

BOK KAI TEMPLE

Historic Structure Impact Report

Prepared for
HDR, Inc.

Prepared by
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Innovating Tradition

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FIGURES

A. EXECUTIVE SUMMARY

A variety of reports, studies, and theoretical projections of the impacts of construction-related vibrations on buildings are available for consideration when analyzing potential project impacts. Using the Caltrans *Transportation- and Construction-Induced Vibration Guidance Manual* and other previously prepared MRL reports and analyses, Garavaglia Architecture, Inc. finds that the anticipated vibrations projections of 0.05 – 0.13 in/sec PPV as measured at 40-feet from vibration sources are within the industry thresholds for vibrations limits near historic or fragile structures. This anticipated PPV is also below the levels generally required to cause aesthetic or structural harm to historic or fragile buildings. Therefore, there is very low probability for aesthetic or structural damage to either the Bok Kai Temple or nearby contributors to the Marysville Downtown Historic District. Using a conservative approach, Garavaglia Architecture, Inc. recommends that the lower vibration threshold presented by Caltrans of 0.08 in/sec PPV be used as the vibrations threshold for the MRL Phase 2b project. This represents the maximum recommended vibration as measured by monitoring equipment. Recommended placement of monitors range from approximately 35-feet from construction (south foundation wall of the Temple) to approximately 90-feet (within the property line of 7 D Street).

A.1 Recommendations

A.1.1 Pre-Construction

Establishing Baseline Vibrations Conditions
Ambient vibrations conditions should be collected immediately prior to the start of construction. This should be compared to the empirical construction-related data gathered at the Phase 1 construction-site (0.01 – 0.04 in/sec typically) and the anticipated vibrations from construction along Phase 2b (0.05 – 0.13 in/sec). If ambient vibrations exceed the actual and anticipated construction-related vibrations level, the likelihood of damage from future construction is quite low. If ambient vibrations are lower than anticipated construction-related vibrations, greater sensitivity to changing building conditions, such as plaster cracking, chipping, or flaking, building movement or settlement, cracked interior floor or wallboard, falling object, or loosening attachments, may be warranted.

Establishing Baseline Building Conditions
Understanding the difference between current conditions and those anticipated during and after construction is critical for buildings with the cultural and historic value of the Bok Kai Temple. Therefore, a solid understanding of baseline conditions, with supporting documentation for reference, is recommend. Specific recommended actions include:

- 3D laser scans or photogrammetry
  Data gathering is relatively fast (1-2 days at most) and cost effective. Processing of the data may be contingent on the need. If no changes are observed and no construction-related vibrations events exceed the recommended thresholds, it may not be necessary to process and analyze the point-cloud information gathered on-site. This could be a cost savings.

- Systematic recordation with high resolution digital photographs
  As an alternate to laser scanning, thorough recordation of all surfaces with a digital camera can be used to establish a visible baseline of conditions. This method requires 1-2 days in the field and has minimal processing time. It is not as accurate as laser scanning, but is highly superior to regular photographic documentation.

- Pre-construction mural survey
  A detailed conditions survey of the murals should be completed by a qualified murals conservator to record existing conditions. Conditions should be recorded on drawings or high-resolution photographs and accompanied by a brief written report summarizing the findings and highlighting any potential problem areas discovered during the survey process.

- Pre-construction level survey
  A level survey of the floor in the altar room and western storage room is recommended to establish a baseline for existing levels of settlement for the building. These floors are relatively uniform and a laser level survey can be performed with minimal disruption of existing decorative features.

- Installation of crack monitors
  Inexpensive and effective, crack monitors can be installed in sensitive locations with no impact on the historic resource. They will require regular on-site monitoring.

- Pre-construction non-destructive wall survey (optional)
  An ultrasonic, or other non-destructive survey of the sanctuary walls can be done prior to construction to more precisely know the conditions of the underlying brick walls.

Public Outreach & Education
Anticipated vibrations levels are quite low, but they are within the range detectible by humans. Therefore, education of the public is highly recommended. This is especially important because access to private property will be necessary if vibrations monitors are installed as recommended. Specific recommendations include:

- Public notification letters to residents, owners, and business proprietors within 200-feet of the construction zone, and along all proposed haul routes.

- Public meetings with dissemination of any presentations, questions, and answers following each meeting.

- Dissemination of educational materials concerning specific steps owners or tenants can take to limit incidental impacts such as falling objects or dislodging of poorly mounted materials on walls, ceilings, or shelving.

A.1.2 During Construction

Because anticipated vibrations are quite low, no pre-construction stabilization is recommended for the Temple. However the following steps to monitor the historic resource for changes during construction are recommended:

Implementation of a Vibrations Monitoring Plan

- Install a minimum of two (2) monitoring units at the Bok Kai Temple site. One should be located under the temple, in the crawl space below the main entrance and placed near the south wall. The other should be located outside the Temple, near the north wall. This will require owner's permission and may pose an access issue.

- Select a qualified monitoring professional with certified equipment and trained personnel.

- Equipment should allow for remote monitoring and should generate immediate notification to responsible parties when the recommended vibrations threshold of 0.08 in/sec has been exceeded.

- Cease all construction within 200-feet of the resource when the threshold has been exceeded and visually inspect the Temple for damage.

- Establish a regular maintenance and monitoring schedule to collect data and check equipment.

Regular Visual Inspections
All remote monitoring should be augmented by routine visual inspections of the Temple. The exterior murals should be inspected on a daily basis, at a set time, either before or after each shift. This is a quick visual survey of focused areas where the most sensitive historical resources are located. The entire Temple should be inspected on a weekly basis. A standard methodology, perhaps a checklist, should be developed to guide these inspections and provide for consistency across the project's duration.

Equipment Protections
Install barricades to prevent errant material or equipment from rolling off the levee and into the Temple or onto the Temple site.

Dust & Debris Control
Barriers to prevent debris from striking the building should be put in place prior to the start of construction. In addition, a dust mitigation plan should be created to limit dissemination of airborne particles into interior spaces of the Temple.

A.1.3 Post-Construction

Affirming Building Conditions
Understanding the difference between pre-construction conditions and those existing after construction is critical for sensitive historic resources like the Bok Kai Temple. Therefore, a comparison of conditions, with supporting documentation for reference is recommend.

- 3D laser scans or photogrammetry
  This cost effective method can be used to directly compare the data collected prior to construction with that present at the close of construction. Any differences in the information would indicate deterioration that has occurred since the start of construction. A determination of the causes of the damage, and whether it is the result of natural occurrences or of construction activities would then be necessary. This is

recommended as a way to document conditions in case there is any disputed damage in the future.

- Systematic recordation with high resolution digital photographs
  As an alternate to laser scanning, thorough recordation of all surfaces with a digital camera can be used to establish a visible baseline of conditions. This method requires 1-2 days in the field and has minimal processing time. It is not as accurate as laser scanning, but is highly superior to regular photographic documentation.

- Post-Construction Floor Level Survey
  At the end of construction, or after construction has been completed within 200-feet of the Temple, a second floor level survey is recommended. This should be compared to the pre-construction survey results to determine if any additional settlement may have occurred as a result of construction activities.

- Post-construction mural survey
  A detailed conditions survey of the murals should be completed by a qualified murals conservator to record existing conditions. Changed conditions should be recorded on copies of the pre-construction survey and accompanied by a brief written report highlighting any changed conditions with specific recommendations to address any construction-related damage.

A.1.4 Mitigations

Plaster Damage
If damage to the exterior murals is observed, the following procedure should be followed immediately.

- Suspend all construction within 200-feet of the resource immediately.

- Install netting immediately below the murals to prevent loose material from hitting the ground.

- Contact a skilled murals conservator, preferable one familiar with the murals and the work carried out in 2006. At a minimum, the selected conservator should be a member of the American Institute for Conservation (AIC), have at least 10 years experience working on exterior murals, frescos, and/or plaster-based cultural media.

- Temporarily stabilize the murals until all construction activities along the K1, K2, and L1 segments are complete. Do not resume construction until the murals have been stabilized.

- Permanently stabilize the murals according to the recommendations of the murals conservator.

Fallen or Loose Artifacts
If artifacts become dislodged from the interior of the Temple because of construction-related activities, the following procedure should be followed immediately:

- Suspend all construction within 200-feet of the resource immediately.
- Contact a representative from the Bok Kai Temple to document the damaged items.
- Remove the item for assessment and repair offsite. The item should be properly packaged to prevent further damage.
- Survey the remaining attachments for stability. Construction can resume after the damaged item has been removed from the site and wall and ceiling attachments have been verified.
- A skilled artisan familiar with sacred objects, or with the specific materials in question, is recommended to advise on actions needed to restore the damaged item.
- Repair any damage to the wall or ceiling where attachments dislodged.
- Reinstall repaired item only after all construction activities along the K1, K2, and L1 segments are complete.

A.2 SUMMARY

There are very few anticipated impacts on the Bok Kai Temple as a result of construction-related vibrations. Vibration will occur at levels detectable by humans but should remain well below the levels generally required to cause aesthetic damage. Structural damage is highly unlikely based on the current analysis. Pre-construction stabilization activities include recording baseline vibrations conditions, establishing baseline building conditions, and verification of vibrations generated by the proposed construction methods and equipment at the site. Provided the baseline assumptions of this report are supportable by pre-construction stabilization activities, vibrations levels remain under the recommended threshold of 0.08 in/sec, and the project is properly monitored to verify that levels remain below this threshold, impacts to the temple are unlikely.

1. INTRODUCTION

The city of Marysville is located approximately 50 miles north of Sacramento, California in Yuba County. Marysville is surrounded by 7.5 miles of levee that protect it from the flooding of three water courses: the Yuba River to the south; Jack Slough to the north; and the Feather River to the west. These levees vary in height from 16 to 28 feet.

The Yuba River drains out of New Bullards Bar Dam in the Sierra Nevada and runs along the south edge of the Marysville Ring Levee project (MRL) into the Feather River. Jack Slough runs a quarter mile northwest of the MRL and flows into the Feather River. The Feather River drains from Oroville Dam and Reservoir from the north along the western edge of the Marysville Ring Levee and then flows into the Sacramento River.

MRL is a cooperative effort between the United States Army Corps of Engineers (Corps), the State of California Central Valley Flood Protection Board (CVFPB), and the Marysville Levee District (District) to protect the City of Marysville from a 200-year flood event.[1]

Garavaglia Architecture, Inc. has been contracted to assess the potential impacts of proposed levee improvements on two National Register-listed historic resources immediately adjacent to, but located outside of, the project Area of Potential Effect (APE, see Figure 1): the Bok Kai Temple (temple) and the Downtown Marysville Commercial Historic District (district). The temple property is currently encroached upon by the north side of the levee. The district is non-contiguous and approximately three blocks of the National Register district are immediately adjacent to the APE. The Downtown Marysville Commercial Historic District is addressed in a separate Historic Structure Impact Report, also completed by Garavaglia Architecture, Inc.

1.1 MRL PROJECT SUMMARY

As authorized under the United States Army Corps of Engineers (USACE) IDIQ Contract No. W91238-10-D-0003, Delivery Order No. 0009, revised June 15, 2011, HDR/Fugro WLA Joint Venture (JV) was tasked with preparation of the Alternative Analysis for the Marysville Ring Levee Phase 2B (MRL) and the geophysical and pothole exploration of levee penetrations and encroachments, in support of levee improvement and reconstruction. The entire Marysville ring levee consists of approximately 7.5 miles of the levee surrounding and protecting the City of Marysville, California. Planned levee improvement measures throughout the ring levee address underseepage, through-seepage, embankment slope stability, utility penetrations, constructability, settlement, and geometrical corrections to the levee embankment. The MRL Engineering Documentation Report (EDR) and the MRL Environmental Assessment (EA) addresses the engineering and environmental aspects, respectively, of the Phase 1 through 4 levee improvements for the entire Marysville area flood protection system. The Geotechnical Appendix of the MRL EDR identifies Phase 2 as a critical reach requiring levee improvements. In particular, the reach from Stations 244+00 to 285+00, Phase 2B was identified as a critical reach due to past performance and past repairs as well as its close proximity to historic structures. Additionally, penetrations and encroachments in the levee embankment and foundations dating to the mid 19th century have abandoned underground construction with

[1] "Memorandum of Agreement Between the U.S. Army Corps of Engineers and the California State Historic Preservation Officer, Regarding the Marysville Ring Levee Project, Yuba County, California," (March 2011), 1.

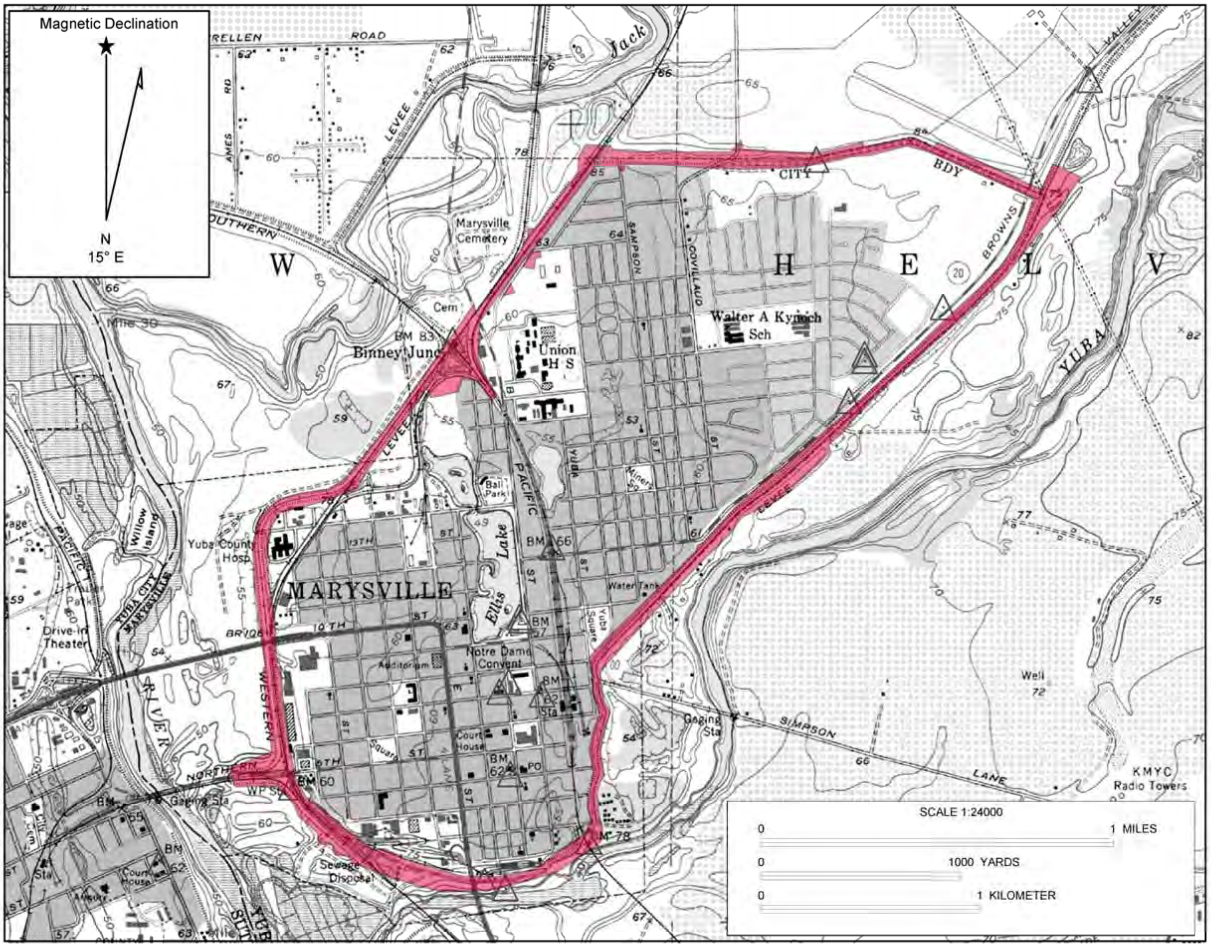

Figure 1. The project APE. The APE follows the physical extent of the levee around Marysville. Areas of anticipated staging are also included where the APE extends beyond the immediate levee confines.[2]

potential voids that may cause instability and/or seepage. The USACE engineer's opinion is that this site may have serious defects due to these conditions and requires through and underseepage mitigation. The MRL Phase 2B project was divided into three segments for the alternative analysis: Segments K1, K2 and L1.

The mitigation measures considered for the MRL Phase 2B project are levee degradation/reconstruction and cutoff wall construction. Levee degradation/reconstruction involves degrading (removal) of the existing levee and reconstructing a new levee. The cutoff wall measure involves degrading approximately the top half of the levee, constructing a cutoff wall to the necessary depth and reconstructing the top portion of the levee. Both mitigation measures involve only standard earthmoving equipment.

[2] *Memorandum of Agreement Between the U.S. Army Corps of Engineers and the California State Historic Preservation Officer, Regarding the Marysville Ring Levee Project, Yuba County, California*, March 2011, Attachment A.

The through-seepage mitigation measures considered in Segment K1 are levee degradation/ reconstruction and a cutoff wall. Only one alignment option was considered (existing alignment). This is the segment in closest proximity to the Bok Kai Temple.

The underseepage and through-seepage mitigation measures considered in Segment K2 only included a cutoff wall. There are two alignment options considered (existing alignment and slightly modified alignment). The cutoff wall in this segment will be slightly deeper for underseepage mitigation. This is the segment in closest proximity to historic district contributing buildings in poor condition.

The through-seepage mitigation measures considered in Segment L1 are levee degradation/ reconstruction and a cutoff wall. There are four alignment options under consideration (existing alignment, slightly modified alignment, and two set forward alignments). For the existing and slightly modified alignments, levee degradation/reconstruction and cutoff wall mitigation measures are considered, similar to Segment K1. Similar to Segment K2, cutoff wall mitigation measures are assumed for the set forward alignments located approximately 100 feet to 300 feet east of the existing levee. Segment L1 is not located near any identified historic resources.

Phase 2B consists of several construction techniques used in combination to install a 50- to 90-foot deep, cutoff wall through much of the length. In addition, jet grouting would occur at the four bridges in this section (5th Street Bridge, Highway 70 Bridge, two railroad bridges). Construction in the Phase 2B portion must consider impacts on the historic resources as well as treatment of existing utilities with through-levee placements. All work associated with Phase 2B is projected to use conventional construction equipment such as loaders, scrapers, graders, and excavators.[3]

The following descriptions represent the extent of construction methods anticipated.

1.1.1 Cutoff Wall Construction

The levee crown would be degraded down 4- to 12-feet to provide a 40- to 50-foot temporary work surface for construction equipment. Conventional cutoff walls are constructed using an excavator with a long-stick boom capable of digging a trench to a maximum depth of approximately 75 to 80 feet. Some excavators can reach depths of up to 90 feet. The trench width will vary depending on depth, but it is assumed for this report the minimum width would be 36 inches (3 feet). A bentonite slurry is placed in the trench as it is excavated to prevent caving while the backfill material is mixed. The excavated soil is mixed with the appropriate slurry (either bentonite or cement-bentonite) to achieve the required cutoff wall strength and permeability, and then backfilled into the trench. The levee portion that was degraded is now reconstructed. All work is completed with standard earthmoving equipment.

1.1.2 Levee Reconstruction

Instead of degrading only a portion of the levee as above, with Levee Reconstruction the levee is completely degraded. In some cases, a cutoff wall described above is installed at the location of the new levee alignment. In these areas, a working platform would be constructed above the existing ground surface for construction of the cutoff wall. After levee degrading and cutoff

[3] United States Army Corps of Engineers, "*Final, Marysville Ring Levee, Yuba River Basin, California, Environmental Assessment, Initial Study*," (April 2010), 10.

wall installation, the levee is reconstructed. All work is completed with standard earthmoving equipment.

1.2 HISTORIC PRESERVATION OBJECTIVES AND REQUIREMENTS

1.2.1 Section 106

The preparation of this *Historic Structure Impact Report* is part of the mandated adherence to Section 106 review, 36 CFR Part 800, as amended in August 2004. Section 106 requires that federal agencies, and entities that they fund or license, consider the effects of their actions on properties that are listed in the National Register of Historic Places (NRHP), or that may be eligible for such listing. To determine whether an undertaking could affect NRHP-eligible properties, cultural resources, including archaeological, historical, and architectural properties, must be inventoried and evaluated. Although compliance with Section 106 is the responsibility of the lead federal agency, others can conduct the work necessary to comply. Additionally, because both the Downtown Marysville Commercial District and the Bok Kai Temple are National Register listed historic resources, it is a statutory requirement under Section 110(f) of the National Historic Preservation Act (NHPA) that the agency official (Corps and CVFPB), to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm resulting from an undertaking.

In compliance with Section 106 of the NHPA, the Corps entered into a Memorandum of Agreement (MOA) with the California Department of Parks and Recreation Office of Historic Preservation (SHPO) regarding treatment of both the Bok Kai Temple and Marysville Commercial Historic District during this project.

The NHPA defines an effect as an alteration to the characteristics of a historic property that qualify it for inclusion in or eligibility for the National Register of Historic Places (NRHP). Effects can be found adverse or not adverse. Adverse effects are defined by the *Criteria of Adverse Effect* as outlined in 36 CFR 800.5(a)(1). An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify that property for inclusion in the NRHP in a manner that would diminish the integrity of that property's location, design, setting, materials, workmanship, feeling, or association. In applying the criteria of adverse effect, regulations require that consideration be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the NRHP. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance, or be cumulative. Examples of adverse effects on historic properties include, but are not limited to:

1. Physical destruction of, or damage to, all or part of the property;

2. Alteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation, and provision of handicapped access, that is not consistent with the Secretary's Standards for the Treatment of Historic Properties and applicable guidelines;

3. Removal of the property from its historic location;

4. Change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance;

5. Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features;

6. Neglect of a property which causes its deterioration, except where such neglect and deterioration are recognized qualities of a property of religious and cultural significance to an Indian tribe or Native Hawaiian organization; and

7. Transfer, lease, or sale of property out of Federal ownership or control or conditions to ensure long-term preservation of the property's historic significance.[4]

1.2.2 CEQA

The California Environmental Quality Act (CEQA) (Section 15064.5) requires the lead CEQA agency to assess the impacts of the project on cultural resources. For the MRL, the lead CEQA agency is the lead non-Federal agency, CVFPB.[5] Historical resources are defined as "any object, building, structure, site, area, place, record, or manuscript which is historically or archaeologically significant, or is significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military, or cultural annals of California."[6] Before the level of significance of impacts can be determined and appropriate mitigation measures developed, the significance of historical resources must be determined. Generally, the application of Section 106 is considered to adequately address the requirements of CEQA.

This report is intended to provide information to related to compliance with both Section 106 and CEQA for the MRL Phase 2B project.

1.3 OVERVIEW OF PREVIOUS STUDIES

In preparation for this project, a number of previous studies have been conducted related to the potential construction methods under consideration, site specific qualities such as soil and levee condition, identification of known and potential historic resources in the area, and possible impacts related to levee repairs. The conclusions in each report are consistent and form the basis for many of the conclusions and recommendations in this document. The following presents the most relevant project-related studies and their findings.

- Roger Zemba, *Memorandum for Record: Structural Observations and Analysis for Historic Structures – Marysville Ring Levee Construction*, 13 January 2010

  This memo is included as Attachment A of the 14 January 2010 memo by Erik James. It briefly describes the condition of the Temple, as observed in October 2009, as good and structurally sound. Recent repairs were noted, including replacement of the tile roof with wood shingles and replacement of the two supporting porch columns. The memo highlights the existence of a sheet pile wall approximately half-way between the Temple

[4] "Code of Federal Regulations, Section 36, Part 800: Protection of Historic Properties, Subpart B, Section 800.5(2)(i-vii)," (Washington, D.C., 2004).
[5] Initial Study, 117.
[6] California Public Resources Code, Section 5020.1(j).

and the proposed construction location. The author states that the construction methods used to install the existing sheet pile wall are much more impactful and likely to have caused damage than the methods proposed for the MRL project. Also, the MRL project would be nearly twice as far away as the existing sheet pile wall, further reducing the likelihood of construction-related adverse impacts to the Temple. It concludes that if construction methods were carefully selected, no impacts were likely to the Bok Kai Temple.

- Erik James, *Memorandum for Record: Marysville Ring Levee EDR – Bok Kai Temple Construction Impact Evaluation*, 14 January 2010

  This memo summarizes the findings of the earlier January 13, 2012 memo and adds calculations of anticipated vibrations based on methodology from Caltrans *Transportation- and Construction-Induced Vibrations Guidance Manual*. They used a conservative distance of 40-feet between the Temple and proposed construction activities and values associated with heavy impact construction equipment such as pile drilling equipment and large bulldozers (0.089 in/sec PPV). Even with site-specific soils data, they used a more conservative *n*-value of 1.1 to provide as conservative an estimate as possible for consideration. Their result was an anticipated peak particle velocity from construction equipment (PPV) of 0.05 in/sec.

  The memo concludes that level of anticipated vibration is below recognized thresholds where damage to buildings in good repair (like the Temple) is unlikely. It recommends a number of measures to limit construction-related vibrations as well as monitoring of the historic resource during construction.

- HDR, Inc., *Engineering Documentation Report, Marysville Ring Levee, Yuba River Basin, California*, April 12, 2010

  The MRL is part of the larger Yuba River Basin project. As such it is covered under the environmental review documents produced for that project. Modifications to the MRL required creation of a separate document to verify that the conditions outlined in the original Environmental Impact Statement (EIS) remain valid. The report concluded that the MRL project is consistent with the original project review. The original NEPA determination of a Finding of No Significant Impact and CEQA findings justifying a Negative Declaration remain valid.

- *Environmental Assessment/Initial Study, Marysville Ring Levee, Yuba River Basin, California*, April 2010

  This document concluded with a finding of No Significant Impact (NEPA) and supported a Negative Declaration (CEQA) for the Marysville Ring Levee improvements. It discussed a number of potential and known historic resources, including the Bok Kai Temple and the Downtown Marysville Commercial District. Drawing primarily from the two January 2010 memos referenced above, it concluded the project was unlikely to result in impacts to these historic resource and recommended additional study and monitoring.

- HDR/Fugro/WLA, *Geotechnical Data Report, Marysville Ring Levee, Phase 2B, Marysville, California*, December 7, 2012

  This survey established areas of previous intrusions or voids in the levee as well as summarizing the known geologic history and categorization of soils in the Marysville area. Previous intrusions include a sheet pile wall near the Bok Kai Temple. The top of the wall will be located four-feet below the ground surface.

- HDR/Fugro/WLA, *Final Alternatives Analysis, Marysville Ring Levee Phase 2B, Yuba River Basin, California*, July 2012

  The major problems with the Phase 2B levee segments are identified as through-seepage and underseepage during high water events. Three possible solutions were deemed viable for the three segments: shallow cutoff wall, deep cutoff walls, and levee reconstruction. Four different possible alignments were also considered. The result was eight different alternatives presented in the report ranging in cost from approximately $11 million to $17 million.

1.4 IMPACT REPORT GOALS AND METHODOLOGY

The goal of this historic structure impact report is to analyze potential impacts of the proposed project and project alternatives on the historic resource. Based on that analysis, recommendations to mitigate any potential impacts have been developed. The bulk of this analysis centers on evaluation of the possible vibrations resulting form proposed construction and comparison of these anticipated values with the body of literature concerned with establishing construction-related vibrations thresholds for historic buildings. This report is the second of a two-phase evaluation process that was preceded by a *Marysville Levee Preliminary Historic Resource Impacts* memo dated July 19, 2012.

1.4.1 Literature Review

Garavaglia Architecture, Inc. reviewed relevant project and historical information including:

- Donald Napoli, *Downtown Marysville Commercial Historic District National Register Nomination* (1999)

  The nomination established the boundaries of the historic district as well as the character defining features of the district. The period of significance includes both 19th and 20th century building campaigns but stops prior to the redevelopment efforts of more recent decades. It provides a historical context for Marysville in general, and minimal contextual information on the Chinese community that established the Bok Kai Temple and occupied the buildings on First Street, closest to the MRL project.

- Architectural Resources Group, Inc., *Historic Structure Report: Bok Kai Temple* (2002)

  The HSR for the Bok Kai Temple describes the conditions of the temple prior to recent repair campaigns. It presents a good overview of the construction chronology of the building and the historical context for the Chinese community in Marysville up through recent times. Appendices to the document include architectural plans and recommendations for structural upgrades to the building. It does not detail what work was undertaken with the 2006 grant awards.

- California Department of Transportation, *Transportation- and Construction-Induced Vibration Guidance Manual* (2004)

  This document serves as the basis for evaluation of vibrations-related impacts on buildings in various states of repair and construction types. It presents formulas for evaluation of site-specific conditions and recommends vibrations thresholds for construction-related activities. While it is not the only vibrations guideline referenced in this report, it is the only one specifically mentioned in the scope of work for the MRL project.

- *Memorandum of Agreement between the U.S. Army Corps of Engineers and the California State Historic Preservation Officer, Regarding the Marysville Ring Levee Project, Yuba County, California* (2011)

  The MOA establishes documentation and methodology requirements regarding the historic resources near the APE for the MRL project. It represents the agreement between the major stakeholders and serves as the overarching guideline for this document.

1.4.2 Field Investigations

After review of relevant background information, a site visit was conducted on December 7, 2011 to inspect the interior and exterior of the Bok Kai Temple for existing conditions, and to conduct a general exterior survey of buildings in the historic district within 200 feet of the MRL project. This site visit included Architectural Conservator and Historian, Becky Urbano (Garavaglia Architecture, Inc.), Structural Engineer, Steve Duquette (Duquette Engineering), and HDR team member and vibrations expert, Dr. Sandy Figuers (Norfleet Consultants). A second site visit was conducted on August 30, 2012 to observe and note interior conditions of the buildings on the south side of First Street. This memo is the result of observations made during those site tours as informed by the background project information and ongoing conversations with HDR, the Corps, and other team members.

2. HISTORICAL CONTEXT AND SIGNIFICANCE

2.1 HISTORY

Architectural Resources Group (ARG) completed a Historic Structure Report for the Bok Kai Temple in 2002 (see Figure 2). The building was listed in the National Register of Historic Places in May 2002. As defined in the National Register nomination, the years 1880-1930 mark the period of significance for the building, spanning from the building's dedication in March 1880 to the time when the Chinese population in Marysville was decreasing. The following historic overview is quoted from ARG's Historic Structure Report for the Bok Kai Temple. Please see the original document for more information.

Figure 2. Bok Kai Temple, c.1880. This image shows the temple shortly after its reached its current form. Note the different colors of the east and west wings and the detail in the wood frieze panel between the porch columns. (Image courtesy of the Bok Kai Temple website.)

2.1.1 Developmental History and Context of Marysville

The city of Marysville lies at the confluence of the Yuba and Feather Rivers in Yuba County on a portion of land granted to John Sutter by the Mexican rulers of California in 1841. Sutter leased part of his land to Theodor Cordua, who built a rancho on the north bank of the Yuba River, just east of its junction with the Feather River, and raised livestock in the surrounding area. This was the beginning of the settlement that would soon become Marysville. In 1848, Cordua sold a half interest in the land to a former employee of his, Charles Covillaud, and later sold his remaining interest to Michael Nye and William Foster. Covillaud's partners in the land grant soon changed so that by 1849 four men, Covillaud, Jose Manuel Ramirez, John Simpson, and Theodore Sicard had become Covillaud and Company. In 1850, town lots were mapped out, parcels sold, and the name of Marysville chosen for the new town in honor of Mary Murphy, the wife of Charles Covillaud and a survivor of the infamous Donner Party. Marysville was incorporated as a town by the California Legislature in 1851.

Marysville's early history is directly linked to the discovery and exploitation of gold in the nearby foothills of the Sierra Nevada Mountains. Following the discovery of gold at Sutter's lumber mill in Coloma in January 1848, Marysville's potential as a point of transfer for goods, people, and riches was quickly realized. The position of Marysville at the meeting of two navigable rivers, and its relative proximity to San Francisco, Sacramento, and the gold fields, made the site well suited to take advantage of the Gold Rush economy. Although gold discoveries were made just a few miles from the town, most of the early growth of Marysville was based on the related industries of trade, transportation, and financing, not directly on mining enterprises.

2.1.2 [Marysville Chinese Community]

As with other communities in California that grew rapidly during the Gold Rush period, Chinese immigrants were quick to establish homes, businesses, and a sizeable presence in Marysville. Although there is evidence of some Chinese presence in California before 1841, it was after the discovery of gold at Sutter's mill that the number of Chinese immigrants became substantial. These Chinese immigrants, many from Kwangtung (Canton) province, voyaged across the Pacific to work in the gold fields, build the railroads, and open the businesses that would help to establish the early California economy.

The earliest temple built by the Chinese community in Marysville was probably constructed in 1854 on the north bank of the Yuba River at what was then the southeast corner of the young town. The likely location of this temple, at the southeast corner of what is currently First and B Streets, was adjacent to the Chinese quarter of Marysville that began to develop along the bank of the Yuba river. The temple was also situated near a stream that drained into the Yuba River, where it provided a spiritual barrier to the outward flow of positive energy away from the community and the inward floor of evil spirits along the stream of the river. As detailed by Dr. Paul Chace, the temple property was owned by attorneys for the Chinese through the 1860s and then transferred to the Hong Woo & Co., the largest Sze Yup business in Marysville. Sze Yup refers to four districts in Southern china populated by peoples sharing a common dialect and ethnic identity. Late in the winter of 1874, devastating flooding of the rivers in Marysville forces the city to widen the levee along the Yuba River, including the area at First and B Streets.

2.1.3 Development of the [Bok Kai Temple] Site

The existing Bok Kai Temple is situated between several structures and the levee along the north bank of the Yuba River. The Temple's current location, south of First Street near D Street, dates to 1880. At that time, the front of the temple would have faced Front Street, and D Street would have run along the west side of the Temple to the bank of the Yuba River. Situated at the northeastern corner of the principal bridge into the city, the Temple became the first building everyone saw when entering early Marysville.

Before the founding of the Bok Kai Temple at its current site, a brick bathhouse and saloon occupied the property at the corner of D and Front Streets. This structure, dating to 1852, was owned by William H. Clark who operated it as the Marysville City Baths. The one-story structure, approximately 20-feet by 60-feet with a basement, was enlarged circa 1856. Clark owned the expanded 20-foot by 80-foot lot until 1857 when it was then auctioned off and passed through a series of owners through the 1860s.

In March 1869, members of the Marysville Chinese community acquired the brick bathhouse building and began work to reconstruct the structure a Chinese temple. The new Chinese temple was dedicated and opened to the public on May 15, 1869. The front of the building was described in newspaper accounts as 'ornamented with Chinese paintings' and the temple hall as 'gay if not gaudy' and 'about fourteen foot square.' This temple is called the 'Bok Ky Church' in Marysville's 1876 tax records. The northern wall of the 1852 bathhouse probably remained as the northern wall of the 1869 temple altar hall. The southern wall of the temple may have been newly constructed in 1869 to create a recessed front porch and entrance to the altar hall, a traditional southern Chinese architectural style. If this is the case, the walls onto which the exterior mural is currently painted would date to 1869.

In the site development scenario proposed above, the 1869 temple building would have occupied the southern half of the current site of the Bok Kai Temple. The property immediately adjacent to the 1869 temple on the north appears to have been undeveloped until 1858. At that time, a substantial improvement is listed for the property in the city's Assessment Roll Book. This improvement may correspond to the construction of an on-site brick building. The owner of the property, as recorded in the 1859 Book of Deeds, is Isaac Belcher, a prominent lawyer in Marysville. Although Belcher owned the20-foot by 80-foot lot until October 1872, it is possible that the lease for the 1869 temple included Belcher's land and building on the northern half of the site. In 1872, Thomas Seward and E.C. Ross acquired the Belcher property. These two men had obtained legal ownership of the southern 20-foot by 80-foot Bok Kai Temple property in August of the same year. Seaward and his estate retained ownership of the consolidated 40-foot by 80-foot lot at Front and D Streets until February 1880, at which time the parcel was purchased by Chow You and Yee Wat Chung through an administrator of the deceased Seward's estate, Title to the property was then transferred to the Trustees of the Bock Ky Church[.]

The renovation and expansion of the structure that is the present Bok Kai Temple was underway by January 1880. Although the extent of renovation is not definitively known, it likely includes the construction of new east and west bearing walls for the expanded Altar Hall and the application of many decorative details, including the mural painting at the front porch walls. The other brick bearing walls at the perimeter of the current Temple structure probably incorporate the walls of the 1852 Bathhouse and 1858 Belcher building. Some of the work performed as part of the expansion of the Bok Kai Temple was carried out by Swain & Hudson, a major building firm in Marysville at the time, Chinese craftsmen did other work, including the painting of the figurative and ornamental murals at the entrance porch. The architectural design of the temple was based on 'models furnished…by the Chinese' and 'plans drawn by Chinese draftsmen,' according to contemporary newspaper accounts. The construction of the 1880 Bok Kai Temple was accomplished with money from Chinese community members. The names of these people who contributed to the Temple are listed in a plaque in the Altar Hall. The Bok Kai Temple was dedicated in March 1880.

The founding of the temple was a symbol of the growing presence and influence of the Chinese community in Marysville. The maintenance and upkeep of the temple required contributions from every member of the community, both in time and money. The Temple provided a network of support for the community, which, from its earliest period and particularly after the passage of the Chinese Exclusion Act of 1882, was faced with various forms of discrimination and isolation. From its founding through the present day, the Council Chamber in the hall to the west of the Altar Hall has been used for community meetings, classes, and other social gatherings.

At the same time that the Chinese community in Marysville built the Bok Kai temple, Chinese immigrants to other areas of California and the west were constructing temples to serve their local community. Among the most prominent of the surviving structures are the temples in Oroville, the Won Lim Temple in Weaverville, and temples in San Francisco rebuilt after that city's earthquake and fire in 1906. These temples display a common organization, relating to the religious and social functions of the temple and the relationship of social hierarchies.[7]

"The Bok Kai Temple is one of the few examples of a Taoist temple built by Chinese immigrants to the western United States, and is significant as a symbol of Chinese immigration and settlement in the west during the second half of the nineteenth century. The Temple's design incorporates elements of traditional and popular cultural imagery and many of the deities associated with the building refer to the importance of water. The Temple is also significant for its exterior

[7] Architectural Resources Group, "Bok Kai Temple Historic Structure Report, " September 2002, 13-17.

Figure 3. Bok Kai Temple, 2011. This is a current image of the Bok Kai Temple as viewed from the top of the levee. The roof has been returned to its original shingled appearance after many years covered in inappropriate clay tile. (Photo by Garavaglia Architecture, Inc.)

mural paintings depicting a combination of calligraphy writings, narrative panels, and decorative scenes. These paintings are significant both nationally and internationally, as rare examples of intact Taoist mural paintings. The Temple is also important as a local community landmark and serves as a center of local history, tradition, and pride," (see Figure 3).[8]

2.2 CHRONOLOGY OF DEVELOPMENT AND USE

The Bok Kai Temple retains a high degree of integrity and appears much as it did at the time of dedication in 1880. The following summary is taken from the *Bok Kai Temple Historic Structure Report*.[9]

[8] Ibid, 5-6.
[9] Ibid, 22-23

1854	Construction of first Chinese temple in Marysville at southeast corner of First and B Streets.
1869	Dedication of first Bok Kai Temple at northeast corner of Front and D Streets. This temple incorporated portions of a one-story brick bathhouse built by William Clark in 1852.
1875	Removal of temple at First and B Streets for the widening of the levee along the north bank of the Yuba River.
1880	Expansion and renovation of the Bok Kai Temple at Front and D Streets. A brick building constructed in 1858 by Isaac Belcher was incorporated into the enlarged Bok Kai temple. New load bearing walls and roofs for the Altar Hall were built as part of this renovation.
Pre-1890	Small addition made to northeast corner of building. This addition was present in 1895 but had disappeared by 1909, based on Sanborn Maps for Marysville.
Pre-1945	Addition on east end of Temple approximately 20 feet by 40 feet.
1960 to 1964	Renovation of the Bok Kai Temple, including repair of the building's foundations, repair to the exterior stucco, and restoration of the building's floors, walls, and ceilings. The existing sprayed-on foam roof was installed at this time, new electrical work, storm drain, and sewer services were provided, and the interior toilet rooms at the southeast corner of the building were installed. Landscaping work and the construction of the archway near D Street leading to the Temple was also included in this renovation plan.
c.1996	Installation of sheet metal housing at wall vent on west gable end of Altar Hall.
c.1998	Installation of iron security gates at exterior doors on south elevation.
c.2006	Grant money allowed for removal of the tile roof and its replacement with a wood shingle roof. At the same time, repairs were completed at the gable end walls to close up and fill substantial cracks that had developed from overloading of the roof and failure of the porch column supports. The wood porch columns were also replaced. Stabilization and minor repairs were made to the murals under the porch roof as well. The building was painted at this time. No seismic upgrades were completed at this time. On the interior, the sanctuary walls were covered with textured panel board and painted, a new tile floor was installed, and a tile-clad altar replaced the previous wood altar.

The following alterations to the Bok Kai Temple and site are undated:

- Rise in levee height between the south facade of the Bok Kai Temple and the Yuba River. Levee height was two feet high until 1872, when its height increased with each flood, ultimately reaching its present height and configuration.
- Original wood shingles replaced with clay tile; figurines and wood bases on top of the wood beam ends (these alterations made before c.1950, according to historical photograph).
- Installation of skylight in Council Chambers.

2.3 HISTORICAL SIGNIFICANCE AND STATUS

The Bok Kai Temple was originally listed on the National Register of Historic Places in 1975. The nomination was updated in 2001. It is California Historic Landmark Number 889 (1976).

"The primary significance of the Bok Kai Temple lies in its contributions to our understanding of the patterns of the country's history, specifically, to patterns of immigration and expressions of ethnic heritage."[10] At the time of construction, it established Marysville as a center for Chinese culture in central California. Its function and appearance have changed little in the intervening years even as the Chinese population in the area has dwindled. 2012 marks the 131st year of the Bok Kai Parade and Bomb Day Festival, ritual celebrations that are intimately associated with the temple and its place in the larger Chinese community.

Architecturally, the temple is significant as one of the last Chinese-built Taoist temples in the United States. The murals and iconography are unique and are some of the last surviving examples of exterior Taoist murals in the world.

The identified period of significance for the Bok Kai Temple is 1880 through 1930. This marks the dedication of the temple in its current form through the retirement of Taoist priest Yee Chow Chung from active service.[11]

[10] Ibid., 5.
[11] Dr. Sue Fawn Chung and Ross Nelson, "National Register of Historic Places Nomination: Bok Kai Temple, Marysville, California," (2001).

3. PHYSICAL DESCRIPTION AND EXISTING CONDITIONS

3.1 GENERAL DESCRIPTION AND CHARACTER DEFINING FEATURES

The following description is from the *Bok Kai Temple Historic Structure Report*:

> The Bok Kai Temple is situated on the northern bank of the Yuba River at a point where the river widens before meeting the Feather River to the west. The temple building occupies a roughly 40-foot by 80-foot area between a levee along the river [to the south], a cluster of structures to the north, a public walkway and park to the west, and a parking lot to the east.[12]
>
> South of the Temple, a concrete walkway separates the south wall of the building from a concrete retaining wall and a series of planting beds and concrete steps that rise up an earthen embankment…The embankment is a levee built up over time to a height greater than the roof of the Temple to protect the City of Marysville from flooding of the Yuba River [see Figure 4].[13]

Figure 4. Bok Kai Temple and surrounding area. The temple faces the levee and is accessible, by foot, via the neighboring park. (Aerial image taken from Google Maps.)

[12] HSR, 25.
[13] Ibid.

The Bok Kai temple is a one-story, brick and wood-frame structure. The exterior unreinforced brick walls are stuccoed and painted white. The exterior wood frame walls are covered with corrugated metal siding. A concrete walkway leads to a raised platform in front of the main entrance to the building on the south elevation. A porch roof supported by wood beams and columns covers the main entrance near the center of the south facade and protects mural paintings on the stuccoed exterior walls of the Temple. Additional exterior doors on the south elevation open into side halls to the west and east of the central Altar Hall. Visor roofs supported by newer steel posts project from the south elevation to shelter these doors. A double-gable roof covers the central section of the building, and gently sloping roofs cover the side halls. The double-gable roof of the Altar Hall and porch and the two visor roofs are covered with ceramic tile; the other roofs have a sprayed-on foam roofing material.[14]

Currently, the Bok Kai Temple is divided into three distinct sections. The westernmost section is a large space separated by a wood partition screen into two rooms of roughly equal size. The screen is located at the former position of the party wall between the two earlier buildings on the site.[15]

The mural paintings were created by a single master artist at the time of the Temple's dedication in 1880. They are a rare example of exterior decoration associated with Chinese religious architecture, either in the United States or in China. The 13 panels comprising the mural paintings have narrative scenes with figures engaged in different activities, calligraphy writings, and decorative scenes of birds and flowers. The use of a colored border ties the composition together. The scenes may represent important Chinese cultural values expressed in popular Taoism. Partially protected by the overhanging porch roof, the colors of the mural painting are still vibrant and the scenes legible. The Taoist mural paintings of the Bok Kai Temple are not only unique in North America, surviving over a century with strong connection of the original Temple buildings still intact, but are also among only a small number of surviving examples in the world. Similar temple paintings in mainland China were destroyed and lost in the 1960s cultural revolution, and most temples in Taiwan have been overpainted or refurbished, compromising significant wall paintings."[16]

3.2 EXTERIOR CONDITIONS AND DESCRIPTION

The exterior of the building is in excellent condition. As part of the recent re-roof and repair project, all exterior surfaces were addressed. Cracks were filled, the stucco was repaired, wood columns were replaced, and the exterior surfaces received a new coat of white or red paint. Under the porch roof, cracks through the murals have been stabilized but not overpainted. The repairs remain visible. At the roof level, the cast figurines at the porch gable ends have been braced and positively attached to the ends of the parapet walls. On the west walls, as one enters the site, the bright paint has been soiled at grade by biogrowth within an infilled door recess. Adjacent to this infilled panel is a downspout draining a portion of the low-slope roof over the western section of the temple. Moisture in this area is becoming trapped in the wall and

[14] Ibid, 26.
[15] Ibid.
[16] HSR, 6.

creating conditions damp enough to support growth. Another downspout at the north end of the wall drains the north slope of the roof over the primary temple chamber. Water is carried by a long series of pipes across the back of the building to a collection box at the northwest corner of the site. This collection box is not functional and water is deposited on the electrical meter and adjacent wall areas.

Soiling from water backsplashing is also evident at grade on the southern half of the west elevation. This is likely from water bouncing off the concrete walkway adjacent to the building and not from runoff from the roof at this location. Drainage at other points around the building parameter appears to be functioning properly.

While cracking of the gable ends over the central building section has been addressed, there is horizontal cracking of the stucco on the barrel-vault roof connecting the two halves of the central building section (Figure 5). It is unclear if this is an active crack or a historical condition that is stable but covered by a failing surface coating.

Figure 5. Horizontal crack in barrel vault. Even though the roof was repaired and strengthened in 2006, horizontal cracking in the small barrel vaulted section is ongoing. (Photo by Garavaglia Architecture, Inc., 2011.)

The north and east sides of the building are largely inaccessible. The east side is covered with corrugated metal finished with stucco. The north is mostly masonry, with corrugated metal over the kitchen wing.

3.3 INTERIOR CONDITIONS AND DESCRIPTION

Interior conditions vary depending on which section of the building. Starting at the western section, the interior is used for storage. The walls are unfinished, with exposed brick. Remnants of a stucco finish are on the south wall and white paint remains on some of the exposed brick. Joist pockets are also visible indicating this section of the building had a second floor in the distant past. On the west and south walls, evidence of former openings are visible as arched brick headers and differences in color and texture of infill brick. This section appeared free from leaks and no cracking or settlement was observed.

Conditions in the central section, where the main temple is located, are obscured by recently installed textured panelboard. A crack was visible above the east door, below the Threshold Screen bracket (Figure 6). The ceiling in this space is quite dark from years of burning candles and incense. The floors are newly installed stone tiles. The same tiles are used on the new altar table. They replaced a wood altar table and wood floor surface to improve fire resistance within the worship space. In general the surfaces appeared to be new and free from defects. However, a number of objects are suspended from the ceiling or attached to the wall in this section of the building. The security of these connections is questionable.

Figure 6. Crack in the new wall paneling. This crack is above the door to the Fortune Readers's Room. The condition of the underlying brick wall could not be surveyed. (Photo by Garavaglia Architecture, Inc., 2011.)

The only accessible basement area is beneath the central section. It is accessed through a small door in the east wall, underneath the stairs into the Fortune Reader's Room. The brick foundation for the altar is clearly visible. Areas of moisture staining were noted at the northeast corner but no active leaks or ponding were evident. The space did not smell musty and overall appeared dry. The one exception was at the northeast corner. This corresponds to a faulty downspout on the exterior. Water is seeping into the soil and through the brick in this location.

The eastern section of the building consists of four main rooms and a number of smaller rooms within the main spaces. It is a combination of brick and wood-frame construction. The floor level is much lower than the other two sections. The masonry sections are dry and sound except for the northwest corner of the Gambler's Room (Figure 7). Here moisture was evident at the ceiling. This roughly corresponds to the area of moisture in the basement, although that would be on the other side of the wall in question. A blocked roof drain is the likely source of moisture. The wood-frame rooms are in poor condition. The wood framing members rest on a stone, brick, concrete pony wall. Where this framing meets the wall, many framing ends are deteriorated or missing entirely. Cross bracing is minimal and poorly connected. The pony wall is crumbling in some locations. While this section remains upright and dry, its overall condition is marginal (Figure 8).

Figure 7. Moisture staining in the Gambler's Room. This area is near a roof drain that was improperly functioning. The area has since been repaired, but the damage is evident. (Photo by Garavaglia Architecture, Inc., 2011.)

Figure 8. Poor pony wall condition. The northeast corner of the Temple is wood frame on a brick pony wall. The framing and the masonry wall are in poor condition. This image shows one area of extreme damage where severe settlement has occurred. (Photo by Garavaglia Architecture, Inc., 2011.)

3.4 Structural Conditions and Description

The existing structure is composed of four sections with two different types of construction – unit masonry and wood frame. The main building (temple section) is an unreinforced brick masonry building with wood roof and floor diaphragms. At the roof, the diaphragms are 1x straight sheathing over 2x rafters. At the floor, the diaphragm is 1x straight floor sheathing over 2x floor joists supported on girders running north-south in the crawlspace. The perimeter walls are unreinforced brick masonry and the foundation is also unreinforced brick masonry. Two smaller unit masonry building sections flank the main temple. Each has a slab on grade foundation and a low slope roof.

These sections of the building are in excellent structural condition. However it was noted that no seismic upgrades have been made. Unreinforced brick masonry buildings are generally accepted as being hazardous and requiring seismic upgrade to mitigate the life safety risk.

To the east is a wood-frame addition with corrugated metal roofing and siding. The siding is clad with stucco on the exterior face of the material. This section has a wood frame roof consisting of corrugated metal roofing over 2x roof rafters. There is no sheathing. The walls are 2x studs covered with corrugated metal siding, again with no sheathing. This structure sits on an on-grade concrete slab. The perimeter foundation is a combination of shallow concrete and shallow unreinforced brick continuous foundations. There are several areas where the bricks are loose and have settled away from the wall sill plate.

This section of the building is in poor structural condition. The quality of the foundation materials and the lack of any lateral system makes this area of the structure most susceptible to damage.

3.4.1 Common Structural Deficiencies

The Bok Kai Temple is fairly well maintained and in good condition. It is constructed of unreinforced brick masonry with wood frame additions. While its condition is good, structures constructed of unreinforced masonry have inherent deficiencies that make them susceptible to damage due to seismic loads or other heavy vibrations. The common deficiencies noted are as follows:

- *Parapet Bracing*
  The parapets extend more that 12-inches above the roof plane without proper bracing. These parapets are unstable under seismic loading and may be unstable when subjected to continual, low-grade vibrations. This condition could result in collapse.

- *Out-of-Plane Wall Anchorage*
  There is a lack of continuity between the heavy masonry walls, the wood floor, and roof diaphragms. This can result in separation and collapse under seismic loading.

- *In-Plane Shear Transfer*
  There is a lack of continuity between the floor and roof diaphragms for shear transfer. This can result in separation and collapse under seismic loading.

- *Floor and Roof Diaphragms*
  The floor and roof diaphragms typically are not adequate to support the lateral seismic loads imposed by the heavy masonry walls without strengthening or additional interior shear walls or frames.

These deficiencies are most critical when the building is subjected to seismic loading. The anticipated construction-related vibrations are much smaller but can cause architectural cracking and minor separations when the structure has these major structural discontinuities. Adequate monitoring as described in the recommendations section is imperative.

4. VIBRATIONS PARAMETERS

Potential impacts on the Bok Kai Temple due to the MRL project are likely to be the result of vibrations caused by construction nearby. Vibrations are caused by construction activities themselves, such as blasting, drilling, compacting, etc. as well as by everyday activities related to construction such as material transport, material movement on adjacent streets, construction activities on staging sites, etc. In the K1 and K2 sections of Phase 2B, a small staging site is proposed for an empty lot immediately adjacent to the southeast corner of the historic district. Construction activities range from 10-100+ feet from the closest historical resources to the APE. How buildings react to these increased events is as much a function of condition, construction, and location as it is of the project-related activities themselves. Therefore, a determination of impacts must establish a baseline threshold for construction-related events then analyze the individual buildings' ability to tolerate those vibrations.

4.1 LITERATURE REVIEW

To place modern understanding of the impacts of construction-related vibrations on buildings into context, it is important to consider the international body of work on the subject. Generally, the British and German standards are most heavily referenced, although Swiss standards play an important role in studies done by Caltrans. In the United States, the body of work is a mixture of data from large construction projects, such as Boston's Big Dig project, and data collected by the federal government agencies such as the Bureau of Mines. Each study references earlier studies and each is based on particular sets of criteria that are not necessarily translatable across situations, or across applications. Therefore, while there is relative consistency in the findings, the methodologies can differ.

For the purposes of this analysis, information is primarily presented from the most widely referenced international standards and compared with the common domestic standards. Differences to keep in mind include nuances of language. Many of the German studies are not translated into English. Those that are available as translated documents are provided by the German government only. Therefore, slight nuances of translation are lost because the translation is from a single source.

4.1.1 Overview - German Standards

Internationally, the German standards are generally considered to be the most restrictive when considering impacts from vibrations on structures. In actuality, there are three building-related vibration German standards: DIN 4150-1, DIN 4150-2, and DIN 4150-3. DIN 4150-1 discusses the mathematical evaluation of vibration parameters, such as creating attenuation curves. DIN 4150-2 describes how to evaluate human exposure to vibrations from construction activities. DIN 4150-3 discusses measuring and evaluating the effects of vibrations on structures (non-earthquake loading). Of these, only DIN 4150-2 and DIN 4150-3 have been translated into English and made widely available to the international engineering community. For the purposes of this analysis, DIN 4150-3 is the most applicable to the immediate goals of establishing vibration thresholds for the historic resources near the MRL project. It includes evaluation of vibrations on pipelines, non-cohesive soil settlement, vibrations in floors and walls, as well as generalized methods for reducing vibrations from construction activities.

The German standards are integrated and broad. The DIN 4150-3 incorporates by reference six other German standards. Most have not been translated into English. DIN 4150-3 includes evaluation of vibrations on pipelines, non-cohesive soil settlement, vibrations in floors and walls, as well as generalized methods for reducing vibrations from construction activities.

One concern with referencing the German standard for an international audience is that the German authorities have never provided any information on how the standard was set. Further complicating comparisons is the differences in definitions of what constitutes a short-term vibration versus a long-term vibration. Section 3.4 of DIN 4150-3 defines a short-term vibration as: "vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated." Section 3.5 defines a long-term vibration as: "all types of vibration not covered by the definition of 'short-term vibration' in subclause 3.4" (i.e. dynamic/harmonic vibrations).

In DIN 4150-3 the definitions for short- and long-term vibrations are based on the ability of those vibrations to cause damage. A short-term vibration can cause damage, but not structural fatigue. A long-term vibration causes structural fatigue and building resonance. DIN 4150-3 occasionally refers to long-term vibrations as harmonic. A weak impulse or continuous vibration that does not cause structural fatigue (but causes cosmetic cracking) would be called a short-term vibration while a vibration (impulse or continuous) strong enough to cause structural fatigue or building resonance would be classified as a long-term vibration.

4.1.2 Overview – British Standards

The British have two vibration standards, BS 5228-2 (2009) and BS 7385-2 (1993) (see Figures 9a and 9b). BS 5228-2 covers vibration control on construction and open sites and BS 7385-2 covers evaluation and measurement of vibrations in buildings. These standards have evolved over the years and sometimes the recommendations between the two publications have differed. They currently are consistent. Vibration level recommendations in both standards are judged to give a minimal risk of direct vibration-related cosmetic damage (threshold values- formation of hairline cracks). The PPV values are frequency dependent.

BS 5228-2 (2009) provides recommendations for retaining walls (no lateral support). For walls in good condition, the threshold limit for transient vibrations is 0.4 in/sec (10 mm/s) (PPV) at the base of the wall and 1.6 in/sec (40 mm/s) at the top. For continuous vibrations, the recommend limits should be reduced by a factor of 1.5 to 2.5 depending on circumstances and external supports may be needed.

4.1.3 Overview – United States Studies

The Federal Railroad Administration (FRA) provides a vibration damage threshold criterion of 0.5 in/sec (12.7mm/s) for fragile buildings and 0.12 in/sec (3 mm/s) for extremely fragile historic buildings from typical construction equipment.[17] These criteria were taken from Swiss standards. The FRA report provided typical vibration levels for construction equipment, and defined frequent events as more than 70 events per day.

[17] United States Department of Transportation, "High-Speed Ground Transportation Noise and Vibration Impact Assessment, Report 293630-1," (1998).

Line [see Figure 9b]	Type of Building	Peak Component Particle Velocity in Frequency Rage of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s [1.97 in/s] at 4 Hz and above	50 mm/s [1.97 in/s] at 4 Hz and above
2	Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s [0.59 in/s] at 4 Hz increasing to 20 mm/s [0.79 in/s] at 15 Hz	20 mm/s [0.79 in/s] at 15 Hz increasing to 50 mm/s [1.97 in/s] at 40 Hz and above

Figure 9a. Transient vibration guide values for cosmetic damage. Values referred to are at the base of the building. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (0.02 in) [zero to peak)] is not to be exceeded.

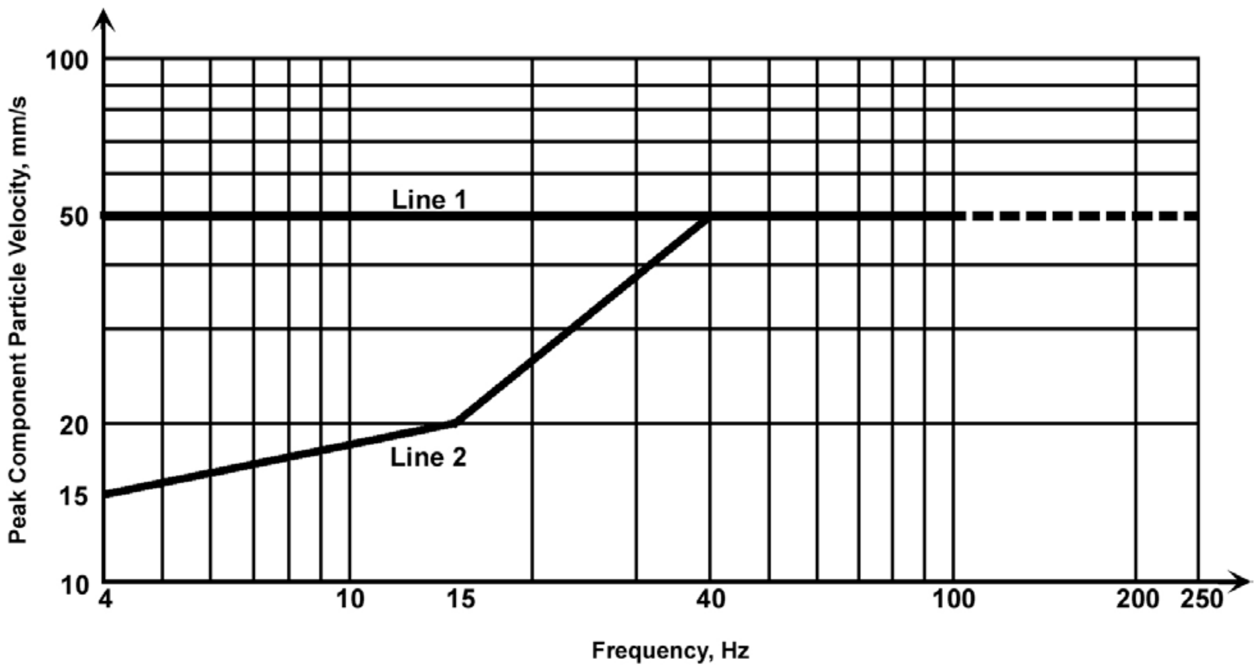

Figure 9b. Transient vibration guide values for cosmetic damage. Transient vibration guide values for cosmetic damage for the current BS 5228-2 (2009). This diagram was originally developed for BS 7385-2 (1993) and was included in BS 5228-2 in 2009. Cosmetic damage is defined as creation of hairline cracks. The accompanying text indicates that minor damage is possible at vibration levels twice that shown, and major damage can occur at four times the listed values. For continuous vibrations, the guide values might need to be reduced by half. Important buildings that may be difficult to repair might require special consideration on a case-by-case basis. A historical building should not be assumed to be more sensitive unless it is structurally unsound. BS 7385-2 notes that the probability of [cosmetic] damage tends towards zero at 12.5 mm/s (0.49 in/s) PPV.

Findings in report RI-8507 by the U. S. Bureau of Mines are commonly used to define minimum ground vibration levels for structural and cosmetic damage to buildings from blasting.[18] These recommendations are based upon detailed monitoring of one- and two-story wood framed houses in good condition that were built to 1980's construction standards. The vibration limits were set at a 95% confidence level with a 5% chance that damage could occur below the proposed limits (Figure 10). The authors noted that no damage had been recorded occurring below 0.5 in/s (12.7 mm/s). They indicated that their vibration limits should not be applied to steady state sources such as traffic because of the different nature of those vibrations.

RI 8507 also provides safe blasting vibration criteria for residential structures. The data upon which this criteria is based is well documented, widely available, and was the result of many years of full-scale testing and monitoring. The criteria are frequency based and are taken from ground measurements adjacent to the foundation. The criteria are expressed as probabilities. It was noted that the probability of cosmetic damage from PPV values below 0.5 in/s is small (5 percent for the worst case) and decreases rapidly.[19] However, this study only evaluated blast vibration effects on buildings.

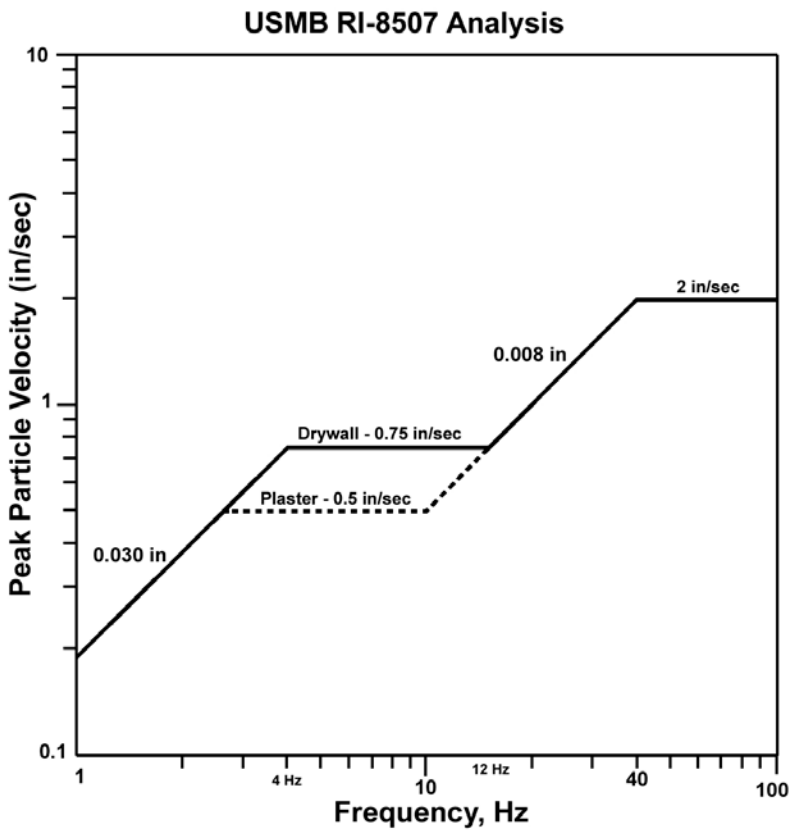

Figure 10. Figure B-1 from Siskind, et al (1980). This shows their vibration limits for safe blasting near homes (transient vibrations). This diagram was not to be used for continuous vibrations.

[18] D.E. Siskind, M.S. Skagg, J.W. Kopp and C.H. Dowding, *Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting*, (United States Bureau of Mines, 1989). The term vibrations will refer to ground vibrations unless otherwise indicated. Vibration values refer to the Peak Particle Velocity (PPV) of the full waveform.
[19] Siskind et al., 1989, 68.

The Federal Transit Authority (FTA) set a vibration limit of 0.12 in/s for fragile historic structures.[20] Many projects use this value for historic buildings. The FTA analysis are commonly used for low-level, continuous vibrations, such as trains and light rail projects.

For construction projects within the City of New Orleans, the City Government set the following vibration limits:[21]

Structure and Condition	in/sec
Historic structures	0.25
Residential structures	0.25
New residential structures	0.5
Industrial building	1.0
bridges	1.0

Figure 11. Limiting sustained peak particle velocities. Limits as applied by the City of New Orleans based on studies of preconstruction vibrations and conditions at the LSU Medical Center in New Orleans.

The PPV is the largest along any of a 3-axis geophone and the PPV values are for sustained (continuous) vibrations.

4.1.4 Caltrans Vibrations Standards

As required by the MOA, Caltrans *Transportation- and Construction-Induced Vibration Guidance Manual* is the guiding document for this project in terms of determining appropriate vibrations levels within the APE where historic resources may be impacted. In this manual, Caltrans references standards developed by various parties over the last 30 years for various types of buildings, including many of the studies noted in the preceding sections as well as other supporting analysis, including those conducted by Yong Chae and the Swiss Association of Standardization.

The Chae Building Vibrations Criteria state a range for single-events of 0.5-1 in/sec PPV for old buildings in "poor to very poor" condition and a repeated-events threshold of 0.5 in/sec PPV.[22] (It does not provide a repeated-events threshold for those buildings in the "very poor" category.) The Swiss Association of Standardization notes single-event vibration ranges from 0.3 – 1.2 in/sec PPV and continuous-source ranges from 0.12 – 0.5 in/sec PPV for a variety of building classes (see Figure 12.).[23] The Swiss Association of Standardization recommendations (SN640312a, April 1992) have become a standard classification used by Caltrans and other entities as a guideline for both continuous and single-event vibration sources.[24]

[20] Carl E. Hanson, David A. Towers and Lance D. Meister, *Transit Noise and Vibrations Impact Assessment, FTA-VA-90-1003-06*, (Federal Transit Administration, 2006), 12-13.
[21] Professional Service Industries, Inc., *Report of Preconstruction Survey and Vibration Monitoring Services, LSU Medical Center, New Orleans, Louisiana,* (Stanley Group, January 13, 2010), Table 2, 6.
[22] Yong S. Chae, "Design of Excavation Blasts to Prevent Damage," Civil Engineering, ASCE, (Vol. 48, No. 4, 1978) as presented in *Transportation and Construction Induced Vibration Guidance Manual*, Caltrans, 2004, 16.
[23] "Swiss Association of Standardization Vibration Damage Criteria Building Class," as presented in *Transportation and Construction Induced Vibration Guidance Manual*, Caltrans, 2004, 16.
[24] Ibid.

Building Class	Continuous Source PPV (in/sec)	Single-Event Source PPV (in/sec)
Class I: buildings in steel or reinforced concrete, such as factories, retaining walls, bridges, steel towers, open channels, underground chambers, and tunnels with and without concrete alignment	0.5	1.2
Class II: buildings with foundation walls and floors in concrete, walls in concrete or masonry, stone masonry retaining walls, underground chambers, and tunnels with masonry alignments, conduits in loose material	0.3	0.7
Class III: buildings as mentioned above but with wooden ceilings and walls in masonry	0.2	0.5
Class IV: construction very sensitive to vibration; objects of historic interest	0.12	0.3

Figure 12. Swiss Association of Standardization vibration damage criteria.

In addition to recommended vibrations thresholds, the Swiss study established a structural categorization system based on construction types. This information is paraphrased in Figure 12. While it lists historic buildings as a category IV type of construction, the condition of the Bok Kai Temple is such that is more accurately categorized between Categories III and IV. This corresponds to a continuous source vibrations range of 0.12 – 0.2 in/sec.

Like the Bureau of Mines report, RI 8507 , more recent studies cited in the Caltrans report discussed vibrations in term of the probability of certain types of damage occurring at different levels of vibrations exposure. For each type of damage they provide a range of exposure that has a certain likelihood causing an impact. For instance, the report draws upon the Whiffen Vibrations Criteria for continuous events to illustrate the types of damage that can be expected at various sustained vibrations levels (see Figure 13).[25]

PPV (in/sec)	Effect on Buildings
0.4 - 0.6	Architectural damage and possible minor structural damage
0.2	Threshold at which there is a risk of architectural damage to houses with plastered walls and ceilings
0.1	Virtually no risk of architectural damage to normal buildings
0.08	Recommended upper limit of vibrations to which ruins and ancient monuments should be subjected
0.006 – 0.019	Vibration unlikely to cause damage of any type

Figure 13. Whiffen Vibration Criteria for Continuous Vibration

[25] A. C. Whiffen, "A Survey of Traffic-Induced Vibrations," (Crowthorne, Berkshire, England: United Kingdom Department of Environment, Road Research Laboratory, 1971,) as presented in *Transportation and Construction Induced Vibration Guidance Manual, Caltrans*, 2004, 17.

	PPV (in/sec)			
Damage Type	**5% probability**	**10% probability**	**50% probability**	**90% probability**
Threshold damage: loosening of paint, small plaster cracks at joints between construction elements	0.5	0.7	2.5	9.0
Minor damage: loosening and falling of plaster, cracks in masonry around openings near partitions, hairline to 3mm (1/8-inch) cracks, fall of loose mortar	1.8	2.2	5.0	16.0
Major damage: cracks of several mm in walls, rupture of opening vaults, structural weakening, fall of masonry, load support ability affected	2.5	3.0	6.0	17.0

Figure 14. Siskind Vibration Damage Thresholds

The Caltrans manual goes on to reference the likelihood of certain types of damage from the same 1980 Siskind et. al study referenced by the Bureau of Mines in RI 8507 (see Figure 14).[26]

The combination of these and other relevant studies became the basis for the threshold limits recommended in the 2004 report and subsequently used by Caltrans for construction project near historic buildings. These recommendations are summarized in Figure 15.[27]

	Maximum PPV (in/sec)	
Structure and Condition	**Transient Sources**	**Continuous/Frequent Intermittent Sources**
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Figure 15. Caltrans vibrations threshold recommendations for various types and conditions of buildings. Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

4.1.5 Analysis of Caltrans Vibrations Threshold Recommendations

In the U.S., the terms short- and long-term vibrations are generic terms that describe the duration of a vibration, while the terms impulse, semi-continuous, and continuous are

[26] Siskind et al., as presented in *Transportation and Construction Induced Vibration Guidance Manual*, Caltrans, 2004, 17.
[27] Table 19, *Transportation and Construction Induced Vibration Guidance Manual*, Caltrans, 2004, 26.

descriptors used to describe the nature/style of a vibration. The terms are not related to the ability of vibrations to cause damage. This is how the definitions are applied in the Caltrans manual – they are time dependent and not related to ability to cause damage even though they are based on studies that equate values to capacity to cause damage.

This is contrasted with the German DIN 4150-3 standard. The German standard defines duration as the time until damage occurs. Caltrans does not adopt these definitions and instead discusses vibrations in terms of their duration of use. The two sets of definitions are therefore not directly interchangeable. Figures 16 and 17 provide a summary of the vibrations limits presented in DIN 4150-3 for short-term vibrations, or for vibrations exposure that is not great enough to cause damage. Because the goal of this Historic Structure Impact Report is to establish initial parameters for avoiding potential damage, the German definition of "short-term" vibrations is most applicable (and is most closely represented by Caltrans' analysis.)

Caltrans lists recommended PPV limits for continuous vibrations that have PPV values based on the peak vertical axis velocity in the ground adjacent to a building. The values were taken from Whiffen and Leonard who assembled it from an earlier German DIN standard that has since changed.[28] Since then, the long-term (i.e. continuous) DIN vibration guideline for ancient

Line	Type of structure	Guideline values for velocity, v_i, in mm/s			
		Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz*	
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

* At frequencies above 100 Hz, the values given in this column may be used as minimum values.

Figure 16. Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures, DIN 4150-3 vibration recommendations, 1999. In Section 5.1, of DIN 4150-3 (1999) $|v|_{i,max}$ is defined as the maximum absolute value of the velocity signal for the three components (x, y, or z) measured on the building foundation. This parameter is referred to as V_i. This is not a vector sum value. Measurements can also be made on the highest floor of a building. In this case, the highest of the two horizontal components shall be used. This value is also referred to as V_i. Note that the guideline values are frequency dependent if vibrations at foundation level are measured, and not frequency dependent if vibrations are measured on the top floor.

[28] Whiffin and Leonard, 1971.

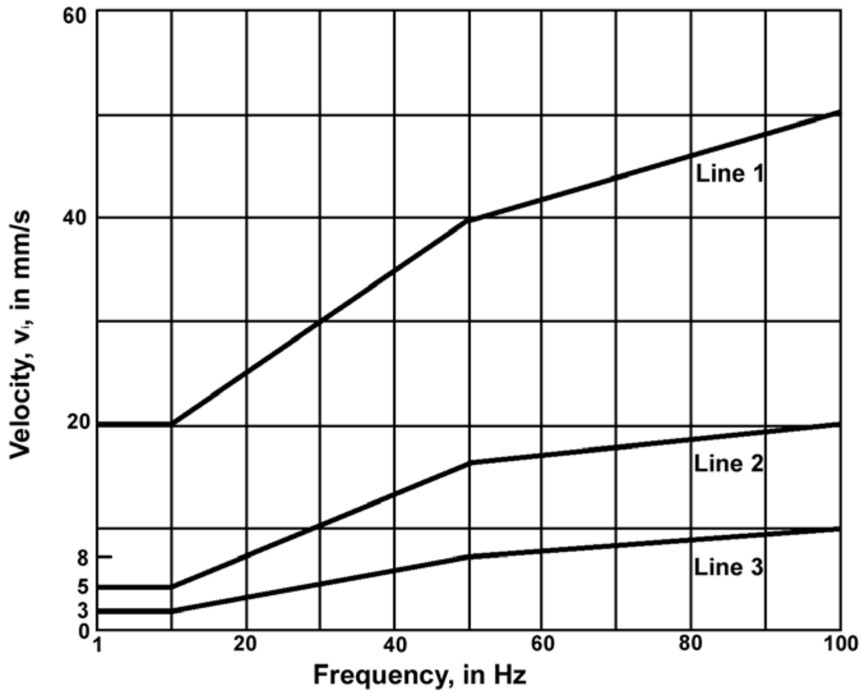

Figure 17. Curves for guideline values specified in Figure 16 for velocities measured at the foundation DIN 4150-3 vibration recommendations, 1999.

monuments has increased from 0.08 to 0.1 in/sec. The current short-term (i.e. non-continuous) DIN vibration guideline for ancient monuments is 0.1 in/sec, and the method on how the vibrations are measured has since changed as well.

The current DIN guidelines for short-term (non-continuous) vibrations are .012 - 0.31 in/sec for old buildings, depending on the frequency. For continuous vibrations (long-term vibrations as defined by Caltrans) the guidelines would be 0.1 in/sec, measured on the top floor.

The main differences between the current DIN standard and the one used by Caltrans are:

- The structure types have been renamed/condensed into three types: industrial, houses, and sensitive structures.
- The current DIN uses the vector sum to calculate velocity instead of just the vertical axis. This likely caused the increase in the vibration limit for sensitive structures from 0.08 to 0.1 in/sec. The PPV values are not frequency dependent.
- The method for measuring vibrations has changed between the DIN 4150-3 version references in the Caltrans manual and that currently in use today. The sensor is placed on the top floor of the structure, not on the ground adjacent to the foundation. Seismic amplification is now included, making the vibration limit even more restrictive. An equivalent ground-level velocity could be as low as 0.04 in/sec. This is well in the range of background traffic vibrations.

The Alternatives Analysis does not contain any proposed construction methods that involve pile driving or other types of quasi-continuous vibration producing machinery. This suggests that the use of either long-term vibration guidelines (DIN 4150-3) or continuous (long-term) vibration guides from the Caltrans manual may too conservative. To put this in perspective, the Swiss non-blasting vibration standard for historic buildings is 0.12 to 0.2 in/sec (Figure 12).[29]

4.2 SITE SPECIFIC CONDITIONS

Preliminary evaluations completed in January 2010 looked at the proposed construction methods and site specific conditions to develop anticipated construction-generated vibrations levels for the MRL Phase 2B project. It assumed high-impact equipment, such as vibratory rollers would not be allowed and adopted a very conservative approach to estimating vibrations levels based on the use of bulldozers and other earthmoving construction equipment. As the project has developed, limited use of vibratory rollers is likely. Therefore, the following discusses potential vibrations from both earthmoving equipment and vibratory rollers.

According to Table 18 in the Caltrans study, earthmoving equipment would generate vibrations of 0.089 in/s at a distance of 25 feet. Vibratory rollers would generate vibrations of 0.210 in/s at the same distance.

These values were calculated using Equation 10 of the Caltrans study:

$$PPV_{Equipment} = PPV_{Ref}(25/D)^{n} \quad (in/s)$$

In this equation, *D* is the distance from the vibration source and *n* is a coefficient based on soil type. Gathering information from boring 2F-08-61 taken at the levee crown near the steps at the Bok Kai Temple, project engineers classified the soils in the area as "low-plastic, stiff to hard Sandy Silts (ML) and medium dense to dense Silty Sands (SM) with Standard Penetration test blow N60 values ranging from 10 to 50 with a median value of 33."[30] From this, a value for *n* of 1.1 was selected, as it was the value used by Caltrans to obtain the 0.089 in/s and 0.210 in/s values and it was more conservative than the coefficient corresponding to site specific conditions.

Caltrans used a distance of 25 feet, but with an average construction distance of 75 feet or more, a median distance of 40 feet was used by project engineers to assess potential vibrations. Looking at a distance of 40 feet and using a *n* coefficient of 1.1, project engineers calculated the following as a very conservative estimate of anticipated continuous vibrations from heavy equipment for the project:

$$PPV_{Equipment} = PPV_{Ref}(25/D{=}40)^{1.1} \quad (in/s)$$

$$PPV_{Equipment} = 0.05 \quad (in/s)$$

Using this same formula, and a reference PPV of 0.210 in/s for vibratory rollers, the anticipated vibrations from these rollers at a distance of 40 feet is 0.13 in/s. To reiterate, this assumes large,

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[29] Skipp (1998) contains good review of the framework of European vibrations standards.
[30] "Memorandum for Record: Marysville Ring Levee EDR – Bok Kai Temple Construction Impact Evaluation," (January 14, 2010), 2.

heavy construction equipment within 40 feet of the Bok Kai Temple. In reality, anticipated construction methods generally utilize equipment that generate vibrations levels well below that of a large bulldozer, and would be operating at 75 feet or more from the Bok Kai Temple. Limited use of vibratory rollers is anticipated. The soils at the site have steeper attenuation curves, thereby reducing vibrations at a faster rate as distance from the source is increased. They are classified as Class II soils with a n value of 1.3 and would therefore result in even lower anticipated PPV values than that presented above.

4.3 Analysis and Anticipated Impacts

4.3.1 Application of Theoretical Data

In widely applied studies, the recommended thresholds for vibration levels range from 0.04 to 0.5 in/sec. The core level range is 0.08 to 0.2 in/sec. Based on the information presented in Figures 13, 14, and 15, the data suggests that even at the average upper threshold of 0.2 in/sec, there is a less than 5% chance of damage to loose plaster and paint, of falling plaster and dislodging of loose mortar, and of major damage. Caltrans recommendations of 0.08 – 0.12 in/sec for the most fragile resources, fall within this average range and are more conservative than many of the recommendations in other studies. This suggests that at the maximum vibrations threshold recommended by Caltrans has a less than 5% probably of causing further damage to loose plaster and paint, or causing falling plaster and dislodging of loose materials.

Using a conservative average distance of 40 feet, project engineers calculated an anticipated continuous-source vibrations level of 0.05 in/s for bulldozers and earthmoving equipment. Using their parameters, an anticipated continuous-source vibrations level of 0.13 in/s is anticipated for vibratory rollers at 40 feet.. This is consistent with the vibrations threshold recommended by Caltrans, and is still lower than the values expected to cause even minor aesthetic damage.

4.3.2 Comparison with Ambient Vibrations and Phase 1 Vibrations

For many subject buildings, everyday vibrations from street traffic, passing trains, and minor seismic events often produce vibrations in excess of those recommended in the charts presented. Therefore, the proposed construction methods are anticipated to generate vibrations well below the conservative ranges of value needed to cause architectural damage. The level is so low that structural damage is highly unlikely.[31]

For comparison of actual construction-generated vibrations, readings taken from Phase 1 of the Marysville Ring Levee project generally ranged from 0.01 in/sec to 0.04 in/sec. Monitors were placed at the toe of the levee, measuring vibrations at a distance comparable to those anticipated at the porch area of the Bok Kai Temple. Soils at the Phase 1 locations are comparable to those within the Phase 2b APE and the construction methods are similar to those proposed for the Phase 2b work. This average range of vibrations from the Phase 1 APE is below those levels anticipated for Phase 2b and demonstrates the capability of the proposed methods to comply with the Caltrans recommended long-term, or continuous, vibration levels of 0.08-0.12 in/sec for fragile structures.

[31] Ibid., 3.

4.3.3 Vibrations-Related Settlement

Within the fields of geophysics and engineering that deal with vibrations analysis, there are two general views on low-level vibrations (such as those generated by the proposed construction methods) and soil settlement. The common view is that there are vibration limits (approximately 0.1 in/sec) and shear strain limits (approximately 0.01%) below which ground settlement (compaction/strain accumulation) in granular soils does not occur.[32] The other view is that any level of ground vibration (no matter how small) over a sufficient length of time will cause strain accumulation, and thereby deformation, in granular soils.[33]

Within the last decade a series of German Doctoral theses and papers studied the relationship between long-term, low-level ground vibrations and settlement in granular soils.[34] These studies combined cyclic loaded, triaxial tests over a range of frequencies and up to 100,000 cycles with 2-D numerical models. The key findings of these studies are:

> The cyclic loading follows Miner's rule. This was experimentally checked with multiple triaxial tests with over 100,000 cycles. Miner's rule (also called Miner's cumulative fatigue damage ratio) is based on the idea that every stress cycle (large or small) uses up a proportional part of the fatigue life of a structure. In granular soils, shear stresses (cyclic load) cause compaction until the void ratio for that particular stress level is reached. That stress can continue to be applied, but no additional compaction will occur. In a loading sequence, the peak stresses cause most of the settlement and are the most important. The average stress is unimportant. Also, the order or frequency that large or small stresses are applied does not alter the end result.[35]

In summary, the soil type, soil conditions, and peak vibration levels control the amount of settlement/compaction that can occur. No additional settlement will occur unless the vibration levels are increased.

In this analysis, we assume that the minimum shear strain to cause a soil volume change (settlement/compaction) is 0.01%.

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[32] Roy H. Borden, Lisheng Shao and Ayushman Gupta, *Construction Related Vibrations*, *FHWA/NC/94-007,* (Federal Highway Administration/North Carolina Division Study, 1994); S. Drabkin, H. Lacy and D.S. Kim, "Estimating Settlement of Sand Caused By Construction Vibration," American Society of Civil Engineers Journal of Geotechnical Engineering, (November, 1996), 920-928; K.R. Massarsch, "Settlements and Damage Caused by Construction-Induced Vibrations," Proceedings from the International Workshop Wave (2000), 299-315; A.S. Suiker, "The Mechanical Behaviour of Ballasted Railway Tracks," (Germany: Delft University: PhD thesis, 2002); C.C. Hsu and M. Vucetic, "Volumetric Threshold Shear Strain for Cyclic Settlement," Journal of Geotechnical and Geoenvironmental Engineering (Vol. 130, No.1, 2004), 58-70.

[33] T. Wichtmann, "Explicit Accumulation Model for Non-Cohesive Soils Under Cyclic Loading," (Germany: University of Bochum: PhD thesis, 2005).

[34] Suiker, 2002; S. Werkmeister, "Permanent Deformation Behaviour of Unbound Granular Materials in Pavement Constructions," (Germany: Dresden University: PhD thesis, 2003);, Wichtmann, 2005; T. Wichtmann, A. Niemunis and T. Triantafyllidis, "Strain Accumulation in Sand Due to Drained Cyclic Loading," Soil Dynamics and Earthquake Engineering (Vol.30, No.8, 2010), 736-745.

[35] C. Karg, "Modeling of Strain Accumulation Due to Low Level Vibrations in Granular Soils," (Belgium: University of Gent, PhD thesis, 2007).

At the Bok Kai temple site, the near surface site soils are loose sands and likely have a relatively high void ratio. We assume that the shear velocity is in the 500 ft/sec range.[36] Using the recommended vibrations threshold of 0.08 in/sec maximum PPV:

Shear Strain = PPV/shear velocity
= [0.08 in/sec]/[(500 ft/sec)*(12 in/ft)
= 0.000014
= 0.0014% strain

This strain value is much less than the minimum strain (0.01%) needed for settlement to develop. It would require a PPV greater than 0.5 in/sec before settlement is likely to present a problem.

4.3.4 Conclusions

The condition of the Bok Kai Temple is good. The concern is not necessarily with structural failure, but damage to the artistic elements on and within the building. These include the exterior murals as well as alter decorations and elements attached to the walls and ceiling of the sanctuary.

Based on the proposed construction methods it appears the anticipated 0.05 – 0.13 in/sec levels are below internationally recognized damage thresholds. The relatively good condition of the Bok Kai Temple is another factor for consideration. Following the Caltrans manual and information in the general body of work on the subject, Garavaglia Architecture, Inc. recommends a conservative upper vibrations limit of 0.08 in/sec PPV. This value has a low probability of causing vibrations-related damage and is well within the anticipated range of vibrations induced by construction activities.

[36] B.O. Hardin and F.E. Richart Jr., "Elastic Wave Velocities in Granular Soils," Proceedings of the American Society of Civil Engineers (Vol.89, No. SM1, 1963), Figures 6-7, 33-65.

5. RECOMMENDATIONS

5.1 PRE-CONSTRUCTION

Prior to beginning construction, it is important to establish the baseline conditions under normal circumstances. This provides a reference point for comparison of altered conditions both during and after construction. During this time, it is also highly recommended that public outreach be increased to prepare the residents and business-owners for the possible disruptions caused by construction activities. This is also an opportunity to educate the public on what they can do to minimize potential indirect damage of their property and to establish reasonable expectations for construction, communication, and project scope.

5.1.1 Establishing Baseline Vibrations Conditions

Ambient conditions along First Street and adjacent to the K1, K2, and L1 segments of the MRL project already include vibrations from heavy traffic, large vehicles, and regular freight train service. On top of this, these areas have been subjected to other intense development and construction project within the last 50 years, including major work on the Levee in the early 1960s. In general, all buildings near the APE experience vibrations of some sort on a daily basis. It is possible that these ambient levels are below the anticipated construction-generated vibrations thresholds. However, only systematic testing of current, pre-construction conditions can establish the difference between the norm and the proposed. Therefore, the following tests are recommended:

- *Proposed construction equipment and methods*
  Some of the construction methodologies being considered for the Phase 2b work are currently being implemented on another segment of the levee as part of Phase 1 work. Soil conditions are similar as well. Therefore, measurement of the vibrations generated by both equipment and methods in Phase 1 is directly applicable to work associated in Phase 2b. Measurements taken between June 21, 2011 and October 11, 2011 showed a vibrations range of 0.01 – 0.04 on average, as measured at the toe of levee. Comparing the theoretical and limited empirical data from the recommendations in this study with real-world conditions demonstrates the validity of the proposed construction methods to limit damages to historic resources from construction-related vibrations.

- *Ambient vibrations levels from traffic and trains*
  The amount and types of traffic in the area generate surface vibrations do not yet appear to have caused aesthetic or structural damage to the Temple or surrounding buildings. A comparison between the existing, daily vibrations levels to those anticipated for construction activities will provide for more detailed outreach and preparedness planning.

5.1.2 Establishing Baseline Building Conditions

Understanding the difference between current conditions and those anticipated during and after construction is even more critical for individual buildings. A reference point is necessary for comparison of condition changes during construction, and possibly for use in determining the cause of any conditions changes. As a means to protect the project sponsors from unsubstantiated claims of damage, a baseline of existing building conditions should be recorded prior to starting construction. Depending on the resource and access to the various elevations and spaces for each building, different methodologies can be employed. Specific recommendations are as follows:

- *3D laser scans or photogrammetry*
  These methods are most appropriate for building exteriors or for spaces that are large enough to allow for entire walls to fit within a single view. Laser scans are the most common method for this type of recordation. It is fast and relatively cost effective. Multiple scans can be done in a single day with processing of the raw data completed over a period of several weeks. It is possible to collect the data and process it at a later date on an as-needed basis. In general, resolution and accuracy vary. Determination of the most appropriate equipment should be done in consultation with a trained operator who is experienced with scanning architectural subjects in the field.

  This method is recommended for relatively flat building surfaces where the view is straight on such as for the murals. For the Temple, this technology may be of limited use because of site constraints, however it should be used to record the murals prior to construction. While it may not record hairline cracks, it will provide a detailed record that can be used in conjunction with other measures listed here to accurately record existing conditions.

- *Systematic recordation with high resolution digital photographs*
  As an alternate to laser scanning, thorough recordation of all surfaces with a digital camera can be used to establish a visible baseline of conditions. This method is relatively quick and inexpensive although it won't be able to record hairline cracks with much precision and differences in rough surfaces, such as a sandblasted brick wall, may be difficult to discern. This method is best used in combination with a hand-recorded survey on interior elevation drawings and for hand-recorded survey information on exterior elevation drawings for the murals. For the Bok Kai Temple, interior elevation drawings would need to be created to enable accurate recordation of surface cracks and other existing conditions. Exterior elevations already exist.

  Photographs should be organized according to room and surface orientation. The organization system should be consistent throughout the project to enable comparison between before and after images.

- *Pre-construction mural survey*
  A detailed survey of the mural conditions should be completed by a qualified murals conservator. This survey should be used in conjunction with the other recordation methodologies listed here to provide as complete a picture of the murals' conditions prior to the start of any construction.

- *Pre-construction floor level survey*
  The floor heights and materials vary throughout the Bok Kai Temple. The western section of the building is used for storage and has a concrete floor, set at grade. The central section contains the altar and has a framed floor finished with tile that is approximately 3-feet or more above grade. The eastern rooms are framed wood floors set at, or near grade and are highly irregular in surface heights and texture and would not be suitable for a reliable laser-level reading. Therefore, pre-construction floor level

surveys should be conducted on the western and central building sections to establish a baseline for existing conditions. This can then be compared to a post-construction level survey to determine if any settlement might have occurred as a result of construction-related activities.

- *Pre-construction ultrasonic survey of interior walls* (optional)
  The condition of the brick walls within the main sanctuary room is unknown. They are currently covered with modern textured panels. An ultrasonic survey or other non-destructive scan of the walls could be completed prior to construction to more precisely know the condition of the underlying walls.

- *Installation of crack monitors*
  Where cracks currently exist and appear to be actively moving, installation of crack monitors during pre-construction is recommended as a means to establish trends in movement prior to any construction activity. Once a baseline has been established, the monitors should be left in place and recorded at regular intervals over the course of construction. The relatively low cost and disposable nature of crack monitors makes them an economical way to track building movement over time.

5.1.3 Public Outreach & Education

One of the most important pre-construction recommendations is community outreach and education. The vibrations levels needed to cause aesthetic damage are higher than those commonly detected by people. Therefore, people are going to be well aware of the construction-generated vibrations, making them hyper-vigilant about any changes to their building. Communication regarding what types of construction are proposed, what levels of vibrations they will likely experience, and for how long is important when striving to maintain positive pubic perception. The City of Marysville has earned a reputation for good public outreach. This should be used to the project sponsor's advantage through the following actions:

- *Public notification letters*
  All residents, owners, and business proprietors within 200-feet of the construction zone, and along all proposed haul routes, should be sent a letter that outlines the nature of the proposed construction, the approximate dates of construction, anticipated vibrations and other impacts (increased traffic, dirt and debris hauling, etc.) that may be experienced by these residents. Clearly communicated methods to report damage, file complaints, get more information, or otherwise engage the project sponsor should be provided. At a minimum, Garavaglia Architecture, Inc. recommends a dedicated hotline and monitored website to allow for two-way communication regarding construction activities.

- *Public meetings*
  A series of public forums should be scheduled to allow for direct dissemination of project-related information prior to the start of any construction in the area. At a minimum, the information in the notification letter should be presented and expanded upon. Adequate time for questions and answers should be accommodated. All questions and answers should then be posted online, or sent to interested parties.

- *Dissemination of educational materials*
  As an added measure of good will and preparedness, the project sponsor should prepare a set of guidelines for residents to follow lessen chances of indirect damage, from falling items, improperly braced furniture, or other conditions that are outside the control of the project sponsor. For the Bok Kai Temple, items of particular value or fragility should be moved off-site for the duration of construction if possible. At a minimum horizontal storage of fragile items should be encouraged. These recommendations would include movement of fragile items from high shelves to low, of attaching shelving to the wall, securely anchoring items hung on walls, and other methods to address decorating choices that could be impacted by construction vibration.

  At a minimum, information should be readily available in print form at the public library, at City Hall and the local Post Office. If possible, a website should be established with public information such as these guidelines, project updates, photos, and a monitored method for registering comments or complaints.

5.2 DURING CONSTRUCTION

The anticipated vibrations levels for the proposed construction methods within the APE are below the generally accepted thresholds above which damage would be likely. Therefore, the construction methodology is unlikely to cause damage to the Bok Kai Temple. The recommendation is to monitor vibrations levels at the building and regularly inspect the building for damage during periods of construction in the immediate vicinity.

5.2.1 Monitoring Plan

Buildings of concern and vibration limits
The Bok Kai Temple is considered a highly valuable cultural and historic resource, therefore the specified vibration limits are lower than those typically specified on similar construction projects. The information from vibration monitoring is used to help control the level of construction vibrations the properties will experience during construction activities. It is in good condition but its value warrants a highly conservative approach. Therefore, a vibrations limit of 0.08 in/sec is recommended. This level is the minimum vibrations level recommended by Caltrans, and is still below many international vibrations standards. This value is also below that generally required to cause damage to finishes in historic buildings.

Instrument and operator specifications
Monitoring equipment can be very helpful, but only if installed and used by qualified and trained personnel. These qualifications and specifications will be further developed during the design phase along with specific installation and monitoring guidelines. Base recommended requirements are:

- The vibration monitoring equipment should conform to the *Performance Specifications For Blasting Seismographs*, 2011 edition, issued by the International Society of Explosive Engineers (ISEE).[37]

[37] International Society of Explosive Engineers, "*Performance Specifications For Blasting Seismograph*," (2011).

- The installation of the monitoring equipment should conform to Part II, Sections A and B of the *Field Practice Guidelines For Blasting Seismographs*, 2009 edition, issued by the International Society of Explosive Engineers (ISEE).[38]

- Integral, three-axis geophones are recommended for project. All three axes should be monitored. Noise monitoring may be desired, but is not needed as part of the vibrations monitoring protocols. Microphones do not have to be installed.

- The vibration data should be recorded, stored, and analyzed digitally. Analog (paper) on-site printouts are not recommended because of their fragility and lack of reliable backup recordation systems.

- Waveform recording mode is acceptable. Cell modem instrument communications are also viable solutions. The operator would be responsible for confirmation of adequate cell coverage. On-site, 110-volt power may not be available at all lots and arrangements may be necessary to draw power from adjacent lots.

- At the time of measurement the vibration monitoring equipment should have a current, valid calibration certificate.

- The operator should responsible for the maintenance and security of their equipment. The project Contractor should not be responsible for damaged or stolen instruments unless an instrument is directly damaged by Contractor activities. The operator should inform the Contractor and project sponsor of the location of the instruments via written documentation.

- The installation, operation, and analysis of the vibration monitoring instruments should be performed under the supervision of a Registered Civil Engineer, Geophysicist, or Geologist in the State of California who has at least five (5) years of experience and who has expertise in the field of vibration monitoring that includes instrument set up, data processing, and data interpretation (hereinafter referred to as the Instrumentation Professional). A technician under the supervision of the Instrumentation Professional may conduct the actual measurements. Further definition of "expertise" will be included in the specifications developed during the design phase for the project.

- Vibration-monitoring personnel, which include those persons, firms, or entities providing vibration monitoring, recording, documentation and the production of reports, should also have the qualifications specified above. The selected vibrations-monitoring contractor should be independent and should be neither employed nor compensated by subcontractors, or by persons or entities hired by subcontractors, who will provide other services or material for the Project. Monitoring personnel must be impartial to the outcomes of the monitoring and this neutrality should be readily verifiable.

[38] International Society of Explosive Engineers, "*Field Practice Guidelines For Blasting Seismographs*," (2009), 2-4; The referenced documents are for blasting, but the same instruments are used to monitor construction vibrations. The installation methodologies are the same regardless of the vibration-generation source.

- Further development of security procedures and qualifications for personnel will be included during the design phase for the project.

Monitoring operations
Implementation of monitoring activities should follow a clear, logical plan. All parties involved should be aware of the plan including location of monitoring equipment and frequency of on-site monitoring equipment inspections or readings. To this end, the following are recommendations to guide development and implementation of such a plan:

- Prior to performing any vibration monitoring, including baseline vibration monitoring, the Contractor shall submit to the Engineer a written plan detailing the procedures for vibration monitoring. The plan shall include (but not be limited to) the following:

    - The name of the firm providing the vibration monitoring services.
    - Description of the instrumentation and equipment to be used.
    - The proposed location(s) for the instruments.
    - Methods for fixing the geophones to the ground or building.
    - Data collection/analysis methods and procedures.
    - The number of vibration monitors to be used on this project.
    - Means and methods for providing warning when particle velocity exceeds specified limits.
    - Name of the responsible person(s) designated by the Contractor that can stop vibration-producing work (as necessary).
    - A contingency plan for alternative construction methods if the particle velocity exceeds the specified vibration limits.

- Pre-construction vibration levels (baseline monitoring) shall be monitored for three (3) weeks prior to construction activity occurring within 500-feet of the subject properties. Monitoring shall occur from 6 am to 9 pm, seven days a week during this time period. Monitoring equipment should be placed to monitor street traffic vibration levels. After completion of the baseline monitoring, the Contractor shall submit a report of findings to the Engineer in a timely manner.

  Based on the results of this baseline monitoring, additional pre-construction stabilization measures may be considered.

- If possible, monitoring equipment should be placed within 2-feet of the building foundations on the side facing the Contractor's work site (south or rear for most buildings). Monitoring equipment can be placed either outside the perimeter foundation or in a crawlspace/ basement at locations recommended in *Section 5.2.1-Locations* on page 44. If construction within the 200-foot area occurs for one year or longer, provisions should be made to allow switching out individual instruments for yearly calibration without loss of monitoring coverage. Inoperative, damaged, and/or stolen instruments shall be replaced in a timely manner.

- The vibration monitoring equipment shall be in place and functioning properly prior to any construction activity within 200-feet of the Bok Kai Temple or for work at greater distances as determined by the Engineer. No construction activity shall occur within this 200-foot zone unless the vibration monitoring equipment is active and functioning properly. The instruments should be on and recording between the hours of 7 am to 5 pm, or at least 30-minutes before and after daily construction hours, whenever construction activities occur within the 200-foot zone.

- During construction monitoring, the Contractor should submit daily reports by 8 am of the next day of construction activities to the Engineer documenting the results of the vibration monitoring.

- All vibration monitoring reports should be reviewed and signed by the Instrumentation Professional. At a minimum, these reports should include:

    - Project identification, location, project name, date, name of individual responsible for monitoring, name of individual who prepared report, and monitoring results with conclusions.
    - Location of monitoring equipment, including the address of the monitored building or facility.
    - Description and location of vibration source(s).
    - If thresholds are exceeded, a description of any resulting damage and the actions taken to address the cause and damage, should also be included in the monitoring report.

- The vibration monitoring equipment shall be set up in a manner such that an immediate warning is given when a vertical peak velocity equal to or exceeding 0.08 in/sec is produced. The warning emitted by the vibration monitoring equipment should be instantaneously transmitted to the responsible person designated by the Contractor by means of warning lights, audible sounds, or electronic transmission. Notification to a cell phone, beeper, or other personal communication device is recommended. The responsible person shall have the authority to stop work causing the vibrations. The Contractor should notify the Engineer every time the vibration exceeds the vibration limit.

Locations
For the Bok Kai Temple, a minimum of two (2) monitors is recommended. One should be placed in the crawlspace beneath the main temple room, at the south wall closest to the levee. A second monitor should be placed on the north side of the temple. This area is within the property line of 7 D Street, a private residence. If permissible by the owner, this monitor would also serve to record conditions relevant to the adjacent historic buildings in the historic district (330-320 First Street and 7 D Street in particular).

Access and Security Considerations
The above guidelines assume that monitoring equipment can be placed next to the building's foundations. If the owners for neighboring structures refuse to provide access to their properties, the instruments may have to be set at the property line. Depending on the distance between the property line and the Temple's foundation, this could have a significant effect on Contractor operations. Vibrations readings of 0.1 in/sec at 50-feet from construction activities imply a potentially different set of circumstances than 0.1 in/sec at a building foundation located 100-feet from construction activities. Because the property lines along First Street are much closer to the construction-site than the building foundations, monitors at the property line could potentially record higher vibrations levels than what is actually experienced by the buildings themselves. Outreach to building owners in critical, early in the pre-construction

phases, to educate them on the monitors, access frequency, and its impact on safety for their properties. Most buildings are businesses and are occupied during normal work hours. This should enable regular maintenance of the monitors with advanced notification to building tenants and owners.

Maintenance
Remote access to the monitoring equipment is recommended. This is most cost effective if 110-volt power can be provided on a continuous basis. If a live power feed is not available, there is a reliance on battery-supplied power. Typically, an instrument can stay in the field for six (6) days before it has to be recharged. Depending on the installation, this would require replacement of the external batteries or removal for overnight recharging an average of once a week. This would require site visits at a minimum frequency of once a week. If a direct power source is available, the number of site visits can be reduced to once every four (4) to six (6) weeks. Batteries can be recharged with solar cells, but this greatly complicates secure installation and makes the units greater targets for theft. Secure installations can be done, but the associated costs are higher. An alternative to regular site visits to maintain the equipment is to train a Contractor technician to download the data from the instruments and change the batteries or charge the instruments as needed.

5.2.2 Regular Inspections

Remote monitoring of vibrations levels will not necessarily indicate the existing conditions at the site. To avoid causing unnecessary damage, a regular inspection routine is recommended. This is a quick visual survey of focused areas where the most sensitive historical resources are located. A standard methodology, perhaps a checklist, should be developed to guide these inspections and provide for consistency across the project's duration.

- The exterior murals on the Bok Kai Temple are the most significant feature of the historic resource. They should be inspected daily, either at the end of the construction shift, or just before it, during construction on the K1 segment. Any changes in condition should be immediately reported. Depending on the nature of damage, steps should be taken to temporarily halt any ongoing construction until a remedy is implemented.

- The remainder of the Bok Kai Temple should be inspected weekly, following the procedures established above.

- When a monitoring station in the area records a PPV above the recommended vibrations threshold of 0.08 in/sec, a complete visual inspection of the temple should be completed. The pre-construction documentation should be used as a base to record any additional conditions discovered during this inspection.

- If a crack monitor in the Bok Kai Temple registers movement of 1/32-inch or ½-millimeter, a complete visual inspection of the temple should be completed. The pre-construction documentation should be used as a base to record any additional conditions discovered during this inspection.

5.2.3 Equipment Protections

The Bok Kai Temple is located immediately adjacent to the existing levee. A portion of the temple grounds extends up part of the embankment on the backside of the levee. Currently there is an iron fence around the property and at the foot of the levee. This fence would provide only minimal protection for the temple should an object fall from the levee crest during construction. Additional measures should be installed to prevent errant materials and equipment from rolling down the back of the levee. Additional fencing or barricades should be installed as close to the top of the levee as possible to limit impact speeds. These barricades should be reversible and temporary while still providing adequate protection for the resource below.

5.2.4 Dust & Debris Control

Barriers to prevent debris from striking the building should be put in place prior to the start of construction. In addition, a dust mitigation plan should be created to limit dissemination of airborne particles into interior spaces of the Temple. These particles could cause damage to the sensitive artifacts in the sanctuary space. Given the height of the construction-site above the Temple, barriers need only be high enough to limit debris from falling down the back of the levee. The nature of the barriers should be determined once the exact scope of construction activities and methodologies in the area has been finalized since barrier protection should be based on potential hazards. No barriers should be directly attached to the building or situated as to cause damage to the building.

5.3 POST - CONSTRUCTION

3D laser scans or photogrammetry
This cost effective method can be used to directly compare the data collected prior to construction with that present at the close of construction. Any differences in the information would indicate deterioration that has occurred since the start of construction. A determination of the causes of the damage, and whether it is the result of natural occurrences or of construction activities would then be necessary. This is recommended as a way to document conditions in case there is any disputed damage in the future.

Systematic recordation with high resolution digital photographs
As an alternate to laser scanning, thorough recordation of all surfaces with a digital camera can be used to establish a visible baseline of conditions. This method requires 1-2 days in the field and has minimal processing time. It is not as accurate as laser scanning, but is highly superior to regular photographic documentation.

Post-construction level survey
A post-construction floor-level survey should be performed in the western and central sections of the Bok Kai Temple. This should then be compared to the pre-construction level survey results to determine if any changes have occurred that might be the result of construction-related settlement.

Post-construction mural survey
A post-construction mural survey is recommended to provide for a comparison of before and after conditions. Conditions should be noted on copies of the pre-construction survey results to allow for efficient comparison of observed conditions. Survey work should be completed by a qualified murals conservator. If possible, the same contractor responsible for the pre-construction survey should be sought to provide for continuity of the assessment process.

5.4 MITIGATIONS

5.4.1 Plaster Damage

The most likely area of damage will be to the exterior murals on the stucco surface of the temple, above the main door. These murals were stabilized in 2006, but the extent of work is not fully known. No plaster anchors or other fasteners are currently visible and are not likely installed. It is therefore assumed the conservators found the plaster to be adequately adhered to the wall and no additional reinforcement was required at that time. Should cracks develop or paint or stucco begin to flake off the wall during construction, the following mitigations are recommended:

- Suspend all construction within 200-feet of the resource immediately.
- Install netting immediately below the murals to prevent loose material from hitting the ground.
- Contact a skilled murals conservator, preferably one familiar with the murals and the work carried out in 2006.
- Temporarily stabilize the murals until all construction activities along the K1, K2, and L1 segments are complete. Do not resume construction until the murals have been stabilized.
- Permanently stabilize the murals according to the recommendations of the murals conservator.

5.4.2 Fallen or Loose Artifacts

Within the temple are a number of items suspended from the ceiling or attached to the wall. The current wall surface is a textured wallboard that is furred out from the brick substrate. It is unknown how deep the connections are for anchoring devices used to support mounted artifacts. They may extend into the masonry wall or they may be only through the wallboard. Regardless, falling objects are a concern if vibrations levels due to construction are in excess of current ambient vibrations levels. Should attachments loosen or become dislodged, the following mitigations are recommended:

- Suspend all construction within 200-feet of the resource immediately.
- Contact a representative from the Bok Kai Temple to document the damaged item.
- Remove the item for assessment and repair offsite. The item should be properly packaged to prevent further damage.
- Survey the remaining attachments for stability. Construction can resume after the damaged item has been removed from the site and wall and ceiling attachments have been verified.

- A skilled artisan familiar with sacred objects, or with the specific materials in question, is recommended to advise on actions needed to restore the damaged item
- Repair any damage to the wall or ceiling where attachments dislodged.

- Reinstall repaired item only after all construction activities along the K1, K2, and L1 segments are complete.

6. SUMMARY

The Bok Kai Temple is a highly valued cultural and historic resource. It derives its significance from its place in the development of Chinese culture in the Central Valley, and for its architecture and murals. Sensitivity to these features is a critical part of designing a project that complies with Section 106 and CEQA.

As proposed, the construction methods anticipated for completion of the Phase 2B section of the Marysville Ring Levee project will not pose a significant risk to the Bok Kai Temple or to other historic resources in the area. To help limit any potential impacts, limited recommendations for documentation and monitoring should be implemented. These include:

- Establishing baseline conditions through laser scanning or digital photogrammetry
- Implementation of a comprehensive vibrations monitoring plan
- Installation and monitoring of crack monitors within the Temple
- Installation of debris, equipment, and dust barriers
- Public outreach
- Post-construction affirmation of building conditions through re-surveying (laser scanning or digital photogrammetry, level surveys, mural survey)

Vibration will occur at levels detectable by humans but should remain well below the levels generally required to cause aesthetic damage. Structural damage is highly unlikely based on the current analysis. Provided limited pre-construction stabilization measures are implemented, vibrations levels remain under the recommended threshold of 0.08 in/sec, and the project is properly monitored to verify that levels remain below this threshold, impacts to the historic resource are highly unlikely.

7. BIBLIOGRAPHY

7.1 REFERENCE CITED

Architectural Resources Group. *Bok Kai Temple Historic Structure Report.* September 2002.

Borden, Shao and Gupta. “Construction Related Vibrations,” *Federal Highway Administration/North Carolina Division Study, FHWA/NC/94-007* (1994).

Caltrans. *Transportation and Construction Induced Vibration Guidance Manual*. State of California Department of Transportation, 2004.

Chae, Yong S., “Design of Excavation Blasts to Prevent Damage.” *Civil Engineering*, Vol. 48, No. 4, 1978.

Chung, Dr. Sue Fawn and Ross Nelson. *National Register of Historic Places Nomination: Bok Kai Temple, Marysville, California*. 2001.

Code of Federal Regulations, Section 36, Part 800: Protection of Historic Properties, Subpart B, Section 800.5(2)(i-vii). Washington, D.C.: National Archives and Records Administration, 2004.

Drabkin, S., Lacy, H, and Kim, D.S. “Estimating Settlement of Sand Caused By Construction Vibration,” *American Society of Civil Engineers Journal of Geotechnical Engineering* (November, 1996).

Hanson, Carl E., Towers, David A., and Lance D. Meister. *Transit Noise and Vibrations Impact Assessment, FTA-VA-90-1003-06.* Federal Transit Administration, 2006.

Hardin, B.O. and Richart Jr., F.E. “Elastic Wave Velocities in Granular Soils,” *Proceedings of the American Society of Civil Engineers* (1963), 89, no. SM1.

Hsu, C.C., and Vucetic, M. “Volumetric Threshold Shear Strain for Cyclic Settlement,” *Journal of Geotechnical and Geoenvironmental Engineering* (2004), 130, no.1

International Society of Explosive Engineers. *Performance Specifications For Blasting Seismographs.* ISEE, 2011.

---- *Field Practice Guidelines For Blasting Seismographs*. ISEE, 2009.

Karg, C. 2007; *Modeling of Strain Accumulation Due to Low Level Vibrations in Granular Soils*. Belgium: University of Ghent: PhD thesis (2007).

Massarsch, K.R. “Settlements and Damage Caused by Construction-Induced Vibrations,” *Proceedings from the International Workshop Wave* (2000)

Memorandum of Agreement Between the U.S. Army Corps of Engineers and the California State Historic Preservation Officer, Regarding the Marysville Ring Levee Project, Yuba County, California. March 2011.

Memorandum for Record: Marysville Ring Levee EDR – Bok Kai Temple Construction Impact Evaluation. January 14, 2010.

Napoli, Donald. *National Register of Historic Places Nomination: Marysville Historic Commercial District.* 1999.

Professional Service Industries, Inc. *Report of Preconstruction Survey and Vibration Monitoring Services, LSU Medical Center, New Orleans, Louisiana.* Stanley Group. January 13, 2010.

Siskind, D.E., Skagg, M.S., Kopp, J.W. and C.H. Dowding. *Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting*. United States Bureau of Mines, 1989.

Suiker, A.S. *The Mechanical Behaviour of Ballasted Railway Tracks.* Germany: Delft University: PhD thesis (2002).

United States Army Corps of Engineers. *Final, Marysville Ring Levee, Yuba River Basin, California, Environmental Assessment, Initial Study.* April 2010.

United States Department of Transportation. *High-Speed Ground Transportation Noise and Vibration Impact Assessment, Report 293630-1.* USDOT, 1998.

Werkmeister, S. *Permanent Deformation Behaviour of Unbound Granular Materials in Pavement Constructions*. Germany: Dresden University: PhD thesis (2003).

Whiffen, A. C., *A Survey of Traffic-Induced Vibrations*. Crowthorne, Berkshire, England: United Kingdom Department of Environment, Road Research Laboratory, 1971.

Wichtmann,T. *Explicit Accumulation Model for Non-Cohesive Soils Under Cyclic Loading.* Germany: University of Bochum: PhD thesis (2005).

Wichtmann, T. Niemunis, A, and Triantafyllidis, T. "Strain Accumulation in Sand Due to Drained Cyclic Loading," *Soil Dynamics and Earthquake Engineering* (2010), 30, no.8.

7.2 REFERENCES CONSULTED

Amick, H. and Gendreau, M. "Construction Vibrations and Their Impact On Vibration-Sensitive Facilities," *American Society of Civil Engineers Construction Congress* (2000).

Anderson, T.L. *Fracture Mechanics, Fundamentals and Applications*, New York: CRC Press, 1995.

Boone, S.J., Westland, J., and Nusink, R. "Comparative Evaluation of Building Responses to an Adjacent Braced Excavation," *Canadian Geotech Journal* (1999), v. 36.

Brandenberg, S.J., Coe, J., Nigbor, R.L. and Tanksley, K. "Different Approaches For Estimating Ground Strains From Pile Driving Vibrations At a Buried Archeological Site," *Journal of Geotechncial and Geoenvironmental Engineering* (2009), 135, no.8.

BSI Group. *BS 5228-2: Code of Practice for Noise and Vibration Control on Construction and Open Sites.* 2009.

BSI Group. *BS 7385-2: Evaluation and Measurement for Vibration in Buildings, Guide to Damage Levels From Groundborne Vibration*. 1993

CalTrans. "Survey of Earth-Borne Vibrations Due to Highway Construction and Highway Traffic," *Report CA-DOT-TL-6391-1-76-20* (1976).

---- "Transportation Related Earthborne Vibrations," *Technical Advisory, Vibration TAV-02-01-R9601* (2002).

---- "Transportation Related Earthborne Vibrations," *Technical Advisory*, *TAV-04-01-R0201* (2004).

Cardno, C. "Monitoring Vibrations in the Interests of Archaeology," *Civil Engineering* (February, 2008).

Chiostrini, S., Marradi, A., and Vignoli, A. "Evaluation of Traffic-Induced Vibrations in Historic Buildings: The case of the 'Galleria Varariana' in Florence," *Transactions on the Built Environment* (1995), 55.

Clemente, P. and Rinaldis, D. "Protection of a Monumental Building Against Traffic-Induced Vibrations," *Soil Dynamics and Earthquake Engineering* (1998), 17

DIN 4150-1, Erschütterungen im Bauwesen; Vorermittlung und Messung von Schwingungsgrössen. (*Vibrations in Building; Principles, Predetermination and Measurement of the Amplitude of Oscillations*). Vornorm DIN 4150 Teil 1, Deutsches Institut für Normung, Beuth Verlag GmbH, Berlin, 2001.

DIN 4150-2, Erschütterungen im Bauwesen; Einwirkungen auf Menschen in Gebäuden. (*Vibrations in Building; Influence on Persons in Buildings).* Vornorm DIN 4150 Teil 2 bzw. Entwurf Norm DIN 4150 Teil 2, Deutsches Institut für Normung, Beuth Verlag GmbH, Berlin, 1975 bzw. 1999.

DIN 4150-3, Vibrations in Building; Effects on Structures. (available also in German). Norm DIN 4150 Teil 3, Deutsches Institut für Normung, Beuth Verlag GmbH, Berlin, 1999.

Dowding, Charles. *Construction Vibrations*. Upper Saddle River, NJ: Prentice Hall International, 1996.

---- *Micrometer Crack Response to Vibration and Weather.* Cleveland: International Society of Explosives Engineers, 2008.

Friedman, D. "Ambiguity in Building Investigation: A study of sampling and decision-making with field data," *Bulletin of the Association for Preservation Technology* (2000), 31, no. 2/3.

Hassan, Obama A.B. *Train-Induced Groundborne Vibration and Noise in Buildings.* Essex, United Kingdom: Multi-Science Publishing Company Ltd., 2006.

Henwood, J.T. and Haramy, K.Y. 2002; *Vibrations Induced by Construction Traffic: A historic case study.* Federal Highway Administration, available at www.dot.ca.gov/hq/esc/geotech/geo_support/geophysics_geology/documents/geophysics *2002/043henwood_construction_vibrations.pdf*

Hiller D.M. and Crabb G.I. "Groundborne Vibration Caused By Mechanized Construction Works," *Transport and Road Research Laboratory* 429 (2000).

Jackson, M.W. "Thresholds of Damage Due to Ground Motion," *Proceedings of the International Symposium on Wave Propagation* (1967): 961-969.

Jackson, N.M., Hammons, M.I., Walker, R. and H. Von Quintus. "Use of Nondestructive Techniques to Estimate the Allowable Vibratory Compaction Level During Construction," *State of Florida Research Report FL/DOT/SMO/07-BDB-11* (2007).

Korkmaz, K.A., Ay, Z, Keskin, S.S., and Ceditoulu, D. 2010; "Investigation of Traffic-Induced Vibrations on Masonry Buildings in Turkey and Countermeasures," *Journal of Vibration and Control* (2010) 17, no.1.

Martin, D.J. "Ground Vibrations Caused By Road Construction Operations," *Transport and Road Research Laboratory* 328 (1977).

---- "Ground Vibrations From Impact Pile Driving," *Transport and Road Research Laboratory* 544 (1980).

Melkumyan, M.; 2001; "Proposal on Movement of the Church" *Transactions on the Built Environment* (2001), 55

Oriard, L.L. "The Effects of Vibrations and Environmental Forces," *International Society of Explosive Engineers* (1999).

Rainer, J.H. "Effects of Vibrations on Historic Buildings, an Overview," *Bulletin of the Association for Preservation Technology* 11, no.1 (1982): 2-10.

Sedovic, W. "Assessing the Effect of Vibration On Historic Buildings." *Bulletin of the Association for Preservation Technology* 16, no. 3/4 (1984): 52-61.

Skipp, B.O. "Ground Dynamics and Man-Made Processes: Prediction, Design and Management," *Ground Engineering Board* (1998): 29-38.

Walter, E.J. "Long Term Vibration and Damage Effects," *Proceedings of the Second Conference of Explosives and Blasting Techniques* (1976): 249-252.

Walter, E.J. and Walter Jr. E.J. "Low Level Continuous Vibration and Potential Damage," *Proceedings of the Fifth Conference of Explosives and Blasting Techniques* (1979): 206-219.

Watts, G.R. "Traffic-Induced Ground-Borne Vibrations in Dwellings," *Transport and Road Research Laboratory* 102 (1987).

---- “Case Studies of Effects of Traffic Induced Vibrations on Heritage Buildings,” *Transport and Road Research Laboratory* 156 (1988).

---- “Traffic Induced Vibrations In Buildings,” *Transport and Road Research Laboratory* 246 (1990).

Wiss, J.F. “Construction Vibrations: State of the Art,” *Journal of Soil Mechanics Division, ASCE* 107 (1981): 167-181.

8. PROFESSIONAL QUALIFICATIONS

Garavaglia Architecture, Inc. is a full service architecture firm located in San Francisco, specializing in providing historic preservation architecture and planning services. Founded in 1986, we have worked with Federal, State and local clients for over 25 years. We have a wide range of professional experience with the Secretary of the Interior's Standards and Guidelines for the Treatment of Historic Properties, NEPA, CEQA, and Section 106 compliance, and application of the California Building Code, California Historical Building Code, energy codes, and accessibility regulations (including ADA) to a variety of building and structure types. The firm has an in-house staff of architects, historians, and building conservation professionals who exceed the Professional Qualifications Standards used by the National Park Service, previously published in the Code of Federal Regulations, 36 CFR Part 61 in either Historic Architecture or Architectural History.

APPENDIX A: 2002 HSR

The 2002 HSR cannot be added electronically as it is a protected document. It should be included as a hard copy in the final submission and is attached as a separate document to this report