5.00E-05        0.00   8.44E+10
161.1921    415753.       0.00
   22.2000   -0.00242      9858.      -4510.    5.24E-05        0.00   8.44E+10
149.9923    446797.       0.00
   22.8000   -0.00204    -18760.      -3474.    5.20E-05        0.00   8.44E+10
137.6812    486750.       0.00
   23.4000   -0.00167    -40240.      -2530.    4.95E-05        0.00   8.44E+10
124.5863    537911.       0.00
   24.0000   -0.00132    -55259.      -1682.    4.55E-05        0.00   8.44E+10
110.9837    603841.       0.00
   24.6000   -0.00101    -64522.   -933.1051    4.04E-05        0.00   8.44E+10
97.1024    690165.      0.00
   25.2000  -7.42E-04    -68747.   -284.3003    3.47E-05        0.00   8.44E+10
83.1212    806255.      0.00
   25.8000  -5.14E-04    -68660.    263.8918    2.88E-05        0.00   8.44E+10
69.1544    969094.      0.00
   26.4000  -3.27E-04    -64984.    694.0304    2.31E-05        0.00   8.44E+10
50.3286   1106603.      0.00
   27.0000  -1.81E-04    -58695.    977.6536    1.78E-05        0.00   8.44E+10
28.4557   1131753.      0.00
   27.6000  -7.06E-05    -50929.       1121.    1.32E-05        0.00   8.44E+10
11.3513   1156903.      0.00
   28.2000   8.47E-06    -42570.       1157.    9.17E-06        0.00   8.44E+10
-1.3897   1182053.      0.00
   28.8000   6.14E-05    -34282.       1115.    5.89E-06        0.00   8.44E+10
-10.3004    1207203.      0.00
   29.4000   9.34E-05    -26526.       1020.    3.30E-06        0.00   8.44E+10
-15.9778    1232353.      0.00
   30.0000   1.09E-04    -19596.    894.0942    1.33E-06        0.00   8.44E+10
-19.0334    1257503.      0.00
   30.6000   1.13E-04    -13652.    753.3787   -8.30E-08        0.00   8.44E+10
-20.0543    1282653.      0.00
   31.2000   1.08E-04     -8748.    610.7043   -1.04E-06        0.00   8.44E+10
-19.5775    1307803.      0.00
   31.8000   9.76E-05     -4857.    475.1633   -1.62E-06        0.00   8.44E+10
-18.0728    1332953.      0.00
   32.4000   8.45E-05     -1903.    352.7371   -1.91E-06        0.00   8.44E+10
-15.9345    1358104.      0.00
   33.0000   7.02E-05   224.8131    246.8455   -1.98E-06        0.00   8.44E+10
-13.4798    1383254.      0.00
   33.6000   5.60E-05      1654.    158.8902   -1.90E-06        0.00   8.44E+10
-10.9522    1408404.      0.00
   34.2000   4.28E-05      2515.     88.7624   -1.72E-06        0.00   8.44E+10
-8.5278   1433554.      0.00
   34.8000   3.12E-05      2934.     35.2949   -1.49E-06        0.00   8.44E+10
```

BRIDGE PILES

-6.3243	1458704.	0.00				
35.4000	2.14E-05	3025.	-3.3526	-1.23E-06	0.00	8.44E+10
-4.4111	1483854.	0.00				
36.0000	1.34E-05	2888.	-29.3798	-9.82E-07	0.00	8.44E+10
-2.8187	1509004.	0.00				
36.6000	7.27E-06	2604.	-45.1018	-7.48E-07	0.00	8.44E+10
-1.5485	1534154.	0.00				
37.2000	2.68E-06	2239.	-52.7699	-5.41E-07	0.00	8.44E+10
-0.5815	1559304.	0.00				
37.8000	-5.23E-07	1844.	-54.4491	-3.67E-07	0.00	8.44E+10
0.1150	1584454.	0.00				
38.4000	-2.60E-06	1456.	-51.9444	-2.26E-07	0.00	8.44E+10
0.5807	1609604.	0.00				
39.0000	-3.78E-06	1097.	-46.7649	-1.17E-07	0.00	8.44E+10
0.8580	1634754.	0.00				
39.6000	-4.29E-06	782.2504	-40.1183	-3.72E-08	0.00	8.44E+10
0.9883	1659904.	0.00				
40.2000	-4.31E-06	519.0174	-32.9257	1.83E-08	0.00	8.44E+10
1.0097	1685054.	0.00				
40.8000	-4.02E-06	308.0971	-25.8510	5.36E-08	0.00	8.44E+10
0.9555	1710204.	0.00				
41.4000	-3.54E-06	146.6953	-19.3374	7.30E-08	0.00	8.44E+10
0.8538	1735355.	0.00				
42.0000	-2.97E-06	29.5455	-13.6479	8.05E-08	0.00	8.44E+10
0.7266	1760505.	0.00				
42.6000	-2.38E-06	-49.9369	-8.9043	7.96E-08	0.00	8.44E+10
0.5910	1785655.	0.00				
43.2000	-1.82E-06	-98.7785	-5.1243	7.33E-08	0.00	8.44E+10
0.4590	1810805.	0.00				
43.8000	-1.33E-06	-123.8210	-2.2533	6.38E-08	0.00	8.44E+10
0.3385	1835955.	0.00				
44.4000	-9.06E-07	-131.3077	-0.1914	5.29E-08	0.00	8.44E+10
0.2342	1861105.	0.00				
45.0000	-5.65E-07	-126.6440	1.1852	4.19E-08	0.00	8.44E+10
0.1481	1886255.	0.00				
45.6000	-3.03E-07	-114.2936	2.0077	3.16E-08	0.00	8.44E+10
0.08031	1911405.	0.00				
46.2000	-1.10E-07	-97.7738	2.4031	2.26E-08	0.00	8.44E+10
0.02952	1936555.	0.00				
46.8000	2.30E-08	-79.7185	2.4868	1.50E-08	0.00	8.44E+10
-0.00627	1961705.	0.00				
47.4000	1.07E-07	-61.9837	2.3581	8.99E-09	0.00	8.44E+10
-0.02947	1986855.	0.00				
48.0000	1.53E-07	-45.7731	2.0986	4.40E-09	0.00	8.44E+10
-0.04262	2012005.	0.00				
48.6000	1.70E-07	-31.7691	1.7719	1.09E-09	0.00	8.44E+10
-0.04813	2037155.	0.00				
49.2000	1.68E-07	-20.2586	1.4252	-1.13E-09	0.00	8.44E+10
-0.04818	2062305.	0.00				
49.8000	1.54E-07	-11.2447	1.0911	-2.47E-09	0.00	8.44E+10

BRIDGE PILES

```
-0.04461   2087455.       0.00
   50.4000   1.33E-07    -4.5429     0.7904  -3.14E-09       0.00   8.44E+10
-0.03892   2112605.       0.00
   51.0000   1.09E-07    0.1417     0.5343  -3.33E-09       0.00   8.44E+10
-0.03225   2137756.       0.00
   51.6000   8.47E-08    3.1546     0.3266  -3.19E-09       0.00   8.44E+10
-0.02543   2162906.       0.00
   52.2000   6.27E-08    4.8489     0.1665  -2.85E-09       0.00   8.44E+10
-0.01904   2188056.       0.00
   52.8000   4.36E-08    5.5561    0.04971  -2.41E-09       0.00   8.44E+10
-0.01341   2213206.       0.00
   53.4000   2.80E-08    5.5678   -0.02990  -1.93E-09       0.00   8.44E+10
-0.00871   2238356.       0.00
   54.0000   1.58E-08    5.1279   -0.07913  -1.48E-09       0.00   8.44E+10
-0.00497   2263506.       0.00
   54.6000   6.75E-09    4.4302    -0.1047  -1.07E-09       0.00   8.44E+10
-0.00215   2288656.       0.00
   55.2000   4.22E-10    3.6211    -0.1129  -7.25E-10       0.00   8.44E+10
-1.36E-04   2313806.       0.00
   55.8000  -3.68E-09    2.8047    -0.1091  -4.51E-10       0.00   8.44E+10
0.00120   2338956.       0.00
   56.4000  -6.07E-09    2.0502   -0.09765  -2.44E-10       0.00   8.44E+10
0.00199   2364106.       0.00
   57.0000  -7.19E-09    1.3989   -0.08188  -9.66E-11       0.00   8.44E+10
0.00239   2389256.       0.00
   57.6000  -7.46E-09    0.8713   -0.06428       0.00       0.00   8.44E+10
0.00250   2414406.       0.00
   58.2000  -7.19E-09    0.4733   -0.04650   5.76E-11       0.00   8.44E+10
0.00244   2439556.       0.00
   58.8000  -6.63E-09    0.2015   -0.02956   8.63E-11       0.00   8.44E+10
0.00227   2464706.       0.00
   59.4000  -5.95E-09   0.04746   -0.01399   9.69E-11       0.00   8.44E+10
0.00206   2489856.       0.00
   60.0000  -5.23E-09      0.00       0.00   9.90E-11       0.00   8.44E+10
0.00183   1257503.       0.00
```

```
* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 3:

Pile-head deflection              =     0.31516691 inches
Computed slope at pile head       =    -0.00284004 radians
Maximum bending moment            =       1354559. inch-lbs
Maximum shear force               =        -16159. lbs
```

BRIDGE PILES

```
Depth of maximum bending moment  =    11.40000000 feet below pile head
Depth of maximum shear force     =    16.20000000 feet below pile head
Number of iterations             =             17
Number of zero deflection points =              5
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 4

Pile-head conditions are Shear and Moment (Loading Type 1)

```
Shear force at pile head                              =     -15451.6 lbs
Applied moment at pile head                           =    -192441.0 in-lbs
Axial thrust load on pile head                        =      35104.7 lbs
```

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	-0.4152	-192441.	-15452.	0.00333	0.00	8.47E+10	61.8052	535.8199	0.00
0.6000	-0.3913	-302930.	-14992.	0.00331	0.00	8.47E+10	65.8355	1211.	0.00
1.2000	-0.3676	-409999.	-14504.	0.00328	0.00	8.46E+10	69.6092	1363.	0.00
1.8000	-0.3441	-513451.	-13991.	0.00324	0.00	8.46E+10	73.1153	1530.	0.00
2.4000	-0.3210	-613101.	-13453.	0.00319	0.00	8.46E+10	76.3422	1712.	0.00
3.0000	-0.2982	-708781.	-12892.	0.00313	0.00	8.45E+10	79.2779	1914.	0.00
3.6000	-0.2759	-800335.	-12312.	0.00307	0.00	8.45E+10	81.9096	2138.	0.00
4.2000	-0.2540	-887626.	-11714.	0.00300	0.00	8.44E+10	84.2237	2387.	0.00
4.8000	-0.2327	-970532.	-11100.	0.00291	0.00	7.58E+10	86.2057	2667.	0.00
5.4000	-0.2121	-1048946.	-10474.	0.00282	0.00	7.54E+10	87.8489	2983.	0.00
6.0000	-0.1921	-1122780.	-9837.	0.00271	0.00	7.52E+10	89.1403	3340.	0.00
6.6000	-0.1730	-1191967.	-9192.	0.00260	0.00	7.51E+10	90.0660	3749.	0.00

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7.2000	-0.1547	-1256455.	-8541.	0.00249	0.00	7.49E+10	90.6110	4218.	0.00
7.8000	-0.1372	-1316215.	-7888.	0.00236	0.00	7.48E+10	90.7593	4763.	0.00
8.4000	-0.1206	-1371239.	-7561.	0.00223	0.00	7.48E+10	0.1489	8.8845	0.00
9.0000	-0.1051	-1426221.	-7560.	0.00210	0.00	7.47E+10	0.1513	10.3671	0.00
9.6000	-0.09045	-1481161.	-7559.	0.00196	0.00	7.46E+10	0.1503	11.9645	0.00
10.2000	-0.07687	-1536057.	-7558.	0.00181	0.00	7.45E+10	0.1458	13.6577	0.00
10.8000	-0.06436	-1590907.	-7557.	0.00166	0.00	7.45E+10	0.1378	15.4191	0.00
11.4000	-0.05296	-1645712.	-5029.	0.00150	0.00	7.44E+10	702.1195	95453.	0.00
12.0000	-0.04271	-1664079.	-231.1464	0.00134	0.00	7.44E+10	630.4940	106297.	0.00
12.6000	-0.03361	-1649720.	4052.	0.00118	0.00	7.44E+10	559.3456	119819.	0.00
13.2000	-0.02567	-1606324.	7826.	0.00103	0.00	7.45E+10	488.7851	137117.	0.00
13.8000	-0.01884	-1537551.	11093.	8.74E-04	0.00	7.45E+10	418.7657	160047.	0.00
14.4000	-0.01308	-1447031.	13857.	7.30E-04	0.00	7.47E+10	348.9589	192067.	0.00
15.0000	-0.00833	-1338386.	16115.	5.96E-04	0.00	7.48E+10	278.4474	240715.	0.00
15.6000	-0.00450	-1215273.	17855.	4.73E-04	0.00	7.50E+10	204.7581	327376.	0.00
16.2000	-0.00152	-1081516.	19020.	3.63E-04	0.00	7.53E+10	118.8902	564039.	0.00
16.8000	7.23E-04	-941570.	19193.	2.71E-04	0.00	8.44E+10	-70.7591	704202.	0.00
17.4000	0.00239	-805272.	18402.	1.97E-04	0.00	8.45E+10	-149.0159	449595.	0.00
18.0000	0.00356	-676682.	17211.	1.34E-04	0.00	8.45E+10	-181.8946	368375.	0.00
18.6000	0.00431	-557506.	15835.	8.10E-05	0.00	8.46E+10	-200.2571	334615.	0.00
19.2000	0.00472	-448699.	14359.	3.81E-05	0.00	8.46E+10	-209.6174	319682.	0.00
19.8000	0.00486	-350750.	12839.	4.14E-06	0.00	8.46E+10	-212.6437	315139.	0.00
20.4000	0.00478	-263816.	11314.	-2.20E-05	0.00	8.47E+10	-210.9401	317689.	0.00
21.0000	0.00454	-187812.	9815.	-4.12E-05	0.00	8.47E+10	-205.5982	325947.	0.00
21.6000	0.00419	-122462.	8364.	-5.44E-05	0.00	8.47E+10	-197.4216	339450.	0.00

BRIDGE PILES

22.2000	0.00376	-67344.	6980.	-6.25E-05	0.00	8.47E+10	-187.0351	358304.	0.00
22.8000	0.00329	-21920.	5677.	-6.62E-05	0.00	8.47E+10	-174.9433	383073.	0.00
23.4000	0.00280	14435.	4465.	-6.66E-05	0.00	8.47E+10	-161.5650	414798.	0.00
24.0000	0.00233	42414.	3354.	-6.42E-05	0.00	8.47E+10	-147.2531	455118.	0.00
24.6000	0.00188	62759.	2347.	-5.97E-05	0.00	8.47E+10	-132.3077	506534.	0.00
25.2000	0.00147	76243.	1450.	-5.38E-05	0.00	8.47E+10	-116.9815	572905.	0.00
25.8000	0.00111	83662.	663.2670	-4.70E-05	0.00	8.47E+10	-101.4810	660425.	0.00
26.4000	7.94E-04	85818.	-11.5125	-3.98E-05	0.00	8.47E+10	-85.9578	779710.	0.00
27.0000	5.34E-04	83516.	-574.7035	-3.26E-05	0.00	8.47E+10	-70.4842	950914.	0.00
27.6000	3.25E-04	77559.	-1016.	-2.57E-05	0.00	8.47E+10	-52.1789	1156903.	0.00
28.2000	1.63E-04	68895.	-1301.	-1.95E-05	0.00	8.47E+10	-26.8041	1182053.	0.00
28.8000	4.40E-05	58840.	-1424.	-1.41E-05	0.00	8.47E+10	-7.3723	1207203.	0.00
29.4000	-3.93E-05	48401.	-1426.	-9.51E-06	0.00	8.47E+10	6.7281	1232353.	0.00
30.0000	-9.30E-05	38310.	-1343.	-5.82E-06	0.00	8.47E+10	16.2357	1257503.	0.00
30.6000	-1.23E-04	29060.	-1206.	-2.96E-06	0.00	8.47E+10	21.9403	1282653.	0.00
31.2000	-1.36E-04	20947.	-1038.	-8.33E-07	0.00	8.47E+10	24.6247	1307803.	0.00
31.8000	-1.35E-04	14110.	-859.5187	6.57E-07	0.00	8.47E+10	25.0220	1332953.	0.00
32.4000	-1.26E-04	8570.	-683.8056	1.62E-06	0.00	8.47E+10	23.7872	1358104.	0.00
33.0000	-1.12E-04	4263.	-520.8390	2.17E-06	0.00	8.47E+10	21.4813	1383254.	0.00
33.6000	-9.49E-05	1069.	-376.6716	2.39E-06	0.00	8.47E+10	18.5652	1408404.	0.00
34.2000	-7.73E-05	-1163.	-254.3944	2.39E-06	0.00	8.47E+10	15.4007	1433554.	0.00
34.8000	-6.05E-05	-2596.	-154.8240	2.23E-06	0.00	8.47E+10	12.2577	1458704.	0.00
35.4000	-4.52E-05	-3393.	-77.1277	1.97E-06	0.00	8.47E+10	9.3246	1483854.	0.00
36.0000	-3.21E-05	-3707.	-19.3666	1.67E-06	0.00	8.47E+10	6.7202	1509004.	0.00
36.6000	-2.12E-05	-3673.	21.0521	1.36E-06	0.00	8.47E+10	4.5072	1534154.	0.00

BRIDGE PILES

37.2000	-1.25E-05	-3405.	47.0163	1.06E-06	0.00	8.47E+10	2.7050	1559304.	0.00
37.8000	-5.91E-06	-2997.	61.4379	7.86E-07	0.00	8.47E+10	1.3010	1584454.	0.00
38.4000	-1.17E-06	-2521.	67.0611	5.52E-07	0.00	8.47E+10	0.2610	1609604.	0.00
39.0000	2.03E-06	-2031.	66.3386	3.58E-07	0.00	8.47E+10	-0.4617	1634754.	0.00
39.6000	3.99E-06	-1566.	61.3638	2.05E-07	0.00	8.47E+10	-0.9202	1659904.	0.00
40.2000	4.99E-06	-1148.	53.8461	9.00E-08	0.00	8.47E+10	-1.1680	1685054.	0.00
40.8000	5.29E-06	-790.2411	45.1195	7.65E-09	0.00	8.47E+10	-1.2560	1710204.	0.00
41.4000	5.10E-06	-497.9300	36.1717	-4.71E-08	0.00	8.47E+10	-1.2295	1735355.	0.00
42.0000	4.61E-06	-269.3441	27.6881	-7.97E-08	0.00	8.47E+10	-1.1271	1760505.	0.00
42.6000	3.95E-06	-99.1813	20.1011	-9.54E-08	0.00	8.47E+10	-0.9804	1785655.	0.00
43.2000	3.24E-06	20.1596	13.6418	-9.87E-08	0.00	8.47E+10	-0.8138	1810805.	0.00
43.8000	2.53E-06	97.3104	8.3884	-9.38E-08	0.00	8.47E+10	-0.6454	1835955.	0.00
44.4000	1.89E-06	141.0001	4.3099	-8.36E-08	0.00	8.47E+10	-0.4875	1861105.	0.00
45.0000	1.33E-06	159.4157	1.3035	-7.09E-08	0.00	8.47E+10	-0.3476	1886255.	0.00
45.6000	8.66E-07	159.8060	-0.7753	-5.73E-08	0.00	8.47E+10	-0.2298	1911405.	0.00
46.2000	5.02E-07	148.2798	-2.0888	-4.42E-08	0.00	8.47E+10	-0.1351	1936555.	0.00
46.8000	2.29E-07	129.7493	-2.8000	-3.24E-08	0.00	8.47E+10	-0.06249	1961705.	0.00
47.4000	3.60E-08	107.9764	-3.0608	-2.23E-08	0.00	8.47E+10	-0.00994	1986855.	0.00
48.0000	-9.12E-08	85.6857	-3.0048	-1.40E-08	0.00	8.47E+10	0.02549	2012005.	0.00
48.6000	-1.66E-07	64.7143	-2.7440	-7.64E-09	0.00	8.47E+10	0.04696	2037155.	0.00
49.2000	-2.01E-07	46.1761	-2.3675	-2.92E-09	0.00	8.47E+10	0.05762	2062305.	0.00
49.8000	-2.08E-07	30.6238	-1.9429	3.43E-10	0.00	8.47E+10	0.06032	2087455.	0.00
50.4000	-1.96E-07	18.1978	-1.5185	2.42E-09	0.00	8.47E+10	0.05757	2112605.	0.00
51.0000	-1.73E-07	8.7560	-1.1261	3.56E-09	0.00	8.47E+10	0.05143	2137756.	0.00
51.6000	-1.45E-07	1.9804	-0.7842	4.02E-09	0.00	8.47E+10	0.04353	2162906.	0.00

52.2000	-1.15E-07	-2.5389	-0.5014	4.00E-09	0.00	8.47E+10	0.03505	2188056.	0.00
52.8000	-8.73E-08	-5.2412	-0.2785	3.67E-09	0.00	8.47E+10	0.02685	2213206.	0.00
53.4000	-6.25E-08	-6.5516	-0.1119	3.16E-09	0.00	8.47E+10	0.01944	2238356.	0.00
54.0000	-4.18E-08	-6.8540	0.00538	2.59E-09	0.00	8.47E+10	0.01313	2263506.	0.00
54.6000	-2.52E-08	-6.4755	0.08145	2.03E-09	0.00	8.47E+10	0.00800	2288656.	0.00
55.2000	-1.26E-08	-5.6821	0.1248	1.51E-09	0.00	8.47E+10	0.00403	2313806.	0.00
55.8000	-3.41E-09	-4.6793	0.1433	1.07E-09	0.00	8.47E+10	0.00111	2338956.	0.00
56.4000	2.87E-09	-3.6191	0.1439	7.18E-10	0.00	8.47E+10	-9.42E-04	2364106.	0.00
57.0000	6.93E-09	-2.6075	0.1322	4.54E-10	0.00	8.47E+10	-0.00230	2389256.	0.00
57.6000	9.40E-09	-1.7151	0.1126	2.70E-10	0.00	8.47E+10	-0.00315	2414406.	0.00
58.2000	1.08E-08	-0.9861	0.08806	1.55E-10	0.00	8.47E+10	-0.00367	2439556.	0.00
58.8000	1.16E-08	-0.4471	0.06054	9.41E-11	0.00	8.47E+10	-0.00398	2464706.	0.00
59.4000	1.22E-08	-0.1144	0.03105	7.02E-11	0.00	8.47E+10	-0.00421	2489856.	0.00
60.0000	1.26E-08	0.00	0.00	6.53E-11	0.00	8.47E+10	-0.00442	1257503.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 4:

```
Pile-head deflection              =     -0.41524910 inches
Computed slope at pile head       =      0.00332863 radians
Maximum bending moment            =        -1664079. inch-lbs
Maximum shear force               =           19193. lbs
Depth of maximum bending moment   =     12.00000000 feet below pile head
Depth of maximum shear force      =     16.80000000 feet below pile head
Number of iterations              =              16
Number of zero deflection points  =               5
```

BRIDGE PILES

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
3	V, lb	7599.	M, in-lb	654000.	88569.	0.3152	-0.00284	-16159.	1354559.
4	V, lb	-15452.	M, in-lb	-192441.	35105.	-0.4152	0.00333	19193.	-1664079.

Maximum pile-head deflection = -0.4152490982 inches
Maximum pile-head rotation = 0.0033286331 radians = 0.190717 deg.

The analysis ended normally.

ZFA STRUCTURAL ENGINEERS

Job #	Engineer:	Project Name
Pier Capacity	Date	1

PIER DEMANDS:

Batter Angle =	14	deg	(see batter)
Axial Demand =	88.6	k	(see pier demands and batter)

PIER CAPACITY:

L = depth/cos(batter)

Depth (ft)	Length (ft)	Skin Friction (psf)
0	0.0	0
3	3.1	200
11	11.3	350

Skin Friction (psf) =	311	$= f_s$	(weighted avg)
Pier Diameter (in) =	20.00	$= D$	
Pier Length (ft) =	**60.00**	$= H_t$	
Neglect top (ft) =	0.00	$= H_n$	for skin friction
Pier capacity (k) =	**98**	$= \pi * D * (f_s) * (H_t - H_n)$	
DCR =	**0.91**		

Geotechnical investigation is based on borings from the top of the street
Street elevation is ~9.5', top of pier elevation is ~ -1.5' , so 11' below street
therefore top 3' of piers are in very soft soils with no skin friction (14-11)
and next 8' of piers are in soft soil (22-14)
below that is competent soil

Per Geo Report

Skin Friction - The portion of the piles extending below a depth of 22 feet from the ground surface may be designed using an allowable skin friction of 350 pounds per square foot (psf) for dead load plus long-term live loads. This value can be increased by ⅓ for total loads, including downward vertical wind or seismic forces. A skin friction value of 230 psf should be used to resist uplift forces.

Per Email from Geo (dated 9/8/2020)

As discussed, I reviewed the subsurface conditions observed in our borings for the project. Based on the conditions, I can give you some nominal skin friction above 22 feet for the dead load plus live load condition, but this friction cannot be used to resist seismic loading due to liquefaction. There will be some uplift resistance in the materials above the liquefiable soil as this soil will help hold the piles down. I am hoping that this information will help you reduce the pile depths.

Skin Friction from 14 to 22 feet - 200 psf, no increase for downward vertical seismic loads as you cannot count on these materials during an earthquake

Uplift during seismic event from 14 to 22 feet - 130 psf

Let me know if you have questions or need additional information. If these recommendations are useful, I will prepare a supplemental recommendations letter.

Thanks,

Eric G. Chase
President
Principal Geotechnical Engineer

Pier Strength

Steel Casing

OD =	20	in
t =	1	in
Section Loss =	0.075	in
OD' =	19.85	in
t' =	0.925	in
ID =	18	in
A =	55.00	in^2
I =	2468	in^4
E =	29000	ksi
y =	9.93	in
S =	249	in^3
Z =	332	in^3
Fy =	35	ksi
ϕ =	0.9	
φMn = Sfyφ =	7833	k-in
	653	k-ft
EI =	7.16E+07	$k\text{-}in^2$

Concrete Fill

D =	18	in	
A =	254	in^2	
Ig =	5153	in^4	
y =	9.00	in	
S =	573	in^3	
fc' =	3000	psi	
γ =	150	pcf	
E =	3321	ksi	
fr =	411	psi	
Mcr =	20	k-ft	fr*Ig/y
Cracked factor =	0.35		
I_{CR} =	1804	in^4	
EI_{CR} =	5.99E+06	$k\text{-}in^2$	

Load Share Based on Stiffness

ΣIE =	7.76E+07	$k\text{-}in^2$	
% Steel Pipe =	92%		
% Conc Core =	8%		
	Casing essentialy provides all the flexural strength		

Capacity Check (see pier design sheet for demands)

ASD to LRFD ratio =	1.60		
M_{max} =	140	k-ft	Lpile output
M_u =	224.0	k-ft	
ϕM_n =	652.7	k-ft	(steel casing only, see above)
DCR =	**0.34**		
V_{max} =	19.2	k	Lpile output
V_u =	30.7	k	
ϕV_n =	167.9	k	(concrete only, see shear friction)
DCR =	**0.18**		

ZFA STRUCTURAL ENGINEERS

Job #
Title

Engineer:
Date:

Project Name
1

SHEAR FRICTION PER ACI 318 § 22.9

Location : Pier

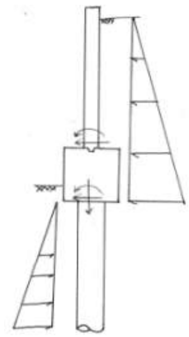
Surface : Concrete placed monolithically

μ =	1.40				
$\mu\,\lambda$ =	1.40		V_n Max *(§ 22.9.4.4)*		
A_c =	254	in^2	$0.2\,f'_c\,A_c$ =	254.5	k
Bar Size :	# 7		1600 Ac =	407.15	k
No. of Bars =	6		(480 + 0.08 f'c) Ac =	223.933	k
Bar Angle, α =	90	deg			
A_v =	3.6	in^2			
$V_n = A_v\,f_y\,(\mu \sin\alpha + \cos\alpha)$ =	302.4	k	*(Eq 22.9.4.2)*		
$\phi\,V_n$ =	167.9	k			
V_u =	52.16	k			
D/C =	**0.31**	**OK**			

Retaining Wall

Retaining Wall Loading

Wing walls and infill walls are supported on grade beams and piers
Grade beams are integral with the grade beams supporting the main arch



Use Active pressure

γ_{soil} = 42 pcf

Vehichle Surcharge

h = 2 ft
q = 84 psf

Wall dimensions

h_{max} = 9.5 ft wall abv BG
h_{GB} = 2.5 ft

Check Wall for bending and shear at base

σ_{active} = 399 psf
V = 1895 plf
at d = 3.17 ft abv base, triangular

$\sigma_{vehicle}$ = 84 psf
V = 798 plf
at d = 4.75 ft abv base, rectangular

ΣV = 2.69 k/ft
ΣM = 9.79 k-ft/ft

V_U = 3.77 k/ft 1.4D
M_U = 13.71 k-ft/ft 1.4D

See following pages for wall strength

Check grade beam to span to pier
Vertical

Wall t = 12 in
Wall h = 9.5 ft
GB b = 30 in
DB d = 30 in
A = 15.8 ft^2/ft
Unit Weight = 150 pcf
ω = 2.3625 klf (self weight)
ω_U = **3.3075** klf 1.4D

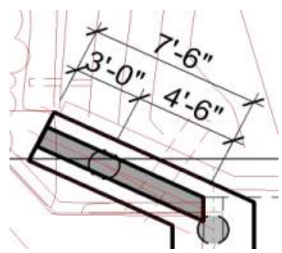
Horizontal

Σh =	12	ft	
σ_{active} =	504	psf	
V =	3024	plf	
at d =	4.00	ft	abv base, triangular
$\sigma_{vehicle}$ =	84	psf	
V =	1008	plf	
at d =	6	ft	abv base, rectangular
ΣV =	4.03	k/ft	
ΣM =	18.14	k-ft/ft	
ω_U =	**5.64**	k/ft	1.4D

See following pages for GB strength

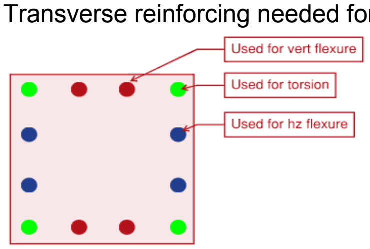
M_U =	25.40	k-ft/ft	1.4D Torque

Design for Torsion



bw =	30	in	
d =	30	in	
Torque =	305	k-in/ft	
span =	3.0	ft	
T_U =	914	k-in	
A_{cp} =	900	in^2	
p_{cp} =	120	in	
λ =	1		
f'c =	5000	psi	
T_{th} =	477	k-in	
ϕ =	0.75		
ϕT_{th} =	358	k-in	$T_{cr}/4$
DCR =	**2.55**		**Design for torsion is required** See following pages
T_u =	76	k-ft	
V_u =	19.6	k	SSRS vert+hz

Each longitudinal bar in the GB is used to resist only one type of loading
Transverse reinforcing needed for torsion is added to that used for shear

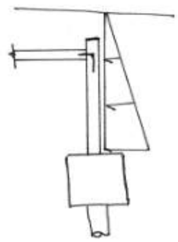


Cheack pier for vertical and horizontal loading with overturning moment

L =	5.25	ft	Trib to pier	
P_U =	12.4	k	vert load * length	ASD (1.0D)
V_U =	21.2	k	hz load * length	
M_u =	95.3	k-ft	torque * length	
M/V =	4.5	ft		

Infill Wall Loading

Wing walls and infill walls are supported on grade beams and piers
Grade beams are integral with the grade beams supporting the main arch
Infill walls are better than wing walls by observation because they are supported at the top by the precast arch



Use Active pressure

γ_{soil} =	42	pcf	

Vehichle Surcharge

h =	2	ft	
q =	84	psf	

Wall dimensions

h_{over} =	2	ft	
h_{max} =	7	ft	wall abv BG

Check Wall for bending at midspan

σ_{active} =	378	psf	concervatively apply full ht
$\sigma_{vehichle}$ =	84	psf	
ω =	462	plf	
$\omega L^2/8$ =	2.83	k-ft	
M_U =	**3.96**	k-ft/ft	1.4D

See following pages for wall strength

ZFA STRUCTURAL ENGINEERS
Job #
Concrete Beam Design

Engineer:
Date:

Project Name

DSA? NO

Beam: Retaining Wall at base

Properties			**Flexural Reinf.**			**Shear Reinf.**	
f'_c =	5000 psi		1.2	#6 bars		1 Legs	
f_y =	60 ksi		A_s =	0.53 in^2	OK	#4 @ 12 "oc	
f_{yt} =	60 ksi		$A_{s,min\ T\&S}$ =	0.26 in^2			
			$A_{s,min\ Flexure}$ =	0.26 in^2			
Beam Dimensions			$A_{s,min}$ =	0.26 in^2			
Width =	12.0 in		a =	0.62 in			
Depth =	12.0 in		β_1 =	0.80			
Cover =	3.0 in		c =	0.78 in			
d =	8.1 in		ε_s =	0.028			
			Clear Spacing =	20.5 in oc			
s_{bar} =	10.0 in						
			ϕ_b =	0.90			
			M_{ult} =	13.7 k-ft			
			$\phi_b\ M_n$ =	18.6 k-ft			
			DCR =	**0.74**	OK		

DSA? NO

Beam: Wall Grade beam vertical

Properties			**Flexural Reinf.**			**Shear Reinf.**	
f'_c =	5000 psi		2.0	#6 bars		2 Legs	
f_y =	60 ksi		A_s =	0.88 in^2	NG	#5 @ 24 "oc	
f_{yt} =	60 ksi		$A_{s,min\ T\&S}$ =	1.62 in^2			
			$A_{s,min\ Flexure}$ =	1.62 in^2		ϕ_v =	0.75
Beam Dimensions			$A_{s,min}$ =	1.62 in^2		V_{ult} =	19.8 k
Width =	30.0 in		a =	0.41 in		V_c =	110.3 k
Depth =	30.0 in		β_1 =	0.80		$V_{s,max}$ =	441.2 k
Cover =	3.0 in		c =	0.52 in		V_s =	40.3 k
d =	26.0 in		ε_s =	0.148		$V_{s,gov}$ =	40.3 k
			Clear Spacing =	21.3 in oc		$\phi_v\ V_n$ =	113.0 k
ω =	3.31 klf					**DCR =**	**0.18** OK
			ϕ_b =	0.90			
			M_{ult} =	41.3 k-ft			
			$\phi_b\ M_n$ =	102.1 k-ft			
			DCR =	**0.40**	OK		

Continuous Span

L =	6 ft	
M =	9.92 k-ft	$wL^2/12$
V =	9.92 k	wL/2

Cantilever Span

L =	5 ft	
M =	41.34 k-ft	$wL^2/2$
V =	19.85 k	wL

Mmax =	**41.34** k-ft
Vmax =	**19.85** k

ZFA STRUCTURAL ENGINEERS
Job #
Concrete Beam Design

Engineer:
Date:

Project Name

DSA? NO

Beam: Wall Grade beam horizontal

Properties

f'_c = 5000 psi
f_y = 60 ksi
f_{yt} = 60 ksi

Beam Dimensions

Width = 30.0 in
Depth = 30.0 in
Cover = 3.0 in
d = 26.0 in

ω = 5.64 klf

Flexural Reinf.

2.0 #6 bars
A_s = 0.88 in^2 NG
$A_{s,min\ T\&S}$ = 1.62 in^2
$A_{s,min\ Flexure}$ = 1.62 in^2
$A_{s,min}$ = 1.62 in^2
a = 0.41 in
β_1 = 0.80
c = 0.52 in
ε_s = 0.148
Clear Spacing = 21.3 in oc

ϕ_b = 0.90
M_{ult} = 70.6 k-ft
$\phi_b M_n$ = 102.1 k-ft
DCR = 0.69 OK

Shear Reinf.

2 Legs
#5 @ 24 "oc

ϕ_v = 0.75
V_{ult} = 33.9 k
V_c = 110.3 k
$V_{s,max}$ = 441.2 k
V_s = 40.3 k
$V_{s,gov}$ = 40.3 k
$\phi_v V_n$ = 113.0 k
DCR = 0.30 OK

Continuous Span

L = 6 ft
M = 16.93 k-ft $wL^2/12$
V = 16.93 k $wL/2$

Cantilever Span

L = 5 ft
M = 70.56 k-ft $wL^2/2$
V = 33.87 k wL

Mmax = 70.56 k-ft
Vmax = 33.87 k

DSA? NO

Beam: Infill Wall

Properties

f'_c = 5000 psi
f_y = 60 ksi
f_{yt} = 60 ksi

Beam Dimensions

Width = 12.0 in
Depth = 8.0 in
Cover = 3.0 in
d = 4.2 in

s_{bar} = 12.0 in

Flexural Reinf.

1.0 #5 bars
A_s = 0.31 in^2 OK
$A_{s,min\ T\&S}$ = 0.17 in^2
$A_{s,min\ Flexure}$ = 0.17 in^2
$A_{s,min}$ = 0.17 in^2
a = 0.36 in
β_1 = 0.80
c = 0.46 in
ε_s = 0.025
Clear Spacing = #DIV/0! in oc

ϕ_b = 0.90
M_{ult} = 4.0 k-ft
$\phi_b M_n$ = 5.6 k-ft
DCR = 0.71 OK

Shear Reinf.

1 Legs
#4 @ 24 "oc

Design for Torsion in Concrete Beams (ACI 318-14 22.7)

Demand Loads

T_u =	76.2	k-ft
V_u =	19.6	k

Beam Geometry

b =	30	in
h =	30	in
Cover Top =	3	in
Cover Bottom =	3	in
Cover Side 1 =	3	in
Cover Side 2 =	3	in
d_{max} =	27	in

Material Properties

f'_c =	5	ksi
f_y =	60	ksi
f_{yt} =	60	ksi

Threshold Torsion

ϕ =	0.75	
λ =	1.0	
A_{cp} =	900	in^2
p_{cp} =	120	in

$\phi\lambda\sqrt{f'_c}\left(\frac{A_{cp}^2}{p_{cp}}\right)$ = 29.8 kip-ft < 76.2 kip-ft §11.5.1

Provide additional reinforcement to resist torsion.

ZFA STRUCTURAL ENGINEERS
Job # 16000 | Engineer: | Project Name
Beam Torsion | Date | 2

Design of Stirrups to Resist Torsion

Stirrup size = #5 @ 24" oc
d = 0.63 in
A_t = 0.31 in^2

A_{oh} = 518 in^2
$A_o = 0.85A_{oh}$ = 440 in^2
θ = 45 °

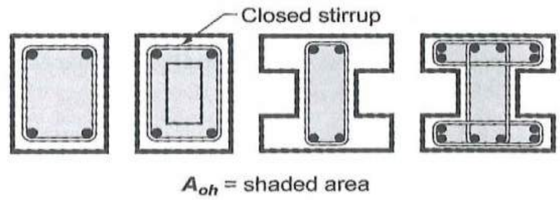


Fig. R11.5.3.6(b)—Definition of A_{oh}.

$$T_n = \frac{2A_oA_tf_{yt}}{s}\cot\theta = 682 \text{ kip-in}$$

ϕT_n = 511 kip-in   DCR = 0.15   OK

Design of additional longitudinal reinforcement

p_h = 91 in

$$A_\ell = \frac{A_t}{s}p_h\left(\frac{f_{yt}}{f_y}\right)\cot^2\theta_l = 1.18 \text{ in}^2$$

Provide: (4) #6
$A_{l,provided}$ = 1.76 in^2 OK

Verify torsional moment strength

V_c = 114.6 kips

$$\sqrt{\left(\frac{V_u}{b_wd}\right)^2+\left(\frac{T_up_h}{1.7A_{oh}^2}\right)^2} = 28.6 \quad < \quad \phi\left(\frac{V_c}{b_wd}+8\sqrt{f'_c}\right) = 530$$

OK

ZFA STRUCTURAL ENGINEERS

Job #
Title

Engineer:
Date:

Project Name
1

SHEAR FRICTION PER ACI 318 § 22.9

f'_c = 5000 psi f_y = 60 ksi   λ = 1.00   ϕ = 0.75

Location : Base of retaining wall

Surface : Concrete placed against hardened concrete with surface intentionally roughened

μ = 1.00

μ λ = 1.00

A_c = 144 in^2

Bar Size : # 6

No. of Bars = 1.2

Bar Angle, α = 90 deg

A_v = 0.528 in^2

$V_n = A_v f_y (\mu \sin\alpha + \cos\alpha)$ = 31.68 k   *(Eq 22.9.4.2)*

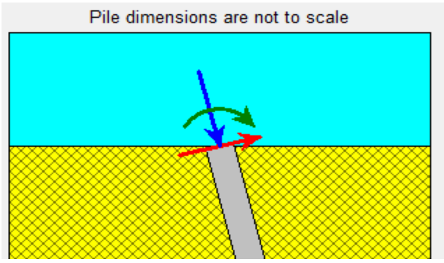
V_n Max *(§ 22.9.4.4)*		
0.2 f'_c A_c =	144.0	k
1600 Ac =	230.4	k
(480 + 0.08 f'c) Ac =	126.72	k

ϕ V_n = 23.76 k

V_u = 3.77 k

D/C = 0.16 OK

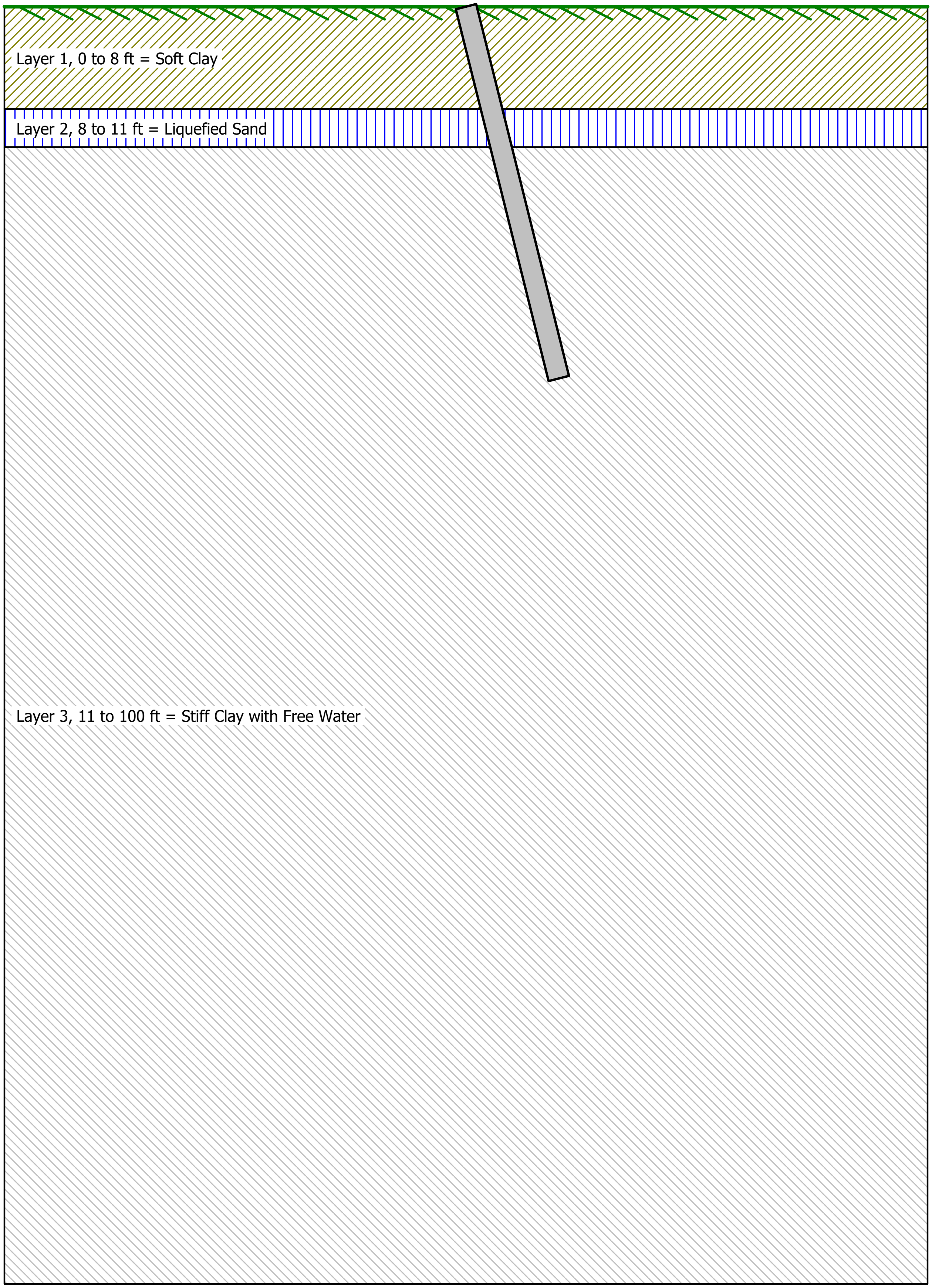
Battered Pier



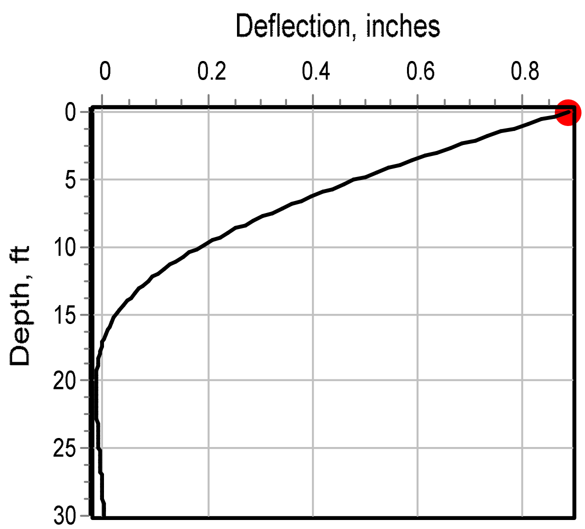
DO NOT PRINT

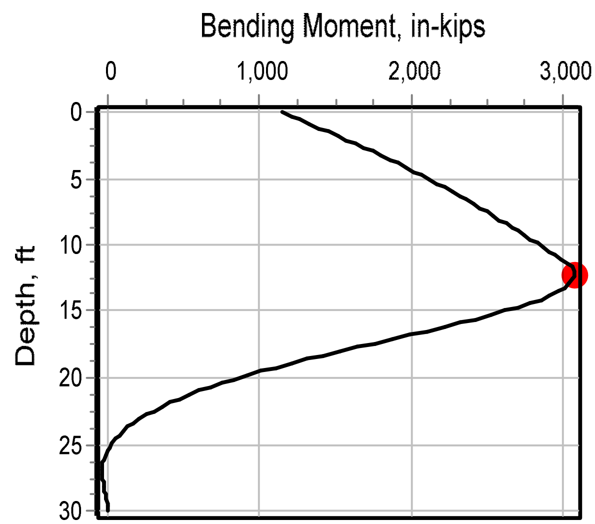
	Batter =	4 :1		V:H				
	α =	14.0		Batter angle			0.244979 rad	
	Vert (k)	Horiz (k)	M (k-ft)	Axial	Shear	Moment		
Max	12.4	21.2	95.3	**17.2**	**17.5**	**95.3**	24.53409	24.53409

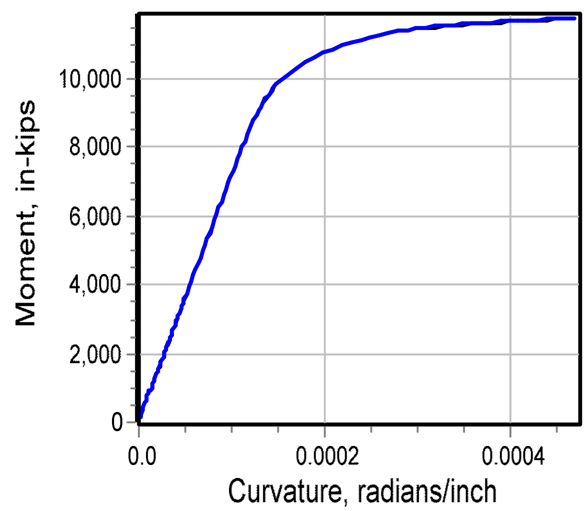
RETAINING WALL PILES

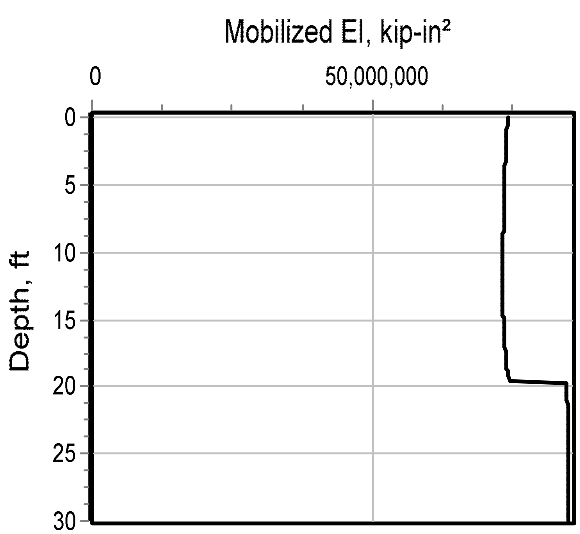


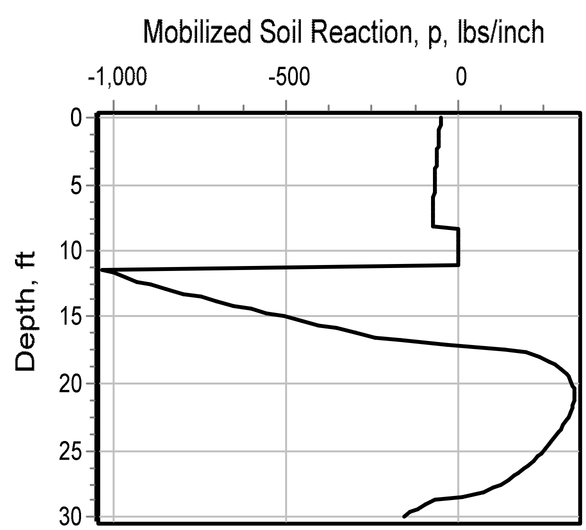
RETAINING WALL PILES











RETAINING WALL PILES

```
===============================================================================

                 LPile for Windows, Version 2019-11.005

             Analysis of Individual Piles and Drilled Shafts
            Subjected to Lateral Loading Using the p-y Method
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===============================================================================

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-------------------------------------------------------------------------------
                          Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\\Zfa.com\sr\Projects\2010-2015\2013\13415 Evaluation of First and F Street bridge
in Petaluma\Calculations\

Name of input data file:
2020-10-22-LPile_AT RET WALL_20in-shed80-batter.lp11d

Name of output report file:
2020-10-22-LPile_AT RET WALL_20in-shed80-batter.lp11o

Name of plot output file:
2020-10-22-LPile_AT RET WALL_20in-shed80-batter.lp11p

Name of runtime message file:
2020-10-22-LPile_AT RET WALL_20in-shed80-batter.lp11r


-------------------------------------------------------------------------------
                         Date and Time of Analysis
-------------------------------------------------------------------------------
```

RETAINING WALL PILES

```
               Date:  January 25, 2021           Time:  11:42:43


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: 1st and F Bridge


Job Number: 13415


Client:


Engineer: MJR


Description:




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed                  =          500
 - Deflection tolerance for convergence                  =   1.0000E-05 in
 - Maximum allowable deflection                          =      50.0000 in
 - Number of pile increments                             =          100

Loading Type and Number of Cycles of Loading:
 - Static loading specified
```

RETAINING WALL PILES

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	30.000 ft
Depth of ground surface below top of pile	=	0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	19.8500 ← 20" - corrosion
2	30.000	19.8500

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 30.000000 ft

RETAINING WALL PILES

```
   Casing outside diameter                            =    19.850000 in
   Shear capacity of section                          =       0.0000 lbs



--------------------------------------------------------------------------------
                      Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                    =        0.000 degrees
                                                      =        0.000 radians

Pile Batter Angle                                     =      -14.000 degrees
                                                      =       -0.244 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 3 layers
```

soil properties as provided by Geo

```
Layer 1 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =       0.0000 ft
   Distance from top of pile to bottom of layer       =     8.000000 ft
   Effective unit weight at top of layer              =    43.000000 pcf
   Effective unit weight at bottom of layer           =    43.000000 pcf
   Undrained cohesion at top of layer                 =   300.000000 psf
   Undrained cohesion at bottom of layer              =   300.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 2 is liquefiable sand, by Rollins et al., 2004

   Distance from top of pile to top of layer          =     8.000000 ft
   Distance from top of pile to bottom of layer       =    11.000000 ft
   Effective unit weight at top of layer              =    60.000000 pcf
   Effective unit weight at bottom of layer           =    60.000000 pcf


Layer 3 is stiff clay with water-induced erosion

   Distance from top of pile to top of layer          =    11.000000 ft
   Distance from top of pile to bottom of layer       =   100.000000 ft
   Effective unit weight at top of layer              =    60.000000 pcf
```

RETAINING WALL PILES

```
Effective unit weight at bottom of layer            =    60.000000 pcf
Undrained cohesion at top of layer                  =        1500. psf
Undrained cohesion at bottom of layer               =        1500. psf
Epsilon-50 at top of layer                          =       0.0000
Epsilon-50 at bottom of layer                       =       0.0000
Subgrade k at top of layer                          =       0.0000 pci
Subgrade k at bottom of layer                       =       0.0000 pci
```

NOTE: Default values for Epsilon-50 will be computed for this layer.

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 70.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	E50 or krm	kpy pci
1	Soft	0.00	43.0000	300.0000	default	--
	Clay	8.0000	43.0000	300.0000	default	--
2	Liquefied	8.0000	60.0000	--	--	--
	Sand	11.0000	60.0000	--	--	--
3	Stiff Clay	11.0000	60.0000	1500.	default	default
	with Free Water	100.0000	60.0000	1500.	default	default

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

RETAINING WALL PILES

```
--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 2

Load    Load         Condition                    Condition            Axial Thrust
Compute Top y       Run Analysis
 No.    Type            1                            2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   -----------------
---------------    ------------
   1     1     V =       21200. lbs   M =     1143600. in-lbs              12400.
    No                No
   2     1     V =       17570. lbs   M =     1143072. in-lbs              17160.
    No                Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.
```

WALL BATTERED PIER

```
--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                       =    30.000000 ft
Outer Diameter of Casing                                =    19.850000 in
Concrete Cover Thickness Inside Casing                  =     1.500000 in
Casing Wall Thickness                                   =     0.800000 in
Moment of Inertia of Steel Casing                       =        2176. in^4
Yield Stress of Casing                                  =       35000. psi
Elastic Modulus of Casing                               =    29000000. psi
Number of Reinforcing Bars                              =            6 bars
```

RETAINING WALL PILES

```
Area of Single Reinforcing Bar                             =     0.440000 sq. in.
Edge-to-Edge Bar Spacing                                   =     6.500000 in
Maximum Concrete Aggregate Size                            =     0.750000 in
Ratio of Bar Spacing to Aggregate Size                     =         8.67
Offset of Center of Rebar Cage from Center of Pile         =       0.0000 in
Yield Stress of Reinforcing Bars                           =       60000. psi
Modulus of Elasticity of Reinforcing Bars                  =    29000000. psi
Gross Area of Pile                                         =   309.464548 sq. in.
Area of Concrete                                           =   258.946676 sq. in.
Cross-sectional Area of Steel Casing                       =    47.877872 sq. in.
Area of All Steel (Casing and Bars)                        =    50.517872 sq. in.
Area Ratio of All Steel to Gross Area of Pile              =        16.32 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As        =     2494.440 kips
Tensile Load for Cracking of Concrete                      =     -263.625 kips
Nominal Axial Tensile Capacity                             =    -1834.126 kips


Reinforcing Bar Dimensions and Positions Used in Computations:
```

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	0.750000	0.440000	7.250000	0.00000
2	0.750000	0.440000	3.625000	6.278684
3	0.750000	0.440000	-3.625000	6.278684
4	0.750000	0.440000	-7.250000	0.00000
5	0.750000	0.440000	-3.625000	-6.278684
6	0.750000	0.440000	3.625000	-6.278684

```
NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero =  6.500 inches
between bars 5 and 6.

Ratio of bar spacing to maximum aggregate size = 8.67


Concrete Properties:
--------------------

Compressive Strength of Concrete                           =        3000. psi
Modulus of Elasticity of Concrete                          =     3122019. psi
Modulus of Rupture of Concrete                             =  -410.791918 psi
Compression Strain at Peak Stress                          =     0.001634
Tensile Strain at Fracture of Concrete                     =   -0.0001160
```

RETAINING WALL PILES

Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
1	12.400
2	17.160

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 12.400 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Max Casing Stress ksi	Run Msg
0.00000125	105.9918113	84793449.	14.0360054	0.00001755	-0.00000727	0.0636453	0.3900774	0.5052074	
0.00000250	211.8934002	84757360.	11.9827731	0.00002996	-0.00001967	0.1081271	0.6312954	0.8615554	
0.00000375	317.6788530	84714361.	11.2984192	0.00004237	-0.00003207	0.1522702	0.8725197	1.2179097	
0.00000500	423.3474056	84669481.	10.9562552	0.00005478	-0.00004447	0.1960740	1.1137458	1.5742658	
0.00000625	528.8989612	84623834.	10.7509622	0.00006719	-0.00005687	0.2395384	1.3549729	1.9306229	
0.00000750	634.3334960	84577799.	10.6141035	0.00007961	-0.00006927				

RETAINING WALL PILES

0.2826633	1.5962007	2.2869807			
0.00000875	739.6510020	84531543.	10.5163495	0.00009202	-0.00008167
0.3254489	1.8374290	2.6433390			
0.00001000	844.8514754	84485148.	10.4430358	0.0001044	-0.00009407
0.3678949	2.0786579	2.9996979			
0.00001125	949.9349155	84438659.	10.3860156	0.0001168	-0.0001065
0.4100016	2.3198873	3.3560573			
0.00001250	949.9349155	75994793.	9.5016146	0.0001188	-0.0001294
0.4161526	-2.5640116	-3.7153116 C			
0.00001375	1016.	73906300.	9.4558859	0.0001300	-0.0001429
0.4539326	-2.8386470	-4.1050770 C			
0.00001500	1107.	73819833.	9.4179331	0.0001413	-0.0001565
0.4914421	-3.1132153	-4.4947753 C			
0.00001625	1198.	73744292.	9.3858716	0.0001525	-0.0001700
0.5286760	-3.3877589	-4.8844489 C			
0.00001750	1289.	73677455.	9.3585894	0.0001638	-0.0001836
0.5656431	-3.6622015	-5.2740215 C			
0.00001875	1380.	73617579.	9.3351308	0.0001750	-0.0001972
0.6023431	-3.9365429	-5.6634929 C			
0.00002000	1471.	73563356.	9.3147793	0.0001863	-0.0002107
0.6387757	-4.2107830	-6.0528630 C			
0.00002125	1562.	73513785.	9.2969868	0.0001976	-0.0002243
0.6749407	-4.4849215	-6.4421315 C			
0.00002250	1653.	73468088.	9.2813271	0.0002088	-0.0002378
0.7108379	-4.7589584	-6.8312984 C			
0.00002375	1744.	73425652.	9.2674637	0.0002201	-0.0002513
0.7464670	-5.0328934	-7.2203634 C			
0.00002500	1835.	73385986.	9.2551274	0.0002314	-0.0002649
0.7818277	-5.3067264	-7.6093264 C			
0.00002625	1925.	73348690.	9.2441002	0.0002427	-0.0002784
0.8169199	-5.5804571	-7.9981871 C			
0.00002750	2016.	73313441.	9.2342040	0.0002539	-0.0002919
0.8517432	-5.8540854	-8.3869454 C			
0.00002875	2107.	73279956.	9.2252560	0.0002652	-0.0003055
0.8862944	-6.1276406	-8.7756306 C			
0.00003000	2197.	73248016.	9.2171467	0.0002765	-0.0003190
0.9205739	-6.4011149	-9.1642349 C			
0.00003125	2288.	73217444.	9.2098005	0.0002878	-0.0003325
0.9545841	-6.6744855	-9.5527355 C			
0.00003250	2379.	73188080.	9.2031296	0.0002991	-0.0003460
0.9883246	-6.9477523	-9.9411323 C			
0.00003375	2469.	73159787.	9.1970590	0.0003104	-0.0003595
1.0217952	-7.2209151	-10.3294251 C			
0.00003500	2560.	73132451.	9.1915247	0.0003217	-0.0003730
1.0549956	-7.4939737	-10.7176137 C			
0.00003625	2650.	73105969.	9.1864713	0.0003330	-0.0003866
1.0879256	-7.7669280	-11.1056980 C			
0.00003750	2741.	73080256.	9.1818510	0.0003443	-0.0004001
1.1205850	-8.0397778	-11.4936778 C			
0.00003875	2831.	73055235.	9.1776219	0.0003556	-0.0004136

RETAINING WALL PILES

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1.1529734    -8.3125228   -11.8815528 C
0.00004000        2921.     73030840.     9.1737476    0.0003669    -0.0004271
1.1850906    -8.5851629   -12.2693229 C
0.00004125        3012.     73007012.     9.1701959    0.0003783    -0.0004405
1.2169364    -8.8576979   -12.6569879 C
0.00004250        3102.     72983701.     9.1669386    0.0003896    -0.0004540
1.2485106    -9.1301276   -13.0445476 C
0.00004375        3192.     72960860.     9.1639506    0.0004009    -0.0004675
1.2798128    -9.4024518   -13.4320018 C
0.00004500        3282.     72938449.     9.1612096    0.0004123    -0.0004810
1.3108428    -9.6746704   -13.8193504 C
0.00004625        3372.     72916432.     9.1586956    0.0004236    -0.0004945
1.3416003    -9.9467830   -14.2065930 C
0.00004750        3463.     72894776.     9.1563910    0.0004349    -0.0005079
1.3720851   -10.2187896   -14.5937296 C
0.00004875        3553.     72873453.     9.1542797    0.0004463    -0.0005214
1.4022970   -10.4906900   -14.9807600 C
0.00005125        3733.     72831703.     9.1505811    0.0004690    -0.0005483
1.4619008   -11.0341712   -15.7545012 C
0.00005375        3913.     72791000.     9.1475007    0.0004917    -0.0005753
1.5204095   -11.5772251   -16.5278151 C
0.00005625        4092.     72751197.     9.1449570    0.0005144    -0.0006022
1.5778212   -12.1198501   -17.3007001 C
0.00005875        4272.     72712171.     9.1428825    0.0005371    -0.0006290
1.6341336   -12.6620446   -18.0731546 C
0.00006125        4451.     72673818.     9.1412205    0.0005599    -0.0006559
1.6893447   -13.2038070   -18.8451770 C
0.00006375        4631.     72636051.     9.1399235    0.0005827    -0.0006828
1.7434523   -13.7451359   -19.6167659 C
0.00006625        4810.     72598797.     9.1389508    0.0006055    -0.0007096
1.7964543   -14.2860295   -20.3879195 C
0.00006875        4989.     72561993.     9.1382681    0.0006283    -0.0007364
1.8483486   -14.8264862   -21.1586362 C
0.00007125        5167.     72525583.     9.1378454    0.0006511    -0.0007632
1.8991329   -15.3665044   -21.9289144 C
0.00007375        5346.     72489522.     9.1376572    0.0006739    -0.0007900
1.9488051   -15.9060826   -22.6987526 C
0.00007625        5525.     72453769.     9.1376811    0.0006967    -0.0008168
1.9973630   -16.4452189   -23.4681489 C
0.00007875        5703.     72418287.     9.1378977    0.0007196    -0.0008436
2.0448044   -16.9839118   -24.2371018 C
0.00008125        5881.     72383045.     9.1382898    0.0007425    -0.0008703
2.0911271   -17.5221597   -25.0056097 C
0.00008375        6059.     72348015.     9.1388425    0.0007654    -0.0008971
2.1363288   -18.0599608   -25.7736708 C
0.00008625        6237.     72313174.     9.1395424    0.0007883    -0.0009238
2.1804074   -18.5973134   -26.5412834 C
0.00008875        6415.     72278499.     9.1403778    0.0008112    -0.0009505
2.2233605   -19.1342158   -27.3084458 C
0.00009125        6592.     72243971.     9.1413382    0.0008341    -0.0009772
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RETAINING WALL PILES

2.2651859	-19.6706663	-28.0751563 C			
0.00009375	6770.	72209572.	9.1424143	0.0008571	-0.0010038
2.3058813	-20.2066633	-28.8414133 C			
0.00009625	6947.	72175287.	9.1435975	0.0008801	-0.0010305
2.3454444	-20.7422048	-29.6072148 C			
0.00009875	7124.	72141102.	9.1448805	0.0009031	-0.0010571
2.3838729	-21.2772893	-30.3725593 C			
0.0001013	7301.	72107004.	9.1462563	0.0009261	-0.0010838
2.4211645	-21.8119149	-31.1374449 C			
0.0001038	7478.	72072982.	9.1477190	0.0009491	-0.0011104
2.4573169	-22.3460799	-31.9018699 C			
0.0001063	7654.	72039024.	9.1492629	0.0009721	-0.0011370
2.4923277	-22.8797824	-32.6658324 C			
0.0001088	7831.	72005122.	9.1508831	0.0009952	-0.0011635
2.5261945	-23.4130207	-33.4293307 C			
0.0001113	8007.	71971267.	9.1525748	0.0010182	-0.0011901
2.5589150	-23.9457930	-34.1923630 C			
0.0001138	8183.	71937451.	9.1543341	0.0010413	-0.0012166
2.5904868	-24.4780974	-34.9549274 C			
0.0001163	8354.	71864748.	9.1540748	0.0010642	-0.0012434
2.6205914	-25.0169523	-35.0000000 CY			
0.0001188	8516.	71717361.	9.1497814	0.0010865	-0.0012707
2.6489436	-25.5697353	-35.0000000 CY			
0.0001213	8667.	71482645.	9.1406281	0.0011083	-0.0012985
2.6754574	-26.1402308	-35.0000000 CY			
0.0001238	8806.	71161827.	9.1265552	0.0011294	-0.0013270
2.7001708	-26.7297087	-35.0000000 CY			
0.0001263	8936.	70781604.	9.1089828	0.0011500	-0.0013561
2.7233346	-27.3340400	-35.0000000 CY			
0.0001288	9059.	70360908.	9.0889353	0.0011702	-0.0013855
2.7451322	-27.9501636	-35.0000000 CY			
0.0001313	9176.	69910177.	9.0669716	0.0011900	-0.0014153
2.7656747	-28.5764810	-35.0000000 CY			
0.0001338	9287.	69436724.	9.0434858	0.0012096	-0.0014454
2.7850462	-29.2118907	-35.0000000 CY			
0.0001363	9393.	68938761.	9.0192943	0.0012289	-0.0014757
2.8033812	-29.8534939	35.0000000 CY			
0.0001388	9493.	68419691.	8.9947712	0.0012480	-0.0015062
2.8207491	-30.4999400	35.0000000 CY			
0.0001413	9586.	67866625.	8.9718970	0.0012673	-0.0015365
2.8374085	-31.1431860	35.0000000 CY			
0.0001438	9674.	67295334.	8.9497955	0.0012865	-0.0015669
2.8532528	-31.7865287	35.0000000 CY			
0.0001463	9756.	66705649.	8.9287083	0.0013058	-0.0015972
2.8683141	-32.4287740	35.0000000 CY			
0.0001488	9830.	66085623.	8.9099975	0.0013254	-0.0016273
2.8827403	-33.0638261	35.0000000 CY			
0.0001588	10088.	63544392.	8.8454245	0.0014042	-0.0017470
2.9324617	-35.5838841	35.0000000 CY			
0.0001688	10295.	61010300.	8.7919166	0.0014836	-0.0018661

RETAINING WALL PILES

2.9687700	-38.0872412	35.0000000 CY			
0.0001788	10469.	58566736.	8.7455254	0.0015633	-0.0019849
2.9912867	-40.5847446	35.0000000 CY			
0.0001888	10617.	56250835.	8.7045767	0.0016430	-0.0021037
2.9999027	-43.0793609	35.0000000 CY			
0.0001988	10746.	54068210.	8.6687533	0.0017229	-0.0022223
2.9999033	-45.5681879	35.0000000 CY			
0.0002088	10860.	52022456.	8.6365192	0.0018029	-0.0023408
2.9996693	-48.0560643	35.0000000 CY			
0.0002188	10960.	50104121.	8.6073676	0.0018829	-0.0024593
2.9987802	-50.5430812	35.0000000 CY			
0.0002288	11050.	48307812.	8.5817221	0.0019631	-0.0025776
2.9998630	-53.0237484	35.0000000 CY			
0.0002388	11132.	46626577.	8.5590168	0.0020435	-0.0026957
2.9985302	-55.4989321	35.0000000 CY			
0.0002488	11206.	45050834.	8.5386731	0.0021240	-0.0028137
2.9991173	-57.9702493	35.0000000 CY			
0.0002588	11274.	43571255.	8.5204581	0.0022047	-0.0029315
2.9995703	-60.0000000	35.0000000 CY			
0.0002688	11332.	42166266.	8.5019533	0.0022849	-0.0030498
2.9997301	-60.0000000	35.0000000 CY			
0.0002788	11377.	40814849.	8.4794015	0.0023636	-0.0031696
2.9996787	-60.0000000	35.0000000 CY			
0.0002888	11414.	39530350.	8.4553459	0.0024415	-0.0032902
2.9993964	-60.0000000	35.0000000 CY			
0.0002988	11448.	38318473.	8.4333922	0.0025195	-0.0034107
2.9987562	-60.0000000	35.0000000 CY			
0.0003088	11478.	37176927.	8.4120739	0.0025972	-0.0035315
2.9974566	-60.0000000	35.0000000 CY			
0.0003188	11507.	36099136.	8.3925620	0.0026751	-0.0036521
2.9999934	-60.0000000	35.0000000 CY			
0.0003288	11533.	35079877.	8.3738273	0.0027529	-0.0037728
2.9994228	-60.0000000	35.0000000 CY			
0.0003388	11556.	34114323.	8.3562932	0.0028307	-0.0038935
2.9975336	-60.0000000	35.0000000 CY			
0.0003488	11579.	33201044.	8.3398088	0.0029085	-0.0040142
2.9999629	-60.0000000	35.0000000 CY			
0.0003588	11599.	32331869.	8.3242790	0.0029863	-0.0041349
2.9985547	-60.0000000	35.0000000 CY			
0.0003688	11619.	31508147.	8.3094489	0.0030641	-0.0042556
2.9993329	-60.0000000	35.0000000 CY			
0.0003788	11636.	30723267.	8.2955119	0.0031419	-0.0043763
2.9987860	-60.0000000	35.0000000 CY			
0.0003888	11653.	29976685.	8.2826577	0.0032199	-0.0044968
2.9990853	-60.0000000	35.0000000 CY			
0.0003988	11669.	29264773.	8.2695803	0.0032975	-0.0046177
2.9983912	-60.0000000	35.0000000 CY			
0.0004088	11685.	28586000.	8.2583566	0.0033756	-0.0047381
2.9999935	-60.0000000	35.0000000 CY			
0.0004188	11698.	27935958.	8.2469888	0.0034534	-0.0048588

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   2.9971472    60.0000000    35.0000000 CY
    0.0004288         11711.     27315223.     8.2367313     0.0035315    -0.0049792
   2.9996765    60.0000000    35.0000000 CY
    0.0004388         11723.     26719568.     8.2272295     0.0036097    -0.0050995
   2.9965579    60.0000000    35.0000000 CY
    0.0004488         11733.     26146303.     8.2197107     0.0036886    -0.0052191
   2.9983535    60.0000000    35.0000000 CY
    0.0004588         11742.     25596676.     8.2134229     0.0037679    -0.0053383
   2.9999647    60.0000000    35.0000000 CY
    0.0004688         11750.     25067007.     8.2082107     0.0038476    -0.0054571
   2.9951609    60.0000000    35.0000000 CY


Axial Thrust Force =      17.160 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens
  Max Conc      Max Steel     Max Casing  Run
   Curvature      Moment       Stiffness     N Axis        Strain        Strain
   Stress        Stress        Stress    Msg
    rad/in.       in-kip       kip-in2         in           in/in         in/in
     ksi           ksi           ksi
------------- ------------- ------------- ------------- ------------- -------------
------------- ------------- ------------- ---
   0.00000125   105.9685537     84774843.    15.6148456    0.00001952   -0.00000529
   0.0708124     0.4473103     0.5624403
   0.00000250   211.8672200     84746888.    12.7729220    0.00003193   -0.00001769
   0.1152462     0.6885812     0.9188412
   0.00000375   317.6520559     84707215.    11.8257568    0.00004435   -0.00003009
   0.1593424     0.9298676     1.2752576
   0.00000500   423.3203496     84664070.    11.3522047    0.00005676   -0.00004249
   0.2030995     1.1711584     1.6316784
   0.00000625   528.8717504     84619480.    11.0680851    0.00006918   -0.00005489
   0.2465172     1.4124514     1.9881014
   0.00000750   634.3061719     84574156.    10.8786783    0.00008159   -0.00006728
   0.2895954     1.6537457     2.3445257
   0.00000875   739.6235843     84528410.    10.7433917    0.00009400   -0.00007968
   0.3323341     1.8950410     2.7009510
   0.00001000   844.8239736     84482397.    10.6419296     0.0001064   -0.00009208
   0.3747332     2.1363371     3.0573771
   0.00001125   949.9073360     84436208.    10.5630171     0.0001188    -0.0001045
   0.4167928     2.3776340     3.4138040
   0.00001250   949.9073360     75992587.     9.7012786     0.0001213    -0.0001269
   0.4246531    -2.4916334    -3.6429334 C
   0.00001375         1021.     74226271.     9.6378811     0.0001325    -0.0001404
   0.4623930    -2.7660764    -4.0325064 C
   0.00001500         1112.     74112401.     9.5849982     0.0001438    -0.0001540
   0.4998518    -3.0405420    -4.4221020 C
   0.00001625         1203.     74013728.     9.5404039     0.0001550    -0.0001675
   0.5370403    -3.3149355    -4.8116255 C
   0.00001750         1294.     73927059.     9.5023784     0.0001663    -0.0001811
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RETAINING WALL PILES

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0.5739615    -3.5892286    -5.2010486 C
0.00001875         1385.    73849991.     9.4696080     0.0001776    -0.0001946
0.6106154    -3.8634209    -5.5903709 C
0.00002000         1476.    73780721.     9.4411079     0.0001888    -0.0002082
0.6470015    -4.1375123    -5.9795923 C
0.00002125         1567.    73717800.     9.4160356     0.0002001    -0.0002217
0.6831136    -4.4115577    -6.3687677 C
0.00002250         1657.    73660175.     9.3938275     0.0002114    -0.0002353
0.7189521    -4.6855519    -6.7578919 C
0.00002375         1748.    73607065.     9.3741052     0.0002226    -0.0002488
0.7545224    -4.9594441    -7.1469141 C
0.00002500         1839.    73557791.     9.3564959     0.0002339    -0.0002623
0.7898243    -5.2332341    -7.5358341 C
0.00002625         1930.    73511803.     9.3406982     0.0002452    -0.0002759
0.8248576    -5.5069219    -7.9246519 C
0.00002750         2020.    73468649.     9.3264651     0.0002565    -0.0002894
0.8596219    -5.7805072    -8.3133672 C
0.00002875         2111.    73427960.     9.3135928     0.0002678    -0.0003029
0.8941171    -6.0539898    -8.7019798 C
0.00003000         2202.    73389425.     9.3019115     0.0002791    -0.0003164
0.9283428    -6.3273695    -9.0904895 C
0.00003125         2292.    73352783.     9.2912783     0.0002904    -0.0003300
0.9622989    -6.6006462    -9.4788962 C
0.00003250         2383.    73317814.     9.2815726     0.0003017    -0.0003435
0.9959851    -6.8738197    -9.8671997 C
0.00003375         2473.    73284331.     9.2726915     0.0003130    -0.0003570
1.0294012    -7.1468897   -10.2553997 C
0.00003500         2564.    73252173.     9.2645468     0.0003243    -0.0003705
1.0625468    -7.4198562   -10.6434962 C
0.00003625         2654.    73221201.     9.2570625     0.0003356    -0.0003840
1.0954218    -7.6927190   -11.0314890 C
0.00003750         2745.    73191295.     9.2501728     0.0003469    -0.0003975
1.1280259    -7.9654777   -11.4193777 C
0.00003875         2835.    73162351.     9.2438202     0.0003582    -0.0004110
1.1603588    -8.2381324   -11.8071624 C
0.00004000         2925.    73134277.     9.2379546     0.0003695    -0.0004245
1.1924203    -8.5106827   -12.1948427 C
0.00004125         3016.    73106991.     9.2325318     0.0003808    -0.0004380
1.2242102    -8.7831285   -12.5824185 C
0.00004250         3106.    73080419.     9.2274934     0.0003922    -0.0004515
1.2557258    -9.0554936   -12.9699136 C
0.00004375         3196.    73054497.     9.2228106     0.0004035    -0.0004649
1.2869675    -9.3277731   -13.3573231 C
0.00004500         3286.    73029176.     9.2184691     0.0004148    -0.0004784
1.3179368    -9.5999466   -13.7446266 C
0.00004625         3376.    73004406.     9.2144412     0.0004262    -0.0004919
1.3486337    -9.8720142   -14.1318242 C
0.00004750         3467.    72980142.     9.2107024     0.0004375    -0.0005054
1.3790577   -10.1439756   -14.5189156 C
0.00004875         3557.    72956344.     9.2072305     0.0004489    -0.0005188
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RETAINING WALL PILES

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  1.4092086   -10.4158307   -14.9059007 C
 0.00005125          3737.    72910003.      9.2010101      0.0004716     -0.0005458
  1.4686903   -10.9592211   -15.6795511 C
 0.00005375          3917.    72865135.      9.1956427      0.0004943     -0.0005727
  1.5270766   -11.5021837   -16.4527737 C
 0.00005625          4096.    72821536.      9.1910155      0.0005170     -0.0005996
  1.5843655   -12.0447171   -17.2255671 C
 0.00005875          4276.    72779034.      9.1870350      0.0005397     -0.0006264
  1.6405547   -12.5868196   -17.9979296 C
 0.00006125          4455.    72737487.      9.1836229      0.0005625     -0.0006533
  1.6956423   -13.1284897   -18.7698597 C
 0.00006375          4634.    72696776.      9.1807132      0.0005853     -0.0006802
  1.7496260   -13.6697258   -19.5413558 C
 0.00006625          4814.    72656799.      9.1782498      0.0006081     -0.0007070
  1.8025037   -14.2105262   -20.3124162 C
 0.00006875          4992.    72617467.      9.1761849      0.0006309     -0.0007338
  1.8542732   -14.7508894   -21.0830394 C
 0.00007125          5171.    72578706.      9.1744773      0.0006537     -0.0007606
  1.9049324   -15.2908137   -21.8532237 C
 0.00007375          5350.    72540452.      9.1730915      0.0006765     -0.0007874
  1.9544792   -15.8302975   -22.6229675 C
 0.00007625          5528.    72502647.      9.1719964      0.0006994     -0.0008142
  2.0029112   -16.3693391   -23.3922691 C
 0.00007875          5707.    72465242.      9.1711653      0.0007222     -0.0008410
  2.0502264   -16.9079369   -24.1611269 C
 0.00008125          5885.    72428195.      9.1705743      0.0007451     -0.0008677
  2.0964224   -17.4460892   -24.9295392 C
 0.00008375          6063.    72391467.      9.1702028      0.0007680     -0.0008944
  2.1414971   -17.9837943   -25.6975043 C
 0.00008625          6241.    72355024.      9.1700323      0.0007909     -0.0009211
  2.1854482   -18.5210505   -26.4650205 C
 0.00008875          6418.    72318836.      9.1700464      0.0008138     -0.0009478
  2.2282734   -19.0578562   -27.2320862 C
 0.00009125          6596.    72282877.      9.1702307      0.0008368     -0.0009745
  2.2699706   -19.5942095   -27.9986995 C
 0.00009375          6773.    72247122.      9.1705721      0.0008597     -0.0010012
  2.3105373   -20.1301089   -28.7648589 C
 0.00009625          6950.    72211551.      9.1710592      0.0008827     -0.0010278
  2.3499713   -20.6655524   -29.5305624 C
 0.00009875          7127.    72176143.      9.1716813      0.0009057     -0.0010545
  2.3882703   -21.2005384   -30.2958084 C
  0.0001013          7304.    72140881.      9.1724291      0.0009287     -0.0010811
  2.4254320   -21.7350651   -31.0605951 C
  0.0001038          7481.    72105750.      9.1732941      0.0009517     -0.0011077
  2.4614541   -22.2691308   -31.8249208 C
  0.0001063          7658.    72070736.      9.1742686      0.0009748     -0.0011343
  2.4963341   -22.8027336   -32.5887836 C
  0.0001088          7834.    72035824.      9.1753457      0.0009978     -0.0011609
  2.5300697   -23.3358717   -33.3521817 C
  0.0001113          8010.    72001003.      9.1765189      0.0010209     -0.0011874
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RETAINING WALL PILES

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 2.5626586   -23.8685433   -34.1151133 C
  0.0001138          8186.    71966263.     9.1777826     0.0010440    -0.0012140
 2.5940984   -24.4007466   -34.8775766 C
  0.0001163          8358.    71901054.     9.1775004     0.0010669    -0.0012407
 2.6241401   -24.9379786   -35.0000000 CY
  0.0001188          8522.    71763400.     9.1733366     0.0010893    -0.0012679
 2.6524493   -25.4886169   -35.0000000 CY
  0.0001213          8674.    71537825.     9.1643094     0.0011112    -0.0012956
 2.6789170   -26.0569614   -35.0000000 CY
  0.0001238          8814.    71223967.     9.1502625     0.0011323    -0.0013241
 2.7035677   -26.6446291   -35.0000000 CY
  0.0001263          8945.    70848720.     9.1326221     0.0011530    -0.0013531
 2.7266535   -27.2474904   -35.0000000 CY
  0.0001288          9068.    70432047.     9.1124698     0.0011732    -0.0013825
 2.7483657   -27.8622910   -35.0000000 CY
  0.0001313          9185.    69984697.     9.0903809     0.0011931    -0.0014122
 2.7688181   -28.4873797   -35.0000000 CY
  0.0001338          9298.    69514150.     9.0667575     0.0012127    -0.0014423
 2.7880955   -29.1216255   -35.0000000 CY
  0.0001363          9403.    69016261.     9.0427669     0.0012321    -0.0014725
 2.8063769   -29.7607481    35.0000000 CY
  0.0001388          9504.    68495155.     9.0186219     0.0012513    -0.0015029
 2.8237079   -30.4039709    35.0000000 CY
  0.0001413          9597.    67943959.     8.9956295     0.0012706    -0.0015332
 2.8402621   -31.0459757    35.0000000 CY
  0.0001438          9684.    67368381.     8.9739872     0.0012900    -0.0015634
 2.8560641   -31.6856796    35.0000000 CY
  0.0001463          9766.    66775783.     8.9526953     0.0013093    -0.0015937
 2.8709998   -32.3270390    35.0000000 CY
  0.0001488          9840.    66152153.     8.9344415     0.0013290    -0.0016237
 2.8853658   -32.9583810    35.0000000 CY
  0.0001588         10097.    63604829.     8.8703293     0.0014082    -0.0017430
 2.9346229   -35.4692281    35.0000000 CY
  0.0001688         10305.    61067454.     8.8174370     0.0014879    -0.0018617
 2.9703630   -37.9623509    35.0000000 CY
  0.0001788         10478.    58619016.     8.7711296     0.0015678    -0.0019803
 2.9921691   -40.4520183    35.0000000 CY
  0.0001888         10626.    56299126.     8.7303192     0.0016478    -0.0020988
 2.9999778   -42.9384534    35.0000000 CY
  0.0001988         10755.    54115082.     8.6943150     0.0017280    -0.0022172
 2.9999802   -45.4208568    35.0000000 CY
  0.0002088         10869.    52066138.     8.6617212     0.0018081    -0.0023356
 2.9998411   -47.9034980    35.0000000 CY
  0.0002188         10969.    50145274.     8.6333230     0.0018885    -0.0024536
 2.9991645   -50.3784271    35.0000000 CY
  0.0002288         11059.    48346461.     8.6074453     0.0019690    -0.0025717
 2.9999701   -52.8531066    35.0000000 CY
  0.0002388         11141.    46662908.     8.5845816     0.0020496    -0.0026896
 2.9986841   -55.3219274    35.0000000 CY
  0.0002488         11215.    45085537.     8.5642371     0.0021304    -0.0028073
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 2.9994725   -57.7858370   35.0000000 CY
  0.0002588        11283.    43605617.    8.5459017    0.0022113   -0.0029249
 2.9998109   -60.0000000   35.0000000 CY
  0.0002688        11341.    42200621.    8.5274004    0.0022917   -0.0030429
 2.9999158   -60.0000000   35.0000000 CY
  0.0002788        11387.    40850332.    8.5053511    0.0023709   -0.0031623
 2.9998948   -60.0000000   35.0000000 CY
  0.0002888        11424.    39564534.    8.4814384    0.0024490   -0.0032827
 2.9997251   -60.0000000   35.0000000 CY
  0.0002988        11458.    38352338.    8.4592354    0.0025272   -0.0034030
 2.9992666   -60.0000000   35.0000000 CY
  0.0003088        11488.    37209690.    8.4386002    0.0026054   -0.0035233
 2.9982571   -60.0000000   35.0000000 CY
  0.0003188        11517.    36131682.    8.4189090    0.0026835   -0.0036437
 2.9987573   -60.0000000   35.0000000 CY
  0.0003288        11543.    35110289.    8.4000359    0.0027615   -0.0037642
 2.9997783   -60.0000000   35.0000000 CY
  0.0003388        11566.    34144588.    8.3823379    0.0028395   -0.0038847
 2.9983752   -60.0000000   35.0000000 CY
  0.0003488        11589.    33229775.    8.3659642    0.0029176   -0.0040051
 2.9992991   -60.0000000   35.0000000 CY
  0.0003588        11609.    32360164.    8.3501372    0.0029956   -0.0041256
 2.9992058   -60.0000000   35.0000000 CY
  0.0003688        11629.    31536347.    8.3352475    0.0030736   -0.0042461
 2.9973568   -60.0000000   35.0000000 CY
  0.0003788        11647.    30749838.    8.3212981    0.0031517   -0.0043665
 2.9994004   -60.0000000   35.0000000 CY
  0.0003888        11664.    30003222.    8.3084339    0.0032299   -0.0044868
 2.9970039   -60.0000000   35.0000000 CY
  0.0003988        11680.    29290295.    8.2950082    0.0033076   -0.0046076
 2.9991381   -60.0000000   35.0000000 CY
  0.0004088        11694.    28610389.    8.2837858    0.0033860   -0.0047277
 2.9983391   -60.0000000   35.0000000 CY
  0.0004188        11708.    27960052.    8.2724812    0.0034641   -0.0048481
 2.9982282    60.0000000   35.0000000 CY
  0.0004288        11721.    27338641.    8.2617747    0.0035422   -0.0049685
 2.9999564    60.0000000   35.0000000 CY
  0.0004388        11733.    26741604.    8.2537651    0.0036213   -0.0050878
 2.9961027    60.0000000   35.0000000 CY
  0.0004488        11743.    26167767.    8.2460257    0.0037004   -0.0052073
 2.9992128    60.0000000   35.0000000 CY
  0.0004588        11752.    25616593.    8.2400798    0.0037801   -0.0053261
 2.9986241    60.0000000   35.0000000 CY
  0.0004688        11760.    25086995.    8.2352605    0.0038603   -0.0054444
 2.9968506    60.0000000   35.0000000 CY
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   Summary of Results for Nominal Moment Capacity for Section 1
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RETAINING WALL PILES

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	12.400	11602.497	0.00300000
2	17.160	11610.324	0.00300000

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	12.400000	11602.	8.060000	7542.	72060664.
2	0.65	17.160411	11610.	11.154267	7547.	72092712.
1	0.75	12.400000	11602.	9.300000	8702.	71402786.
2	0.75	17.160411	11610.	12.870308	8708.	71462095.
1	0.90	12.400000	11602.	11.160000	10442.	58941161.
2	0.90	17.160411	11610.	15.444370	10449.	59027395.

RETAINING WALL PILES

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	18986.
2	8.0000	8.0000	No	No	18986.	9156.
3	11.0000	29.3955	No	No	28142.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Lateral Loading Analysis for Load Case Number 1

Analysis was not performed.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 17570.4 lbs
Applied moment at pile head = 1143072.0 in-lbs
Axial thrust load on pile head = 17160.4 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.8875	1143072.	17570.	-0.00728	0.00	7.41E+10			

RETAINING WALL PILES

```
-47.8354    97.0181       0.00
    0.3000    0.8614   1206464.     17395.   -0.00722       0.00   7.41E+10
-49.4095   206.4947       0.00
    0.6000    0.8355   1269211.     17215.   -0.00716       0.00   7.39E+10
-50.9365   219.4732       0.00
    0.9000    0.8098   1331295.     17029.   -0.00710       0.00   7.39E+10
-52.4154   233.0045       0.00
    1.2000    0.7844   1392695.     16837.   -0.00703       0.00   7.38E+10
-53.8456   247.1243       0.00
    1.5000    0.7592   1453393.     16641.   -0.00696       0.00   7.38E+10
-55.2263   261.8710       0.00
    1.8000    0.7343   1513372.     16440.   -0.00689       0.00   7.38E+10
-56.5565   277.2864       0.00
    2.1000    0.7096   1572612.     16234.   -0.00681       0.00   7.37E+10
-57.8355   293.4155       0.00
    2.4000    0.6852   1631099.     16024.   -0.00674       0.00   7.37E+10
-59.0623   310.3075       0.00
    2.7000    0.6611   1688814.     15809.   -0.00666       0.00   7.36E+10
-60.2362   328.0156       0.00
    3.0000    0.6373   1745745.     15590.   -0.00657       0.00   7.36E+10
-61.3563   346.5980       0.00
    3.3000    0.6138   1801874.     15367.   -0.00648       0.00   7.36E+10
-62.4216   366.1180       0.00
    3.6000    0.5906   1857190.     15141.   -0.00639       0.00   7.35E+10
-63.4312   386.6449       0.00
    3.9000    0.5677   1911677.     14911.   -0.00630       0.00   7.35E+10
-64.3841   408.2547       0.00
    4.2000    0.5452   1965325.     14677.   -0.00621       0.00   7.35E+10
-65.2795   431.0303       0.00
    4.5000    0.5230   2018120.     14441.   -0.00611       0.00   7.35E+10
-66.1162   455.0634       0.00
    4.8000    0.5012   2070053.     14201.   -0.00601       0.00   7.34E+10
-66.8934   480.4545       0.00
    5.1000    0.4798   2121112.     13959.   -0.00591       0.00   7.34E+10
-67.6099   507.3148       0.00
    5.4000    0.4587   2171289.     13715.   -0.00580       0.00   7.34E+10
-68.2647   535.7671       0.00
    5.7000    0.4380   2220574.     13468.   -0.00569       0.00   7.34E+10
-68.8566   565.9478       0.00
    6.0000    0.4177   2268960.     13219.   -0.00558       0.00   7.34E+10
-69.3845   598.0082       0.00
    6.3000    0.3978   2316441.     12968.   -0.00547       0.00   7.33E+10
-69.8474   632.1168       0.00
    6.6000    0.3783   2363008.     12716.   -0.00536       0.00   7.33E+10
-70.2438   668.4620       0.00
    6.9000    0.3592   2408659.     12463.   -0.00524       0.00   7.33E+10
-70.5726   707.2546       0.00
    7.2000    0.3406   2453387.     12208.   -0.00512       0.00   7.33E+10
-70.8325   748.7315       0.00
    7.5000    0.3224   2497190.     11953.   -0.00500       0.00   7.33E+10
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RETAINING WALL PILES

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-71.0221   793.1594       0.00
    7.8000     0.3046   2540065.      11697.   -0.00487        0.00   7.33E+10
-71.1401   840.8397       0.00
    8.1000     0.2873   2582010.      11441.   -0.00475        0.00   7.32E+10
-71.1849   892.1141       0.00
    8.4000     0.2704   2623025.      11311.   -0.00462        0.00   7.32E+10
-0.6895     9.1797      0.00
    8.7000     0.2540   2664023.      11309.   -0.00449        0.00   7.32E+10
-0.6905     9.7872      0.00
    9.0000     0.2381   2705004.      11306.   -0.00436        0.00   7.32E+10
-0.6887    10.4157      0.00
    9.3000     0.2226   2745968.      11304.   -0.00423        0.00   7.32E+10
-0.6841    11.0639      0.00
    9.6000     0.2076   2786915.      11301.   -0.00409        0.00   7.32E+10
-0.6766    11.7305      0.00
    9.9000     0.1932   2827844.      11299.   -0.00395        0.00   7.32E+10
-0.6661    12.4138      0.00
   10.2000     0.1792   2868756.      11297.   -0.00381        0.00   7.32E+10
-0.6526    13.1118      0.00
   10.5000     0.1657   2909651.      11294.   -0.00367        0.00   7.31E+10
-0.6363    13.8222      0.00
   10.8000     0.1528   2950529.      11292.   -0.00352        0.00   7.31E+10
-0.6171    14.5424      0.00
   11.1000     0.1403   2991390.      11290.   -0.00338        0.00   7.31E+10
-0.5953    15.2695      0.00
   11.4000     0.1284   3032234.       9425.   -0.00323        0.00   7.31E+10
-1035.     29020.       0.00
   11.7000     0.1171   3059650.       5755.   -0.00308        0.00   7.31E+10
-1004.     30857.       0.00
   12.0000     0.1063   3074049.       2203.   -0.00293        0.00   7.31E+10
-969.7100     32849.      0.00
   12.3000    0.09600   3075871.      -1223.   -0.00278        0.00   7.31E+10
-933.4835     35004.      0.00
   12.6000    0.08628   3065587.      -4513.   -0.00263        0.00   7.31E+10
-894.2661     37314.      0.00
   12.9000    0.07710   3043703.      -7647.   -0.00248        0.00   7.31E+10
-847.1253     39556.      0.00
   13.2000    0.06845   3010831.     -10609.   -0.00233        0.00   7.31E+10
-798.2363     41979.      0.00
   13.5000    0.06035   2967605.     -13395.   -0.00218        0.00   7.31E+10
-749.4724     44711.      0.00
   13.8000    0.05276   2914657.     -16005.   -0.00203        0.00   7.31E+10
-700.8084     47816.      0.00
   14.1000    0.04570   2852617.     -18441.   -0.00189        0.00   7.32E+10
-652.1987     51380.      0.00
   14.4000    0.03914   2782116.     -20701.   -0.00175        0.00   7.32E+10
-603.5707     55519.      0.00
   14.7000    0.03307   2703784.     -22786.   -0.00162        0.00   7.32E+10
-554.8135     60399.      0.00
   15.0000    0.02748   2618254.     -24695.   -0.00149        0.00   7.32E+10
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RETAINING WALL PILES

-505.7607	66257.	0.00				
15.3000	0.02235	2526162.	-26427.	-0.00136	0.00	7.33E+10
-456.1607	73463.	0.00				
15.6000	0.01767	2428149.	-27978.	-0.00124	0.00	7.33E+10
-405.6235	82617.	0.00				
15.9000	0.01343	2324873.	-29345.	-0.00112	0.00	7.33E+10
-353.5171	94797.	0.00				
16.2000	0.00959	2217008.	-30519.	-0.00101	0.00	7.34E+10
-298.7342	112185.	0.00				
16.5000	0.00614	2105264.	-31487.	-9.06E-04	0.00	7.34E+10
-239.0697	140194.	0.00				
16.8000	0.00306	1990416.	-32221.	-8.06E-04	0.00	7.35E+10
-168.8934	198488.	0.00				
17.1000	3.39E-04	1873373.	-32586.	-7.11E-04	0.00	7.35E+10
-33.7009	358388.	0.00				
17.4000	-0.00206	1755887.	-32397.	-6.22E-04	0.00	7.36E+10
138.2960	242148.	0.00				
17.7000	-0.00414	1640189.	-31795.	-5.39E-04	0.00	7.37E+10
196.3081	170644.	0.00				
18.0000	-0.00594	1527030.	-31019.	-4.62E-04	0.00	7.37E+10
235.0794	142514.	0.00				
18.3000	-0.00747	1416912.	-30121.	-3.90E-04	0.00	7.38E+10
263.6092	127096.	0.00				
18.6000	-0.00875	1310207.	-29133.	-3.24E-04	0.00	7.39E+10
285.3105	117432.	0.00				
18.9000	-0.00980	1207196.	-28076.	-2.62E-04	0.00	7.40E+10
301.9536	110961.	0.00				
19.2000	-0.01064	1108094.	-26966.	-2.06E-04	0.00	7.41E+10
314.6145	106497.	0.00				
19.5000	-0.01128	1013066.	-25816.	-1.55E-04	0.00	7.44E+10
324.0139	103409.	0.00				
19.8000	-0.01175	922235.	-24638.	-1.10E-04	0.00	8.44E+10
330.6738	101327.	0.00				
20.1000	-0.01208	835686.	-23439.	-7.30E-05	0.00	8.45E+10
335.2431	99946.	0.00				
20.4000	-0.01227	753480.	-22228.	-3.91E-05	0.00	8.45E+10
337.9904	99135.	0.00				
20.7000	-0.01236	675653.	-21009.	-8.71E-06	0.00	8.46E+10
339.1338	98801.	0.00				
21.0000	-0.01234	602219.	-19788.	1.85E-05	0.00	8.46E+10
338.8539	98883.	0.00				
21.3000	-0.01222	533175.	-18571.	4.26E-05	0.00	8.46E+10
337.3031	99338.	0.00				
21.6000	-0.01203	468501.	-17362.	6.40E-05	0.00	8.46E+10
334.6113	100137.	0.00				
21.9000	-0.01176	408162.	-16164.	8.26E-05	0.00	8.47E+10
330.8902	101264.	0.00				
22.2000	-0.01143	352110.	-14981.	9.88E-05	0.00	8.47E+10
326.2367	102709.	0.00				
22.5000	-0.01105	300286.	-13817.	1.13E-04	0.00	8.47E+10

RETAINING WALL PILES

```
320.7350     104471.        0.00
   22.8000    -0.01062    252618.     -12673.    1.24E-04         0.00    8.47E+10
314.4580     106556.        0.00
   23.1000    -0.01016    209024.     -11554.    1.34E-04         0.00    8.47E+10
307.4688     108979.        0.00
   23.4000    -0.00966    169414.     -10461.    1.42E-04         0.00    8.48E+10
299.8212     111759.        0.00
   23.7000    -0.00913    133690.      -9396.    1.49E-04         0.00    8.48E+10
291.5602     114926.        0.00
   24.0000    -0.00859    101744.      -8362.    1.54E-04         0.00    8.48E+10
282.7218     118519.        0.00
   24.3000    -0.00803     73462.      -7361.    1.57E-04         0.00    8.48E+10
273.3334     122591.        0.00
   24.6000    -0.00745     48722.      -6395.    1.60E-04         0.00    8.48E+10
263.4124     127209.        0.00
   24.9000    -0.00687     27396.      -5466.    1.62E-04         0.00    8.48E+10
252.9658     132463.        0.00
   25.2000    -0.00629      9348.      -4575.    1.62E-04         0.00    8.48E+10
241.9883     138473.        0.00
   25.5000    -0.00571     -5564.      -3725.    1.62E-04         0.00    8.48E+10
230.4597     145401.        0.00
   25.8000    -0.00512    -17489.      -2917.    1.62E-04         0.00    8.48E+10
218.3412     153472.        0.00
   26.1000    -0.00454    -26584.      -2154.    1.61E-04         0.00    8.48E+10
205.5699     163009.        0.00
   26.4000    -0.00396    -33015.      -1438.    1.60E-04         0.00    8.48E+10
192.0493     174487.        0.00
   26.7000    -0.00339    -36957.   -772.5099    1.58E-04         0.00    8.48E+10
177.6340     188651.        0.00
   27.0000    -0.00282    -38597.   -160.9838    1.57E-04         0.00    8.48E+10
162.1028     206731.        0.00
   27.3000    -0.00226    -38135.    391.9917    1.55E-04         0.00    8.48E+10
145.1058     230955.        0.00
   27.6000    -0.00171    -35793.    880.0704    1.53E-04         0.00    8.48E+10
126.0490     265889.        0.00
   27.9000    -0.00116    -31818.       1294.    1.52E-04         0.00    8.48E+10
103.7880     322957.        0.00
   28.2000   -6.12E-04    -26497.       1617.    1.51E-04         0.00    8.48E+10
75.5036     444089.        0.00
   28.5000   -7.13E-05    -20198.       1774.    1.50E-04         0.00    8.48E+10
11.8245     597314.        0.00
   28.8000    4.66E-04    -13745.       1676.    1.49E-04         0.00    8.48E+10
-65.8586     508289.        0.00
   29.1000     0.00100     -8146.       1384.    1.49E-04         0.00    8.48E+10
-96.5531     346875.        0.00
   29.4000     0.00154     -3798.    995.0758    1.48E-04         0.00    8.48E+10
-119.5661     280154.        0.00
   29.7000     0.00207   -999.5377    530.0250    1.48E-04         0.00    8.48E+10
-138.7955     241358.        0.00
   30.0000     0.00260        0.00        0.00    1.48E-04         0.00    8.48E+10
```

RETAINING WALL PILES

```
-155.6628    107607.       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
  polated from the output for nonlinear bending properties relative to the
  magnitude of bending moment developed in the pile.


Output Summary for Load Case No. 2:
```

ACCEPTABLE FOR SITE WALL

```
Pile-head deflection                =     0.88750258 inches
Computed slope at pile head         =    -0.00727876 radians
Maximum bending moment              =       3075871. inch-lbs
Maximum shear force                 =        -32586. lbs
Depth of maximum bending moment     =    12.30000000 feet below pile head
Depth of maximum shear force        =    17.10000000 feet below pile head
Number of iterations                =             17
Number of zero deflection points    =              2


--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                 Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head  Loading  Deflection  Rotation     in
Pile     in Pile
 No.  1       Load 1       2        Load 2       lbs       inches      radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  2  V, lb     17570.  M, in-lb    1143072.     17160.     0.8875   -0.00728
-32586.   3075871.


Maximum pile-head deflection = 0.8875025757 inches
Maximum pile-head rotation   = -0.0072787639 radians = -0.417042 deg.
```

RETAINING WALL PILES

```
The analysis ended normally.
```

ZFA STRUCTURAL ENGINEERS

Job #	Engineer:	Project Name
Pier Capacity (2)	Date	1

PIER DEMANDS:

Batter Angle =	14	deg	(see batter)
Axial Demand =	17.2	k	(see pier demands and batter)

PIER CAPACITY:

L = depth/cos(batter)

Depth (ft)	Length (ft)	Skin Friction (psf)
0	0.0	0
3	3.1	200
11	11.3	350

Skin Friction (psf) = 273 $= f_s$ (weighted avg)

Pier Diameter (in) = 20.00 $= D$

Pier Length (ft) = **30.00** $= H_t$

Neglect top (ft) = 0.00 $= H_n$ for skin friction

Pier capacity (k) = 43 $= \pi * D * (f_s) * (H_t - H_n)$

DCR = **0.40**

Capacity Check (see pier design sheet for demands)

ASD to LRFD ratio =	1.60		
M_{max} =	256	k-ft	Lpile
M_u =	409.6	k-ft	
ϕM_n =	652.7	k-ft	(steel casing only, see above)
DCR =	**0.63**		
V_{max} =	32.6	k	Lpile
V_u =	52.2	k	
$\phi\ V_n$ =	167.9	k	(concrete only, see shear friction)
DCR =	**0.31**		

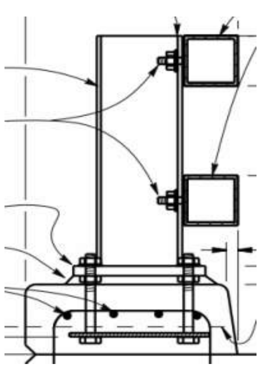
Guardrail

Guardrail is per AASHTO Bridge Design Specifications 7th Edition chapter 13. The roadway is a local collector with limited truck traffic and reduced speeds, therefore, AASHTO load level TL-2 per 13.7.2 is most applicable. Guardrail assemblies (including anchorage) require full scale testing therefore a rail based on Caltrans standard steel rail ST-30 which has been tested and used throughout the state will be used here.

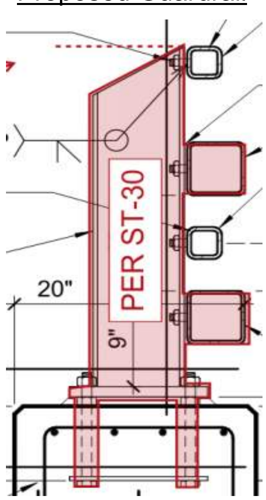
As indicated by the city, this roadway is accessible to pedestrians and cyclists, increase the barrier height to 42" per AASHTO 13.8 (pedestrian rails), AASHTO 13.9 (bicycle rails) and CBC. Pedestrian and cyclist loads do not govern over vehicle loads by observation.

- TL-2—Test Level Two—taken to be generally acceptable for work zones and most local and collector roads with favorable site conditions as well as where a small number of heavy vehicles is expected and posted speeds are reduced;

CALTRANS ST-30



Proposed Guardrail



Top rail added as handrail/cyclist barrier

HSS5x5 rails per ST-30 are still prominent and will therefore still resist vehicle impacts

Intermediate rail added for aesthetics and to reduce gap between rails

Steel Beam

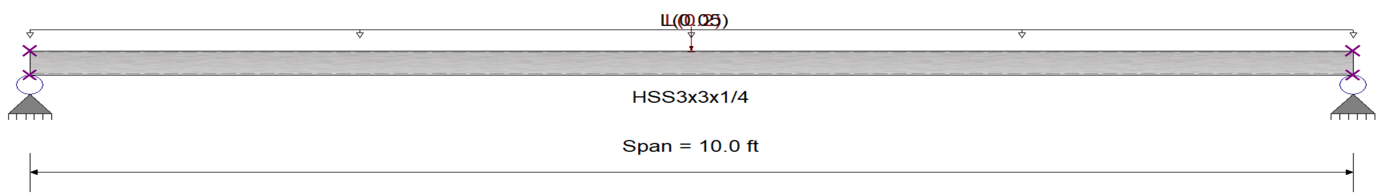
DESCRIPTION: Guardrail

CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, CBC 2013, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	46.0 ksi
Beam Bracing :	Completely Unbraced	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : L = 0.050 k/ft, Tributary Width = 1.0 ft, (rail load)

Point Load : L = 0.20 k @ 5.0 ft, (rail load)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.226** : 1	Maximum Shear Stress Ratio =	**0.023** : 1
Section used for this span	**HSS3x3x1/4**	Section used for this span	**HSS3x3x1/4**
Mu : Applied	1.932 k-ft	Vu : Applied	0.6129 k
Mn * Phi : Allowable	8.556 k-ft	Vn * Phi : Allowable	26.635 k
Load Combination	+1.20D+0.50Lr+1.60L+1.60H	Load Combination	+1.20D+0.50Lr+1.60L+1.60H
Location of maximum on span	5.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.211 in	Ratio =	567 >=360
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.234 in	Ratio =	512 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0