APPENDIX D: QUARRY AND BALLAST HAULING MEMORANDUM

Memorandum

To: Gary Kennerley, HSR
Alice Lovegrove, HSR

From: Cory Matsui, ICF
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Date: October 4, 2017

Re: Merced to Fresno Section: Central Valley Wye Alternatives and Ranch Road to Merced Variation Estimated Emissions from Hauling Ballast Material

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Introduction

Construction of the Merced to Fresno Section: Central Valley Wye (Central Valley Wye alternatives) and the Ranch Road to Merced Variation would require a substantial amount of railroad sub-ballast and ballast material to serve as the foundation for the track alignment. Adjacent to the Central Valley Wye alternatives is the Ranch Road to Merced Variation, which extends approximately 7.5 miles from the northern end of the Central Valley Wye alternatives near the intersection of SR 99 and Ranch Road north to East 16th Street, just south of the Merced Station.

This memorandum describes the methods used to: (1) determine six possible scenarios of material hauling that could occur during construction of the four Central Valley Wye alternatives and during construction of the Ranch Road to Merced Variation; and (2) calculate criteria pollutant and greenhouse gas (GHG) emissions associated with the material hauling activities for each Central Valley Wye alternative scenario and for each Ranch Road to Merced Variation scenario. The wye alternatives are SR 152 (North) to Road 13 (SR152N Rd 13), SR 152 (North) to Road 19 (SR152N Rd 19), Avenue 21 to Road 13 (Avenue 21 Rd 13), and SR 152 (North) to Road 11 (SR152N Rd 11). The Ranch Road to Merced Variation pertains to modifications to the Hybrid Alternative that was approved as the preferred alternative in the 2012 Merced to Fresno Final Environmental Impact Report (EIR)/Environmental Impact Statement (EIS). The Ranch Road to Merced Variation does not change this preferred alternative and does not add any other alternatives for consideration. The information contained in this memo is intended to be used as an initial estimate of criteria pollutant and GHG emissions associated with truck and rail trips from material hauling that would occur outside of the SJVAB. The actual distances and quantities associated with material hauling activities for the Central Valley Wye alternatives and the Ranch Road to Merced Variation are not known at this time, but this memo represents a reasonable estimate of these activities given currently available information.

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This memorandum describes the methods used to: (1) determine six possible scenarios of material hauling that could occur during construction of the four Central Valley Wye alternatives and during construction of the Ranch Road to Merced Variation; and (2) calculate criteria pollutant and greenhouse gas (GHG) emissions associated with the material hauling activities for each Central Valley Wye alternative scenario and for each Ranch Road to Merced Variation scenario. The wye alternatives are SR 152 (North) to Road 13 (SR152N Rd 13), SR 152 (North) to Road 19 (SR152N Rd 19), Avenue 21 to Road 13 (Avenue 21 Rd 13), and SR 152 (North) to Road 11 (SR152N Rd 11). The Ranch Road to Merced Variation pertains to modifications to the Hybrid Alternative that was approved as the preferred alternative in the 2012 Merced to Fresno Final Environmental Impact Report (EIR)/Environmental Impact Statement (EIS). The Ranch Road to Merced Variation does not change this preferred alternative and does not add any other alternatives for consideration. The information contained in this memo is intended to be used as an initial estimate of criteria pollutant and GHG emissions associated with truck and rail trips from material hauling that would occur outside of the SJVAB. The actual distances and quantities associated with material hauling activities for the Central Valley Wye alternatives and the Ranch Road to Merced Variation are not known at this time, but this memo represents a reasonable estimate of these activities given currently available information.

Table 1. Material Quantities by Alternative

Material Type and Phase	SR152N Rd 13	SR152N Rd 19	Avenue 21 Rd 13	SR152N Rd 11
Ballast	872,565	1,060,814	899,067	853,915
Sub-Ballast	535,578	669,611	550,035	525,032

Notes:

[1] These values assume a 1-year construction schedule for the track-work construction phases that would occur from December 2021 to December 2022.

Table 2. Material Quantities for the Ranch Road to Merced Variation

Material Type	Quantities (tons)
Ranch Road to Merced Variation	
Ballast Material	106,281
Sub-Ballast Material	12,787

Quarries Evaluated

Five potential quarries were identified for the Merced to Fresno and Fresno to Bakersfield segments of the California High-Speed Rail Project in a URS/HMM/Arup Joint Venture memorandum from April 2012 (URS/HMM/Arup 2012). The quarries included in the 2012 memorandum were used as a starting point for identifying quarries that could fulfill the ballast and sub-ballast material requirements of the Central Valley Wye alternatives and the Ranch Road to Merced Variation. Regional Consultant air quality professionals determined that two quarries from the 2012 memorandum, Kaiser Eagle Mountain Quarry in Desert Center, CA and Bangor Rock Quarry in Bangor, CA, are no longer operational. Thus, two additional quarries were identified, using the screening criteria identified in the 2012 memorandum, to ensure that there is enough material production capacity to cover the needs of the Central Valley Wye alternatives and the Ranch Road to Merced Variation. The three operational quarries from the 2012 memorandum were contacted to confirm and/or update their production information. All five quarries were asked the following questions:

1. If they could manufacture ballast material to American Railway Engineering and Maintenance-of-Way Association (AREMA) 4 specifications.
2. The distance from the quarry to the nearest railhead for transport (via roads).
3. The amount of ballast material that could be produced by the quarry in one year.
4. The amount of Caltrans Class 2 Aggregate sub-ballast material that could be produced by the quarry in 1 year.

Table 3 summarizes the results of these inquiries.

Table 3. Quarry Information

Quarry Name and Address	Distance to SJVAB (Rail miles)[1]	AREMA 4 Ballast Availability	Distance to Nearest Railhead[2]	Truck Hauling Distance to SJVAB (Road miles)	Annual Ballast Production Capacity (tons and cubic yards)	Annual Sub-Ballast Production Capacity (Caltrans Class 2 Aggregate)[8]
Napa Quarry 2301 Napa-Vallejo Highway Napa, CA 94558 (San Francisco Bay Air Basin)	70	Yes	0 miles (railhead onsite)	70	50,000 tons[3] 45,455 cy	150,000 tons 107,143 cy
Lake Herman Quarry 885 Lake Herman Road Vallejo, CA 94951 (San Francisco Bay Air Basin)	42	Yes	15 miles	55	150,000 tons[4] 115,385 cy	150,000 tons 107,143 cy
San Rafael Rock Quarry 1000 Point San Pedro Road San Rafael, CA 94901 (San Francisco Bay Air Basin)	100	Yes	12 miles	66	580,000 tons[5] 400,000 cy	250,000 tons 178,571 cy
Stony Point Rock Quarry 7171 Stony Point Road 94931 Cotati, CA (San Francisco Bay Air Basin)	106	Yes	2 miles	93	100,000 tons[6] 90,909 cy	90,000 tons 64,286 cy
Granite Rock Serpa Quarry 2122 Old Calaveras Rd Milpitas, CA 95035-7104 (San Francisco Bay Area Basin)	45	Yes	0 miles (railhead onsite)	64	250,000 tons[7] 183,824 cy	500,000 tons 357,143 cy

Notes:

[1] Measured by Regional Consultant staff from each railhead, following the rail tracks, to the boundary of the SJVAB, using Google Earth imagery.

[2] Measured by Regional Consultant staff from each quarry to the boundary of the SJVAB using Google Maps directions

Conversion Formulas:

(Conversion formulas differ by quarry due to slight differences in material density and composition)

[3] 1.1 tons per cy

[4] 1.3 tons per cy

[5] 1.45 tons per cy

[6] 1.1 tons per cy

[7] 1.36 tons per cy

[8] No conversion factors were provided by the quarries for the sub-ballast material. A conversion factor of 1.4 tons per cy was assumed, based on input from the regional engineering team.

cy = cubic yards

Methodology for Developing Ballast Hauling Scenarios

Based on the total quantities of ballast and sub-ballast material that would be transported for each of the four wye alternatives—SR152N Rd 13, SR152N Rd 19, Avenue 21 Rd 13, and SR152N Rd 11—it was determined that the maximum amount of material to be transported occurs for the SR152N Rd 19 Alternative (1,060,814 tons/year of ballast and 669,611 tons/year of sub-ballast). There are no alternatives for the Ranch Road to Merced Variation; thus, a maximum-case alternative assumption is not necessary.

To provide a conservative estimate of emissions that would occur in the SFBAAB for the Central Valley Wye alternatives, it was assumed that the maximum material amounts would be used for this analysis (i.e., this analysis estimates emissions associated with the SR152N Rd 19 Alternative). The actual hauling scenarios that would occur during construction are not known at this time. Thus, six potential total hauling scenarios for both ballast and sub-ballast material for the four wye alternatives, were developed for the quarries listed in Table 3. For the same reasons six scenarios were also developed for the Ranch Road to Merced Variation. These scenarios were developed to provide a reasonable range of potential criteria pollutant and GHG emissions that might be generated by material hauling activities. Even the lower end of the range would be a conservative estimate, because, as discussed above, the maximum amount of material that could be needed for any of the Central Valley Wye alternatives was assumed to be used. The scenarios characterize a range of combinations of supply from the different quarries, representing worst case scenarios (where the quarries that are the greatest distance from the SJVAB are used to their maximum capacity) and less intensive scenarios (where the quarries that are the closest to the SJVAB are used for material) for both truck and rail methods of transport.

Construction of the Central Valley Wye alternatives and Ranch Road to Merced Variation are anticipated to occur in different years; thus, the potential for overlap was not considered.

Central Valley Wye Alternatives - Ballast

- **Scenario 1:** Maximum ballast from quarries that are furthest away in rail miles from the SJVAB. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. This scenario involves utilizing the quarries that are furthest away from the SJVAB in terms of rail miles and minimizing, to the extent possible, material from the closest quarry (Lake Herman Quarry). This represents the maximum emissions-intensive scenario for rail hauling.
- **Scenario 2:** Maximum ballast from quarries that are furthest away in rail miles from the SJVAB. This scenario follows the same assumptions as Scenario 1, except for the method of transport (truck instead of rail). Although this scenario maximizes the amount of material from the furthest away quarries, it is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.
- **Scenario 3:** Maximum ballast hauled from quarries that are closest to the SJVAB in terms of rail miles. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance.

This scenario involves utilizing the quarries that are closest to the SJVAB in terms of rail miles and minimizing, to the extent possible, material from the furthest quarry (Stony Point Rock Quarry). This represents a lower emissions-intensive scenario for rail hauling, along with Scenario 5 (described below).

- **Scenario 4:** Maximum ballast from quarries that are closest to the SJVAB in terms of rail miles. This scenario follows the same assumptions as Scenario 3, except for the method of transport (truck instead of rail). Although this scenario minimizes the amount of material from the furthest away quarry (Stony Point Rock Quarry), it is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.
- **Scenario 5:** Minimize ballast from 2nd furthest quarry to the SJVAB in terms of rail miles. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. This scenario involves minimizing material from the 2nd furthest quarry from the SJVAB (San Rafael Rock Quarry). Because the San Rafael Quarry (minimized in this scenario) is a similar distance from the Stony Point Rock Quarry (minimized in Scenario 3), this represents a lower emissions-intensive scenario for rail hauling, along with Scenario 3 (described above).
- **Scenario 6:** Minimize ballast from 2nd furthest quarry to the SJVAB in terms of rail miles. This scenario follows the same assumptions as Scenario 5, except for the method of transport (truck instead of rail). Although this scenario minimizes the amount of material from a quarry further away (San Rafael Rock Quarry), it is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.

Central Valley Wye Alternatives - Sub-Ballast

- **Scenario 1:** Maximum sub-ballast from quarries that are furthest away in rail miles from the SJVAB. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. This scenario involves utilizing the quarries that are furthest away from the SJVAB in terms of rail miles and minimizing, to the extent possible, material from the closest quarries (Granite Rock Serpa Quarry and Lake Herman Quarry). This represents the maximum emissions-intensive scenario for rail hauling.
- **Scenario 2:** Maximum sub-ballast from quarries that are furthest away in truck miles from the SJVAB. This scenario follows the same assumptions as Scenario 1, except for the method of transport (truck instead of rail). Although this scenario maximizes the amount of material from the furthest away quarries, it is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.
- **Scenario 3:** Maximum sub-ballast hauled from quarries that are closest to the SJVAB in terms of rail miles. Haul sub-ballast by truck to the nearest railhead, then by rail the remainder of the distance. This scenario involves utilizing only the three quarries that are closest to the SJVAB in terms of rail miles (Lake Herman Quarry, Granite Rock Serpa Quarry, and Napa Quarry). No other quarries would be utilized under this scenario. This represents the lowest emissions-intensive scenario for rail hauling.

- **Scenario 4:** Maximum sub-ballast from quarries that are closest to the SJVAB in terms of rail miles. This scenario follows the same assumptions as Scenario 3, except for the method of transport (truck instead of rail). Although this scenario only utilizes three quarries that are the closest to the SJVAB in terms of rail miles, it is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.
- **Scenario 5:** Minimize sub-ballast from San Rafael Quarry and Granite Rock Serpa Quarry, haul maximum sub-ballast from all other quarries, by rail. Haul sub-ballast by truck to the nearest railhead, then by rail the remainder of the distance. This scenario involves hauling sub-ballast from Napa Quarry, Lake Herman Quarry, and Stony Point Quarry. San Rafael Quarry would not be used and sub-ballast from Granite Rock Serpa Quarry would be minimized. This represents a moderate emissions-intensive scenario for rail hauling.
- **Scenario 6:** Minimize sub-ballast from San Rafael Quarry and Granite Rock Serpa Quarry, haul maximum sub-ballast from all other quarries, by truck. This scenario follows the same assumptions as Scenario 5, except for the method of transport (truck instead of rail). This scenario is similar to the other truck-hauling scenarios described here in terms of emissions intensity, because the truck-miles from the quarries to the SJVAB border are similar for all truck-hauling scenarios.

Ranch Road to Merced Variation - Ballast

- **Scenario 1:** All ballast hauled from Lake Herman Quarry by rail. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. Because this scenario involves the quarry that is the smallest amount of rail miles from the SJVAB border, this represents the least emissions-intensive scenario for rail hauling.
- **Scenario 2:** All ballast hauled from Lake Herman Quarry by truck only. This scenario follows the same assumptions as Scenario 1, except for the method of transport (truck instead of rail). This scenario would involve the least amount of truck miles and is thus the least-emissions intensive scenario for truck hauling.
- **Scenario 3:** Maximum ballast hauled from Napa Quarry up to production limits, with the balance covered by Lake Herman Quarry, by rail. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. Because the Napa Quarry is a moderate rail-distance from the SJVAB border, relative to the other quarries, this represents a moderately emissions-intensive scenario.
- **Scenario 4:** Maximum ballast hauled from Napa Quarry, with the balance covered by Lake Herman Quarry, by truck only. This scenario follows the same assumptions as Scenario 3, except for the method of transport (truck instead of rail). This scenario would involve a moderate amount of truck miles, relative to Scenarios 2 and 6, and is thus a moderately-emissions intensive scenario for truck hauling.
- **Scenario 5:** Maximum Ballast from Stony Point Rock Quarry up to production limits, with the balance covered by San Rafael Rock Quarry, all by rail. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. Because the Stony Point and San Rafael quarries are the furthest rail-distance to the SJVAB border, this represents the maximum emissions-intensive scenario for rail hauling.

- **Scenario 6:** Maximum Ballast from Stony Point Rock Quarry up to production limits, with the balance covered by San Rafael Rock Quarry, all by truck only. This scenario follows the same assumptions as Scenario 5, except for the method of transport (truck instead of rail). This scenario would involve the highest amount of truck miles and is thus the most emissions-intensive scenario for truck hauling.

Ranch Road to Merced Variation – Sub-Ballast

- **Scenario 1:** All sub-ballast hauled from Lake Herman Quarry by rail. Haul sub-ballast by truck to the nearest railhead, then by rail the remainder of the distance. Because this scenario involves the quarry that is the smallest amount of rail miles from the SJVAB border, this represents one of the least emissions-intensive scenario for rail hauling along with Scenario 5.
- **Scenario 2:** All ballast hauled from Lake Herman Quarry by truck only. This scenario follows the same assumptions as Scenario 1, except for the method of transport (truck instead of rail). This scenario would involve the least amount of truck miles and is thus the least-emissions intensive scenario for truck hauling.
- **Scenario 3:** All ballast hauled from Stony Point Quarry by rail. Haul ballast by truck to the nearest railhead, then by rail the remainder of the distance. Because the Stony Point Quarry is the greatest rail-distance from the SJVAB border, this represents the most emissions-intensive scenario.
- **Scenario 4:** All ballast hauled from Stony Point Quarry by truck only. This scenario follows the same assumptions as Scenario 3, except for the method of transport (truck instead of rail). This scenario would involve the greatest amount of truck miles and is thus the most emissions-intensive scenario for truck hauling.
- **Scenario 5:** All ballast from Granite Rock Serpa Quarry, by rail. Because the Granite Rock Serpa Quarry is one of the closest quarries in terms of rail miles to the SJVAB border, this represents one of the least emissions-intensive scenarios for rail hauling along with Scenario 1.
- **Scenario 6:** All ballast from Granite Rock Serpa Quarry, by truck only. This scenario follows the same assumptions as Scenario 5, except for the method of transport (truck instead of rail). This scenario would involve the second highest amount of truck miles and is thus a moderately emissions-intensive scenario for truck hauling.

Tables 4 through 7 show the amounts of ballast and sub-ballast material that would be provided by each quarry for all Central Valley Wye alternatives and Ranch Road to Merced Variation scenarios. The material amounts in Tables 4 through 9 have been determined based on the descriptions above.

Table 4. Central Valley Wye Alternatives – Amount of Ballast Material Hauled from Each Quarry for Scenarios 1-6 (tons per year / cubic yards per year)[1]

	Scenario					
Quarry Name	**1**	**2**	**3**	**4**	**5**	**6**
Napa Quarry						
Rail	50,000 / 45,455	-	50,000 / 45,455	-	50,000 / 45,455	-
Truck	-	50,000 / 45,455	-	50,000 / 45,455	-	50,000 / 45,455
Lake Herman Quarry						
Rail	80,814 / 62,164	-	150,000 / 115,385	-	150,000 / 115,385	-
Truck	-	80,814 / 62,164	-	150,000 / 115,385	-	150,000 / 115,385
San Rafael Rock Quarry						
Rail	580,000 / 400,000	-	580,000 / 400,000	-	510,814 / 352,285	-
Truck	-	580,000 / 400,000	-	580,000 / 400,000	-	510,814 / 352,285
Stony Point Rock Quarry						
Rail	100,000 / 90,909	-	30,814 / 28,013	-	100,000 / 90,909	-
Truck	-	100,000 / 90,909	-	30,814 / 28,013	-	100,000 / 90,909
Granite Rock Serpa Quarry						
Rail	250,000 / 183,824	-	250,000 / 183,824	-	250,000 / 183,824	-
Truck	-	250,000 / 183,824	-	250,000 / 183,824	-	250,000 / 183,824
Total	1,060,814 / 782,352	1,060,814 / 782,352	1,060,814 / 772,675	1,060,814 / 772,675	1,060,814 / 787,857	1,060,814 / 787,857

Notes:
[1] The total cubic yard values vary by scenario because of differences in the ballast conversion factors between tons and cubic yards. See Table 3 for the conversion factors.

Table 5. Central Valley Wye Alternatives – Amount of Sub-Ballast Material Hauled from Each Quarry for Scenarios 1-6 (tons per year / cubic yards per year)[1]

	Scenario					
Quarry Name	**1**	**2**	**3**	**4**	**5**	**6**
Napa Quarry						
Rail	150,000 / 107,143	-	19,611 / 14,008	-	150,000 / 107,143	-
Truck	-	150,000 / 107,143	-	19,611 / 14,008	-	150,000 / 107,143
Lake Herman Quarry						
Rail	-	-	150,000 / 107,143	-	150,000 / 107,143	-
Truck	-	-	-	150,000 / 107,143	-	150,000 / 107,143
San Rafael Rock Quarry						
Rail	250,000 / 178,571	-	-	-	-	-
Truck	-	250,000 / 178,571	-	-	-	-
Stony Point Rock Quarry						
Rail	90,000 / 64,286	-	-	-	90,000 / 64,286	-
Truck	-	90,000 / 64,286	-	-	-	90,000 / 64,286
Granite Rock Serpa Quarry						
Rail	179,611 / 128,294	-	500,000 / 357,143	-	279,611 / 199,722	-
Truck	-	179,611 / 128,294	-	500,000 / 357,143	-	279,611 / 199,722
Total	669,611 / 478,294	669,611 / 478,294	669,611 / 478,294	669,611 / 478,294	669,611 / 478,294	669,611 / 478,294

Notes:

[1] A conversion factor of 1.4 tons per cubic yard was assumed.

Table 6. Ranch Road to Merced Variation - Amount of Ballast Material Hauled from Each Quarry for Scenarios 1-6 (tons per year / cubic yards per year)[1]

	Scenario					
Quarry Name	**1**	**2**	**3**	**4**	**5**	**6**
Napa Quarry						
Rail	-	-	50,000 / 45,455	-	-	-
Truck	-	-	-	50,000 / 45,455	-	-
Lake Herman Quarry						
Rail	106,281 / 81,755	-	56,281 / 43,293	-	-	-
Truck	-	106,281 / 81,755	-	56,281 / 43,293	-	-
San Rafael Rock Quarry						
Rail	-	-	-	-	6,281 / 4,332	-
Truck	-	-	-	-	-	6,281 / 4,332
Stony Point Rock Quarry						
Rail	-	-	-	-	100,000 / 90,909	-
Truck	-	-	-	-	-	100,000 / 90,909
Granite Rock Serpa Quarry						
Rail	-	-	-	-	-	-
Truck	-	-	-	-	-	-
Total	106,281 / 81,755	106,281 / 81,755	106,281 / 88,748	106,281 / 88,748	106,281 / 95,241	106,281 / 95,241

Notes:
[1] The total cubic yard values vary by scenario because of differences in the ballast conversion factors between tons and cubic yards. See Table 3 for the conversion factors.

Table 7. Ranch Road to Merced Variation - Amount of Sub-Ballast Material Hauled from Each Quarry for Scenarios 1-6 (tons per year / cubic yards per year)[1]

	Scenario					
Quarry Name	**1**	**2**	**3**	**4**	**5**	**6**
Napa Quarry						
Rail	-	-	-	-	-	-
Truck	-	-	-	-	-	-
Lake Herman Quarry						
Rail	12,787 / 9,134	-	-	-	-	-
Truck	-	12,787 / 9,134	-	-	-	-
San Rafael Rock Quarry						
Rail	-	-	-	-	-	-
Truck	-	-	-	-	-	-
Stony Point Rock Quarry						
Rail	-	-	12,787 / 9,134	-	-	-
Truck	-	-	-	12,787 / 9,134	-	-
Granite Rock Serpa Quarry						
Rail	-	-	-	-	12,787 / 9,134	-
Truck	-	-	-	-	-	12,787 / 9,134
Total	12,787 / 9,134	12,787 / 9,134	12,787 / 9,134	12,787 / 9,134	12,787 / 9,134	12,787 / 9,134

Notes:
[1] The total cubic yard values vary by scenario because of differences in the ballast conversion factors between tons and cubic yards. See Table 3 for the conversion factors.

Considerations for the Criteria Pollutant and Greenhouse Gas Emissions Analysis

The material quantities in Tables 4 through 7 for the six Central Valley Wye alternatives and six Ranch Road to Merced Variation scenarios were used to determine the pollutant emissions that would be generated outside of the SJVAB from ballast and sub-ballast material hauling activities for each construction phase. The criteria pollutants evaluated were carbon monoxide (CO), nitrogen oxide (NO_X), particulate matter with a diameter of 10 micrometers or less (PM_{10}), particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$), reactive organic gases (ROG), and sulfur dioxide (SO_2). CO_2e, including the contributions of methane (CH_4) and nitrous oxide (N_2O) was evaluated. Emissions were calculated by multiplying the mileage associated with each scenario by criteria pollutant and CO_2 emission factors for rail and truck hauling. CO_2 was converted into CO_2e using the U.S. Environmental Protection Agency's assumption that CH_4+N_2O is equal to approximately 5% of CO_2 emissions (U.S. Environmental Protection Agency 2014). For rail emissions, the emission factors were multiplied by the material tonnage values, as the emission factors for trains are in grams per-ton-mile.

The distances between each quarry and the SJVAB border for rail hauling were estimated using Google Earth imagery from the railhead nearest to the quarry, and following the tracks to the SJVAB border. The distances between each quarry and the SJVAB border for truck hauling were estimated using Google Maps directions from the quarry to Chowchilla, and then subtracting the distance from the SJVAB border to Chowchilla.

Single hauling trip distances for each scenario were estimated by taking a weighted average, using the material quantities, of the quarry-to-SJVAB distances. For example, the trip distance associated with Central Valley Wye Alternatives Scenario 3 for ballast hauling is the weighted average of the quarry-to-SJVAB distance for each quarry. The weighting was based on the proportions of material quantities for each of the quarries.

Total hauling distances associated with each scenario were calculated by multiplying the number of truck trips needed by the single hauling trip distances associated with each scenario. The number of truck trips needed was determined by dividing the material quantities for each scenario by an assumed truck-hauling capacity of 25 tons per truck. This step is not necessary for rail hauling, because the emission factor used for trains is in units of grams per-ton-mile (see Table 8) and can be multiplied directly by the tons quantities for each scenario.

Table 8 provides the emission factors used in the analysis. Rail emission factors are based on the EPA document *Emission Factors for Locomotives* (U.S. Environmental Protection Agency 2009). Haul Truck emission factors are from EMFAC2014, based on the statewide fleet of heavy-heavy duty trucks and the default range of vehicle years spanning the previous 45 years.

Table 8. Rail and Truck Emission Factors

Emission Source	Emission Factors						
	ROG	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	CO_2
Rail (grams per-ton-mile)[1]							
2020[2]	0.008	0.056	0.207	0.005	0.005	0.002	21.3
2021-2022[3]	0.007	0.056	0.186	0.004	0.004	0.0002	21.3
Haul Trucks (grams per-mile)[4]							
2020[2]	0.05	0.23	2.84	0.12	0.05	0.02	1,410
2021-2022[3]	0.05	0.22	2.41	0.11	0.05	0.02	1,395

Notes:

[1] Based on a conversion factor of 479 ton-mile/gallon from the Association of American Railroads and grams/gallon emission factors from the EPA document *Emission Factors for Locomotives* (American Association of Railroads 2015 and U.S. Environmental Protection Agency 2009).

[2] 2020 emission factors were used for the Ranch Road to Merced Variation, because track work is anticipated to occur in 2020.

[3] 2021-2022 emission factors were used for the Central Valley Wye alternatives scenarios. Track work is anticipated to occur from December 2021 to December 2022. Thus, analysts calculated a multi-year weighted emission factor for trucks and locomotives based on the 2021 emission factors and number of days of track construction in 2021, and the 2022 emission factors and the number of days of track construction in 2022.

[4] Based on EMFAC2014 statewide fleet for heavy-heavy duty trucks, and default range of 45 years for vehicle model years.

For this analysis, the significance of the criteria pollutant emissions associated with hauling activities is determined by comparing the emissions to the emissions thresholds relevant to the SFBAAB, the basin in which all of the quarries that were considered in this analysis are located. The federal and state air quality attainment status of the SFBAAB, which determines the General Conformity *de minimis* thresholds that apply to the Central Valley Wye alternatives and the Ranch Road to Merced Variation, are shown in Table 9. These General Conformity *de minimis* thresholds that are applicable to the SFBAAB are shown in Table 10, and daily California Environmental Quality Act (CEQA) emissions thresholds for construction activities from the BAAQMD are shown in Table 11.

The BAAQMD's CEQA Guidelines do not identify a quantitative GHG emission threshold for construction-related emissions. Instead BAAQMD recommends that GHG emissions from construction be quantified and disclosed, and that a determination regarding the significance of these GHG emissions be made with respect to whether a project is consistent with the Assembly Bill 32 (AB 32) GHG emission reduction goals. The BAAQMD further recommends incorporation of best management practices to reduce GHG emissions during construction, as feasible and applicable. Best management practices applicable to the Central Valley Wye alternatives could include the use of alternative-fueled (e.g., biodiesel, electric) construction vehicles.

Table 9. San Francisco Bay Area Air Basin Attainment Status

Criteria Pollutant	Federal Designation	State Designation
O_3 (1-hour)	--[1]	Nonattainment
O_3 (8-hour)	Marginal Nonattainment	Nonattainment
CO	Maintenance	Attainment
PM_{10}	Attainment	Nonattainment
$PM_{2.5}$	Nonattainment (2006)	Nonattainment
NO_2	Attainment	Attainment
SO_2	Attainment	Attainment
Lead	Attainment (2008)	Attainment
Sulfates	(No Federal Standard)	Attainment
Hydrogen Sulfide	(No Federal Standard)	Unclassified
Visibility Reducing Particles	(No Federal Standard)	Unclassified

Sources:
California Air Resources Board. 2015 and 2017.
U.S. Environmental Protection Agency 2016.
Notes:
CO = carbon monoxide.
PM10 = particulate matter less than or equal to 10 microns.
PM2.5 = particulate matter less than or equal to 2.5 microns.
NO2 = nitrogen dioxide.
SO2 = sulfur dioxide.
[1] The federal 1-hour standard of 12 parts per hundred million (pphm) was in effect from 1979 through June 15, 2005. The revoked standard is referenced here because it was employed for such a long period and because this benchmark is addressed in the state implementation plans.

Table 10. General Conformity Rule *de minimis* Thresholds for the San Francisco Bay Area Air Basin

VOC or ROG (ozone precursor)	100 tons per year
NOx (ozone precursor)	100 tons per year
PM2.5	100 tons per year
CO	100 tons per year

Source:
USEPA Title 40 CFR, Part 93, 1993
VOC = volatile organic compounds
ROG = reactive organic gas
NOx = nitrous oxides
CO = carbon monoxide

Table 11. Bay Area Air Quality Management District CEQA Thresholds

Pollutant	Construction
ROG	54 lbs./day
NOX	54 lbs./day
CO	–
PM10 (total)	–
PM10 (exhaust)	82 lbs./day
PM2.5 (exhaust)	54 lbs./day
PM10 /PM2.5 (fugitive dust)	Best management practices

Source: Bay Area Air Quality Management District. 2011

Annual Hauling Activity Emissions

Annual criteria pollutant and GHG emissions associated with hauling the ballast and sub-ballast material during construction of the Central Valley Wye alternatives are shown in Tables 12 for the six potential hauling scenarios described above. Ballast and sub-ballast hauling would occur for approximately one year, from December 2021 to December 2022. In Table 12, the annual emissions are assessed against the General Conformity *de minimis* thresholds applicable to the SFBAAB (see Table 10). As shown in the tables below, annual emissions would be below the General Conformity *de minimis* thresholds.

Annual criteria pollutant and GHG emissions associated with hauling the Ranch Road to Merced Variation ballast and sub-ballast material are shown in Table 14. It was assumed that the hauling activities would occur for approximately one year, in 2020. As shown in Table 14, annual emissions for the Ranch Road to Merced Variation would be below the General Conformity *de minimis* thresholds.

Daily Hauling Activity Emissions

Daily criteria pollutant emissions associated with hauling were approximated by dividing annual rail hauling emissions by 104, which assumes a rail hauling frequency of two times per week (2 x 52 weeks/year), and dividing annual truck hauling emissions by 260, which assumes 260 work days of truck hauling per year (5 days per week, 52 weeks per year).

Daily hauling emissions are shown in Tables 13 for the Central Valley Wye alternatives. Emissions associated with hauling would be below the BAAQMD daily construction thresholds for all pollutants except for NO_X. NO_X emissions would exceed the BAAQMD threshold for all six scenarios. NO_X emissions would exceed the threshold by 127 pounds per day for the least emissions-intensive scenario (Scenario 4), and by 517 pounds per day for the most emissions-intensive scenario (Scenario 1).

To reduce NO_X emissions to levels below the BAAQMD CEQA thresholds, emissions offsets can be purchased through the BAAQMD's Carl Moyer Program and other applicable BAAQMD incentive programs. With mitigation to purchase sufficient offsets through the Carl Moyer Program or other incentives program, NO_X emissions would not exceed the BAAQMD thresholds for hauling activities.

As shown in Table 15, daily criteria pollutant emissions for Ranch Road to Merced Variation material hauling would be below the BAAQMD daily construction threshold for all pollutants under all scenarios, so no emissions offsets would be required.

Greenhouse Gas Emissions

While there are no BAAQMD or federal construction thresholds for GHGs, the BAAQMD advises that construction GHG emissions should be quantified and disclosed. Annual GHG emissions (in terms of CO_2e) from Central Valley Wye alternatives hauling activities, as shown in Table 12, would be a maximum of 13,906 metric tons. Annual CO_2e emissions from Ranch Road to Merced Variation hauling activities, as shown in Table 13, would be a maximum of 1,265 metric tons. Statewide GHG emissions in 2014, the most recent year for which emissions data are available, were 441,540,000 metric tons of CO_2 equivalent (California Air Resources Board 2016). The contributions of CO_2e emissions from the Central Valley Wye alternatives would each be less than of 0.003% of statewide 2014 emissions. The contribution of CO_2e emission from the Ranch Road to Merced Variation would be 0.0003% of statewide 2014 emissions. Because the CO_2 emissions associated with hauling represent a marginal proportion of statewide 2014 emissions, the Central Valley Wye alternatives and Ranch Road to Merced Variation impact on statewide global climate change would be negligible. In addition, material hauling activities to construct the Central Valley Wye alternatives and Ranch Road to Merced Variation would be consistent with the AB 32 reduction goals, as the California High Speed Rail project is included in the AB 32 scoping plan as Measure #T-9.

Table 12. Central Valley Wye Alternatives – Annual Ballast and Sub-Ballast Hauling Emissions (tons/year)

Scenario/Thresholds	Emissions[1]						
	CO	NO_X	PM_{10}	$PM_{2.5}$	ROG	SO_2	CO_2e
Scenario 1	8.79	31.17	0.76	0.68	1.14	0.05	4,497.35
Scenario 2	2.29	25.14	1.15	0.52	0.52	0.17	13,905.90
Scenario 3	7.11	25.54	0.63	0.56	0.93	0.04	3,879.04
Scenario 4	2.14	23.47	1.07	0.49	0.49	0.16	12,981.34
Scenario 5	7.66	27.31	0.67	0.59	0.99	0.04	4,024.70
Scenario 6	2.24	24.58	1.12	0.51	0.51	0.16	13,599.21
General Conformity Threshold for SFBAAB	N/A	100	N/A	100	100	N/A	N/A
Exceedances of the General Conformity Threshold	N/A	None	N/A	None	None	N/A	N/A

Notes:
[1] The units for CO_2 are metric tons, not short tons

Table 13. Central Valley Wye Alternatives – Daily Ballast and Sub-Ballast Hauling Emissions

	Emissions (Pounds per Day)[1]						
Scenario/Thresholds	**CO**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_2**	**CO_2e**
Scenario 1	166.37	571.06	13.30	12.46	21.31	0.71	78,077.51
Scenario 2	17.65	193.37	8.83	4.01	4.01	1.28	117,912.42
Scenario 3	134.14	462.92	10.86	10.10	17.21	0.59	65,016.21
Scenario 4	16.48	180.51	8.24	3.75	3.75	1.20	110,072.76
Scenario 5	144.85	498.27	11.64	10.87	18.56	0.62	68,868.57
Scenario 6	17.26	189.11	8.63	3.92	3.92	1.26	115,311.91
BAAQMD Daily Construction Threshold	N/A	54	82	54	54	N/A	N/A
Exceedances of the BAAAQMD Threshold	N/A	Scenarios 1-6	None	None	None	N/A	N/A

Notes:

Notes:

[1] Exceedances of the applicable threshold are shown in bold

Table 14. Ranch Road to Merced Variation - Annual Ballast and Sub-Ballast Hauling Emissions in 2020

	Emissions (Tons per Year in 2020)[1]						
Scenario/Thresholds	**CO**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_2**	**CO_2e**
Scenario 1	0.04	0.50	0.02	0.01	0.01	0.00	214.58
Scenario 2	0.14	1.85	0.07	0.03	0.03	0.01	786.79
Scenario 3	0.02	0.25	0.01	0.00	0.00	0.00	104.50
Scenario 4	0.17	2.19	0.08	0.04	0.04	0.01	935.28
Scenario 5	0.01	0.08	0.00	0.00	0.00	0.00	33.08
Scenario 6	0.23	2.97	0.11	0.06	0.06	0.01	1,265.47
General Conformity Threshold for SFBAAB	N/A	100	N/A	100	100	N/A	N/A
Exceedances of the General Conformity Threshold	N/A	None	N/A	None	None	N/A	N/A

Notes:
[1] The units for CO_2e are metric tons, not short tons

Table 15. Ranch Road to Merced Variation - Daily Ballast and Sub-Ballast Hauling Emissions

Scenario/Thresholds	Emissions (Pounds per Day)[1]						
	CO	NO_X	PM_{10}	$PM_{2.5}$	ROG	SO_2	CO_2e
Scenario 1	0.30	3.87	0.15	0.07	0.07	0.02	1,819.49
Scenario 2	1.11	14.20	0.53	0.27	0.27	0.07	6,671.45
Scenario 3	0.15	1.89	0.07	0.04	0.04	0.01	886.09
Scenario 4	1.32	16.88	0.63	0.32	0.32	0.08	7,930.51
Scenario 5	0.05	0.60	0.02	0.01	0.01	0.00	280.53
Scenario 6	1.78	22.84	0.86	0.43	0.43	0.11	10,730.27
BAAQMD Daily Construction Threshold	N/A	54	82	54	54	N/A	N/A
Exceedances of the BAAAQMD Threshold	N/A	Scenarios 1-6	None	None	None	N/A	N/A

Notes:
[1] Exceedances of the applicable threshold are shown in bold

Conclusion

The material hauling scenarios discussed in this memorandum represent possible ballast and sub-ballast material hauling activities for the Central Valley Wye alternatives and for the Ranch Road to Merced Variation. While it is unknown which quarries and transport methods would be used at this time, this memorandum provides a reasonable estimation of potential hauling scenarios and the corresponding criteria pollutant and CO_2e emissions.

For the Central Valley Wye alternatives, annual hauling activity emissions would not exceed the General Conformity *de minimis* thresholds for any criteria pollutants, and daily emissions would not exceed the BAAQMD daily construction emission thresholds for any pollutants, except for NO_X. With mitigation to purchase emissions offsets, NO_X emissions would be reduced to below the BAAQMD CEQA threshold. As discussed above, GHG emissions would represent a marginal fraction of statewide GHG emissions, and the material hauling activities to construct the Central Valley Wye alternatives would be consistent with the reduction goals of AB 32.

For the Ranch Road to Merced Variation, annual hauling activity emissions would not exceed the General Conformity *de minimis* thresholds for any criteria pollutants, and daily emissions would not exceed the BAAQMD daily construction emission thresholds for any pollutants. No mitigation offset purchases would be required. Like the Central Valley Wye alternatives, GHG emissions would represent a marginal fraction of statewide GHG emissions, and the Ranch Road to Merced Variation hauling activities would be consistent with the reduction goals of AB32.

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