CALIFORNIA
High-Speed Rail Authority

Capital Cost Basis of Estimate Report

2016 BUSINESS PLAN: TECHNICAL SUPPORTING DOCUMENT

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Prepared by WSP | PARSONS BRINCKERHOFF

for the California High-Speed Rail Authority

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Signer: Name (Print): Gary Griggs	Reviewer's Initial/Date: 4/29/16	Comments:
Reviewer #1 Name (Print): Frank Vacca	Reviewer's Initial/Date: 4/20/16	Comments:
Author #1 Name (Print): Vladimir Kanevskiy	Reviewer's Initial/Date: VK / 04.20.16	Comments:
Author #2 Name (Print): Rob Ball	Reviewer's Initial/Date: 4/21/16	Comments:
	Reviewer's Initial/Date:	Comments:

☐ Approval/Signoff (initials)

☒ Signature

☒ Hand Carry or Call for Pick up
Name: Kris Livingston Ext.: 384-9515

☐ Information

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Executive Office Control No.:	Name of Contact Person:
	Phone Number:
	Office:
	Office Control No.:

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Acronyms

ARRA	American Recovery and Reinvestment Act
ARTIC	Anaheim Regional Transportation Intermodal Center
BART	Bay Area Rapid Transit
BNSF	Burlington North Santa Fe Railway
FRA	Federal Railroad Administration
GAO	Government Accountability Office (United States)
HMF	Heavy Maintenance Facility
LMF	Light Maintenance Facility
SCC	Standard Cost Category
SCRIP	Southern California Regional Interconnector Project
UIC	International Union of Railways
UPRR	Union Pacific Railroad

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1 Background and Context

The California High-Speed Rail Authority (Authority) is responsible for planning, designing, building and operating a high-speed rail system in California. The system will connect and transform California. It will improve mobility, contribute to economic development and a cleaner environment, create jobs and preserve agricultural and other protected lands. The Phase 1 system will run approximately 520 miles from San Francisco/Merced to Los Angeles/Anaheim through the Central Valley in under three hours at speeds capable of over 200 miles per hour. Phase 2 will eventually extend the system to Sacramento and San Diego, totaling 800 miles with up to 24 stations.

This *2016 Business Plan* Capital Cost Basis of Estimate Report presents updated capital cost estimates in support of the Authority's *2016 Business Plan*. It lays out the estimating approach, methodology and assumptions that serve as the basis for the Phase 1 system capital cost estimates and for the Silicon Valley to Central Valley line capital cost estimates described and presented in the *2016 Business Plan*. It summarizes how the estimates are organized and presented (i.e., by geographic segment and by cost category). This report identifies specific changes to the estimates as compared to those presented in the 2014 Business Plan, describes the basis for the changes, and identifies the key drivers for cost changes (both increases and decreases). Finally, it provides a detailed segment by segment comparison of the updated 2016 capital cost estimates to those presented in the 2014 Business Plan.

The last major update to the capital cost estimates was completed as part of the 2012 Business Plan. At that time, the Authority updated its estimates which also reflected its adoption of a blended system approach in which high-speed rail service would be provided over a mix of dedicated tracks and upgraded regional rail infrastructure on the San Francisco Peninsula and in the Los Angeles Basin. After the 2012 Business Plan was finalized, the Authority's forecasts and estimates underwent in-depth reviews by the Legislative Peer Review Group.[1] In addition, as a result of a bipartisan Congressional request, the Authority underwent a comprehensive year-long review of its capital cost estimates by the United States Government Accountability Office (GAO). The GAO found that the California High-Speed Rail Authority "substantially met best practices for developing accurate cost estimates."[2]

At the time that the 2014 Business Plan was developed, planning and design work was more advanced on the two Central Valley project environmental sections—Merced-Fresno and Fresno-Bakersfield. The Board of Directors selected the preferred alignment for the Merced to Fresno section and awarded its first design-build contract, known as Construction Package 1, for the 29-mile segment which runs from Avenue 17 in Madera south to East American Avenue in Fresno. Alternatives analysis, environmental planning and design work was still in relatively early stages of development on the other Phase 1 sections. As a result, in 2014 no fundamental changes were made to the capital cost estimates for the 2014 Business Plan. The only refinements that were made in the 2014 Business Plan estimate included:

[1] AB 3034 (Galgiani, Chapter 267), Statutes of 2008) established a Peer Review Group (PRG) whose duty is to evaluate the California High-Speed Rail Authority's funding plans and prepare its independent judgment as to the feasibility and the reasonableness of the California High-Speed Rail Authority's plans, appropriateness of assumptions, analyses and estimates, and any observations or evaluations the PRG deems necessary. http://www.cahsrprg.com/

[2] http://www.gao.gov/assets/660/653401.pdf

- Updates to the baseline capital costs, which were inflated to 2013 constant dollars and the year-of-expenditure (YOE) planning estimates
- Inclusion of the actual construction contract amounts for Construction Package 1
- Reflection of the Fresno-Bakersfield staff recommendation for the preferred alignment alternative within the limits of the first construction segment in the Central Valley

Capital costs evolve as any major transportation infrastructure project, like high-speed rail, transitions from early planning and conceptual engineering through preliminary engineering, contract procurement and ultimately to final design and construction. As the project scope, alignment, procurement strategies, delivery mode and other key decisions are finalized—and as environmental mitigation and other project components are more accurately specified—capital costs become more certain and risk factors become more defined supporting contingency modifications and schedule confidence.

This report reflects several major advancements in the development of the program resulting in the Authority's determination that a comprehensive update to the capital cost estimate was warranted. Specific refinements and design reviews that have contributed to the updates in the capital cost estimate include:

- The executed contract amounts for Construction Package 1 and Construction Package 2-3 in the Central Valley were incorporated into the updated capital cost estimate
- Analysis of contractor's competitive bids for Construction Package 1 and Construction Package 2-3 provided insight regarding Alternative Technical Concepts (ATC) to be used in reviewing and reducing costs.[3]
- Advancement of final design on Construction Package 1 added insight to contractor construction methodologies, allowing refinement of estimating assumptions applied to other sections where appropriate.
- Evaluation of the competitive bid environment leading to an assessment of cost factors such as indirect and margin markups
- Detailed review of the capital cost estimates by Certified Professional Estimators, senior project staff and third party industry professionals resulted in validation of the estimating methodology and to revised approaches where appropriate
- Contingencies were based on further project definition (See Section 3.3)

To better reflect varying geographical, environmental and economic conditions associated with each environmental section, the Authority has subdivided the previous seven environmental sections into twelve discrete geographic segments plus the maintenance facilities and two trainset packages (an initial acquisition package to support the start of initial operations and a subsequent acquisition package to support service levels for the full Phase 1 system).

[3] Alternate Technical Concepts are proposed by the bidders and reflect their unique technical solutions

2 Capital Cost Summary

A comprehensive update to the capital cost estimates has been conducted, factoring in lessons derived from the Authority's first design-build construction bids, design refinements suggested in those proposals and through other reviews, advancing more detailed engineering and design work, conducting value engineering and incorporating contractors' viewpoints. Through this process, the overall Phase 1 cost estimate has been reduced. For a comparable scope of work as the 2014 Business Plan, these updated estimates have decreased from $67.6 billion (YOE$) in the 2014 Business Plan to $62.1 billion (YOE$) representing an eight percent (8%) decrease when comparing equivalent investments.

Value engineering was conducted (by the Authority and by the design build contractors), which provided valuable insight into design efficiencies. These value engineering concepts were also applied to alignment sections with similar characteristics and in areas that included what appeared to be overly conservative assumptions. Lessons learned from bids resulted in the use of Alternative Technical Concepts to reduce total construction costs without fundamentally changing functionality.

These cost reductions allowed for additional scope to be added to the Los Angeles to Anaheim section over what was previously assumed in the 2014 Business Plan cost estimates. Specifically, an additional investment in that section has been identified to enhance the capacity, speed and reliability of this high travel demand corridor and provide one-seat ride service all the way to Anaheim. The estimated cost of these enhancements, which represents a scope expansion from the 2014 Business Plan, is $2.1 billion. This increase in scope and additional cost has now been incorporated into the overall cost estimate and is factored into the estimates presented below.

Figure 1 below from the *2016 Business Plan* represents the basis for the $5.5 billion dollar (YOE$) decrease and the increased cost associated with the Los Angeles to Anaheim addition, summarizing the total changes between the *2014 Business Plan* and the *2016 Business Plan* capital cost estimates.

Figure 1 – Basis for Capital Cost Reductions (in billions of YOE$)

Table 1 and Table 2 present the *2016 Business Plan* capital cost estimates by the Federal Railroad Administration (FRA) Standard Cost Category (SCC) in both base year 2015 dollars and in year of expenditure dollars (YOE$) for the Silicon Valley to Central Valley line and the Phase 1 system, respectively.

Table 1. Silicon Valley to Central Valley Cost Estimate by SCC (millions, 2015$ and YOE$)

Standard Cost Category (SCC)	2015$	YOE$
10 TRACK STRUCTURES & TRACK	$7,038	$7,851
20 STATIONS, TERMINALS, INTERMODAL	$279	$308
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$193	$219
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$4,910	$5,309
50 COMMUNICATIONS & SIGNALING	$468	$528
60 ELECTRIC TRACTION	$1,108	$1,258
70 VEHICLES	$774	$865
80 PROFESSIONAL SERVICES (applies to Cats. 10-60)	$2,994	$3,249
90 UNALLOCATED CONTINGENCY	$985	$1,091
100 FINANCE CHARGES	—	—
Total:*	**$18,749**	**$20,679**

**Subtotals for information only, figures may not sum due to rounding.*

Table 2. Phase I Capital Cost Estimate by SCC (millions, 2015$ and YOE$)

Standard Cost Category (SCC)	2015$	YOE$
10 TRACK STRUCTURES & TRACK	$22,782	$26,848
20 STATIONS, TERMINALS, INTERMODAL	$2,345	$2,630
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$993	$1,212
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$11,286	$12,581
50 COMMUNICATIONS & SIGNALING	$1,158	$1,370
60 ELECTRIC TRACTION	$3,021	$3,574
70 VEHICLES	$3,400	$4,192
80 PROFESSIONAL SERVICES (applies to Cats. 10-60)	$6,375	$7,250
90 UNALLOCATED CONTINGENCY	$2,133	$2,509
100 FINANCE CHARGES	—	—
Sub-Total (San Francisco – Los Angeles Union Station)*	**$53,491**	**$62,167**
Enhanced Design Los Angeles – Anaheim Corridor	**$1,804**	**$2,072**
Total:**	**$55,295**	**$64,238**

**Includes funding for early improvement projects in Los Angeles-Anaheim section.*
***Subtotals for information only, figures may not sum due to rounding.*

Figure 2 shows a comparison of the capital cost estimates for the Phase 1 system between the 2014 Business Plan and the 2016 Business Plan by SCC. For the purpose of this comparison, the 2014 Business Plan costs have been escalated to base year 2015 dollars. In addition, for purposes of comparison, the Los Angeles to Anaheim section costs have been excluded from both estimates. The more significant cost reductions are found in three categories: (1) Track and Structures ($3,500 million), (2) Stations ($1,200 million), and in (3) Site Work and Right-of-Way ($1,600 million).

These decreases in capital costs are in part offset by smaller increases in (1) Support Facilities, (2) Systems and Electrification and (3) in Professional Services. Unallocated Contingencies have also increased overall by $150 million (see Figure 2 below for a more detailed listing of major cost differences in each environmental section).

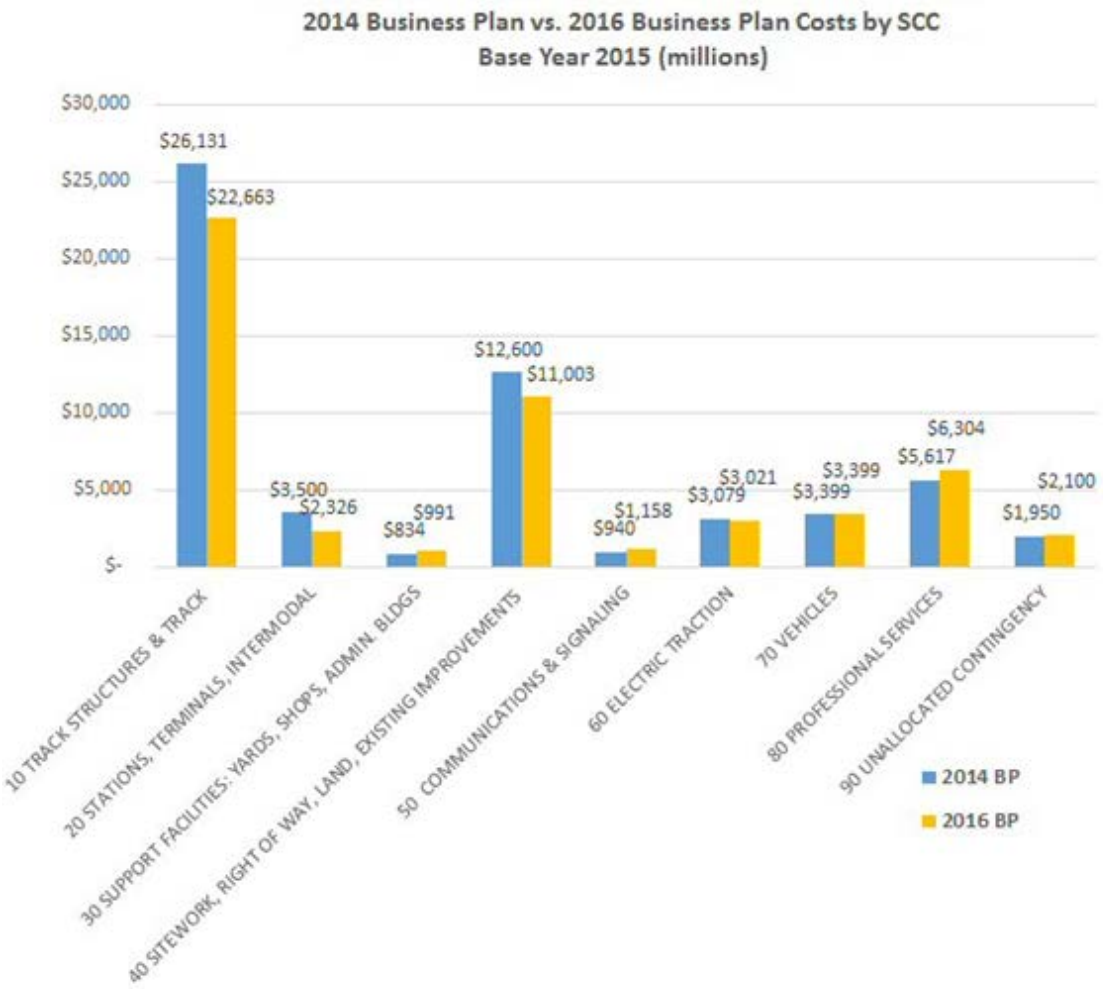

Figure 2 - Capital Cost Comparison by SCC in 2015 dollars (does not include Los Angeles-Anaheim section)

The changes between 2014 Business Plan and 2016 Business Plan capital cost estimates are further illustrated by showing the resulting cost increases and decreases within each environmental section as shown on Figure 3 below. The environmental sections where cost changes have been most significant are San Francisco, San Jose and San Jose-Merced. The San Francisco-San Jose section cost decreased due to a reduction in the Transbay Transit Center allowance based on the Transbay Joint Powers Authority's estimate for the Authority's contribution. It also decreased due to the elimination of dedicated tracks at Millbrae and of an aerial approach to Diridon Station in San Jose. The San Jose-Merced section had a major cost reduction associated with changing the Diridon Station from being aerial to at-grade, extending the at-grade alignment in the Caltrain corridor to Tamien, and applying value engineering solutions to tunnel designs.

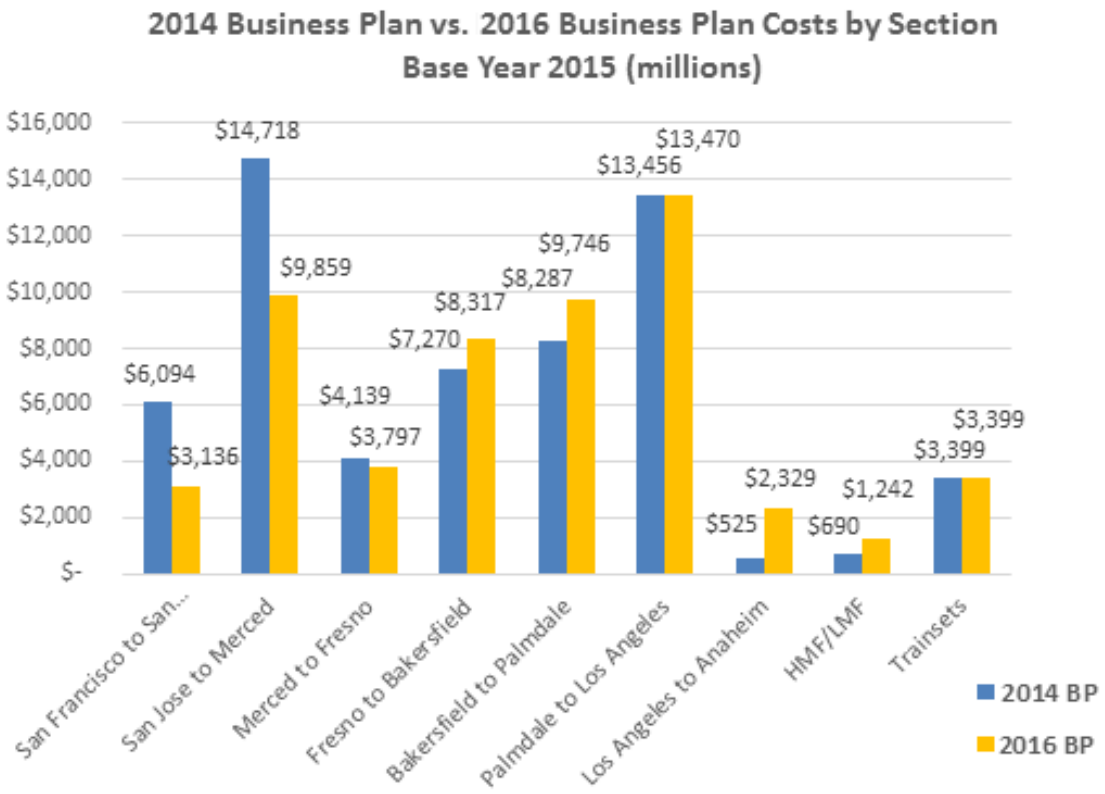

Figure 3 - Capital Cost Comparison by Environmental Section

The Authority has been implementing design refinements and pricing updates as highlighted in more detail in Table 3 below. In addition, since the 2014 Business Plan, Authority has awarded two design-build construction packages in the Central Valley. The bids for these packages came in lower than originally estimated and reflect the competitive bid environment that currently exists. In the review of these bids, further insights have been gained from the design build contractors' construction means and methods, final design approaches and pricing, which has been applied to other sections where appropriate. Other cost reductions resulted from further clarification on alignment alternatives.

Table 4 identifies the key drivers of the cost changes in each environmental section. This comparison is presented in constant 2015 dollars, as opposed of YOE dollars, in order to highlight the changes in scope and/or in pricing assumptions that influenced the resulting cost differences without a compounding effect of differences in timing or escalation assumptions.

Table 3. 2014 to 2016 Business Plan Capital Cost Comparison

Environmental Section	2014 BP (2015 $, Millions)	2016 BP (2015 $, Millions)	Change (2015 $, Millions)	Comments*
San Francisco to San Jose	$6,094	$3,136	$(2,958)	• Reduced Transbay Transit Center contribution to match the Transbay Joint Powers Authority's estimate (-$1.5B) • Added upgrades to existing Caltrain stations to be shared with high-speed rail (+0.5B) • Removed dedicated guideway at Millbrae and aerial approach to San Jose Station (-$1.7B) • Upgraded existing track to Class 6 track; grade crossing and right-of-way safety improvements (+ $0.1 B) • Moved cost of Light Maintenance Facility (LMF) to Heavy Maintenance Facility (HMF) (-$0.2B)
San Jose to Merced	$14,718	$9,859	$(4,859)	• Reduced San Jose station costs by changing from aerial to at-grade (-$0.5B) • Reduction in tunneling costs per value engineering (-$1.4B) • Increase in aerial guideway (+$0.2 B) • Reduction in earthwork and walls due to increase in aerial guideway (-$0.4B) • Decrease in grade separations costs due to increase in aerial guideway (-$0.6B) • Reduction in utility relocations due to increase in aerial guideway (-$0.2B) • Reduction in right-of-way costs due to increase in aerial guideway (-$0.2B)
Merced to Fresno	$4,139	$3,797	$(342)	• Reduction in grade separations costs per input from final design on CP 1 (-$0.3B) • Increase in right-of-way costs (+$0.1B)
Fresno to Bakersfield	$7,270	$8,317	$1,047	• Reflects selected alignment alternative per Final Environmental Impact Report/Statement • Reduction in aerial guideway per CP 2-3 ATC (-$0.5B) • Increase in retaining walls due to decrease in aerial guideway (+$0.2B) • Increase in utility relocation costs (+$0.9B) • Increase in grade separations costs due to decrease in aerial guideway in CP 2-3 (+$0.3B)

Environmental Section	2014 BP (2015 $, Millions)	2016 BP (2015 $, Millions)	Change (2015 $, Millions)	Comments*
Bakersfield to Palmdale	$8,287	$9,746	$1,458	• Reflected Supplemental Analysis 2016 alignment alternative • Increase in earthwork in lieu of viaducts and tunnels (+$2.0B) • Increase in right-of-way costs (+$1.0B) • Decrease in aerial guideway due to increase in embankments (-$0.9B) • Decrease in tunneling due to increase in cuts (-$0.4B)
Palmdale to Los Angeles	$13,456	$13,470	$14	• Reflected Supplemental Alternative Analysis East Corridor alignment under the Angeles National Forest • Increase in tunneling costs due to increase in tunnel length (+$0.8B) • Increase in retaining walls due to constrained right-of-way (+$1.4B) • Increase in Los Angeles Union Station costs with shared tracks into station and dedicated platform faces for high-speed rail (+$0.6B) • Decrease in aerial guideway due to increase in tunneling (-$0.7B) • Decrease in grade separations costs by avoiding existing rail corridor in North San Fernando Valley (-$0.7B) • Decrease in right-of-way costs (-$0.7B) • Reduced utility relocation costs due to increase in tunneling (-$0.2B) • Moved cost of LMF to HMF (-$0.2B)
Los Angeles to Anaheim	$525	$2,329	$1,804	• Dedicated passenger tracks and additional grade separations
HMF/LMF	$690	$1,242	$552	• Moved cost of LMFs to HMF
Trainsets	$3,399	$3,399	—	—
Total Phase 1:**	**$58,579**	**$55,295**	**$(3,283)**	—

**Numerical values indicating cost increases/decreases are not representative of the total cost variances. Other costs including allowances based on percentages also contribute to the total difference but are not listed in this table.*

***Subtotals for information only, figures may not sum due to rounding.*

As mentioned in Section 1, the seven environmental sections have been further broken down into twelve geographic segments, plus the maintenance facilities and two trainset packages. Section 4.2 provides a detailed breakdown of the *2016 Business Plan* capital cost estimates for each geographic segment level. This section also includes a detailed comparison with the 2014 Business Plan capital cost estimates, as well as major assumptions used to update the costs.

3 Approach and Methodology

This report presents a summary of current capital cost estimates along with detailed FRA Standard Cost Categories (SCC) and sub-categories for cost elements. The methodology outlined in this report includes:

- Methods and processes used to develop the updated capital cost estimate in support of the *2016 Business Plan*
- Design completion stage and the definition of alternatives used in developing of the capital cost estimates
- Source documents and methodology used for quantity take offs
- Assumptions used for the estimates
- Updates to the Unit Price Elements based upon industry review and experience from executed contracts
- Work breakdown structure with respect to FRA Standard Cost Categories (SCC)

The *2016 Business Plan* capital cost estimate is a Class 3 estimate as defined by the Association for the Advancement of Cost Engineering (see the summary of estimate classifications in Table 4). Class 3 estimates are typically prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they provide the initial control estimate against which actual costs and resources are monitored. The level of engineering ranges from 10% to 40% complete and typically includes: horizontal and vertical alignments, typical cross sections, preliminary roadway and structure design, preliminary assessment of utility impacts, preliminary identification of systems facilities, development of environmental footprints and right-of-way requirements and initial constructability reviews.

Table 4 - Estimate Classifications by AACE International

Estimate Class	Primary Characteristic	Secondary Characteristic		
	Maturity Level of Project Definition Deliverables (Expressed as % of complete definition)	End Usage (Typical Purpose of estimate)	Methodology (Typical estimating method)	Expected Accuracy Range (Typical variation in low and high ranges) [A]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study of feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with forced detailed take-off	L: -3% to -10% H: +3% to +15%

Note A: *The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope).*

Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side and +10% to +30% on the high side, depending on the complexity of the project, appropriate reference information, and the inclusion of an appropriate contingencies. Ranges could exceed those shown in unusual circumstances. A consistent format is used for the reporting, estimating, and managing of the project's capital costs. Standard Cost Categories (SCC) established by the FRA continue to be used in the development of the *2016 Business Plan* capital cost estimate update.

The methodology used for generating the capital cost estimate is consistent with FRA guidelines for estimating capital costs. The FRA guidance enables FRA-funded projects to develop budget baselines that summarize to the SCC. This cost structure was used for capital cost detail and summary sheets and is described below. Where the level of design did not support quantity measurements, parametric estimating techniques were utilized. Parametric estimating techniques utilize historical data and other industry published materials to develop unit pricing for similar work scope.

This involved development of the work breakdown structure applied to both cost estimating and cost reporting. The work breakdown structure for estimating included a coding system that is used for estimating elements. The work breakdown structure for reporting included the development of a coding system that allows the cost estimates to be sorted and presented by categories and subcategories as prescribed by the FRA as presented in the Appendix.

3.1 Unit Costs

The development of individual or composite estimated unit costs was accomplished using standard industry practices based on historical bid data and by unit cost analysis, as appropriate, using labor, equipment and material rates. Unit costs were expressed in current year dollars and adjusted to reflect any regional variations.

Two methods have been used to determine unit costs. The first one is based on historical bid prices and the second reflects regional specific conditions for complex elements. These methods were used either individually or in combination. When limited engineering details are available, the historical bid price method was typically used. This reflects current best practice in the industry for large and complex programs.

3.1.1 Historical Bid Price Method

Historical bid prices are typically used to develop costs for common construction elements. When using this method, the time of bid and conditions of the historical project used for pricing is taken into account and factors applied as needed:

- Adjust bid prices where the bid date is older than 12 months from the current date by using an appropriate escalation factor
- Adjust bid prices to reflect conditions of the project, such as type of terrain, geographical location, soil, traffic and other related factors. For location factor adjustments, the City Cost Indexes as published by *RSMeans* have been used

Sources for historical bid prices that are used may come from local, regional, statewide and national levels, as well as from international high-speed rail projects with unique high-speed elements. Historical unit prices that are used for the California High-Speed Rail Program were verified for appropriateness from active projects in the state and were documented as to their source as well as any adjustments for site, escalation or location factors.

3.1.2 Unit Cost Analysis Method

The estimated unit cost analysis method is typically used to develop costs for complex construction elements including but not limited to viaducts, retained earth systems, tunneling and underground structures. This method allows for unit costs to be developed based on current local construction and market conditions, such as changes which might affect productivity or the cost of labor or materials. The following steps are required in order to develop a unit price using this method:

- Analyze the proposed construction conditions
- Estimate production rates
- Compile a list of materials
- Obtain materials prices using local available sources
- Determine labor and equipment rates
- Calculate direct unit price using the above factors
- Add allowances for contractor indirect and margin markups in addition to direct costs

The following sources were used to obtain basic cost data:

- Labor Rates – Federal Davis-Bacon Wage Determination and/or California Department of Industrial Relations Prevailing Wage Determinations
- Equipment Rates – Corp of Engineers Construction Equipment Ownership and Operating Expense Schedule, Region VII or State of California (Caltrans) Ownership and Operating Rates
- Permanent average Construction Material Prices - Material and supply prices for locally available material are obtained from local supplier quotes, if possible. Secondary sources of material cost data may be taken from Engineering News-Report (ENR) or other published resource

A list of unit price elements and the units of measure have been developed with corresponding estimated unit costs. When required, additional project-specific work elements reflecting unique site conditions and configurations were identified and their estimated costs were developed in addition to unit price elements. Examples of these project-specific unit costs include very high and/or long span iconic bridge structures, grade separations, specific roadway improvements, unique utility relocations, staged construction to accommodate existing rail or vehicular traffic and restrictive site access conditions in urban areas.

3.1.3 Contractor's Markups

Contractor margin is added on top of fully burdened direct construction cost to have a complete in place cost. This approach is based on the contractor's field staffing which includes indirect costs such as office spaces, field consumables, bonds, insurance, and contractor's home office overhead and margin. Contractor's design coordination costs required in the design-build process are also included as part of the contractor's overhead.

Project Office Indirect Cost		6.0%
Home Office Overhead		0.5%
Margin		3.0%
Design Coordination		2.5%
	Total	**12.0%**

3.2 Quantity Takeoffs

The development of construction costs for each construction activity was identified and quantified from the preliminary design documents developed by the Authority and its consultants. The task of material quantity takeoffs involved preparation of estimated quantities either by direct measurement and calculation of construction elements that are shown in design drawings, sketches, electronically calculated from Computer-Aided Design and Drafting files or established as an allowance quantity based on professional experience and judgment.

Basis of Quantities Estimate Reports prepared by the Authority and its consultants in support of the 2014 Business Plan estimates were mainly used in project sections that have not progressed beyond the 5% to 15% design development stage since the 2014 Business Plan. Alignment and value engineering refinements were made in the San Francisco to Gilroy and Merced to Wye segments. In the southern segments (Bakersfield to Anaheim), the updated plan and profile drawings were provided by the Authority and its consultants and were quantified by the project estimating team (see Appendix B – List of Drawings).

3.3 Allocated and Unallocated Contingencies

Contingency, in the statistical sense, is the estimated percentage by which a calculated value may differ from its true or final value and is typically included in an estimate as an allowance for the level of engineering design completion or to address imperfections in the estimating methods used at the various project development stages. Contingency is typically added to a particular item or group of items by the use of percentage multipliers. Contingency is generally greatest for the early stage of project development and decreases with advancement in the level of engineering design and pricing detail. During the preliminary design of the high-speed rail project, the limited level of design information that is available requires the use of contingency allowances that are allocated against specific construction or procurement cost categories. The percentage selected for a given cost category are generally based on level of definition of the scope of work involved and substantiated by professional judgment and experience relative to level of uncertainty and historical cost variability typically seen for work within a particular cost category. For the purposes of this estimating program, contingency is divided into two major categories – allocated and unallocated.

Allocated contingency is added to each cost category based on an assessment of the level of design information, complexity of design element, means and methods and site accessibility available for individual items of work. This contingency typically falls in a range of 10% to 25%. The exact percentage selected for each cost category is based on professional judgment and experience related to the cost variability typically seen for items of work within a particular cost category. The contingency is generally higher for underground work reflecting the additional exposure for unknowns as well as the construction complexity. It is also higher for stations, terminals, storage yard facilities and utilities since their design progress is still in the conceptual level and identification of all the utilities are not determined. The percentages shown in Table 5 are the values that are normally used; however, slightly higher or lower values are used if a project-specific condition warrants.

Table 5. Allocated Contingency Percentages by Cost Category

Standard Cost Category No.	Description	Allocated Contingency (Ranges from 10% -25%)
10 Track Structures and Track	Elevated track structure, tunnels, at-grade guideway and trackwork	10% - 25%
20 Stations, Terminals, Intermodal	Stations, platforms, parking lots, and site work	20% - 25%
30 Support Facilities: Yards, Shops, Admin. Bldgs.	All maintenance facilities, service yards and yard track	20% - 25%
40 Sitework, Right-of-Way, Land, Existing Improvements	All right-of-way, utilities, environmental, roadwork	15% - 25%
50 Communications & Signaling	Train controls, signalization, and communications	10% - 15%
60 Electric Traction	Traction power supply and distribution	10% - 15%
70 Vehicles	Trainsets	see below*
80 Professional Services	Engineering design, project management, construction management, and start-up	10% - 15%

** Estimated as part of SCC 40.07*

Unallocated contingency is typically included to address uncertainties that are more global in nature like schedule delays, changes in contracting environment, or other such issues that are not associated with individual construction activities. Unallocated contingencies have been estimated at five percent of the total construction costs excluding right-of-way, rolling stock and professional services for the segments that are in preliminary engineering stage of development. Unallocated contingencies have been adjusted to include approved project contingencies and 3rd party allowances for the segments issued for final design and construction.

3.4 Allowances and Other Costs

Environmental – An environmental allowance is typically used in the industry to account for environmental commitments made related to hydrology and water resources; wetland impact; hazardous material and waste; building abatement; historic/archeology; safety and security; noise, vibration and air quality during construction and permanent aesthetic treatments for visual impacts. The allowance is three percent of the total cost of track structures, track work, station buildings, roadway modification and highway grade separation. Environmental mitigation costs may vary significantly in each geographical area based on level of land development, type of high-speed rail guideway (i.e., at-grade, aerial or underground) and proximity to sensitive environmental resources. The three percent allowance is an average representation of probable environmental mitigation costs for the Phase 1 system.

Temporary Facilities - An allowance to account for the cost of temporary facilities, indirect costs and mobilization is included in the total capital cost. This allowance is four percent of the total cost of track structures, track work, station buildings, roadway modifications and highway grade separations.

Right-of-Way - The 2016 Business plan reflects updated right-of-way costs where project definition has been developed further, and continues to reflect Right-of-Way Requirements Reports prepared in support of the 2014 Business Plan in the sections where new alignment alternatives are still being developed. This methodology for estimating right-of-way acquisition costs involved preparing estimated quantities of impacted properties, either permanent acquisitions or temporary easements, which result from construction, operation, and maintenance of proposed high-speed rail alignment alternatives. In order to arrive at the estimated cost, professional experience and judgment in the area of property valuation, business damages, and legal and administrative issues as they relate to the estimation of right-of-way costs are applied. Projected right-of-way acquisition costs were estimated by the Authority and its consultants.

Vehicles - The projected cost of trainsets in support of various operating scenarios was based on projected demand in the fifth year of operations. The unit price of $45 million dollars (in 2010 dollars) per one 200 meter trainset is based on reported procurements of similar technology passenger equipment in other parts of the world. It also takes in to account anticipated additional markups associated with adopting US standards as well as relatively small orders needed for initial operating scenarios. Design support for vehicle procurement is assumed to be included in the unit price. The projected cost of trainset acquisition has been escalated to 2015 base year and to YOE dollars.

3.5 Program Management and Implementation

Program implementation costs are included to represent the costs of engineering, project and construction management, contract administration, permits and fees, and training/start-up/testing. These add-on costs are calculated as a percentage of construction costs including allocated contingency (applied individually and not cumulatively and excluding the vehicle procurement and right-of-way costs) and presented under Professional Services cost category in the estimate. The management and administration cost associated with right-of-way and vehicles are included with these respective items. The following professional services costs (as percentages of construction costs) were assumed in the *2016 Business Plan* capital cost estimate as commonly used in the industry on design-build projects:

Preliminary Engineering/Environmental	2.5%
Program Management	3.5%
Final Design (Cat. 10 through 40)*	5.5%
Construction Management	5.0%
3rd Party Agency Reviews and Permits	0.5%
Start-up & Testing (Cat. 50 and 60)	5.0%

**Final design costs for systems and electrification are included as part of the construction costs of these elements.*

3.6 Escalation

At the onset of the development of the updated capital cost estimate for the 2016 Business Plan, the baseline costs from the 2014 Business Plan capital cost estimate were brought forward to the 2016 Business Plan estimate and escalated from Base Year 2012 to Base Year 2015 dollars at an approximately 7% escalation rate based on available historic inflation sources such as CCIs (Construction Cost Index) published by ENR (Engineering News Record).

The updated estimate in constant dollars was escalated to year of expenditure (YOE) dollars based on the phased approach to the design and construction and reflecting the schedule milestones outlined in the *2016 Business Plan* as following:

- **Silicon Valley to Central Valley** – includes cost of high-speed rail from San Jose to the southern terminus of the first construction segment. Silicon Valley to Central Valley also includes costs of completing elements not built under the First Construction Segment scope to make it fully operable. In addition, acquisition of 16 trainsets is also included in the total capital cost of this operating segment. Estimated completion of construction is by the end of 2024 with start of revenue operations in 2025.
- **Phase I** – extends from San Francisco in the north to Anaheim Station in the south, and provides sufficient level of improvements through San Francisco Bay Peninsula to allow for a $550 million allowance for high-speed rail service to San Francisco Transbay Transit Center. The Los Angeles to Anaheim segment has been updated to include additional grade separations and two high-speed rail dedicated tracks. An additional 54 trainsets are included with Phase I implementation. The total trainsets for the full operational system will be 70[4]. Estimated completion of construction is by the end of 2028 with start of revenue operations in 2029.

The 2016 Business Plan YOE costs are determined by cost loading the program planning schedule with 2015 Base Year dollars to determine Fiscal Year expenditures. Fiscal Year expenditures are then escalated based on the following projected future inflation factors:

Fiscal Year	2015-2016	2016/2017 to 2024/2025	2025/2026 to 2028/2029
Inflation Factor	2.00%	2.25%	3.0%

[4] 70 trainsets reflect the need for service operations when the Phase 1 system will open (2029) Additional trains will be required in the following years to accommodate future ridership growth.

The inflation factors were forecasted based on construction cost components or commodities using best available industry analysis, historical trends and including general Consumer Price Index factors. These components include:

- Structural steel
- Concrete
- Construction equipment
- Other materials and services
- Rolling stock
- Transportation costs
- Skilled trade labor
- Professional services labor

Finance charges are not included in the overall project estimated cost.

4 Assumptions, Exclusions and Reconciliation

4.1 Design Development Stages

Each geographical segment is at various stages of development ranging from conceptual design, or roughly 5% design, to final design. In addition many segments are still undergoing alternatives review and refinement. This cost estimate has made some assumptions on those segments currently under review that are outside of the CP 1, CP 2-3 and CP 4 construction contracts. Table 6 provides the current design development stages this estimate is based on for each segment. In addition, the level of design completion outlines the assumptions made for each geographical segment. It is important to note that as the environmental documentation is completed and final alignments are selected these estimates will change as more detailed engineering is completed.

Table 6. Design Development Stages

Project Segments	Design Development Stage
San Francisco to San Jose	Conceptual*
San Jose to Gilroy	Conceptual
Gilroy to Carlucci Road	Preliminary**
Merced to Wye Legs 1	Preliminary
Wye Legs 1	Conceptual
Carlucci Road to Madera Acres (Wye Leg 2)	Conceptual
Construction Package 1	Final
Construction Package 2-3	Final
Construction Package 4	Preliminary
First Construction Segment to Bakersfield	Conceptual
Bakersfield to Palmdale	Conceptual
Palmdale to Burbank	Conceptual
Burbank to Los Angeles Union Station	Conceptual
Los Angeles Union Station to Anaheim	Conceptual

**Conceptual design is generally in support of Alternative Analysis / Supplemental Alternative Analysis reports and is about 5% complete*
***Preliminary design is generally in support of EIR documents and is about 15% complete*

4.2 Estimate General Assumptions and Exclusions

The following summarizes the sources and general assumptions used in the development of the *2016 Business Plan* estimate. Since 2012, the estimate has been updated in a number of ways. The 2014 Business Plan capital cost estimate recognized modifications based upon known scope changes and increases associated with known cost escalation. The changes in scope identified do not modify the overall scope and performance of the design for the system. The 2016 capital cost estimate reflects a more comprehensive update looking at changes to the base pricing assumptions and engineering development to refine estimate approaches based upon expert industry review. The information below provides the basis on which the estimate is derived, and assumptions and elements known, as of December 2015. In addition, each geographic segment estimate includes a summary by Major SCC relative to the 2014 Business Plan costs.

General Assumptions

The estimate is based upon the latest information available from a number of different sources. In general the following sources have been used:

- 2014 Business Plan
- Adopted Supplemental Alternatives Analysis or work done supporting environmental analysis
- Industry and peer reviews
- Value engineering review conducted in 2014 and documented in a white paper report[5]
- Additional engineering analysis in northern California
- Lessons learned from the Central Valley work underway
- All sections are under development and agreements on alternatives with corridor owners and operators still need to be reached in order to further define the alternative.

For those segments at the conceptual level, the estimate is typically based upon the 2014 Business Plan assumptions unless major pricing changes or revised alignment information is available and indicated in individual geographic segments. Preliminary engineering estimates have reached a higher level of scrutiny as part of environmental documents. Alternative Technical Concepts provided by design builders have been reflected in the estimates for other geographic segments where applicable.

All cost assumptions outlined in this appendix will be further evaluated and documented through the environmental process.

Other general assumptions include:

- Estimate assumes 2014 right-of-way costs, except in sections such as San Jose to Gilroy or Bakersfield to Palmdale where alignments changes are noted

[5] Cost savings based upon July 2014 White Paper on Cost Reduction Strategies and include a reduction in the nominal inside tunnel diameter to 28 feet, (to be validated further through PE Phase) increase in the spacing of interlockings from 20 to 40 miles, application of lower speed turnouts on station tracks and through the interlockings.

- Estimates are based on quantities for guideway and viaducts, utilities, roadway structures, systems (traction power, overhead catenary, communications and train control)
- Includes allowances for professional services based on estimated construction costs in each segment
- Estimate includes CP 1 and CP 2-3 bid information as awarded
- Cost reductions based on contractor design refinements (CP 1 Final Design)
- Allocated contingencies in the range of 10-25% of the construction costs as noted in Table 5
- Unallocated contingency is 5% of the construction cost, except where adjusted to reflect approved project contingencies for CP 1 and CP 2-3
- Incorporation of value engineering changes that modified engineering requirements where appropriate, reducing costs by $900 million (2012$); these reductions are allocated to the appropriate segments

Exclusions

- Costs associated with Authority administration
- Finance charges

San Francisco to San Jose

Table 7. San Francisco to San Jose Cost Breakdown

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$1,659	$119
20 STATIONS, TERMINALS, INTERMODAL	$1,987	$1,006
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$171	—
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$798	$835
50 COMMUNICATIONS & SIGNALING	$142	$163
60 ELECTRIC TRACTION	$488	$586
80 PROFESSIONAL SERVICES	$640	$351
90 UNALLOCATED CONTINGENCY	$209	$75
SUBTOTAL:*	**$6,094**	**$3,136**

**Subtotals for information only, figures may not sum due to rounding.*

The estimate for this section is based on conceptual engineering developed by the Authority and its consultants in 2015 which defines improvements to existing tracks in order to increase operating speed up to 110 mph along the Peninsula. The dedicated high-speed rail tracks at Millbrae (elevated and in tunnel) and aerial approach to Diridon station have been now removed. Further, the allowance towards the Caltrain Downtown Extension Project has been reduced by $1.5 billion based on the updated information from Transbay Joint Powers Authority. These major modifications developed over the past year will be further defined by the Authority's new Environmental & Engineering consultant and documented in the environmental process.

Assumptions

- Based on an alignment section length of 48 route miles
- At-grade use of Caltrain corridor to just past the San Jose station with alignment adjustments including curve straightening to achieve operating speed up to 110 mph
- Existing track structure rehabilitation including replacement of wood ties, new running rail where confirmed by inspection reports, rail grinding & surfacing, upgrade of interlockings and access control fencing
- Includes an allowance for high-speed rail passing tracks between Hayward Park and Hillsdale, approximately two mile segment recommended for 6/4 operation up to 110 mph
- Contribution of $90 million for three grade separations within the Hayward Park to Hillsdale passing track segment
- An allowance of $500M for additional grade separations that may be required as environmental mitigation
- An allowance for quad gates at 40 grade crossings

- A $50M allowance per station for high platform upgrades to Diridon and Millbrae, and $150M for interim terminal station at 4th & King
- Assumes no cost in the section estimate for modifying hold-out rule stations.
- A $550M allowance (YOE) for work done by others for the Transbay Transit Center connection based on the Transbay Joint Powers Authority's estimate
- A $600M allowance for electrification of Caltrain by others
- An allowance of $1M (not to exceed) to cover professional services for Caltrain consultants
- Five mile track from Santa Clara to San Jose for Union Pacific Railroad (UPRR) freight use is under review and not included in the estimate
- Structural modifications to the four existing tunnels are not included
- Conversion of existing Caltrain platforms to level boarding is included as an allowance in the estimate
- Improvements to existing at-grade vehicular and pedestrian crossings are limited to safety and environmental mitigation as noted above

San Jose to Gilroy

Table 8. San Jose to Gilroy Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$2,120	$2,163
20 STATIONS, TERMINALS, INTERMODAL	$506	$93
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$28	$30
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$1,921	$1,216
50 COMMUNICATIONS & SIGNALING	$63	$55
60 ELECTRIC TRACTION	$200	$116
80 PROFESSIONAL SERVICES	$604	$525
90 UNALLOCATED CONTINGENCY	$206	$176
SUBTOTAL	**$5,649**	**$4,376**

**Subtotals for information only, figures may not sum due to rounding.*

Further alignment refinements in this geographic segment were developed over the past year and are shown on plan and profile conceptual drawings developed from Geographic Information System data available as of May 2014. The Diridon station has been changed from aerial to at-grade, reducing station costs in this section, and the current alignment generally stays outside UPRR right-of-way and travels along the edge of Monterey Road/Monterey Highway to a Gilroy station on an embankment. Increase in aerial alignment south of Tamien allowed for the reduction in the number of required grade separations. The estimate is based upon conceptual engineering developed by the Authority and its consultants in 2015 to define a new elevated alignment alternative along Monterey Road/Highway. It reflects major modifications developed over the past year that will be further defined by the Authority's new Environmental & Engineering consultant and documented in the environmental process.

Assumptions

- Based on an alignment section length of 30 route miles
- Assumes electrification of two high-speed rail /Caltrain tracks and maintaining one non-electrified track for UPRR from Diridon to south of Caltrain's Tamien station
- Between Diridon to south of Tamien in this section, assumes construction of a third non-electrified at-grade track for UPRR, 4.6 miles long
- Freight siding track and a spur track are included as a total added cost
- Includes dedicated high-speed rail viaduct along Monterey Road from south of Tamien to Gilroy
- Includes a 60 foot elevated viaduct to cross major roadways including: Capital Expressway, Blossom Hill Road, St. Rte. 85, Bernal Hwy. and Bailey Ave
- Includes $50 million allowance for UPRR realignment at Communication Hill including a new single track bridge crossing

- Right-of-way cost reductions of 50% from the 2014 Business Plan based on a review of revised alignment assumptions compared to prior regional consultant alignment plans prepared in 2011
- At-grade Diridon station costs are included in the San Francisco to San Jose section.
- Gilroy Station on fill embankment
- An intrusion barrier where high-speed rail is at-grade in Caltrain right-of-way from San Jose to south of Tamien is not required due to operating speeds less than 125 mph

Gilroy to Carlucci Road

Table 9. Gilroy to Carlucci Road Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$5,119	$3,024
20 STATIONS, TERMINALS, INTERMODAL	$55	$12
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$13	$19
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$1,320	$995
50 COMMUNICATIONS & SIGNALING	$102	$85
60 ELECTRIC TRACTION	$323	$271
80 PROFESSIONAL SERVICES	$921	$808
90 UNALLOCATED CONTINGENCY	$296	$270
SUBTOTAL:*	**$8,150**	**$5,483**

**Subtotals for information only, figures may not sum due to rounding.*

This section is based on the same alignment alternative as was included in the 2014 Business Plan, and reflects conceptual engineering drawings consisting of 12 miles of tunnel/cut and cover, embankments and high-speed rail viaducts. This option is detailed in the April 2010 Refined Program Alignment Alternative Report. The tunneling costs were reduced based on the value engineering resulting in reduction of tunnel diameter and revisions to the mechanical ventilation requirements relative to the assumptions included in the 2014 Business Plan estimate. Construction costs were further reduced through application of the design concepts learned from CP 1 final design for viaducts and grade separations.

Assumptions

- Based on an alignment section length of 54 route miles
- Ventilation in tunnels is covered through a trainset compartmentation strategy for smoke control in tunnels which would eliminate requirements for mechanical ventilation. This is currently being reviewed with the Office of State Fire Marshal (OSFM).

Carlucci Road to Madera Acres (Wye Leg 2)

Table 10. Carlucci Road to Madera Acres (Wye Leg 2) Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$540	$340
20 STATIONS, TERMINALS, INTERMODAL	$3	—
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$29	$20
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$580	$203
50 COMMUNICATIONS & SIGNALING	$57	$59
60 ELECTRIC TRACTION	$182	$140
80 PROFESSIONAL SERVICES	$168	$153
90 UNALLOCATED CONTINGENCY	$60	$45
SUBTOTAL:*	**$1,619**	**$960**

**Subtotals for information only, figures may not sum due to rounding.*

Costs associated with this segment are based upon the revised preliminary design assumptions developed for the upcoming environmental documents for the Central Wye. The estimate is based upon the May 2015 15% engineering submittal for SR152 to Road 13 currently under evaluation. This portion of the Wye alignments is different from the alternatives included in the 2014 Business Plan estimate resulting in substantive scope reductions in guideway and grade separation costs.

Assumptions

- Based on an alignment section length of 37 route miles
- Includes design refinement and value engineering conducted as part of the 15% Wye design submittal
- Intrusion protection barriers are not included based on sufficient separation from adjacent railroads

Merced Station to Wye Legs 1

Table 11. Merced Station Wye Legs 1 Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$310	$316
20 STATIONS, TERMINALS, INTERMODAL	$95	$84
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	—	—
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$228	$492
50 COMMUNICATIONS & SIGNALING	$18	$23
60 ELECTRIC TRACTION	$61	$14
80 PROFESSIONAL SERVICES	$73	$64
90 UNALLOCATED CONTINGENCY	$30	$38
SUBTOTAL:*	**$816**	**$1,032**

**Subtotals for information only, figures may not sum due to rounding.*

Costs associated with this segment are based upon the preliminary engineering conducted for the Merced to Fresno Environmental Impact Statement. These costs have been inflated and are based upon the preferred alternative adopted and carried in the 2014 Business Plan. The right-of-way costs were prorated to reflect anticipated real estate acquisition costs in this section resulting in an approximately $200 million increase relative to the cost of this segment as was included in the 2014 Business Plan estimate.

Assumptions

- Based on alignment section length of 9 route miles
- Includes Merced station

Wye Legs 1

Table 12. Wye Legs 1 Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$410	$609
20 STATIONS, TERMINALS, INTERMODAL	—	$45
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	—	—
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$234	$199
50 COMMUNICATIONS & SIGNALING	$24	$38
60 ELECTRIC TRACTION	$78	$119
80 PROFESSIONAL SERVICES	$83	$127
90 UNALLOCATED CONTINGENCY	$32	$45
SUBTOTAL:*	**$862**	**$1,183**

**Subtotals for information only, figures may not sum due to rounding.*

Costs associated with these alignments are based upon the revised preliminary design assumptions developed for the upcoming environmental documents for Wye. The estimate is based upon the May 2015 15 percent engineering submittal for SR152 to Road 13, currently under evaluation. This portion of the Wye alignments is different from the alternatives included in the 2014 Business Plan estimate resulting in substantive scope increases in guideway costs.

Assumptions

- Based on Wye leg lengths of 11 route miles
- Includes both the north-south legs
- Includes further design refinement and value engineering conducted as part of the 15 percent Central Valley Wye May 2015 design submittal
- At-grade, below-grade (open or covered trench) and elevated viaduct sections

Madera Acres to Poplar Avenue

Table 13. Madera Acres to Poplar Avenue Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$2,607	$1,484
20 STATIONS, TERMINALS, INTERMODAL	$218	$174
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$1	—
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$2,237	$2,506
50 COMMUNICATIONS & SIGNALING	$228	$268
60 ELECTRIC TRACTION	$733	$572
80 PROFESSIONAL SERVICES	$582	$1,447
90 UNALLOCATED CONTINGENCY	$234	$457
SUBTOTAL:*	**$6,841**	**$6,908**

**Subtotals for information only, figures may not sum due to rounding.*

This segment is based upon the executed contracts for CP 1 and CP 2-3. It includes a revised estimate for CP 4 reflecting lessons learned and alternative technical concepts from the first two contract procurements. The project limits have also been revised including a 2 ½ mile extension to Madera Acres in the north and ending at Poplar Avenue in Shafter.

Assumptions

- Based on an alignment section length of 118 route miles
- Assumes availability of PG&E power in January 2021 to allow for a test track within this segment
- Includes the Fresno Station and an interim terminal station at Poplar Avenue to support Silicon Valley to Central Valley operations
- Includes CP 5 which is a new contract in development and includes trackwork and systems and electrification elements (Traction Power, Overhead Catenary, Communications and Train Control)
- Includes bid costs for CP 1 and CP 2-3 and approved project contingencies
- Added contingencies to cover increased costs in Central Valley contracts, including third party
- Professional services in this segment also include awarded design-build contractor's construction and project management costs. These costs are normally accounted as part of contractor's markups outside of CP 1 and CP 2-3

Poplar Avenue to Bakersfield

Table 14. Poplar Avenue to Bakersfield Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$1,011	$616
20 STATIONS, TERMINALS, INTERMODAL	$116	$85
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	—	$1
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$589	$900
50 COMMUNICATIONS & SIGNALING	$41	$37
60 ELECTRIC TRACTION	$146	$86
80 PROFESSIONAL SERVICES	$200	$217
90 UNALLOCATED CONTINGENCY	$86	$89
SUBTOTAL:*	**$2,188**	**$2,030**

**Subtotals for information only, figures may not sum due to rounding.*

The estimate is based upon the new settlement agreement with the City of Bakersfield and the alignment from Poplar Street in Shafter to Bakersfield ending at the F Street Bakersfield station.

Assumptions

- Based on an alignment section length of 23 route miles
- Includes Bakersfield F Street Station
- Includes retained fill embankments across the green-field farming areas where appropriate
- Quantities developed using track stationing from the Bakersfield F Street Station Alignment which ends at F Street Bakersfield Station and replaces the previously adopted Hybrid in the Fresno to Bakersfield Record of Decision

Bakersfield to Palmdale

Table 15. Bakersfield to Palmdale Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$5,753	$5,850
20 STATIONS, TERMINALS, INTERMODAL	—	—
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$17	$14
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$669	$1,773
50 COMMUNICATIONS & SIGNALING	$149	$172
60 ELECTRIC TRACTION	$472	$566
80 PROFESSIONAL SERVICES	$934	$992
90 UNALLOCATED CONTINGENCY	$294	$379
SUBTOTAL:*	**$8,287**	**$9,746**

**Subtotals for information only, figures may not sum due to rounding.*

Based on an alignment alternative currently under evaluation by the Authority and its consultants in an updated 2016 Supplemental Alternatives Analysis. The 2014 Business Plan estimate reflected a conceptual alignment that had been prepared for the AA report adopted in 2010, resulting in major differences in earthwork, viaducts and tunnel quantities. The current estimate update also reflects updated right-of-way costs as were prepared by the Authority and its consultants for the alignment alternative.

Assumptions

- Based on an alignment section length of 80 route miles
- To account for the cost of the access roads and loss of efficiency related to construction in mountainous terrain, an allowance is added to the base assembly unit costs
- Ventilation in tunnels is covered through a trainset compartmentation strategy for smoke control in tunnels that would eliminate requirement for mechanical ventilation. This is currently being reviewed with the Office of State Fire Marshal (OSFM). Based on longer tunnels, an allowance has been included in case that mechanical ventilation is required
- The need for a blast protection zone due to proximity to Cal Portland Cement Quarry is currently under evaluation and is not specifically included in the estimate

Palmdale to Burbank

Table 16. Palmdale to Burbank Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$5,994	$7,580
20 STATIONS, TERMINALS, INTERMODAL	$246	$313
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$149	$19
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$2,367	$1,609
50 COMMUNICATIONS & SIGNALING	$88	$214
60 ELECTRIC TRACTION	$278	$450
80 PROFESSIONAL SERVICES	$1,106	$1,247
90 UNALLOCATED CONTINGENCY	$372	$446
SUBTOTAL:*	**$10,599**	**$11,877**

**Subtotals for information only, figures may not sum due to rounding.*

Estimate assumes a new segment based on the east corridor tunnel alignment option E1a terminating just south of Burbank Airport station, and also reflects a new alternative defined in the Palmdale to Burbank Supplemental Alternative Analysis adopted in June 2015. The 2014 Business Plan estimate for this section was based on a SR-14 West alignment alternative resulting in comprehensive revision to earthwork, viaducts, and tunneling and grade separation quantities. The right-of-way requirements were also reevaluated to reflect the new east corridor tunnel alignment.

Assumptions

- Based on an alignment section length of 33 route miles
- Ventilation in tunnels is covered through a compartmentation strategy for smoke control in tunnels that would eliminate requirement for mechanical ventilation. This is currently being reviewed with the Office of State Fire Marshal (OSFM). Based on longer tunnels, an allowance has been included in case that mechanical ventilation is required
- Third bore service tunnel was assumed not to be required in tunnels over six miles in length

Burbank to Los Angeles Union Station

Table 17. Burbank to Los Angeles Union Station Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$572	$536
20 STATIONS, TERMINALS, INTERMODAL	$275	$514
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	—	—
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$1,572	$216
50 COMMUNICATIONS & SIGNALING	$23	$42
60 ELECTRIC TRACTION	$77	$85
80 PROFESSIONAL SERVICES	$231	$171
90 UNALLOCATED CONTINGENCY	$107	$29
SUBTOTAL:*	**$2,857**	**$1,593**

**Subtotals for information only, figures may not sum due to rounding.*

The *2016 Business Plan* capital cost estimate is based on a new alternative that includes relocation of existing at-grade double track in the Metrolink corridor right-of-way and constructing two new high-speed rail tracks from West Alameda Avenue to Fletcher Drive (5.3 miles). The 2014 Business Plan estimate for this section reflected dedicated high-speed rail tracks between Burbank and LA Union Station and included significant right-of-way acquisition costs associated with this alignment alternative. The current alternative utilizes retaining walls increasing the guideway costs, but also minimizing project footprint and reducing right-of-way acquisitions costs.

Assumptions

- Based on an alignment section length of 13 route miles
- Assumes Metrolink and High-Speed Rail will share tracks from approximately Metrolink's Central Maintenance Facility to Los Angeles Union Station
- Includes an allowance for curve realignment and additional right-of-way through throat area into Los Angeles Union Station. Assumes all tracks with a minimum 650 feet radius in throat area as validated by the Authority's Regional Consultant
- Shares track over the existing bridge over Los Angeles River at Figueroa Street
- Provides three high-speed rail grade separations at Sonora, Grandview and Flower and one roadway grade separation at Chevy Chase Drive. Provides funding contribution for Doran roadway grade separation
- Includes an allowance for impacts to the Metro Gold Line realignment and minor impacts to Chinatown aerial structure
- To account for the cost of staged construction of Metrolink tracks, an allowance is added to cover the loss of efficiency and premium pay for work beyond normal hours
- Includes allowance for work at LA Union Station plus funding contribution for SCRIP project (run-through tracks).
- Does not include allowances for agreements with Metro/UPRR for shared use of this corridor
- Intrusion barriers were assumed to be not required in this section due to operating speeds less than 125mph

Los Angeles to Anaheim

Table 18. Los Angeles to Anaheim Cost

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
SUBTOTAL	**$525***	**$2,329****

*Funding for early improvement projects in Los Angeles-Anaheim section

** Reflects total cost of Los Angeles-Anaheim section inclusive of early improvement projects (2014 Business Plan) plus enhanced design scope (2016 Business Plan)

The Los Angeles to Anaheim section cost included in the *2016 Business Plan* capital cost estimate is based on a conceptual definition of improvements. These were to be added to the assumed allowance that was included for this section in the 2014 Business Plan estimate. This estimate allows for an initial level of HSR service between Los Angeles and Anaheim and includes early investment projects and a simplified section developed by the Authority and its consultants in 2014 for an alternative delivery plan approach.

Assumptions

The Los Angeles to Anaheim corridor is 30. 5 miles long and is made of three distinctive sections:

- A first section (about 3.4 miles) out of the Los Angeles Union station which is owned by LA Metro. The section starts adjacent to the Southern California Regional Interconnector Project (SCRIP) project, which will build through tracks and enhancements at the Los Angeles Union Station. Estimate includes two electrified tracks through this section. Operations will be shared between Metrolink and high-speed rail
- A second section (about 22.1 miles) owned by BNSF. Currently three mainline tracks used throughout most of the section and shared between freight and Metrolink. Triple tracking by BNSF will not be finished until completion of key grade separations like Rosecrans/Marquardt. Estimate includes one electrified track through this section with passing tracks as required. A final build project is being evaluated that would include the construction of one additional track dedicated for high-speed rail (and electrified). BNSF main tracks will be moved to provide the capacity for the new tracks and minimize right-of-way impact. BNSF has requested provision for a fourth mainline track for traffic growth and preserve the two dedicated tracks for high-speed rail)
- A third section (about 5 miles) is made of two existing tracks owned by Orange County Transportation Authority leading into the new Anaheim Regional Transportation Intermodal Center (ARTIC) station. Operations here will be shared between high-speed rail and Metrolink. Freight traffic will turn off before this section but have operating rights on this section. Electrification of both tracks will be required.
- Provisions for additional high-speed rail dedicated capacity (two platform faces and parking) are included at ARTIC station for high-speed rail operations.
- Does not assume an intermediate station at either Norwalk/Santa Fe or Fullerton.

- Intrusion barriers between high-speed rail and BNSF tracks are assumed to be not required due to low operating speeds in this section.
- Does not include allowances for agreements or right-of-way costs with Metro/OCTA or BNSF for shared use of this corridor.
- Includes a ROW allowance of approximately $150 M for additional right-of-way outside the rail corridor.

Maintenance Facilities

Table 19. Maintenance Facilities Cost by SCC

STANDARD COST CATEGORY	2014 BP COST (2015 $, millions)	2016 BP COST (2015 $, millions)
10 TRACK STRUCTURES & TRACK	$36	$26
20 STATIONS, TERMINALS, INTERMODAL	—	—
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$426	$888
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	$86	$59
50 COMMUNICATIONS & SIGNALING	$3	$1
60 ELECTRIC TRACTION	$41	$16
80 PROFESSIONAL SERVICES	$73	$200
90 UNALLOCATED CONTINGENCY	$24	$51
SUBTOTAL:*	**$690**	**$1,242**

**Subtotals for information only, figures may not sum due to rounding.*

Assumptions

- Includes HMF located within the first construction segment with accommodation for initial 16 trainsets
- Includes LMF in Brisbane on the Peninsula (previously included in the San Francisco to San Jose section costs)
- Includes LMF in Los Angeles area (previously included in the Palmdale to Los Angeles section costs).
- Includes combined contract packaging of the HMF/LMF/Rolling Stock
- Assumes ultimate capacity of 70 total trainsets for Phase 1 system

Vehicles

Table 20. Vehicle Cost by SCC

STANDARD COST CATEGORY		2014 BP COST (2015 $)	2016 BP COST (2015 $)
70 VEHICLES		$3,399	$3,399
	SUBTOTAL	**$3,399**	**$3,399**

Assumptions

- Assumes a phased implementation of the HMF to accommodate an initial 16 trainsets. Future expansion, and costs, to be determined by trainset manufacturer
- Estimate includes initial 16 trainsets for the initial operating system and 54 additional train sets for Phase I system (total of 70 trainsets)

Appendix A – SCC Coding Structure

Table 21. SCC Coding Structure

10 TRACK STRUCTURES & TRACK	
10.01	Track structure: Viaduct
10.02	Track structure: Major/Movable bridge
10.03	Track structure: Under grade Bridges
10.04	Track structure: Culverts and drainage structures
10.05	Track structure: Cut and Fill (> 4' height/depth)
10.06	Track structure: At-grade (grading and subgrade stabilization)
10.07	Track structure: Tunnel
10.08	Track structure: Retaining walls and systems
10.09	Track new construction: Conventional ballasted
10.10	Track new construction: Non-ballasted
10.11	Track rehabilitation: Ballast and surfacing
10.12	Track rehabilitation: Ditching and drainage
10.13	Track rehabilitation: Component replacement (rail, ties, etc)
10.14	Track: Special track work (switches, turnouts, insulated joints)
10.15	Track: Major interlocking
10.16	Track: Switch heaters (with power and control)
10.17	Track: Vibration and noise dampening
10.178	Other linear structures including fencing, sound walls
20 STATIONS, TERMINALS, INTERMODAL	
20.01	Station buildings: Intercity passenger rail only
20.02	Station buildings: Joint use (commuter rail, intercity bus)
20.03	Platforms
20.04	Elevators, escalators
20.05	Joint commercial development
20.06	Pedestrian / bike access and accommodation, landscaping, parking lots
20.07	Automobile, bus, van access ways including roads
20.08	Fare collection systems and equipment
20.09	Station security
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	
30.01	Administration building: Office, sales, storage, revenue counting
30.02	Light maintenance facility
30.03	Heavy maintenance facility
30.04	Storage or maintenance-of-way building/bases
30.05	Yard and yard track
40 SITEWORK, RIGHT-OF-WAY, LAND, EXISTING IMPROVEMENTS	
40.01	Demolition, clearing, site preparation

40.02	Site utilities, utility relocation
40.03	Hazardous material, contaminated soil removal/mitigation, ground water treatments
40.04	Environmental mitigation: wetlands, historic/archeology, parks
40.05	Site structures including retaining walls, sound walls
40.06	Temporary facilities and other indirect costs during construction
40.07	Purchase or lease of real estate
40.08	Highway/pedestrian overpass/grade separations
40.09	Relocation of existing households and businesses
50 COMMUNICATIONS & SIGNALING	
50.01	Wayside signaling equipment
50.02	Signal power access and distribution
50.03	On-board signaling equipment
50.04	Traffic control and dispatching systems
50.05	Communications
50.06	Grade crossing protection
50.07	Hazard detectors: dragging equipment high water, slide, etc.
50.08	Station train approach warning system
60 ELECTRIC TRACTION	
60.01	Traction power transmission: High voltage
60.02	Traction power supply: Substations
60.03	Traction power distribution: Catenary and third rail
60.04	Traction power control
70 VEHICLES	
70.00	Vehicle acquisition: Electric locomotive
70.01	Vehicle acquisition: Non-electric locomotive
70.02	Vehicle acquisition: Electric multiple unit
70.03	Vehicle acquisition: Diesel multiple unit
70.04	Vehicle acquisition: Loco-hauled passenger cars w/ ticketed space
70.05	Vehicle acquisition: Loco-hauled passenger cars w/o ticketed space
70.06	Vehicle acquisition: Maintenance of way vehicles
70.07	Vehicle acquisition: Non-railroad support vehicles
70.08	Vehicle refurbishment: Electric locomotive
70.09	Vehicle refurbishment: Non-electric locomotive
70.10	Vehicle refurbishment: Electric multiple unit
70.11	Vehicle refurbishment: Diesel multiple unit
70.12	Vehicle refurbished: Passenger loco-hauled car w/ ticketed space
70.13	Vehicle refurbished: Non-passenger loco-hauled car w/o ticketed space
70.14	Vehicle refurbishment: Maintenance of way vehicles
70.15	Spare parts

80 PROFESSIONAL SERVICES (applies to Cats. 10-60)	
80.01	Service Development Plan/Service Environmental
80.02	Preliminary Engineering/Project Environmental
80.03	Final design
80.04	Project management for design and construction
80.05	Construction administration & management
80.06	Professional liability and other non-construction insurance
80.07	Legal; Permits; Review Fees by other agencies, cities, etc.
80.08	Surveys, testing, investigation
80.09	Engineering inspection
80.10	Start up
90 UNALLOCATED CONTINGENCY	
100 FINANCE CHARGES	

Appendix B – List of Drawings

Table 22 - List of Drawings

Date	Drawing
7/24/2015	Plan Sheet 1
7/24/2015	Plan Sheet 10
7/24/2015	Plan Sheet 11
7/24/2015	Plan Sheet 13
4/15/2011	Alignment and Typical Section Plans Volume I Draft 15% Design San Jose to Merced
4/15/2011	Alignment and Typical Section Plans Volume II Draft 15% Design San Jose to Merced
4/15/2011	Alignment and Typical Section Plans Volume III Draft 15% Design San Jose to Merced
6/18/2015	BFSS Alignment: E1 Profile Viaduct Sheet 1 - Draft
6/18/2015	BFSS Alignment: E1 Profile Viaduct Sheet 2 - Draft
6/19/2015	Roll Plot ALT 4 Sheet 1 - Draft
6/19/2015	Roll Plot ALT 4 Sheet 8 - Draft
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8101A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8102A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8103A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8104A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8105A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8106A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8107A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8108A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8109A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8110A
6/15/2015	Palmdale to Burbank Alignment Section E1a Drawing TB8111A
6/24/2015	Alameda Avenue to Glendale Freeway At-Grade Exhibit
6/24/2015	Glendale Freeway to LA Union Station Shared Track-East Bank Exhibit
6/24/2015	Glendale Freeway to LA Union Station Shared Track-West Bank Exhibit
1/20/2012	Los Angeles to Anaheim Shared Track Alternative Typical Functional Cross Section Drawing TA0001
1/20/2012	Los Angeles to Anaheim Shared Track Alternative Cross Section Drawings TA3001 – TA3021
1/20/2012	Los Angeles to Anaheim Reduced Consolidation Shared Track Alternative Drawings TJ1501 – TJ1562