HUNTER SUBSTATION PROJECT
CITY OF RIVERSIDE, CALIFORNIA

Noise and Vibration Impact Study Technical Report

Prepared for

TRC Companies
17911 Von Karman Ave., Suite 400
Irvine, CA 92614

January 2020

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Executive Summary

The City of Riverside is proposing to replace an existing substation facility with a new facility. The Proposed Project will replace the existing Hunter Substation with a new 69/12kV electrical substation (new or proposed Hunter Substation) to be located on an immediately adjacent vacant parcel. The existing Hunter Substation is located on the east side of Riverside Canal and on the west side of Chicago Avenue, between Milton Street and Blenheim Street, in the City of Riverside, California (City).

The purpose of this Noise and Vibration Impact Study is to assess and discuss the impacts of potential noise and vibration impacts that may occur with the implementation of the proposed project. The analysis describes the existing noise environment in the project area, estimates future onsite operational noise levels at the nearest noise-sensitive receptors in the vicinity of the project site, and identifies the potential for significant noise and vibration impacts.

Impacts would be less than significant.

HUNTER SUBSTATION PROJECT

Noise and Vibration Impact Study

1.0 Introduction

This Noise and Vibration Impact Study is prepared by ESA to support a proposal for the City of Riverside to replace an existing substation facility with a new facility, in the City of Riverside, California.

The main noise and vibration source in a substation is the transformer. The main cause of transformer noise is the Magnetostriction Effect, which is caused by a piece of magnetic sheet steel to extend itself when magnetized. This is where the dimensions of ferromagnetic materials change upon contact with a magnetic field. The alternation current that flows through an electrical transformer's coils has a magnetic effect on its iron core. It causes the core to expand and contract, resulting in a humming sound. However, they are sufficient to cause a vibration, and consequently noise. Applying voltage to a transformer produces a magnetic flux, or magnetic lines of force in the core.

The project-specific analysis provided in this report assesses whether the implementation of the proposed project would have potentially significant noise impacts on the existing residential uses adjacent to the project site.

1.1 Project Location

The existing 69/12 kilovolt (kV) Hunter Electrical Substation (existing Hunter Substation) is located at 1731 Marlborough Avenue, near the intersection of Marlborough Avenue and Chicago Avenue, south of Columbia Avenue in the City of Riverside, California (refer to **Figure 1**, Project Vicinity Map and **Figure 2**, Project Location Map, all figures in **Appendix A**). The Project includes the existing substation site (APN 210-060-049), as well as the adjacent parcel (APN 210-060-033), which is also owned by the City of Riverside. The existing substation and the new substation areas (collectively referred to as the "Project Site") comprise approximately 2.5-acres of land located within an urban area.

1.2 Existing Conditions

The western parcel of the Project Site (APN 210-060-033) is currently undeveloped. The Project Site is bordered by Chicago Avenue to the east with a railroad yard railroad right-of-way beyond, a concrete storm water drainage channel to the west with a residential neighborhood beyond, and commercial/industrial building developments to the north and south.

Both parcels that consist the Project Site are zoned for Industrial (I), as are the adjacent parcels to the north, south, and east (across Chicago Avenue). The parcels to the west (across the water channel ROW), are zoned as Residential (R-1-7000).

1.3 Project Overview

The Proposed Project will replace the existing Hunter Substation with a new 69/12kV electrical substation (new or proposed Hunter Substation) to be located on an immediately adjacent vacant parcel (refer to **Figure 3**, Project Overview Map). Specifically, the Proposed Project will include the following main components:

1. Construction of a new 69/12kV Hunter Substation on previously disturbed land adjacent to and west of the existing Hunter substation;
2. Loop-in (i.e., connection to) four existing 69kV sub-transmission lines and ten existing 12kV distribution lines to the new substation;
3. Decommissioning and removal of the existing substation; and
4. Construct and operate a warehouse facility that will store equipment and materials used by RPU for operation and maintenance of the RPU electrical grid system.

Electrical substations are built and operated to convert electrical power (or electricity) from higher to lower voltages. Higher voltage electric power lines, typically referred to as *transmission or sub-transmission lines*[1], are used to transmit (or transport) electrical power over large distances, typically between where the power is created (i.e., power plant, photovoltaic solar array, wind turbine, etc.) and where it will be distributed for end use (i.e., cities or other developed areas where large groups of customers are located). Transmission lines are broadly defined as having voltage ratings above 100 kV and sub-transmission lines are defined as having voltage rating between 35 kV to 100 kV. Lower voltage electrical power lines, typically referred to as *distribution lines*, convey power from the electric substations to the individual customers (e.g., homes, businesses, etc.). Electric distribution lines are typically defined as having voltages below 35kV, but most distribution lines in California are operated in the immediate range of +/- 12kV.

The existing Hunter Substation is a 69/12kV *distribution substation*[2] because it converts electricity from 69kV to 12kV. The Hunter Substation therefore intakes the higher voltage power from the greater RPU *Electric Grid*[3], and converts it to lower voltage for use by customers in the electric load area.

1 *Transmission lines* are high voltage electric power lines that are utilized to transfer electricity large amounts of electricity over long distances.

2 *Distribution substations* are defined as any substation that is connected to one or more distributions lines.

3 The *Electric Grid*, or *Grid* for short, refers to the full system electrical transmission and distribution system, including generation, energy storage, energy transmission (i.e., transmission lines), and distribution (i.e., distribution lines).

1.4 Project Description

This section provides a detailed description of the existing and proposed project components, including the design, ratings, location, and physical size (all as applicable for each project component).

1.4.1 Existing Hunter Substation and Electrical System

The existing Hunter Substation is a 69/12kV distribution, *air insulated substation*[4] (AIS) approximately one acre in size (fenced area). The existing Hunter Substation was construction in approximately 1960 and has been operated continuously since then by RPU. RPU has made upgrades and incrementally increased the capacity of the substation since its initial construction. The existing Hunter Substation includes the following key features and equipment:

- (4) Four 69kV Sub-transmission Lines
- (8) Eight 69kV Circuit Breakers
- (2) Two 69kV-4.36kV Power Transformers
- (4) Four 69kV-12kV Power Transformers
- (2) Two 4kV Switchgears
- (4) Four 12kV Switchgears
- (1) One 15kV, 2 Stages of 3000kV Capacitor Bank

Access to the existing Hunter Substation is from the east (access directly to Chicago Avenue) and from the north where a substation gate is located at the end of an approximately 150-foot paved driveway that leads from Chicago Avenue to the gate that served as the pervious access to the eastern parcel (refer to **Figure 4**, Existing Site Layout Map).

1.4.2 Proposed New Hunter Substation

The proposed new Hunter 69/12kV distribution substation will be an AIS with four bays and a breaker-and-a-half configuration. and the new Hunter Substation will be constructed on an undeveloped parcel immediately adjacent to the existing Hunter Substation. However, some features of the new substation may ultimately be located on the existing substation site. Key features of the proposed new Hunter Substation, including site layout and arrangement, key equipment specifications and ratings are discussed in the following sub-sections.

4 Electric substations require an insulating substrate to insulate certain energized portions of the substation. The most common method is to use the existing atmosphere, or air, for this insulating substrate. Therefore, these substations are referred to as *air insulated substations*, or AIS.

2.0 Noise Impact Study

2.1 Fundamentals of Noise

2.1.1 Noise Principles and Descriptors

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air). Noise is generally defined as unwanted sound (i.e., loud, unexpected, or annoying sound). Acoustics is defined as the physics of sound. In acoustics, the fundamental scientific model consists of a sound (or noise) source, a receiver, and the propagation path between the two. The loudness of the noise source and obstructions, or atmospheric factors affecting the propagation path to the receiver determines the sound level and characteristics of the noise perceived by the receiver. Acoustics addresses primarily the propagation and control of sound.[5]

Sound, traveling in the form of waves from a source, exerts a sound pressure level (referred to as sound level) that is measured in decibels (dB), which is the standard unit of sound amplitude measurement. The dB scale is a logarithmic scale that describes the physical intensity of the pressure vibrations that make up any sound, with 0 dB corresponding roughly to the threshold of human hearing and 120 to 140 dB corresponding to the threshold of pain. Pressure waves traveling through air exert a force registered by the human ear as sound.[6]

Sound pressure fluctuations can be measured in units of hertz (Hz), which correspond to the frequency of a particular sound. Typically, sound does not consist of a single frequency, but rather a broad band of frequencies varying in levels of magnitude, with audible frequencies of the sound spectrum ranging from 20 to 20,000 Hz. The sound pressure level, therefore, constitutes the additive force exerted by a sound corresponding to the sound frequency/sound power level spectrum.[7] The typical human ear is not equally sensitive to this frequency range. As a consequence, when assessing potential noise impacts, sound is measured using an electronic filter that deemphasizes the frequencies below 1,000 Hz and above 5,000 Hz in a manner corresponding to the human ear's decreased sensitivity to these extremely low and extremely high frequencies. This method of frequency filtering, or weighting, is referred to as A-weighting, expressed in units of A-weighted decibels (dBA), which is typically applied to community noise measurements.[8] Some representative common outdoor and indoor noise sources and their corresponding A-weighted noise levels are shown in **Figure 5**, *Decibel Scale and Common Noise Sources*.

2.1.2 Noise Exposure and Community Noise

An individual's noise exposure is a measure of noise over a period of time; a noise level is a measure of noise at a given instant in time, as presented Figure 3. However, noise levels rarely persist at one level over a long period of time. Rather, community noise varies continuously over

5 M. David Egan, *Architectural Acoustics*, Chapter 1, 1988.
6 M. David Egan, *Architectural Acoustics*, Chapter 1, 1988.
7 M. David Egan, *Architectural Acoustics*, Chapter 1, 1988.
8 M. David Egan, *Architectural Acoustics*, Chapter 1, 1988.

a period of time with respect to the sound sources contributing to the community noise environment. Community noise is primarily the product of many distant noise sources, which constitute a relatively stable background noise exposure, with many of the individual contributors unidentifiable. The background noise level changes throughout a typical day, but does so gradually, corresponding with the addition and subtraction of distant noise sources, such as changes in traffic volume. What makes community noise variable throughout a day, besides the slowly changing background noise, is the addition of short-duration, single-event noise sources (e.g., aircraft flyovers, motor vehicles, sirens), which are readily identifiable to the individual.[9]

These successive additions of sound to the community noise environment change the community noise level from instant to instant, requiring the noise exposure to be measured over periods of time to legitimately characterize a community noise environment and evaluate cumulative noise impacts. The following noise descriptors are used to characterize environmental noise levels over time, which are applicable to the project.[10]

L_{eq}: The equivalent sound level, is used to describe noise over a specified period of time in terms of a single numerical value; the L_{eq} of a time-varying signal and that of a steady signal are the same if they deliver the same acoustic energy over a given time. The L_{eq} may also be referred to as the average sound level.

L_{dn}: The average A-weighted noise level during a 24-hour day, obtained after an addition of 10 dB to measured noise levels between the hours of 10:00 p.m. to 7:00 a.m. to account nighttime noise sensitivity. The L_{dn} is also termed the day-night average noise level (DNL).

CNEL: The Community Noise Equivalent Level (CNEL) is the average A-weighted noise level during a 24-hour day that is obtained after an addition of 5 dB to measured noise levels between the hours of 7:00 a.m. to 10:00 p.m. and after an addition of 10 dB to noise levels between the hours of 10:00 p.m. to 7:00 a.m. to account for noise sensitivity in the evening and nighttime, respectively. CNEL and L_{dn} are close to each other, with CNEL being more stringent and generally 1 dB higher than L_{dn}.

2.1.3 Effects of Noise on People

Noise is generally loud, unpleasant, unexpected, or undesired sound that is typically associated with human activity that is a nuisance, or disruptive. The effects of noise on people can be placed into four general categories:

- Subjective effects (e.g., dissatisfaction, annoyance);
- Interference effects (e.g., communication, sleep, and learning interference);
- Physiological effects (e.g., startle response); and
- Physical effects (e.g., hearing loss).

Although exposure to high noise levels has been demonstrated to cause physical and physiological effects, the principal human responses to typical environmental noise exposure are

9 California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.2.2.1, September, 2013.
10 California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.2.2.2, September, 2013.

related to subjective effects and interference with activities. Interference effects interrupt daily activities and include interference with human communication activities, such as normal conversations, watching television, telephone conversations, and interference with sleep. Sleep interference effects can include both awakening and arousal to a lesser state of sleep.[11]

With regard to the subjective effects, the responses of individuals to similar noise events are diverse and influenced by many factors, including the type of noise, the perceived importance of the noise, the appropriateness of the noise to the setting, the duration of the noise, the time of day and the type of activity during which the noise occurs, and individual noise sensitivity. Overall, there is no completely satisfactory way to measure the subjective effects of noise, or the corresponding reactions of annoyance and dissatisfaction on people. A wide variation in individual thresholds of annoyance exists, and different tolerances to noise tend to develop based on an individual's past experiences with noise. Thus, an important way of predicting a human reaction to a new noise environment is the way it compares to the existing environment to which one has adapted (i.e., comparison to the ambient noise environment). In general, the more a new noise level exceeds the previously existing ambient noise level, the less acceptable the new noise level will be judged by those hearing it. With regard to increases in A-weighted noise level, the following relationships generally occur:[12]

- Except in carefully controlled laboratory experiments, a change of 1 dBA in ambient noise levels cannot be perceived;
- Outside of the laboratory, a 3 dBA change in ambient noise levels is considered to be a barely perceivable difference;
- A change in ambient noise levels of 5 dBA is considered to be a readily perceivable difference; and
- A change in ambient noise levels of 10 dBA is subjectively heard as doubling of the perceived loudness.

These relationships occur in part because of the logarithmic nature of sound and the decibel scale. The human ear perceives sound in a non-linear fashion; therefore, the dBA scale was developed. Because the dBA scale is based on logarithms, two noise sources do not combine in a simple additive fashion, but rather logarithmically. Under the dBA scale, a doubling of sound energy corresponds to a 3 dBA increase. In other words, when two sources are each producing sound of the same loudness, the resulting sound level at a given distance would be approximately 3 dBA higher than one of the sources under the same conditions. For example, if two identical noise sources produce noise levels of 50 dBA, the combined sound level would be 53 dBA, not 100 dBA. Three sources of equal loudness together produce a sound level of approximately 5 dBA louder than one source, and 10 sources of equal loudness together produce a sound level of approximately 10 dBA louder than the single source.[13]

[11] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.2.1, September 2013.
[12] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.2.1, September 2013.
[13] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.2.1.1, September 2013.

2.1.4 Noise Attenuation

When noise propagates over a distance, the noise level reduces with distance depending on the type of noise source and the propagation path. Noise from a localized source (i.e., point source) propagates uniformly outward in a spherical pattern, referred to as "spherical spreading." Stationary point sources of noise, including stationary mobile sources such as idling vehicles, attenuate (i.e., reduce) at a rate between 6 dBA for acoustically "hard" sites and 7.5 dBA for "soft" sites for each doubling of distance from the reference measurement, as their energy is continuously spread out over a spherical surface (e.g., for hard surfaces, 80 dBA at 50 feet attenuates to 74 at 100 feet, 68 dBA at 200 feet, etc.). Hard sites are those with a reflective surface between the source and the receiver, such as asphalt, or concrete, surfaces, or smooth bodies of water. No excess ground attenuation is assumed for hard sites and the reduction in noise levels with distance (drop-off rate) is simply the geometric spreading of the noise from the source. Soft sites have an absorptive ground surface, such as soft dirt, grass, or scattered bushes and trees, which in addition to geometric spreading, provides an excess ground attenuation value of 1.5 dBA (per doubling distance).[14]

Roadways and highways consist of several localized noise sources on a defined path, and hence are treated as "line" sources, which approximate the effect of several point sources. Noise from a line source propagates over a cylindrical surface, often referred to as "cylindrical spreading."[15] Line sources (e.g., traffic noise from vehicles) attenuate at a rate between 3 dBA for hard sites and 4.5 dBA for soft sites for each doubling of distance from the reference measurement.[16] Therefore, noise due to a line source attenuates less with distance than that of a point source with increased distance.

Additionally, receptors located downwind from a noise source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lowered noise levels. Atmospheric temperature inversion (i.e., increasing temperature with elevation) can increase sound levels at long distances (e.g., more than 500 feet). Other factors such as air temperature, humidity, and turbulence can also have significant effects on noise levels.[17]

2.2 Existing Conditions

Some land uses are considered more sensitive to ambient noise levels than others are, due to the amount of noise exposure (in terms of both exposure duration and insulation from noise) and the types of activities typically involved. Residential areas are considered to be the most sensitive type of land use to noise and industrial/commercial areas are considered to be the least sensitive. Existing noise sensitive uses on the project site and in the immediate vicinity include:

- On-site: existing substation facility;
- To the north: commercial building; 100 feet

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[14] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.1.4.2, September 2013.
[15] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.1.4.1, September 2013
[16] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.1.4.1, September 2013.
[17] California Department of Transportation, *Technical Noise Supplement* (TeNS), Section 2.1.4.3, September 2013.

- To the south: commercial building; 50 feet
- To the west: Riverside Canal, then residences along the west side of the canal; 130 to 390 feet
- To the east: Chicago Avenue is located along the project's eastern boundary;

2.3 Regulatory Setting

A number of statutes, regulations, plans, and policies that address noise concerns have been adopted. Below is a discussion of the relevant regulatory setting and noise regulations, plans, and policies.

2.3.1 State

California Code of Regulations (CCR) Title 24 establishes the California Building Code (CBC). The most recent building standard adopted by the legislature and used throughout the state is the 2016 version, which took effect on January 1, 2017. The State of California's noise insulation standards are codified in the CBC (Title 24, Part 2, Chapter 12). These noise standards are for new construction in California for the purposes of interior compatibility with exterior noise sources. The regulations specify that acoustical studies must be prepared when noise-sensitive structures, such as residences, schools, or hospitals, are near major transportation noises, and where such noise sources create an exterior noise level of 60 dBA CNEL, or higher. Acoustical studies that accompany building plans must demonstrate that the structure has been designed to limit interior noise in habitable rooms to acceptable noise levels. For new residential buildings, schools, and hospitals, the acceptable interior noise limit for new construction is 45 dBA CNEL.

2.3.2 Local

The proposed project is located within the City of Riverside. Applicable City of Riverside noise standards and policies are described below.

2.3.3 City of Riverside

Noise Element of the General Plan. The objectives and policies of this noise element are aimed at protecting the citizens of Riverside from excessive noise levels that interfere with daily routine and comfort. Applicable policies are summarized below:

- Policy N-1.1: Continue to enforce noise abatement and control measures particularly within residential neighborhoods.
- Policy N-1.2: Require the inclusion of noise-reducing design features in development consistent with standards in Figure N-10 (Noise/Land Use Compatibility Criteria), Title 24 California Code of Regulations and Title 7 of the Municipal Code.
- Policy N-1.3: Enforce the City of Riverside Noise Control Code to ensure that stationary noise and noise emanating from construction activities, private developments/residences and special events are minimized.
- Policy N-1.4: Incorporate noise considerations into the site plan review process, particularly with regard to parking and loading areas, ingress/egress points and refuse collection areas.

- Policy N-1.5: Avoid locating noise-sensitive land uses in existing and anticipated noise-impacted areas.
- Policy N-1.6: Educate the public about City noise regulations.
- Policy N-1.7: Evaluate noise impacts from roadway improvement projects by using the City's Acoustical Assessment Procedure.
- Policy N-8: Continue to consider noise concerns in evaluating all proposed development decisions and roadway projects.

Municipal Code. It is stated in the City's Municipal Code, Title 7, Noise Control, that

It is stated in the City's Municipal Code that all construction, maintenance, or demolition activities within the City's boundary shall be limited to the hours between 7:00 a.m. and 7:00 p.m., Monday through Friday, and 8:00 am to 5:00 pm on Saturday. No construction work is permitted on Sundays and federal holidays.

In Section 7.25, maximum allowable exterior noise levels in residential areas are set at 45 dBA between 10:00 p.m. and 7:00 a.m. and at 55 dBA between 7:00 a.m. and 10 p.m. Section 7.25 further states that unless a variance has been granted, it shall be unlawful for any person to cause or allow the creation of any noise which exceeds the following:

- The exterior noise standard of the applicable land use category, up to 5 decibels, for a cumulative period of more than 30 minutes in any one hour; or
- The exterior noise standard of the applicable land use category, plus 5 dBA for a cumulative period of more than 15 minutes in any one hour; or
- The exterior noise standard of the applicable land use category, plus 10 dBA for a cumulative period of more than 5 minutes in any one hour; or
- The exterior noise standard of the applicable land use category, plus 15 dBA for a cumulative period of more than 1 minutes in any one hour; or
- The exterior noise standard, plus 20 dBA, or the maximum measured ambient noise level, for any period of time.

If the measured ambient noise level exceeds that permissible within any of the first four noise limit categories, the allowable noise exposure standard shall be increased in five decibel increments in each category as appropriate to encompass the ambient noise level. In the event the ambient noise level exceeds the fifth noise limit category, the maximum allowable noise level under said category shall be increased to reflect the maximum ambient noise level.

Maximum exterior noise standard for office/commercial, industrial, community support, public recreation facility, and nonurban land uses are 65, 70, 60, 65, and 70 dBA, respectively, at any time.

Maximum allowable interior noise levels for residential uses are set at 35 dBA between 10:00 p.m. and 7:00 a.m., and at 45 dBA between 7:00 a.m. and 10:00 p.m. Maximum allowable interior noise standard for school (7 a.m. to 10 p.m. while school is in session) and hospital (any time) is both 45 dBA.

For planning purposes, the 24-hour average sound levels (CNEL) are roughly equivalent to Leq measurements plus 5 dBA when traffic is the dominant noise source (Office of Noise Control, 1976:21).

2.4 Significance Thresholds

Pursuant to Appendix G of the State *CEQA Guidelines*, the project would result in a significant impact related to noise and vibration if it would expose people to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.

2.5. Methodology

During operation of the project site, noise levels would be generated from onsite stationary noise sources such as transformers. The noise levels generated by these stationary noise sources are assessed in this study with the Federal Highway Administration (FHWA) approved equipment source noise level guidelines,

2.6. Environmental Impacts

The project would not result in the exposure of persons to, or generation of, noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies. (Less than Significant Impact)

2.6.1 Project Construction

This section includes an overview of the typical methods, equipment, and work force that would be used for construction of the Proposed Project. Construction of the Proposed Project will be conducted by a construction contractor under contract to RPU and is anticipated to take approximately 17 months total to complete. Construction is currently anticipated to begin in mid-2021 and be completed by the end of 2022. Unless otherwise noted, construction activities are anticipated to occur between the hours of 7am and 7pm, Monday through Friday, consistent with the City of Riverside Noise Ordinance. If construction is required on one of more Saturdays, construction activities will be limited to the hours between 8am and 5pm, also consistent with the Noise Ordinance.

Construction Phasing

Construction of the Proposed Project will occur in distinct phasing, in order to complete the Hunter Substation replacement without loss of electric service. Because the Hunter Substation is a distribution substation, it feeds thousands of end users. Therefore, the new Hunter Substation will be constructed adjacent to the existing substation, while the existing substation remains in service. The existing substation will not be de-energized until the new substation is ready to be energized. **Table 2.1** below outlines the general construction phasing.

TABLE 2.1
CONSTRUCTION PHASING

Construction Phase [a]	Description	Approximate Duration
1	Mobilization	3 days
2	Material Delivery and Inventory	1 month [b]
3a	Grading and Site Preparation - Western Parcel	2 weeks
3b	Temporary relocation of Sub-transmission Line 3 and distribution Circuit 1222.	2 weeks
4a	Civil Survey and Marking	2 days
4b	Below-Grade Civil Construction for the new Hunter Substation (Western parcel)	2 months
4c	Electrical Below-Grade Construction for the new Hunter Substation (Western Parcel)	1 month
5	Underground Distribution Getaways.	2 months
6a	Above-grade (structural) construction for the new Hunter Substation. (western parcel)	2 months
6b	Above-grade (Electrical) construction for the new Hunter Substation (Western Parcel)	2 months
7	Sub-transmission getaways (overhead).	2 weeks
8	Substation testing, energization, and cutover	3 days
9	Demolition and Salvage of the old Hunter Substation (eastern parcel)	2 months
10	Grading and site preparation (eastern parcel)	1 week
11	Below grade construction for the storage facility (eastern parcel)	2 months
12	Above grade construction for the storage facility (eastern parcel)	2 months

NOTES:

[a] While construction phases will occur generally in the order listed, some overlap will occur. The total duration of construction is anticipated to be approximately 17 months.

[b] Construction Phase 2a (material delivery and inventory) will occur simultaneously with phases 2b and 2c. 2b and 2c will occur in succession.

Grading and site development activities would include the following:

- Demolition and/or removal of the buildings, foundations, vegetation, and any other miscellaneous structures located on the western parcel,
- Construct temporary relocation of sub-transmission Line 3 and distribution Circuit 1222 (Phase 3b),
- Grading of the new substation site (western parcel) (Phase 3a),
- Demolition of the existing substation western wall,
- Extension of the northern driveway into the western parcel, and
- Construction of the new CMU substation security wall.

Typical construction work forces for grading and site preparation will be relatively small given the small size of the western parcel. The typical workforce will vary between 5 and 15 workers, with an average of 8 workers on site during these phases. Typical construction work forces for the above grade construction will be the largest workforce for the Proposed Project. The typical workforce can vary between 8 and 20 workers, with an average of 15 workers on site during this phase.

Site preparation and grading activities will typically include the following construction equipment[18]:

- Dozer, Grader, Scraper, Jack hammer, Compactor, Work trucks, Haul/dump trucks, and Water trucks.

In addition, the temporary relocation of sub-transmission Line 4 and distribution Circuit 1222 will require the following equipment:

- Bucket truck, Drill rig, Work trucks, and Truck-mounted crane.

Below grade construction activities will typically include the following construction equipment:

- Excavator, Backhoe, Cement truck, Work trucks, Haul/dump trucks, and Water trucks.

Above grade construction activities will typically include the following construction equipment:

- Bucket truck or manlift, Line truck, Large Crane, Stringing rig, Cable reel trailer, Relay/ Telecommunication/ Wiring Van, SF_6 gas cart (electric), Portable generator, 100-hp Oil Processing Truck, Work trucks, and Water trucks.

Final substation wiring, testing, and energization activities will typically include the following construction equipment:

- Relay/ Telecommunication/ Wiring Van, Wire truck, Line truck, Bucket truck, and Work trucks.

The sub-transmission line getaways will be constructed using the following construction equipment:

- Stringing rig, Cable reel trailer, Drill rig, Truck-mounted crane, Wire truck, Line truck, Bucket truck, and Work trucks.

The distribution line getaways will be constructed using the following construction equipment:

- Puller/ tensioner, Cable reel trailer, backhoe, Truck-mounted crane, Concrete truck, Hauling/dump truck, Water truck, and Work trucks.

The sub-transmission line getaways will be constructed using the following construction equipment:

- Jackhammer, Flatbed truck, Crane or truck-mounted crane, Line trucks, Excavator, Hauling/dump trucks, Water truck, and Work trucks.

[18] Not all equipment would necessarily be needed, and not all equipment would be used simultaneously.

Typical Construction Equipment

Noise levels from on-site construction activities for the proposed project may range up to 62 dBA L_{max} at the closest residential uses in the vicinity of the project site and up to 89 dBA L_{max} at the closest commercial uses adjacent to the project site for very limited times when construction occurs near the project's boundary.

Short-term noise impacts would be associated with demolition, excavation, grading, paving, and underground construction during construction of the proposed project. Construction-related short-term noise levels would be higher than existing ambient noise levels in the project area today but would no longer occur once conversion of the project is completed.

Construction crew commutes and the transport of construction equipment and materials to the site for the proposed project would incrementally increase noise levels on access roads leading to the site. Although there would be a relatively high single-event noise-exposure potential causing intermittent noise nuisance (passing trucks at 50 ft would generate up to a maximum of 87 dBA L_{max}), the effect on longer-term (hourly or daily) ambient noise levels would be small. Therefore, short-term construction-related impacts associated with worker commute and equipment transport to the project site would be less than significant.

The second type of short-term noise impact is related to noise generated during site preparation and onsite construction on the project site. Construction is completed in discrete steps, each of which has its own mix of equipment, and consequently, its own noise characteristics. These various sequential phases would change the character of the noise generated on the site, and therefore, the noise levels surrounding the site as construction progresses. Despite the variety in the type and size of construction equipment, similarities in the dominant noise sources and patterns of operation allow construction-related noise ranges to be categorized by work phase. **Table 2.2** lists typical construction equipment noise levels recommended for noise impact assessments, based on a distance of 50 ft between the equipment and a noise receptor, taken from the Federal Highway Administration (FHWA) Roadway Construction Noise Model (RCNM) (FHWA 2006).

TABLE 2.2
RCNM DEFAULT NOISE EMISSION REFERENCE LEVELS AND USAGE FACTORS

Equipment Description	Impact Device?	Acoustical Usage Factor	Spec. 721.560 L_{max} at 50 Ft (dBA, slow)	Actual Measured L_{max} at 50 Ft (dBA, slow)	Number of Actual Data Samples (Count)
All Other Equipment > 5 HP	No	50	85	N/A	0
Auger Drill Rig	No	20	85	84	36
Backhoe	No	40	80	78	372
Bar Bender	No	20	80	N/A	0
Blasting	Yes	N/A	94	N/A	0
Boring Jack Power Unit	No	50	80	83	1
Chain Saw	No	20	85	84	46
Clam Shovel (dropping)	Yes	20	93	87	4

TABLE 2.2
RCNM DEFAULT NOISE EMISSION REFERENCE LEVELS AND USAGE FACTORS

Equipment Description	Impact Device?	Acoustical Usage Factor	Spec. 721.560 L_{max} at 50 Ft (dBA, slow)	Actual Measured L_{max} at 50 Ft (dBA, slow)	Number of Actual Data Samples (Count)
Compactor (ground)	No	20	80	83	57
Compressor (air)	No	40	80	78	18
Concrete Batch Plant	No	15	83	N/A	0
Concrete Mixer Truck	No	40	85	79	40
Concrete Pump Truck	No	20	82	81	30
Concrete Saw	No	20	90	90	55
Crane	No	16	85	81	405
Dozer	No	40	85	82	55
Drill Rig Truck	No	20	84	79	22
Drum Mixer	No	50	80	80	1
Dump Truck	No	40	84	76	31
Excavator	No	40	85	81	170
Flat Bed Truck	No	40	84	74	4
Front End Loader	No	40	80	79	96
Generator	No	50	82	81	19
Generator (< 25 kVA, VMS Signs)	No	50	70	73	74
Gradall	No	40	85	83	70
Grader	No	40	85	N/A	0
Grapple (on backhoe)	No	40	85	87	1
Horizontal Boring Hydraulic Jack	No	25	80	82	6
Hydra Break Ram	Yes	10	90	N/A	0
Impact Derive	Yes	20	95	101	11
Jackhammer	Yes	20	85	89	133
Man Lift	No	20	85	75	23
Mounted Impact Hammer (hoe ram)	Yes	20	90	90	212
Pavement Scarifier	No	20	85	90	2
Paver	No	50	85	77	9
Pickup Truck	No	40	55	75	1
Pneumatic Tools	No	50	85	85	90
Pumps	No	50	77	81	17
Refrigerator Unit	No	100	82	73	3
Rivit Buster/Chipping Gun	Yes	20	85	79	19
Rock Drill	No	20	85	81	3
Roller	No	20	85	80	16
Sand Blasting (single nozzle)	No	20	85	96	9
Scraper	No	40	85	84	12

TABLE 2.2
RCNM DEFAULT NOISE EMISSION REFERENCE LEVELS AND USAGE FACTORS

Equipment Description	Impact Device?	Acoustical Usage Factor	Spec. 721.560 L_{max} at 50 Ft (dBA, slow)	Actual Measured L_{max} at 50 Ft (dBA, slow)	Number of Actual Data Samples (Count)
Sheers (on backhoe)	No	40	85	96	5
Slurry Plant	No	100	78	78	1
Slurry Trench Machine	No	50	82	80	75
Soil Mix Drill Rig	No	50	80	N/A	0
Tractor	No	40	84	N/A	0
Vacuum Excavator (Vac-Truck)	No	40	85	85	149
Vacuum Street Sweeper	No	10	80	82	19
Ventilation Fan	No	100	85	79	13
Vibrating Hopper	No	50	85	87	1
Vibratory Concrete Mixer	No	20	80	80	1
Vibratory Pile Driver	No	20	95	101	44
Warning Horn	No	5	85	83	12
Welder/Torch	No	40	73	74	5

SOURCE: Federal Highway Administration. Table 9.1, *Highway Construction Noise Handbook* (2006).

dBA = A-weighted decibels
HP = horsepower
ft = feet/foot
N/A = not applicable
ft-lb/blow = foot-pounds per blow
RCNM = Roadway Construction Noise Model

Construction of the proposed project is expected to require the use of various equipment that would be used on the project site. Based on the information in **Table 2.2**, the maximum noise level generated by each piece of equipment that could be used on the proposed project site is shown below:

- **Bulldozer:** 82 dBA L_{max} at 50 ft
- **Water and Pickup Trucks:** 75 dBA L_{max} at 50 ft
- **Concrete Pump Truck:** 81 dBA L_{max} at 50 ft
- **Excavators:** 81 dBA L_{max} at 50 ft
- **Jaw Crushers:** 72 to 81 dBA L_{max} at 50 ft
- **Concrete Mix Truck:** 79 dBA L_{max} at 50 ft
- **Front End Loader:** 79 dBA L_{max} at 50 ft
- **Backhoe:** 78 dBA L_{max} at 50 ft
- **Forklift:** 75 dBA L_{max} at 50 ft
- **Grader**: 85 dBA L_{max} at 50 ft
- **Scraper**: 84 dBA L_{max} at 50 ft

- **Jack hammer**: 89 dBA L_{max} at 50 ft
- **Compactor**: 83 dBA L_{max} at 50 ft
- **Drill rig**: 79 dBA L_{max} at 50 ft
- **Truck-mounted crane**: 75 dBA L_{max} at 50 ft
- **Large Crane**: 81 dBA L_{max} at 50 ft
- **Stringing rig**: 79 dBA L_{max} at 50 ft
- **Portable generator**: 73 dBA L_{max} at 50 ft
- **Puller/ tensioner**: 75 dBA L_{max} at 50 ft

The site preparation phase tends to generate the highest noise levels because the noisiest construction equipment is earthmoving equipment. Earthmoving equipment includes excavating machinery such as backfillers, bulldozers, and front loaders. Earthmoving and compacting equipment include compactors, scrapers, and graders. Typical operating cycles for these types of construction equipment may involve 1 or 2 minutes of full-power operation followed by 3 or 4 minutes at lower power settings. While the operating cycles may involve 1 or 2 minutes of full power operation (generating the maximum sound levels identified in **Table 2.2**), the equipment would be moving around and would not stay at a specific location for the entire cycle. Therefore, adjacent receivers would be exposed to the maximum noise level intermittently rather than continuously. Demolition of on-site facility would use less heavy-duty construction equipment and, therefore, would result in lower construction noise impacts.

Site preparation and grading activities will typically include the following construction equipment: Dozer (82 dBA at 50 ft), Grader (85 dBA), Scraper (84 dBA), Jack hammer (89 dBA), Compactor (83 dBA), Work trucks (75 dBA), Haul/dump trucks (79 dBA), and Water trucks (75 dBA).

It is anticipated that up to six pieces of equipment would be in operation on the project site at the same time. Each doubling of the sound sources with equal strength increases the noise level by 3 dBA. Assuming that each piece of construction equipment operates at some distance from the other equipment, the worst-case combined noise level during this phase of construction would be (79 + 82 + 83 + 84 + 85 + 89=) 93 dBA L_{max} at a distance of 50 ft from the active construction area.

Existing residential uses are located to the west (across Riverside Canal), 130 ft (-8 dBA relative to the noise level at 50 ft) to 390 ft (-18 dBA), from the project site boundary. Commercial uses are located to the north and south of the project site, 59 ft (-1 dBA) to 100 ft (-6 dBA), from the project construction area.

As stated previously, sound levels are generated from a source, and their decibel level decreases as the distance from that source increases. Sound dissipates exponentially with distance from the noise source. For a single point source, sound levels decrease approximately 6 dBA for each doubling of distance from the source. This drop-off rate is appropriate for noise generated by stationary equipment. If noise is produced by a line source, such as highway traffic or railroad operations, the sound decreases 3 dBA for each doubling of distance in a hard site environment. Line source noise in a relatively flat environment with absorptive vegetation decreases 4.5 dBA for each doubling of distance.

Construction on the project site would expose the nearest noise-sensitive uses in the project vicinity to noise levels reaching 75 to 85 dBA L_{max} for the existing residences to the west in the project vicinity. Similarly, the existing commercial buildings in the project vicinity would be exposed to construction activity noise from the project site that vary from 87 to 92 dBA L_{max}.

During other construction phases, noise associated with on-site activity would be lower than those during the grading period.

The City's Municipal Code noise ordinance has not established any upper limits for construction noise because it is temporary and will cease to occur after completion of the project construction. The Noise Ordinance regulates the timing of construction activities and includes special provisions for sensitive land uses. It is stated in the City's Municipal Code that all construction, maintenance, or demolition activities within the City's boundary shall be limited to the hours between 7:00 a.m. and 7:00 p.m., Monday through Friday, and 8:00 am to 5:00 pm on Saturday. No construction work is permitted on Sundays and federal holidays.

Project Design Features for Noise Abatement

The following Project Design Features measures apply to the proposed project and will help to reduce and avoid potential impacts related to noise:

PDF 2-1: **Control of Construction Hours.** Construction activities occurring as part of the project shall be subject to the limitations and requirements of the City of Riverside (City) Municipal Code which states that construction activities may occur between 7:00 a.m. and 7:00 p.m. Mondays through Fridays, and between 8:00 a.m. and 5:00 p.m. on Saturdays. No construction activities shall be permitted outside of these hours or on Sundays and federal holidays unless a temporary waiver is granted by the Chief Building Official or his or her authorized representative.

PDF 2-2: Prior to issuance of grading permits, the City/project applicant shall incorporate the following measures as a note on the grading plan cover sheet to ensure that the greatest distance between noise sources and sensitive receptors during construction activities have been achieved.

- Construction equipment, fixed or mobile, shall be equipped with properly operating and maintained noise mufflers consistent with manufacturers' standards.
- Construction staging areas shall be located away from off-site sensitive uses during project construction.
- The project contractor shall place all stationary construction equipment so that emitted noise is directed away from sensitive receptors nearest the project site, whenever feasible.

PDF 2.3 During installation and mounting, implement the following to minimize audible humming:

- **Mount the Unit on a Solid Surface**
  Thin curtain walls or plywood surfaces will amplify transformer noise, so units should be mounted on dense, heavy surfaces such as reinforced concrete walls or floors. For the best results, mounting surfaces should weigh 10 times as much as the unit itself.
- **Tighten the Bolts on Enclosures**
  Check if the bolts and screws on the transformer's cover and top have been properly tightened. Loose parts will vibrate when the transformer is running and add to the existing sound. Lifting eyebolts can also increase the noise, so make sure to remove any that were used during installation.
- **Use Acoustical Dampening Material**
  You can reduce some of the noise generated by an electrical transformer by using materials that prevent the sound from spreading. Covering the walls of the transformer room with absorbent materials such as kimsul, acoustical tile or fiberglass may help keep the noise contained.
- **Use Oil Barriers or Cushion Padding**
  Like sound dampening materials, oil barriers and cushion padding may also help insulate transformer noise and prevent it from spreading. These don't actually cut down the sound or vibration itself, but help cut down the irritation it causes among people in nearby areas.
- **Try Flexible Mounting Techniques**
  While installing electrical transformers on structural walls, columns, ceilings or frames, use external vibration dampeners along with flexible connections and mounting methods. This prevents metal contact between the mounting surface and the unit, to reduce noise transmission.
- **Follow the Manufacturer's Guidelines**
  As with other electrical materials, follow the instructions and guidelines provided by the manufacturer. For instance, if the design includes vibration dampeners between the case and core and coil assembly mounting, the mounting bolts for these need to be removed after installation.

PDF 2.4: Lowering the Transmission of Air-borne Noise

- In order to abate the transmission of the air-borne noise, it is customary to use the acoustic treatment of all surfaces (walls, ceiling, and floor) of the room housing the transformer by sound barriers and sound absorbing material. Moreover, soundproof doors should be used for that room.

2.6.2 Project Operations and Maintenance

This section describes the activities relating to operation and maintenance of the Proposed Project facilities; including the new Hunter Substation and the new Storage Facility. In reference to the new Hunter Substation, this section also includes a comparison to existing substation operation and maintenance activities.

Substation Operations

The proposed new Hunter Substation will be an unmanned substation. In general, routine substation operations will be commensurate with current operation and maintenance of the existing Hunter Substation. However, because the proposed Hunter Substation will be constructed with new parts and equipment, it will require less maintenance and repair when compared to the existing, aging Hunter Substation. The Proposed Hunter Substation will require a single pickup truck visiting the site a few times a week for switching, as well as several larger substation construction and maintenance trucks visiting the substation several times a year for substation equipment maintenance. Substation maintenance activities typically include equipment testing, equipment monitoring and repair, and emergency and routine procedures for service continuity and preventive maintenance. In general, routine substation maintenance is expected to necessitate approximately six trips per year by a two- to four-person crew at the Hunter Substation site. Routine substation operations will require one or two workers in a light utility truck to visit the substation on a weekly basis. Typically, a major maintenance inspection will take place annually, requiring approximately 10 personnel for approximately one week.

Routine maintenance for vegetation clearing/trimming would occur on an as-needed basis for purposes of safety, access, and aesthetics. Vegetation maintenance activities would typically involve the presence of one to two small maintenance vehicles and one or more employees to clear or trim vegetation to achieve the minimum working space around the substation facilities.

It is not anticipated that additional full-time RPU staff would be required for operation or maintenance purposes at the Proposed new Hunter Substation.

Storage Facility Operations

The Hunter Substation Storage facility will be unmanned, with deliveries and pick-ups occurring monthly, on average. Operation of the storage facility will not require the addition of new or otherwise additional staff or workers. No new infrastructure or water source will be required.

Noise Impact Analysis

Based on data provided in the brochure of Delta Transformers, the highest noise level from a transformer that ranges between 1.2 kV and 1.5 kV is 73 dBA, at a distance of 3 feet (or 1 meter). Therefore, at a distance of 50 feet, the transformer noise is reduced by 24 dBA to 49 dBA. A noise level at 100 ft is 6 dBA lower than the noise level at 50 ft. Noise level at 130 ft from the source is 8 dBA lower than the noise level at 50 ft. At a distance of 160 ft, the noise attenuation is 10 dBA. At a distance of 190 ft, the noise attenuation is 12 dBA. At a distance of 240 ft, the noise attenuation is 14 dBA. At 300 ft, the noise attenuation is 16 dBA. At 390 ft, the noise attenuation is 18 dBA.

Table 2.3 shows that maximum noise levels at the nearest sensitive receptors would be 55 dBA L_{max} or lower. This range of noise levels is lower than the 65 dBA L_{max} and 75 dBA L_{max} maximum noise levels not to be exceeded at any time during the nighttime hours and day time hours, respectively, specified in the City's Municipal Code and therefore would not result in any significant noise impact.

2.7 Mitigation Measures

Project Construction

With implementation of the Project Design Features, no mitigation measures would be necessary for the proposed project during construction.

Project Operations

No mitigation measures would be necessary for project operation.

2.8 Summary of Noise Impact Analysis Results

Operation of the project would not expose persons to, or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies with the implementation of the project design features. Therefore, operation noise impacts would be less than significant.

TABLE 2.3
SUMMARY OF PROJECT OPERATIONAL NOISE LEVEL

	Noise Level (dBA)			
Equipment/Activity	**At 50 ft**	**Distance Attenuation**	**Intervening canal[1]**	**Maximum Noise Level**
Residences across Riverside Canal to the Southwest (130 to 240 ft)				
One Transformer	49	8 – 14	0	41
Two Transformers	52	8 – 14	0	44
Four Transformers	55	8 – 14	0	47
Residences across Riverside Canal to the Northwest (160 to 190 ft)				
One Transformer	49	10 – 12	0	39
Two Transformers	52	10 – 12	0	42
Four Transformers	55	10 – 12	0	45
Commercial Building to the North (100 ft)				
One Transformer	49	6	0	43
Two Transformers	52	6	0	46
Four Transformers	55	6	0	49
Commercial Building to the South (50 ft)				
One Transformer	49	0	0	49
Two Transformers	52	0	0	52
Four Transformers	55	0	0	55

Source: ESA 2020

3.0 Vibration Impact Study

3.1 Fundamentals of Vibration

Vibration refers to ground-borne noise and perceptible motion. Ground-borne vibration is almost exclusively a concern inside buildings and is rarely perceived as a problem outdoors. The motion may be discernible outdoors, but without the effects associated with the shaking of a building, there is less adverse reaction. Vibration energy propagates from a source through intervening soil and rock layers to the foundations of nearby buildings. The vibration then propagates from the foundation throughout the remainder of the structure. Building vibration may be perceived by the occupants as the motion of building surfaces, the rattling of items moving on shelves or hanging on walls, or as a low-frequency rumbling noise. The rumbling noise is caused by the vibrating walls, floors, and ceilings that are radiating sound waves. However, building damage is not a factor for normal transportation projects, except for occasional blasting and pile driving during construction. Annoyance from vibration often occurs when the vibration exceeds the threshold of perception by 10 VdB or less. This is an order of magnitude below the damage threshold for normal buildings.

Typical sources of ground-borne vibration are construction activities (e.g., blasting, pile driving, and operating heavy-duty earth-moving equipment), steel-wheeled trains, and occasional traffic on rough roads. Problems with ground-borne vibration and noise from these sources are usually localized to areas within approximately 100 ft of the vibration source, although there are examples of ground-borne vibration causing interference out to distances greater than 200 ft (FTA 2006). When roadways are smooth, vibration from traffic, even heavy trucks, is rarely perceptible. It is assumed, for most projects, that the roadway surface will be smooth enough that ground-borne vibration from street traffic will not exceed the impact criteria; however, construction of the project could result in ground-borne vibration that could be perceptible and annoying. Ground-borne noise is not likely to be a problem as noise arriving via the normal airborne path usually will be greater than ground-borne noise.

Ground-borne vibration has the potential to disturb people as well as to damage buildings. Although it is very rare for mobile source-induced ground-borne vibration to cause even cosmetic building damage, it is not uncommon for construction processes such as blasting and the pile driving to cause vibration of sufficient amplitudes to damage nearby buildings (FTA 2006). Ground-borne vibration is usually measured in terms of vibration velocity, either the root-mean-square (RMS) velocity or peak particle velocity (PPV). RMS is best for characterizing human response to building vibration, and PPV is used to characterize potential for damage. Decibel notation acts to compress the range of numbers required to describe vibration. Vibration velocity level in decibels is defined as:

$$L_v = 20 \log_{10} [V/V_{ref}]$$

where L_v is the VdB, "V" is the RMS velocity amplitude, and "V_{ref}" is the reference velocity amplitude, or $1x10^{-6}$ inches per second used in the United States. **Table 3.1** illustrates human response to various vibration levels, as described in the *Transit Noise and Vibration Impact Assessment* (FTA 2006).

TABLE 3.1
HUMAN RESPONSE TO DIFFERENT LEVELS OF GROUND-BORNE NOISE AND VIBRATION

Vibration Velocity Level (VdB)	Noise Level (dBA)		
	Low Frequency[1]	Mid Frequency[2]	Human Response
65	25	40	Approximate threshold of perception for many humans. Low-frequency sound usually inaudible, mid-frequency sound excessive for quiet sleeping areas.
75	35	50	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find transit vibration at this level annoying. Low-frequency noise acceptable for sleeping areas, mid-frequency noise annoying in most quiet occupied areas.
85	45	60	Vibration acceptable only if there are an infrequent number of events per day. Low-frequency noise annoying for sleeping areas, mid-frequency noise annoying even for infrequent events with institutional land uses such as schools and churches.

SOURCE: Federal Transit Administration. Table 7-1, *Transit Noise and Vibration Impact Assessment* (2006).

[1] Approximate noise level when vibration spectrum peak is near 30 Hz.

[2] Approximate noise level when vibration spectrum peak is near 60 Hz.

dBA = A-weighted decibels
FTA = Federal Transit Administration
Hz = Hertz
VdB = vibration velocity decibels

Factors that influence ground-borne vibration and noise include the following:

- **Vibration Source:** Vehicle/equipment suspension, wheel types and condition, track/roadway surface, track support system, speed, transit structure, and depth of vibration source
- **Vibration Path:** Soil type, rock layers, soil layering, depth to water table, and frost depth
- **Vibration Receiver:** Foundation type, building construction, and acoustical absorption

Among the factors listed above, there are significant differences in the vibration characteristics when the source is underground compared to at the ground surface. In addition, soil conditions are known to have a strong influence on the levels of ground-borne vibration. Among the most important factors are the stiffness and internal damping of the soil and the depth to bedrock.

Experience with ground-borne vibration shows that vibration propagation is more efficient in stiff clay soils than in loose sandy soils, and shallow rock seems to concentrate the vibration energy close to the surface, resulting in ground-borne vibration problems at large distance from the source. Factors such as layering of the soil and depth to water table can have significant effects on the propagation of ground-borne vibration. Soft, loose, sandy soils tend to attenuate more vibration energy than hard, rocky materials. Vibration propagation through groundwater is more efficient than through sandy soils.

3.1.1 Thresholds of Significance for Vibration

Federal Transit Administration and California Department of Transportation

The criteria for environmental impact from ground-borne vibration are based on the maximum levels for a single event. **Table 3.2** lists the potential vibration damage criteria associated with construction activities, as suggested in the *Transit Noise and Vibration Impact Assessment* (FTA 2006).

TABLE 3.2
CONSTRUCTION VIBRATION DAMAGE CRITERIA

Building Category	PPV (inch/sec)	Approximate L_V[1]
Reinforced-concrete, steel or timber (no plaster)	0.50	102
Engineered concrete and masonry (no plaster)	0.30	98
Non-engineered timber and masonry buildings	0.20	94
Buildings extremely susceptible to vibration damage	0.12	90

SOURCE: Federal Transit Administration. Table 12-3, *Transit Noise and Vibration Impact Assessment* (2006).

[1] RMS velocity in decibels (VdB) re 1 µin/sec.

µin/sec = microinches per second
L_V = velocity in decibels
FTA = Federal Transit Administration
PPV = peak particle velocity
inch/sec = inches per second
RMS = root-mean-square

FTA guidelines show that a vibration level of up to 102 VdB (equivalent to 0.5 inch per second [inch/sec] in RMS) (FTA 2006) is considered safe for buildings consisting of reinforced concrete, steel, or timber (no plaster), and would not result in any construction vibration damage. For a non-engineered timber and masonry building, the construction vibration damage criterion is 94 VdB (0.2 inch/sec in RMS). The RMS values for building damage thresholds referenced above are shown in **Table 3.3**, which is taken from the *Transportation and Construction Vibration Guidance Manual* (Caltrans 2013).

TABLE 3.3
GUIDELINE VIBRATION DAMAGE POTENTIAL THRESHOLD CRITERIA

	Maximum PPV (inch/sec)	
Structure and Condition	Transient Sources[1]	Continuous/Frequent Intermittent Sources[2]
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.20	0.10
Historic and some old buildings	0.50	0.25
Older residential structures	0.50	0.30
New residential structures	1.00	0.50
Modern industrial/commercial buildings	2.00	0.50

SOURCE: Table 19, Transportation and Construction Vibration Guidance Manual (Caltrans 2013).

[1] Transient sources create a single, isolated vibration event, such as blasting or drop balls.

[2] Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Caltrans = California Department of Transportation

inch/sec = inches per second

PPV = peak particle velocity

Based on Table 8-3 in the FTA's *Transit Noise and Vibration Impact Assessment* (FTA 2006), interpretation of vibration criteria for detailed analysis is 78 VdB for residential uses during daytime hours. During nighttime hours, the vibration criterion is 72 VdB. For office and office buildings, the FTA guidelines suggest that a vibration level of 84 VdB should be used for detailed analysis.

City of Riverside

The City's condition states that a vibration annoyance criteria limit of 78 VdB during the daytime should be used for sensitive receptors such as residences and/or churches.

3.1.2 Construction Vibration Impacts

Because vibration level in RMS is best for characterizing human response to building vibration and vibration level in PPV is best used to characterize potential for damage, this construction vibration impact analysis will discuss the human annoyance using vibration levels in VdB and will assess the potential for building damages using vibration levels in PPV (inch/sec).

Outdoor site preparation for the proposed project is expected to use a bulldozer, loader, a water truck, a concrete truck, and a forklift. It is anticipated that the greatest levels of vibration would occur during the site preparation phase. All other phases are expected to result in lower vibration levels.

The closest sensitive receptors are residences to the west of Riverside Canal, approximately 130 ft (-21 VdB compared to the vibration level measured at 25 ft) from the project boundary. The closest commercial building is approximately 59 ft (-11 VdB) to the south. The closest commercial building to the north is 105 ft (-19 VdB) from the project boundary. The closest commercial building to the east across Chicago Avenue is approximately 332 ft (-34 VdB) to the east.

Because vibration impacts occur normally within the buildings, the distance to the nearest sensitive uses, for vibration impact analysis purposes, is measured between the nearest off-site sensitive use buildings and the project boundary (assuming the construction equipment would be used at or near the project boundary).

Bulldozers and other heavy-tracked construction equipment generate approximately 87 VdB of ground-borne vibration when measured at 25 ft, based on the *Transit Noise and Vibration Impact Assessment* (FTA 2006). This level of ground-borne vibration exceeds the threshold of human perception, which is around 65 VdB. Although this range of ground-borne vibration levels would result in potential annoyance to office workers in commercial/industrial buildings adjacent to the project site, they would not cause any damage to the buildings. Construction vibration, similar to vibration from other sources, would not have any significant effects on outdoor activities (e.g., those outside the office buildings in the project vicinity). As shown in **Table B**, FTA guidelines show that a vibration level of up to 102 VdB (an equivalent to 0.5 inch/sec in RMS) (FTA 2006) is considered safe for buildings consisting of reinforced concrete, steel, or timber (no plaster), and would not result in any construction vibration damage. For a non-engineered timber and masonry building, the construction vibration damage criterion is 94 VdB (0.2 inch/sec in RMS). The RMS values for building damage thresholds referenced in **Table 3.4** were taken from the *Transportation and Construction Vibration Guidance Manual* (Caltrans 2013). **Table 3.4** further shows the PPV values at 25 ft from the construction vibration source as well as vibration levels in terms of VdB at 25 ft from the construction vibration source.

TABLE 3.4
VIBRATION SOURCE AMPLITUDES FOR CONSTRUCTION EQUIPMENT

	Reference PPV/L_V at 25 ft	
Equipment	**PPV (inch/sec)**	**L_V (VdB)**
Pile Driver (Impact), Typical	0.644	104
Pile Driver (Sonic), Typical	0.170	93
Vibratory Roller	0.210	94
Hoe Ram	0.089	87
Earth Mover	**0.011**	**69**
Excavator	0.047	81
Fork Lift	**0.047**	**81**
Skid Steer	0.047	81
Wheel Loader	**0.076**	**86**
Large Bulldozer	0.089	87
Caisson Drilling	0.089	87
Loaded Trucks	**0.076**	**86**
Jackhammer	0.035	79
Small Bulldozer	**0.003**	**58**

SOURCE: Federal Transit Administration. Table 12-2, *Transit Noise and Vibration Impact Assessment* (2006).
Note: Equipment and associated source vibration levels that are expected to be used on the project site are shown in **bold**.
ft = feet/foot PPV = peak particle velocity
inch/sec = inch per second VdB = vibration velocity decibels
L_V = velocity in decibels

Construction Vibration Structural Damages

Commercial buildings adjacent to the project site are approximately 59 ft and 105 ft, respectively, from the nearest construction area on the project site. Based on **Tables 3.2 and 3.3**, it would take a vibration PPV level of more than 0.5 inch/sec (or 102 VdB) to potentially result in any building damages. **Table 3.4** shows that none of the construction activities anticipated on the project site would result in a vibration level that would reach 0.5 inch/sec PPV (or 102 VdB) at 25 ft from each of the project construction equipment and/or activities. Other off-site buildings are farther away from the project site and would be exposed to even lower construction vibration levels. Therefore, no building damages would occur as a result of the project construction.

Construction Vibration Human Annoyance

Vibration levels from standard construction equipment are shown below for various pieces of construction equipment that are expected to be used on the project site:

- **Bulldozer:** 87 VdB at 25 ft
- **Water and Pickup Trucks:** 69 VdB at 25 ft
- **Concrete Pump Truck:** 69 VdB at 25 ft
- **Excavators:** 81 VdB at 25 ft
- **Jaw Crushers:** 72 VdB at 25 ft
- **Concrete Mix Truck:** 69 VdB at 25 ft
- **Front End Loader:** 86 VdB at 25 ft
- **Backhoe:** 69 VdB at 25 ft
- **Forklift:** 81 VdB at 25 ft
- **Grader**: 75 VdB at 25 ft
- **Scraper**: 69 VdB at 25 ft
- **Jack hammer**: 79 VdB at 25 ft
- **Compactor**: 81 VdB at 25 ft
- **Drill rig**: 79 VdB at 25 ft
- **Truck-mounted crane**: 75 VdB at 25 ft
- **Large Crane**: 81 VdB at 25 ft
- **Stringing rig**: 79 VdB at 25 ft
- **Portable generator**: 73 VdB at 25 ft
- **Puller/ tensioner**: 69 VdB at 25 ft

LvdB (D) = LvdB (25 ft) – 30 Log (D/25)

A vibration level at 50 ft is 9 VdB lower than the vibration level at 25 ft. Vibration at 100 ft from the source is 18 VdB lower than the vibration level at 25 ft. Therefore, receptors at 50 ft from the construction activity may be exposed to ground-borne vibration up to 78 VdB (or 0.030 inch/sec PPV or lower). Receptors at 100 ft from the source may be exposed to ground-borne vibration up to 69 VdB. At a distance of 130 ft, the vibration attenuation is 21 VdB. At a distance of 160 ft, the vibration attenuation is 24 VdB. At a distance of 190 ft, the vibration attenuation is 26 VdB. At a distance of 240 ft, the vibration attenuation is 29 VdB. At 300 ft, the vibration attenuation is 32 VdB. At 390 ft, the vibration attenuation is 36 VdB.

Table 3.5 lists the projected vibration level from various construction equipment expected to be used on the project site to the sensitive uses in the project vicinity. For the project construction activity, the equipment with the highest vibration generation potential is the large bulldozer, which would generate 87 VdB at 25 ft. With the vibration attenuation through distance divergence, the vibration from project construction would be reduced by 21 and 36 VdB at the nearest residential buildings adjacent to the project site. The highest construction vibration levels at residential buildings adjacent to the project site would be 66 VdB or lower. Construction vibration from the project site would be reduced to 78 VdB or lower at commercial buildings adjacent to the project site.

This range of vibration levels from construction equipment or activity would be below the FTA threshold of 94 VdB (or 0.2 inch/sec PPV) for building damage. No significant construction vibration impacts would occur; therefore, no mitigation measures are required.

As shown in **Table 3.5**, all construction equipment vibration levels would not exceed the FTA's 78 VdB threshold at the nearest noise-sensitive receiver locations during daytime hours or the FTA's 84 VdB threshold for annoyance of occupants in commercial/industrial office buildings.

Summary of Construction Vibration Impacts

Table 3.5 lists the maximum vibration levels that would result from the on-site construction equipment. The projected maximum construction vibration level during project construction at the nearest noise-sensitive receiver locations would not exceed the FTA's vibration standards of 78 VdB for sensitive uses (residences) or the FTA's 84 VdB threshold for commercial/industrial office buildings. No significant construction vibration impacts would occur.

Mitigation Measures for Construction Vibration Impacts

No mitigation measures for vibration impacts are required during project construction.

TABLE 3.5
SUMMARY OF CONSTRUCTION EQUIPMENT AND ACTIVITY VIBRATION

	Vibration Level (VdB)			
Equipment/Activity	**At 25 ft**	**Distance Attenuation**	**Intervening canal[1]**	**Maximum Vibration Level**
Residences across Riverside Canal to the Southwest (130 to 240 ft)				
Large dozers, front end loaders, grader, backhoe	87	21 - 29	5	61
Loaded trucks	86	21 - 29	5	60
Jackhammers, forklift	79	21 – 29	5	53
Residences across Riverside Canal to the Northwest (160 to 190 ft)				
Large dozers, front end loaders, grader, backhoe	87	24 – 26	5	58
Loaded trucks	86	24 – 26	5	57
Jackhammers, forklift	79	24 – 26	5	50
Commercial Building to the North (100 ft)				
Large dozers, front end loaders, grader, backhoe	87	18	0	69
Loaded trucks	86	18	0	68
Jackhammers, forklift	79	18	0	61

TABLE 3.5
SUMMARY OF CONSTRUCTION EQUIPMENT AND ACTIVITY VIBRATION

Equipment/Activity	Vibration Level (VdB)			
	At 25 ft	Distance Attenuation	Intervening canal[1]	Maximum Vibration Level
Commercial Building to the South (50 ft)				
Large dozers, front end loaders, grader, backhoe	87	9	0	78
Loaded trucks	86	9	0	77
Jackhammers, forklift	79	9	0	70

Source: Compiled by ESA (2020).

Note: The FTA recommended building damage threshold is 0.2 inch/sec or approximately 94 VdB at the receiving property structure or building.

[1] Riverside Canal provides a damping effect on vibration.

[2] Large bulldozer represents the construction equipment with the highest vibration potential that would be used on site. Other equipment would result in a lower vibration when compared to that of large bulldozers.

ft = feet
FIDM = Fashion Institute of Design & Merchandising
FTA = Federal Transit Administration
inch/sec = inches per second
VdB = vibration velocity decibels

3.1.3 Operation Vibration Impacts

Electric hum around transformers is caused by stray magnetic fields causing the enclosure and accessories to vibrate. Magnetostriction is a second source of vibration, in which the core iron changes shape minutely when exposed to magnetic fields.

Transformer vibration (and consequently noise) is caused by the magnetostriction of the core laminates (the extension and contraction of the core laminates when magnetized). Under alternating fluxes, this extension and contraction takes place twice during a normal voltage or current cycle, resulting in vibration to occur mainly at 120 Hz and its higher order harmonics (multiples of 120 Hz, i.e., 240, 360, etc). In addition, a lower magnitude vibration also occurs at 60 Hz and its odd multiples, i.e. 180, 300, etc.

Project Design Features for Transformer Noise and Vibration Abatement

When transformers are rigidly (not resiliently) mounted on the floor (or any other structure supporting them), their vibration will transmit to the support structure and find its way in neighboring spaces (rooms, offices, laboratories, etc.), causing an annoying, tiring, tonal noise. This structure-borne noise issue can be addressed by:

- Isolating the core and coils of the transformer from the ground/floor, using proper vibration isolators. In air cooled dry transformers this means to isolate the core and coil from its support structure. For an oil filled unit it means to isolate the core and coil from its tank base and isolate its tank base from the support structure.

- Making certain all the connections to the surrounding are flexible. This includes incoming cables, busbars, stand-off insulators, etc. Note that any rigid connection from the vibrating transformer to a solid structure will transmit vibration.
- Avoiding the use of a room, to house a transformer, with dimensions corresponding to half wavelength of the transformer vibration/noise frequencies. That is, stay clear of the room acoustic resonances being perturbed by the transformer.

3.2 Mitigation Measures

Project Construction

With implementation of the Project Design Features, no mitigation measures would be necessary for the proposed project during construction.

Project Operations

No mitigation measures would be necessary for project operation.

3.3 Summary of Vibration Impact Analysis Results

Operation of the project would not expose persons to, or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies with the implementation of the project design features. Therefore, operation vibration impacts would be less than significant.

References

California Code of Regulations, Title 14, Section 15168(c).

California Department of Transportation, *Technical Noise Supplement* (TeNS). September, 2013.

City of Riverside, Noise Element and Municipal Code.

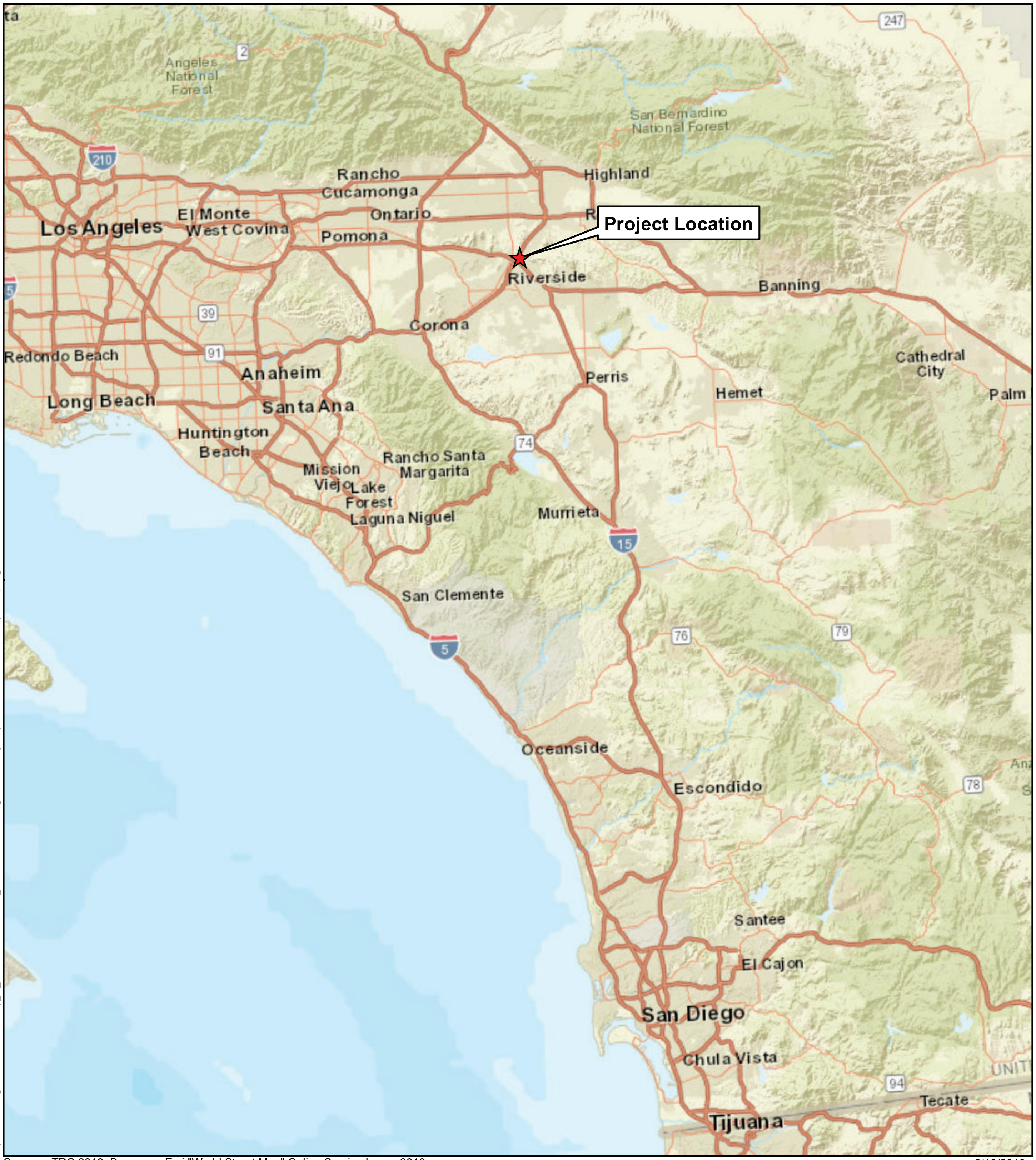
Federal Highway Administration, Roadway Construction Noise Model User's Guide, 2006.

FTA, 2006. Transit Noise and Vibration Impact Assessment. May 2006.

USEPA, *EPA Identifies Noise Levels Affecting Health and Welfare*. April 1974.

USEPA, Protective Noise Levels, Condensed Version of EPA Levels Document (EPA 550/9-79-100, November 1978)

Appendix A
Project Figures



Sources: TRC 2019, Basemap: Esri "World Street Map" Online Service Layer, 2019.

8/13/2019

★ Project Location

Hunter Substation Replacement Project

Vicinity Map

Figure 1

N

1:1,000,000
1 inch = 16 miles
(when printed 8.5x11)

0 8 16 Miles

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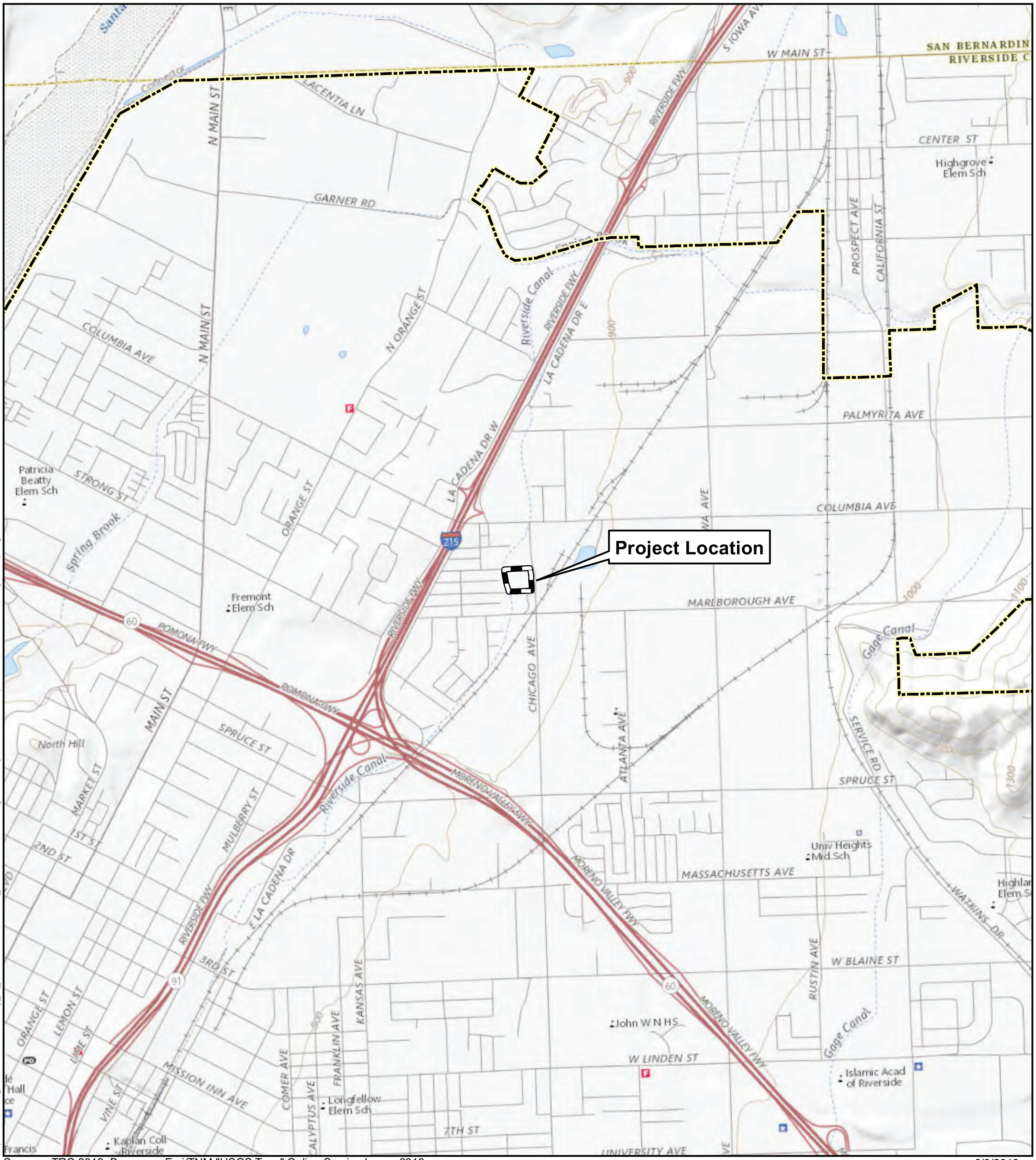

\\apaenvfile01\gis\1-PROJECTS\City_of_RiversideCA\313254_HunterSubstation\Figure 2 Project Location Map.mxd saved: 8/9/2019 by: R. Spring

Sources: TRC 2019, Basemap: Esri/TNM "USGS Topo" Online Service Layer, 2019.

8/9/2019

Project Location

City of Riverside Limits

Hunter Substation Replacement Project

Project Location Map

Figure 2

N

1:24,000
1 inch = 2,000 feet
(when printed 8.5x11)

0 1,000 2,000 Feet

Sources: TRC 2019; Parcel Boundaries Digital Map, 2019; Riverside Easement AGOL, 2019; Basemap: Esri/DigitalGlobe "World Imagery" Online Service Layer, 2018.

9/8/2019

- Overall Project Boundary
- Parcel Boundary
- Existing Hunter Substation Footprint
- Water Canal Easement

Hunter Substation Replacement Project

Project Overview Map

Figure 3

N

1:1,200
1 inch = 100 feet
(when printed 8.5x11)

0 50 100 Feet

Sources: TRC 2019; Parcel Boundaries Digital Map, 2019; Riverside Easement AGOL, 2019; Basemap: Esri/DigitalGlobe "World Imagery" Online Service Layer, 2018.

9/8/2019

Overall Project Boundary
Existing Hunter Substation Footprint
Water Canal Easement
Parcel Boundary

Hunter Substation Replacement Project
Existing Site Layout Map
Figure 4

N

1:1,200
1 inch = 100 feet
(when printed 8.5x11)

0 50 100
Feet

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\\apaenvfile01\gis\1-PROJECTS\City_of_RiversideCA\313254_HunterSubstation\Figure 4 Existing Site Layout Map.mxd saved: 9/8/2019 by: R. Spring

\\apaenvfile01\gis\1-PROJECTS\City_of_RiversideCA\313254_HunterSubstation\Figure 5 Proposed Site Layout Map.mxd saved: 9/8/2019 by: R. Spring

Sources: TRC 2019; Parcel Boundaries Digital Map, 2019; Riverside Easement AGOL, 2019; Basemap: Esri/DigitalGlobe "World Imagery" Online Service Layer, 2018.

9/8/2019

Overall Project Boundary

Proposed Hunter Substation Footprint

Water Canal Easement

Parcel Boundary

Hunter Substation Replacement Project

Proposed Site Layout Map

Figure 5

N

1:1,200

1 inch = 100 feet

(when printed 8.5x11)

0 50 100 Feet

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