DRAFT INTEGRATED GENERAL REEVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

SAN FRANCISCO BAY TO STOCKTON, CALIFORNIA NAVIGATION STUDY

APPENDIX D: Economic Analysis

APRIL 2019

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Introduction

Purpose

The purpose of this report is to describe the National Economic Development (NED) benefits associated with a range of potential future deepening projects of the Pinole Shoal Channel and Suisun Bay Ship Channel. The proposed navigation improvements evaluated in this study include the deepening of the channel from current depth of -35 feet mean lower low water (MLLW) to incremental depths up to -38 feet MLLW.

This analysis describes recent historical throughput at the oil terminals serviced by the channel. The report additionally describes projections of the commodity tonnages expected to pass through the oil terminals over the 50-year period of analysis. The economic benefits of the proposed channel improvements are calculated as the estimated transportation cost savings resulting from a lower cost of moving goods as a result of the ability of shipper to more fully load tankers on a deeper navigation channel.

This analysis is conducted in accordance with ER 1105-2-100 (Planning Guidance Notebook -PGN) and IWR 10-R-4 (National Economic Development Procedures Manual Deep Draft Navigation). Data for the calculation of shipping costs is provided by the IWR Vessel Operating Costs, Economic Guidance Memorandum 17-04: Deep Draft Operating Costs FY 2016, Waterborne Commerce Statistics, the Western States Petroleum Association (WSPA) and its members, interviews with various shipping companies, and the San Francisco Bay Bar Pilots' Association. Project benefits presented in this appendix are for a 50-year period of analysis and incorporate the FY 2019 Federal Discount Rate of 2.875%.

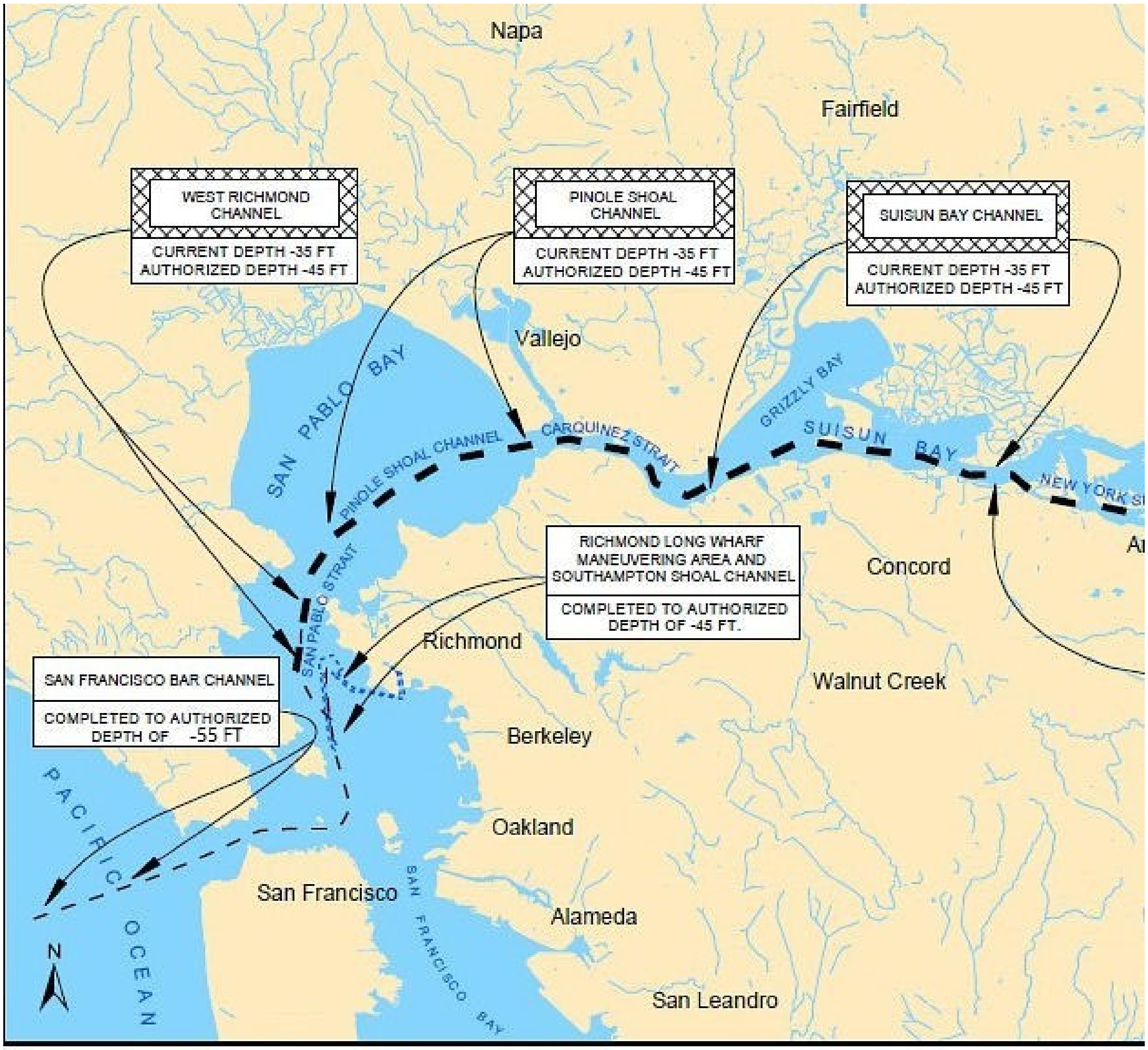
Existing Conditions

The scope of this economic analysis includes the Pinole Shoal Channel and Suisun Bay Channel, which begins in Central San Francisco Bay at the West Richmond Channel and terminates at Avon. It includes portions of the John F. Baldwin (JFB) Ship Channel including the West Richmond Channel, Pinole Shoal Channel and Bulls Head Reach Channel. Figure 1 shows a map of the area.

The San Francisco Bay to Stockton project was authorized and completed circa 1965 to 35 feet Mean Lower Low Water (MLLW) and is still maintained to that depth. The Ship Channel to Avon provides deep draft navigation to oil refineries and various other deep draft facilities in the Carquinez Strait region.

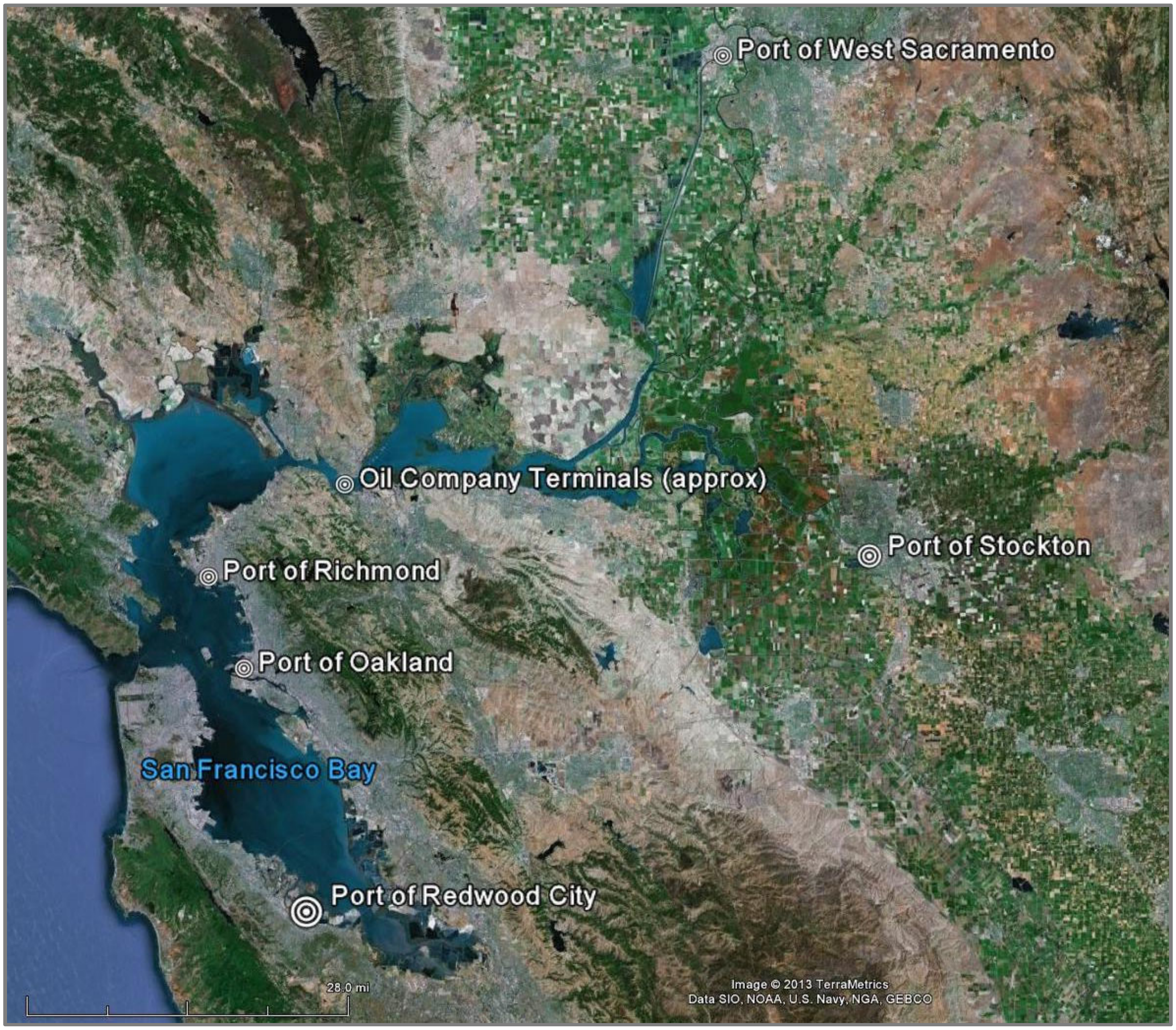
Figure 1 also shows the existing channel depths through the project area. The bar entrance through the Golden Gate Bridge is at its authorized depth of 55 feet, which is consistent with the channel leading to the Port of Oakland – the second largest container port by volume on the U.S. West Coast. Ships heading north through the bay have 45 feet of water to the Port of Richmond, which is both an oil and bulk Port and the location of the Chevron terminal.

Figure 1: Project Area Map and Existing Channel Features



Oil has been imported along the JFB Ship Channel since at least the late 19th century. There are currently five refineries in northern California, four of which are located within the project area. The four refineries are owned by Shell, Tesoro, ConocoPhillips, and Valero. The fifth (Chevron) is located nearby at the Port of Richmond. Because of the size of the California market for transportation fuel, and because the state's refineries require a unique blend of gasoline, a forecast of the state's demand and of the demand for imported fuel needs to go beyond the national perspective. Crude oil production has fallen in California; consequently, demand has been met increasingly more by imports. Figure 2 shows the location of adjacent ports and the oil refineries.

Figure 2: Major Ports in the Area



According to the California Energy Commission, imports of crude oil to California have increased at an average annual rate of 1.2 percent over the last ten years. While no explicit growth rate forecast was found in the Commission's latest available presentation from 2011, the Commission does state that crude oil imports are expected to continue to grow over approximately the next twenty years at a relatively low rate. The Commission predicts that an increase in imports to California will be required to make up for the decline in California-sourced crude over time. Most of the largest crude fields in the central valley of California have been producing since the early 1900's. As crude fields age, production decreases and the amount of reserves in the field decrease as well. As such, the amount of crude produced and available to California refineries is decreasing.

Economic Study Area

The Pinole Shoal Channel and Suisan Bay Channel is located in the Sacramento-San Joaquin Delta Region of Central California. The channel flows through Contra Costa and Solano counties and serve the marine terminals of the oil refineries along the Channel along with other facilities.

Cargo and Vessel Profile

According to data from the Waterborne Commerce Statistics Center, 20 million to 27 million tons of commodities moved through Carquinez Straight annually between 2005 and 2013. In terms of both tonnage and value, the most important commodity that moves through the study is crude oil. Most of the crude oil moving through the channel is imported from foreign countries, although a small percentage of crude comes from domestic sources.

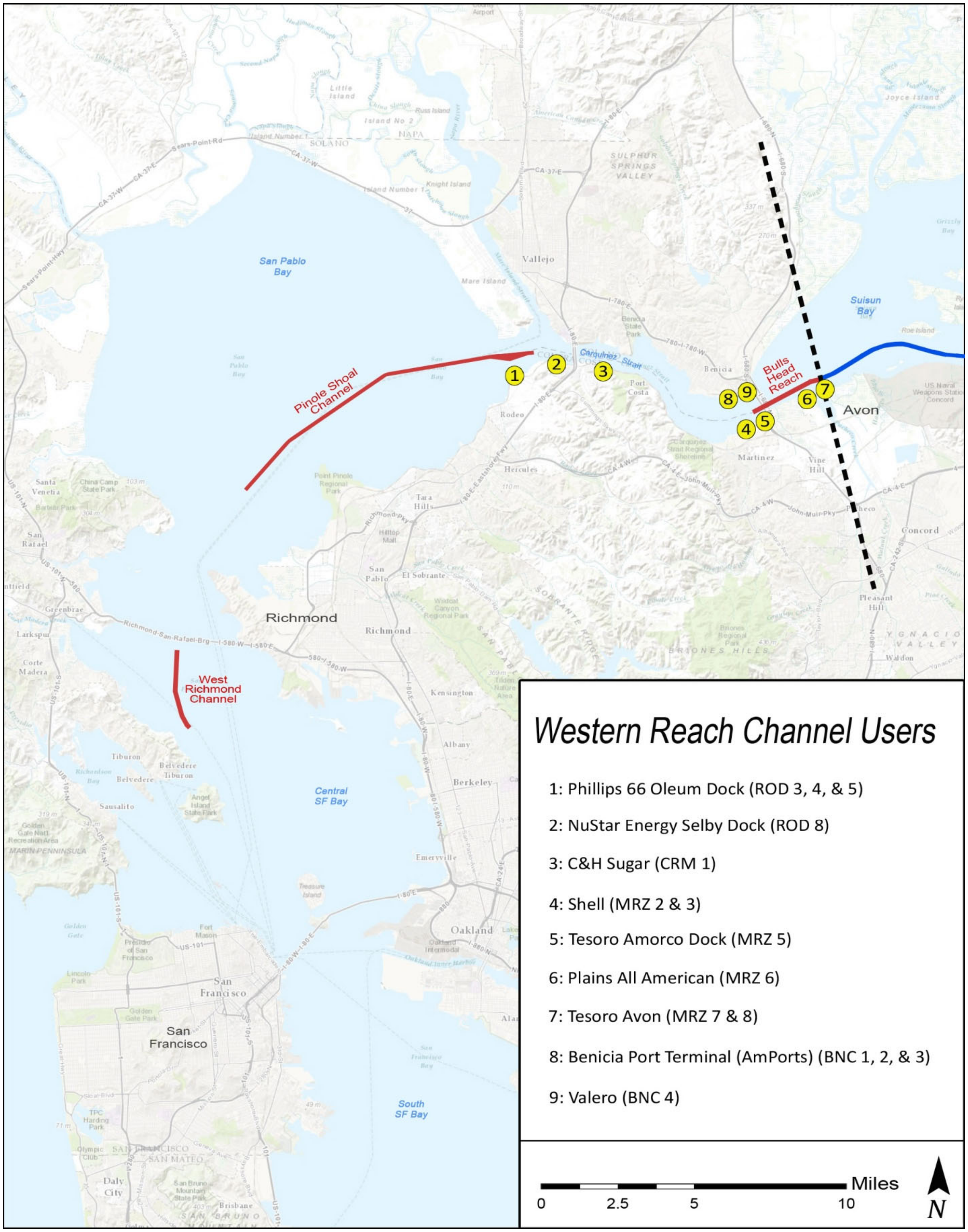
Crude oil import vessels can generally be classified into two groups. The first group is comprised of Aframax and Suezmax tankers with DWTs between 80,000 and 150,000 DWTs. These vessels have design drafts of as much as 57 feet, and arrive in Northern California only after having lightered elsewhere, typically Southern California. The second group is comprised of Panamax tankers that are about 750 feet long, with a design draft of about 45 feet and a beam of about 105 feet.

While in theory both groups of shipments could potentially benefit from a deepening project, significant benefits would not be expected to accrue to the larger group of vessels unless the project depth gets beyond 45 feet. Even with the project deepened to its authorized depth, it will still generally make economic sense for the larger vessels to continue to lighter at a deeper facility before arriving at one of the project area refineries. On the other hand, the shipments on the Panamax vessels would be the ones expected to benefit significantly from a deepening of the navigation channel. Tankers also export a significant amount of gasoline, diesel and other products from the project area refineries.

Facilities and Infrastructure

The facilities that use the deep draft navigation channel are listed below beginning with western most facility moving inland to the east. Figure 3 displays the layout of the dock locations.

Figure 3: Facility Users



Phillips 66 Oleum operates three docks located in the waters off Rodeo, California, at the eastern end of the Pinole Shoal Channel. Crude oil is received by pipelines from California oil fields and also from tankers. The facility has a total capacity of 1 million barrels of crude oil and 2.9 million barrels of petroleum products. The dock has three berthing areas totaling about 2,500 feet. The berths can accommodate vessels up to 1,000 feet length overall. Crude oil pipelines extend from the dock areas to 45 steel storage tanks. The maximum depth of the dock is 40 feet. Based on data from 2011 to 2013, 46% of vessel calls had arrival drafts of 30 feet or greater, 54% had arrival drafts of 29 or less.

NuStar Energy is a privately owned trans-shipper of petroleum products located in Crockett, California. NuStar Energy does not own products shipped through the facility; rather, it warehouses products for its customers. The facility has 24 storage tanks with a capacity of 3.04 million barrels per day. Crude is delivered to refineries through the Kinder Morgan pipeline system and by sea. It operates one dock for offloading petroleum products to storage tanks. The dock has one berth with a draft of 40 feet MLLW and can accommodate vessels with a maximum length of 831 feet length overall (LOA) and 100,000 dead weight tons. NuStar Energy is also services by trucks and rail. Based on data from 2011 to 2013, the distribution of arrival drafts are 33% vessel drafts from 30 feet to 37 feet and 67% arrival drafts of 29 feet and less. Only one vessel had an arrival draft of 37 feet.

California and Hawaii (C&H) Sugar is located east of the Carquinez Bridge on the southern shore of Carquinez Strait, in Crockett, California. The port contains five berths that can accommodate vessels up to 750 feet length overall, with depths up to 36 feet MLLW. It receives unrefined sugar and supplies and ships packaged refined sugar. The current capacity is approximately 112,000 tons of sugar. The facility is also serviced by the Union Pacific Railroad. C&H Sugar is a non-benefitting terminal based on data of arrival drafts with a max of 34 feet. Based on data from 2011 to 2013, the terminal's vessel calls are about half (50%) arrival draft 30 to 34 feet and about half with drafts less than 30 feet.

Shell Oil Refinery is located on approximately 1,100 acres along the southern shore of Carquinez Strait in Martinez, California. The refinery is a tanker and barge petroleum loading and unloading facility that imports and refines crude and exports refined petroleum products. It converts approximately 165,000 barrels of crude oil per day into gasoline, jet fuel, diesel, petroleum coke, industrial fuel oil, liquefied petroleum gas, asphalt, and sulfur. The docking facilities provide four berthing areas. Berths 1 and 2 are on the channel side and are currently in operation. The berths can accommodate vessels up to 1,000 feet length overall with depths of up to 39 feet MLLW. Berths 3 and 4 are on the south side of the dock (inland side) and not currently maintained (State Lands Commission, 2011).

Amorco Marine Oil Terminal is owned and operated by Tesoro Refining and Marketing Company (Tesoro). The terminal is a tanker and barge petroleum unloading facility (i.e., import only) used by Golden Eagle Refinery, located in Martinez, Contra Costa County, California. The terminal imports crude oil to Tesoro's Amorco Tank Farm immediately upland where it later transferred to Tesoro's Golden Eagle Refinery for refining. The single berth dock is approximately 1,130 feet long by 150 feet wide with a depth of 38 to 40 feet MLLW. The terminal can accommodate up to 190,000 dead-weight ton (DWT) vessels with displacements up to 200,000 DWT. The current throughput of the terminal is 16.9 million barrels, with a maximum throughput of 26.8 barrels per year (State Lands Commission, 2014).

The Plains All American Oil Terminal is a 225-acre site located on the south shore of Carquinez Strait, in Martinez, California. The oil terminal owns and operates the Shore Terminal docks in Martinez. The dock is a single vessel berth with associated pumps and pipelines to transport crude to upland storage tanks and refinery. The dock is approximately 100 feet long, 40 feet wide, with a 38-foot MLLW berthing area that operates as a barge and tanker loading and unloading facility. The dock can currently handle vessels up to 950 feet length overall and 150,000 DWT displacements (State Lands Commission 2014). The deepest drafting vessel calling this terminal based on 2011-2013 data is 35 feet. Therefore it is assumed vessels calling this terminal will not benefit from a deeper drafting channel in the economic analysis.

Tesoro Avon Marine Terminal is owned and operated by Tesoro Refining and Marketing Company (Tesoro). The terminal is a tanker and barge petroleum export facility associated with the Golden Eagle Refinery, located in Contra Costa County, California. The facility exports refined petroleum products, including premium fuel oil, gas oil, diesel, and cutter stock, from the refinery to tanker vessels for export. The Avon terminal is a multi-berth terminal facility consisting of two berths, Berth 1 and Berth 5; however, the terminal currently supports only one berth, Berth 1. The docking facility is approximately 1,520 feet long and ranges from 20 to 80 feet wide. The terminal can accommodate vessels up to 113,635 DWT with displacements of up to 102,600 long tons. Annual shop and barge traffic averages 124 vessels per year (between 2004 and 2013) and the throughput ranges from about 5.1 to 12.8 million barrels per year. Future estimates of oil throughput are 10 to 15 million barrels per year (State Lands Commission 2005).

The Port of Benicia is located in the Benicia Industrial Park, immediately west of the Martinez Bridge. It is a small port (640 acres) owned and operated by AMPORTS, one of North America's largest auto processors, processing more than 1 million vehicles each year. The port also provides break bulk service. The port is located near rail service. It can handle up to three 38-foot deep MLLW draft vessels along its 2,400-foot long wharf. According to Waterborne Commerce Data from 2011-2013, only five vessels called with drafts of about 35 feet out of approximately 349 vessels calling the facility.

Valero Refinery is located on the northeastern shore of Carquinez Strait, in Benicia, Solano County, California. The facility currently processes crude oil received by pipeline and marine tanker and barge vessels. It also has significant asphalt production capabilities, producing 25 percent of the asphalt supply in northern California. Currently, Valero refines domestic crude from the San Joaquin Valley (delivered by pipeline) and Alaska North Slope (delivered by tanker or barge), as well as foreign sour crude. The refinery has a throughput capacity of 170,000 barrels per day.

Carriers and Route Groups

Vessels calling regularly at a port usually follow specific trade routes and patterns. The trade routes are a function of the commodity carried by the ship and the inland commodity hinterlands. In the economic model HarborSym, explained in Section 4.1.1, these trade routes are called 'Route Groups'. In looking at the data from 2011 to 2013, nine route groups emerged for vessel operation. One vessel is included in the 'default' route group. Some regions were combined into a route group because the vessel calls were limited in that region. Table 1 shows the route groups identified for this study and their description.

Table 1: Route Group Information

HarborSym Route Group Name	Route Group Description
Canada	Canada
Central America	Mexico, El Salvador, Guatemala, Honduras, Panama
Default	Identified for vessels that did not have route group information in the existing condition
East Asia	China, Japan, Singapore, South Korea
Eastern Atlantic	Middle East, West Coast Africa
USA	Los Angeles, South California
Western Atlantic	Caribbean, East Coast South America
Western South America	Columbia, Ecuador
Pacific	Alaska, Hawaii

Existing Fleet

Data for the current fleet was obtained from Waterborne Commerce of the United States, the oil refineries and the San Francisco Bar Pilots Association. Tables 2 and 3 display the general trend for tankers. Larger vessels comprise a greater percentage of the vessel fleet moving crude and other oil products. In the year 2000, the three smallest classes (20k, 25k, and 35k deadweight tons) comprised 53% of the vessel fleet; in 2015 those three classes comprised just 18 percent of the fleet.

Table 2: Tankers by Class - Year 2000

DWT	20k	25k	35k	50k	60k	70k	80k	90k	110k	150k	165k
Vessel Calls	28	79	102	44	34	15	7	15	14	14	35
Percentage of Calls	7%	20%	26%	11%	9%	4%	2%	4%	4%	4%	9%

Table 3: Tankers by Class - Year 2015

DWT	20k	25k	35k	50k	60k	70k	80k	90k	110k	150k	165k
Vessel Calls	1	1	59	27	34	72	0	34	75	34	0
Percentage of Calls	0%	0%	18%	8%	10%	21%	0%	10%	22%	10%	0%

Table 4 shows vessel fleet data for foreign deep draft vessels calling the refineries. The vessels presented below are separated based on deadweight tons (DWT) and the same vessel types and subtypes used in the HarborSym model. All vessels used in the analysis are tankers. Pilot's logs and data from the Waterborne Commerce Statistics Center were used to determine the vessel classes.

Table 4: Vessel Types and Attributes

Vessel Type	Capacity (DWT)	Maximum Design Draft	Maximum Beam	Maximum Length Overall	Tons Per Inch (TPI)
Panamax Medium	16,000-40,000	40	101	700	100
Panamax	35,000-77,000	45	106	760	154
Aframax	77,001-120,000	50	160	920	238
Suezmax	120,001-195,000	55	165	960	299

Shipping Operations

Vessel operations have implications for the shipping costs associated with the movement of cargo. The analysis uses assumptions relating to vessel operations based on discussions with the San Francisco Bay Bar Pilots. These assumptions include conditions related to tidal delays and underkeel clearance requirements. All assumptions affect the calculations used to determine potential project benefits.

Underkeel Clearance

For all vessels except tankers, a mandatory two foot underkeel clearance requires that the "vertical difference between the lowest protruding section of the hull and the minimum actual channel depth" be two feet. This safety measure helps reduce the risk that a vessel runs aground while transiting the channel. The minimum underkeel clearance for a liquid tanker is three feet, as safety requirements for these types of vessels are generally more stringent due to the types of cargo they carry. Daylight restrictions, fog conditions, excessive shoaling and other factors will further restrict the maximum allowable draft over the course of the year; however, due to their relative rarity and the difficulty in modeling these factors, they were not included in the analysis.

Tide Use

Bar Pilots confirmed that high tide provides greater channel depth, and more deeply drafting vessels must sometimes wait for high tide in order to safely maneuver the channel. This "inactive" waiting time is called the tidal delay. In general, the longest tidal delay for most vessels calling the refineries is approximately 12 hours, although, there are reports of some deeply-drafting vessels having to wait nearly 24 hours for the higher of the daily high tides before moving through the channel.

Astronomical tides in the San Francisco Bay area are of the mixed, semi-diurnal type, with two highs and two lows of unequal height occurring each lunar day. According to the IWR Tide Tool and the National Oceanic and Atmospheric Administration (NOAA), maximum tide elevation is around six feet. The largest water-level excursion typically occurs as the tide falls from higher high water to lower low water, a process that generally requires 7 to 8 hours. Transit time to the terminals on the JFB channel is typically 5 hours from the sea buoy. The pilots use a two hour window around high tide to get to the docks on the JFB channel. The vessels start using the tide for the two hour window around the Pinole Shoal. Therefore, the pilots can transit from the deeper channel to the facilities on the channel in the two hour tide window.

Future Condition

An essential step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port. Under future without and with-project conditions, the same volume of cargo is assumed to move through the channels. However, a deepening project will allow shippers and carriers to load vessels more efficiently. This efficiency translates to cost savings and is the main driver of the benefits.

Commodity Forecast

Baseline

To minimize the impact of potential anomalies in trade volume on long-term forecast, three years of data were used to establish the baseline for the commodity forecast. Empirical data from 2011 to 2013 was used to develop a baseline in which to project commerce.

Table 5 shows historical imports and exports moving through the oil terminals from 2011 to 2015. Crude oil is the main commodity being imported to the terminals, while petroleum products are being exported from the terminals. For the analysis baseline, the average of 2011 to 2013 was used. The 2014 and 2015 data were not available at the time the commodity and fleet forecast were completed, however added to show the import/export trend.

Table 5: Historical Imports and Exports

	2011	**2012**	**2013**	**2014**	**2015**	**2011-2013 3-year Average**
Total Crude Imports	7,864,000	7,729,700	7,292,500	8,960,400	8,701,500	**7,628,700**
Total Petroleum Exports	1,813,300	1,950,000	2,109,400	2,082,100	1,542,800	**1,957,600**

Trade Forecast

The commodity forecast in this analysis is based on the Annual Energy Outlook 2015. The U.S. Energy Information Administration produced the Annual Energy Outlook 2015 (AEO2015) to present long-term annual projections of energy supply, demand, and pricing through 2040. The AEO2015 results are presented as six cases, each of which contains projections under an alternative, internally-consistent set of assumptions. The six cases the report focuses on are as follows: Reference Case, Low and High economic growth cases, Low and High Oil Price cases, and High Oil and Gas Resource case. According to the report, all cases maintain crude oil imports into the West Coast through 2040. The high levels of crude oil imports support growing levels of gasoline, diesel and jet fuel. The reference case is used for the growth rates of crude oil imports and petroleum and other liquids exports. The description for the reference case in the AEO2015 has real gross domestic product (GDP) growing at an average annual rate of 2.4% from 2013 to 2040. The reference case is also under the assumption that current laws and regulations remain generally unchanged throughout the projection period. This analysis focuses on the main oil refineries that import crude oil and export petroleum products. According to the AEO2015, the growth rate for crude oil imports is an annual rate of 0.3%. According to the same report, the growth rate for petroleum and other liquid exports is an annual rate of 2.4%.

Table 6 shows the commodity forecast for the base year 2020, 2030, and 2040. The AEO2015 report ends at year 2040. Even though capacity is not yet reached, the tonnage is held constant after year 2040.

Table 6: Channel Commodity Forecast 2020-2040 (metric tons)

Commodity	**2020**	**2030**	**2040**	**Growth Rate**
Total Crude Imports	7,790,000	8,027,000	8,271,000	0.3%
Total Petroleum and Other Liquid Exports	2,311,000	2,930,000	3,714,000	2.4%

Vessel Fleet

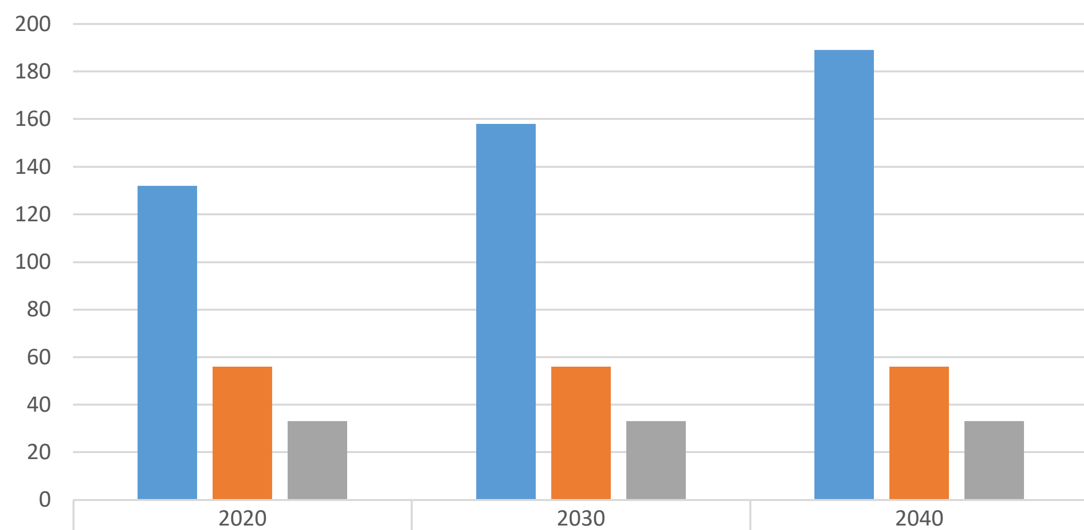
In addition to a commodity forecast, a forecast of the future fleet is required when evaluating navigation projects.

Forecasted Vessel Fleet

Using the fleet mix associated with the current imports and exports, the tonnage and the number of vessels are determined by dock and type of vessel. From the existing condition data, vessel classes were determined as shown in Table 4 calling a specific dock and the cargo tonnage being imported or exported over the dock. Based on the tonnage and number of vessel calls, the average tons per vessel were determined by size and by dock. It was assumed the percent of tonnage by vessel class in the existing condition would be the same in the future conditions for Aframax and Suezmax vessels. Therefore, this percentage of the vessel used is carried over into the forecasted years in order to approximate the tonnage by vessel class for years 2020, 2030 and 2040. Cargo tonnage is forecasted by dock and import or export and is the same for each forecasted year for all future conditions, only the fleet characteristics change.

Figure 4 shows the forecast of vessels calling the terminals for the future without-project condition. The number of Aframax and Suezmax vessels remained the same as the existing condition in the forecasted years because the Panamax vessels are the main benefitting class. Therefore, with Aframax and Suezmax vessels being held constant, the operating cost of Panamax vessels and the resultant transportation cost savings benefits attributed to that vessel class can be captured.

Figure 4: Without-Project Forecasted Vessels



	2020	2030	2040
Panamax	132	158	189
Aframax	56	56	56
Suezmax	33	33	33

Transportation Cost Savings Benefit Analysis

The purpose of this analysis is to describe the benefits associated with deepening the Ship Channel. Benefits were estimated by calculating the reduction in transportation cost for each project depth using the HarborSym Modeling Suite of Tools (HMST) developed by the Institute of Water Resources. The HMST reflects USACE guidance on transportation cost savings analysis. HarborSym model runs were completed for the origin to destination deepening benefits.

Alternatives

As stated in the main report, a total of 16 measures were considered for analysis: 8 non-structural and 8 structural. Non-structural measures considered were: congestion fees, intermodal transportation systems, lightering, light-Loading, use of favorable tides and daylight transit only, traffic management, pipeline, and relocate port facilities. Structural measures considered were: channel deepening in depths from 37 to 45 feet (37, 38, 40, 43, 45), sediment trap, rock outcrop removal, and beneficial use of material for dredged material placement.

The management measures were screened based on an assessment of meeting project objectives, the four planning and guidance accounts, and abilities to be complete, acceptable, efficient and effective. The screening was performed to identify those measures that are appropriate for inclusion in in developing alternative plans.

Non-structural and structural measures were compared and evaluated against a set of 12 different screening criteria to assess positive benefits and attributes which could be attained, worth a total of 2 points each, for a total maximum score of 24 points. Points were assigned as follows: Does Not Meet = 0; Partially Meets = 1; Fully Meets = 2. Negative scores up to -2 points were assigned for areas where negative effects could occur. The total score of each measure was then determined, and only measures which scored greater than 12 (over half of the total available points) were carried forward to be combined into alternatives.

Measures which were screened out include all non-structural alternatives, and deepening alternatives at the 40-foot, 43-foot and 45- foot depth. Measures carried forward include the no-action plan, deepening alternatives at the 37-foot and 38-foot MLLW depth, sediment trap at the 42-foot depth plus 2 feet of overdepth (based on the 4 March 2015 Shoaling Analysis), removal of the rock outcropping, and beneficial use of material.

Remaining measures were then combined into alternatives. These alternatives include the no-action alternative and two deepening alternatives (to depths of -37 feet and -38 feet MLLW), with the dredged material being beneficially used at one or more of the existing permitted beneficial use sites, namely, Cullinan Ranch, Montezuma, as well as other sites including San Francisco Deep Ocean Disposal Site (SFDODS), and inbay disposal. A sediment trap measure is also included at Bulls Head Reach in both of the action alternatives as a separable element, as well as the measure removal of the rock outcropping for increased navigability.

Methodology

Channel improvement modifications result in reduced transportation cost by allowing a more efficient use of vessels. The HMST was designed to allow users to model these benefits. With a deepened channel, carriers will be able to load vessels more efficiently and thereby reduce transiting costs. The primary effect from channel deepening that can induce changes in vessel utilization is an increase in a vessel's loading capacity. Channel restrictions can limit a vessel's capacity by limiting its ability to load to its design draft. Deepening the channel can reduce this constraint and the vessel's capacity can increase towards its design capacity if commodities are available to transit, vessel loading practices allow and the weight of the commodity on the vessel will lower it deeper in the water. This increase in vessel capacity utilization can result in fewer trips being required to transport forecasted cargo.

The US Army Corps of Engineer certified model HarborSym was used in this analysis. To begin, HarborSym was set up with the basic required variables. To estimate origin to destination cost savings benefits, the Bulk Loading Tool (BLT), a module within the HMST was used to generate a vessel call list based on the commodity forecast for a given year and available channel depth under the various alternatives. The resulting vessel traffic was simulated using HarborSym, producing average annual vessel origin to destination transportation costs. The transportation cost savings benefits were then calculated from the existing 35 foot channel for project depths of 37 feet and 38 feet.

HarborSym Model

IWR developed HarborSym as a planning level, general purpose model to analyze the transportation costs of various waterway modifications to a channel. It is a Monte Carlo simulation model of vessel movements at a port for use in economic analysis. HarborSym concentrates on specific vessel movements and transit rules on the waterway, fleet and loading changes, as well as incorporating calculations for both within harbor costs and associated costs with the ocean voyage.

HarborSym represents a port as a tree-structured network of reaches, docks, anchorages and turning areas. Vessel movements are simulated along the reaches moving from the bar to dock and then exiting the port. The driving parameter for the HarborSym model is a vessel call at the port.The HarborSym analysis revolves around the factors that characterize or affect a vessel movement within the Harbor.

HarborSym is an event driven model. Vessel calls are processed individually and the interactions with other vessels are taken into account. For each iteration, the vessel calls for an iteration that fall within the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all of the docks in the vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route. Potential conflicts with other vessels that have previously entered the system are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If a rule activation occurs, such as no passing allowed in a given reach, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. Vessels move from reach to reach, eventually arriving at the dock that is the terminus of the leg.

After the cargo exchange calculations are completed and the time the vessel spends at the dock has been determined, the vessel attempts to exit the dock, starting a new leg of the vessel call. Rules for moving to the next destination (another dock or an exit of the harbor) are checked in a similar manner to the rule checking on arrival, before it is determined that the vessel can proceed on the next leg. As with the entry into the system, the vessel may need to delay departure and re-try at a later time to avoid rule violations and, similarly, the waiting time at the dock is recorded.

Each vessel call has a known (calculated) associated cost, based on time spent in the harbor and ocean voyage and cost per hour. Also, for each vessel call, the total quantity of commodity transferred to the port (both import and export) is known, in terms of commodity category, quantity, tonnage and value. The basic problem is to allocate the total cost of the call to the various commodity transfers that are made. Each vessel call may have multiple dock visits and multiple commodity transfers at each visit, but each commodity transfer record refers to a single commodity and specifies the import and export tonnage. Also, at the commodity level, the "tons per unit" for the commodity is known, so that each commodity transfer can be associated with an export and import tonnage. As noted above, the process is greatly simplified if all commodity transfers within a call are for categories that are measured in the same unit, but that need not be the case.

When a vessel leaves the system, the total tonnage, export tonnage, and import tonnage transferred by the call are available, as is the total cost of the call. The cost per ton can be calculated at the call level (divide total cost by respective total of tonnage). Once these values are available, it is possible to cycle through all of the commodity transfers for the vessel call. Each commodity transfer for a call is associated with a single vessel class and unit of measure. Multiplying the tons or value in the transfer by the appropriate per ton cost and the cost totals by class and unit for the iteration can be incremented. In this fashion, the total cost of each vessel call is allocated proportionately to the units of measure that are carried by the call, both on a tonnage and a value basis. Note that this approach does not require that each class or call carry only a commensurate unit of measure. The model calculates import and export tons, import and export value, and import and export allocated cost. This information allows for the calculation of total tons and total cost, allowing for the derivation of the desired metrics at the class and total level. The model can thus deliver a high level of detail on individual vessel, class, and commodity level totals and costs.

Vessel Call List

The forecasted commodities for the ship channel were allocated to the future fleet using the BLT. The user must provide data to specify the framework for generating the synthetic vessel call list. The BLT relies on much of the information and data from HarborSym, but has additional data specific requirements. Within the BLT, the input requirements include:

- Commodity forecasts (annual import/export) at each dock;
- Description of the available fleet by vessel class, including:
    - Statistical data describing the cumulative distribution function for deadweight tons of vessels within the class,
    - Regression information for deriving length overall (LOA), beam and design draft from capacity,
    - Regression information for calculating TPI based on beam, design draft, capacity and LOA;
    - The number of potential calls that can be made annually by each vessel class;
- Logical constraints describing:
    - Commodities that can be carried by each vessel class,
    - Vessel classes that can be serviced at each dock,
    - Parameters, defined at the vessel class/commodity level for determination of how individual calls and commodity transfers are generated, such as commodity loading factors, allocation priorities, and commodity flow direction (import or export calls).

Procedures exist, using the Extreme Optimization package and some Access routines, to populate much of the required forecast information based on an examination of an existing vessel call list created from historical data. Statistical measures, commodity transfer amounts, and logical constraints can all be derived from an examination of a set of historical calls that have been stored in a HarborSym database. The system populator function facilitates data entry by providing a basis for the forecasts, which the user can edit as necessary.

Load Factor Analysis

A Load Factor Analysis (LFA) is the analytical effort to evaluate the disposition of a vessel carrying capacity according to both weight and volume, and evaluate resulting influences for immersion and associated transit draft as they relate to needs for waterway system depth. A LFA was conducted for this study in order to determine how many calls would be needed to satisfy the commodity forecast for the Future Without Project condition and the Future With-Project condition. The table below shows the vessel class inputs for the LFA.

Table 7: Vessel Class Inputs

	Without Project		**37 Feet**		**38 Feet**	
Vessel Class	**Import Fraction Most Likely**	**Export Fraction Most Likely**	**Import Fraction Most Likely**	**Export Fraction Most Likely**	**Import Fraction Most Likely**	**Export Fraction Most Likely**
Panamax	68	66	71	67	72	68
Aframax	55	40	58	41	59	42
Suezmax	51	-	53	-	54	-

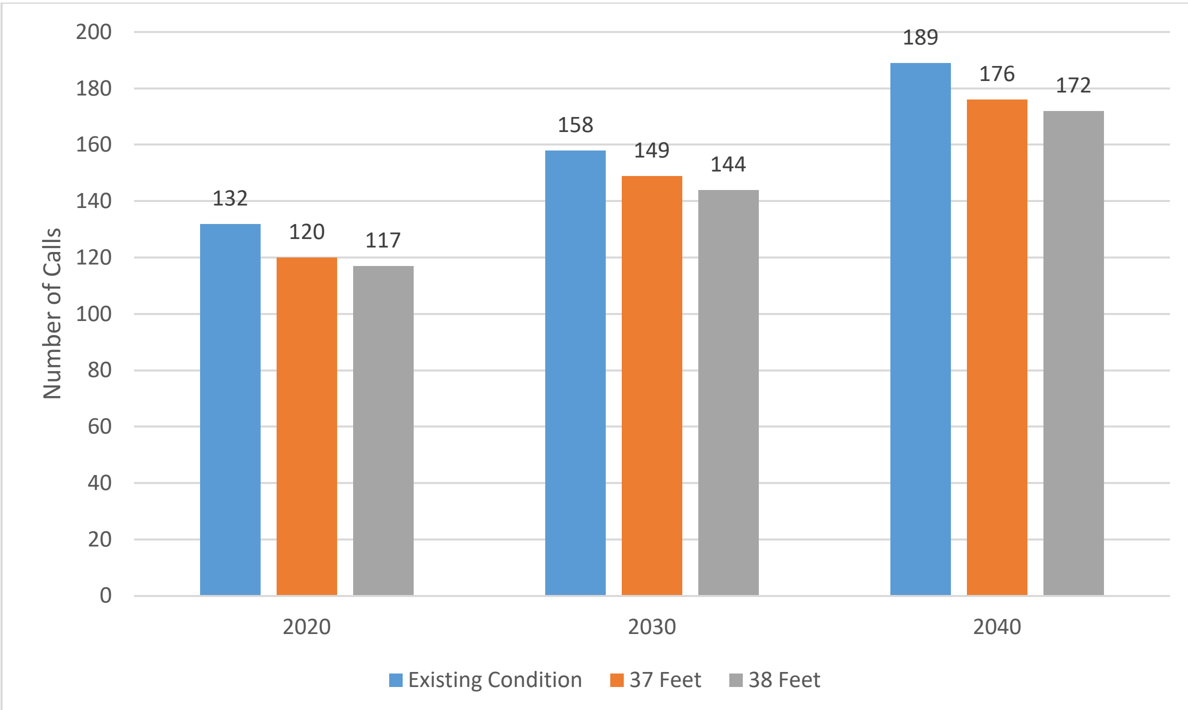
Bulk Loading Tool Data

The bulk fleet was developed using historical calls from 2011 to 2013. Growth was assumed in traffic until 2040 and then assumed constant from 2040 to 2069. Table 8 shows the resultant bulk vessel fleet. Table 9 shows the forecasted Panamax vessel fleet.

Table 8: Bulk Vessel Fleet Forecast

	2020			2030			2040		
	35 feet	37 feet	38 feet	35 feet	37 feet	38 feet	35 feet	37 feet	38 feet
Panamax Import	56	46	45	62	54	50	66	58	54
Aframax Import	52	52	52	52	52	52	52	52	52
Suezmax Import	33	33	33	33	33	33	33	33	33
Panamax Export	76	74	72	96	95	94	123	118	118
Aframax Export	4	4	4	4	4	4	4	4	4
Total	**221**	**209**	**206**	**247**	**238**	**233**	**278**	**265**	**261**

Table 9: With-Project Forecasted Panamax Vessels



Origin-Destination Transportation Cost Savings Benefits by Project Depth

Transportation cost benefits were estimated using the HarborSym Model and reported using the Economic Reporter, a tool that summarizes and annualizes HarborSym results from multiple simulations. This tool collects the transportation costs from various model run output files and generates the transportation cost reduction for all project years, and then produces an Average Annual Equivalent (AAEQ). Transportation costs were estimated for a 50-year period of analysis for the years 2020 through 2069. Transportation costs were estimated using HarborSym for the years 2020, 2030 and 2040. The transportation costs were held constant beyond 2040. The present value was estimated by interpolating between the modeled years. For initial screening of alternatives the FY 2016 Federal Discount rate of 3.125 percent was used and the results are presented below.

Table 10: AAEQ Transportation Costs

Alternative	**AAEQ Transportation Cost**	**AAEQ Transportation Cost Reduction Benefit**
No Action - 35 foot channel	$209,846,000	
Alternative 1 - 37 foot channel	$202,221,000	$7,625,000
Alternative 2 - 38 foot channel	$198,534,000	$11,312,000

Initial Project Costs of Deepening

In the evaluation and comparison of project depth alternatives, which is necessary to arrive at the selected plan, NED costs play a critical role. NED costs include both the financial and economic costs associated with a project throughout its lifecycle. Each of these types of costs and their sources are discussed in this section of the report. Additionally, the NED costs for the depth alternatives being considered in this analysis will be identified.

NED Cost – Financial

Financial costs of the proposed project consist of the construction and mitigation costs accrued during construction of the project and over its lifecycle. More specifically these costs include:

- Land Construction Costs
- Dredging Costs
- Preconstruction, Engineering, and Design Costs (PED)
- Supervision and Administration Costs (S&A)
- Contingency Costs
- Supervision, Inspection, and Overhead Costs (SIOH)
- Mitigation Costs

San Francisco District cost engineers prepared the cost estimate for the two proposed deepening alternatives for use in the economic analysis. The sum of these costs is used to determine Interest During Construction (IDC), which represents the economic cost of building a project. The next section defines IDC and provides an explanation as to how it is calculated and included in the analysis. Together, these costs represent the estimated first cost of construction.

Another financial cost not included above is the annual cost accrued over the life of a project due to Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities that represent an increase over the current OMRR&R costs to maintain the channel. OMRR&R was excluded from the list of financial costs above because it is not included in the calculation of IDC. IDC takes into account only those costs incurred during construction.

NED Cost – Economic

Interest During Construction (IDC) represents an economic cost of building a project that is considered in the selection of the recommended plan, but does not factor in as a paid cost. IDC is the cost of the foregone opportunity to invest the money required to construct a project for another use. The hypothetical return on another investment, measured as IDC, is counted as an NED cost. As an economic, rather than a financial, cost, IDC is not considered in the determination of cost-sharing responsibilities.

IDC reflects that project construction costs are not incurred in one lump sum, but as a flow over the construction period. This analysis assumes that construction expenditures are incurred at a constant rate over the period of construction, an assumption which is supported by the NED Manual for Deep Draft Navigation.

NED Channel Deepening Cost

Table 11 contains the project costs associated with each project depth evaluated in this analysis. As stated before, all costs, with the exception of IDC, were provided by the San Francisco District cost engineers working on this study. The cost were annualized at the FY16 discount rate of 3.125% over 50 years.

Table 11: Project Cost

Project Depth	Project Cost	Construction Duration (months)	IDC	Total Cost Including IDC	Annualized Construction Cost & IDC	O&M Cost	Total Average Annual Cost
37'	$33,400,000	5	$172,000	$33,572,000	$1,917,000	$581,300	$1,917,000
38'	$54,600,000	10	$635,000	$55,235,000	$2,198,000	$1,397,000	$3,596,000

Preliminary Results – Net Benefits and Benefit-Cost Ratio

Having identified the benefit and cost associated with the deepening of the channel, identification of the proposed alternative requires a comparison of the net benefits resulting from each project depth. By definition, the NED Alternative is the alternative that maximizes net benefits. This analysis identifies a proposed plan, which achieved the NED objective among the depths considered. Table 12 below contains the NED Cost and Benefit for incremental channel depths and the resulting net benefit and benefit-cost ratios. The 38 foot depth has the greatest net benefits.

Table 12: Project Results

Project Depth	**37'**	**38'**
Average Annual Benefits	$7,625,000	$11,312,000
Average Annual Costs	$1,917,000	$3,596,000
Net Benefits	$5,708,000	$7,716,000
BCR	3.9	3.1

Tentatively Selected Plan Benefit and Cost Update

Based on preliminary net benefits, the tentatively selected plan (TSP) is the 38 foot deepening. After the TSP was determined, updates were conducted for project cost and benefits. The assumption of 2.5 years of Preconstruction, Engineering and Design and six months of construction was used in the cost update. Benefits were updated using EGM

17-04, Deep Draft Vessel Operating Cost FY 2016. Also, the benefits and cost needed updating based on the discount rate change. The FY19 discount rate of 2.875 percent was used to annualize the cost and benefits. Table 13 shows the updated project costs. Table 14 shows the AAE benefits, AAEQ cost, net benefits and BCR based on the updates.

Table 13: Updated Project Cost

Project Depth	**38'**
PED Duration (Years)	2.5
Construction Duration (months)	6
PED Cost	$1,675,000
Construction Cost	$57,725,000
Total Construction & PED Costs	$59,400,000
IDC	$497,000
Total Cost Including IDC	$59,897,000
Annualized Construction Cost & IDC	$2,273,000
O&M Cost	$1,397,000
Total Average Annual Cost	$3,567,000

Table 14: TSP Benefits, Costs, Net Benefits, and BCR

Project Depth	38’
Average Annual Benefits	$12,859,000
Average Annual Costs	$3,567,000
Net Benefits	$9,292,000
BCR	3.6

Sediment Trap Cost Savings Analysis

A sediment trap was identified as a potential alternative to reduce the occurrences of emergency dredging events in the channel. The strategy is not to reduce the volume of material required to be dredged, but rather, for more material to be trapped in the settling basin or under the channel, rather than the channel itself. This allows for cost savings by reducing the number of maintenance dredging events while providing an operational channel for longer periods of time. Table 15 below shows the cost savings related to the sediment trap. Table 16 displays a summary of the recommended plan, net benefits, and BCR.

Table 15: Sediment Trap Cost Savings Analysis

O&M Alternatives	Total Present Value	Average Annual O&M Cost
Maintenance Costs without Project, with existing emergency maintenance	$26,351,790	$1,000,000
Maintenance Costs with-Project, without Sediment Trap	$26,351,790	$1,000,000
Maintenance Costs with-Project, with Sediment Trap	$8,376,873	$317,886
Savings	$17,974,917	$682,114

Table 16: Summary of Recommended Plan, Net Benefits, and BCR

Project (Depth)	38 Feet
Net Present Value Benefits	$338,859,000
Total Costs with IDC	$59,897,000
Annualized Transportation Cost Savings (Benefits)	$12,859,000
Annual Advanced Maintenance Cost Savings (Benefits)	$682,000
Total Average Annual Benefits	$13,541,000
Total Average Annual Costs	$3,567,000
AA Net NED Benefits	$9,974,000
BCR	3.7

Sensitivity Analysis

Risk and Uncertainty techniques should be used in deep draft navigation studies in the form of sensitivity analysis. The analysis used the growth rates for crude petroleum imports and petroleum product exports from the AEO 2015. Since 2015, additional energy outlooks have been published. Crude oil import growth has fluctuated around 0% and petroleum products exports have declined. To capture the uncertainty of the projected commodity volumes, three sensitivity scenarios are analyzed to display the variance in project benefits based on a change in the commodity forecast and the resultant fleet forecast. The sensitivity scenarios are as follows:

1. Zero growth in imported crude oil and zero growth in exported petroleum products throughout the 50 year period of analysis.
2. Zero growth in imported crude oil and same export growth as original analysis
3. Same import growth as original analysis of crude oil growth and zero growth for exports.

Scenario 1

The State of California adopted the Zero Emission Vehicle (ZAV) regulation in 1990 which aims to reduce emissions from mobile sources and attain health-based air quality standards. In January 2018, Executive Order B-48-18 (2018 ZEV Action Plan) was signed with the goal of having 200 hydrogen fueling stations and 250,000 electric vehicle chargers to support 1.5 million ZEVs in California by 2025 and 5 million ZEVs by 2030. For more information on the ZEV regulation, please see Economic Addendum 1. In order to evaluate the effect this regulation would have on the commodity forecast, a zero-growth sensitivity analysis was conducted for crude oil imports and petroleum product exports. The tonnage was held constant through the period of analysis. Fifty iterations were ran in the HarborSym model to determine the average annual equivalent (AAE) benefits for holding tonnage constant from 2020 to 2069. Using all assumptions from the original analysis, the AAE benefits are $11,985,000. The AAE cost remain at $3,567,000. The net benefits are $8,418,000.

Scenario 2

The second sensitivity scenario analyzed zero growth of imported crude oil and 2.4% growth rate of exported crude oil. Using all assumptions from the original analysis, the AAE benefits are $12,381,000. The AAE cost remain at $3,567,000. The net benefits are $8,814,000.

Scenario 3

The third sensitivity scenario analyzed the expected AEO 2015 imported crude oil growth rate of 0.3% and zero growth for exports. Using all assumptions from the original analysis, the AAE benefits are $10,259,000. The AAE cost remain at $3,567,000. The net benefits are $6,692,000.

Summary of Sensitivity Analysis

The figure below displays the most recent forecast for crude oil imports and petroleum product exports from the AEO 2019 report, which was published in January of 2019. Imports of crude oil are expected to grow at a rate of -0.2% between 2017 and 2050, while exports of petroleum products are expected to grow at a rate of 0.6% during the same time period.

Figure 5: AEO 2019 Forecast

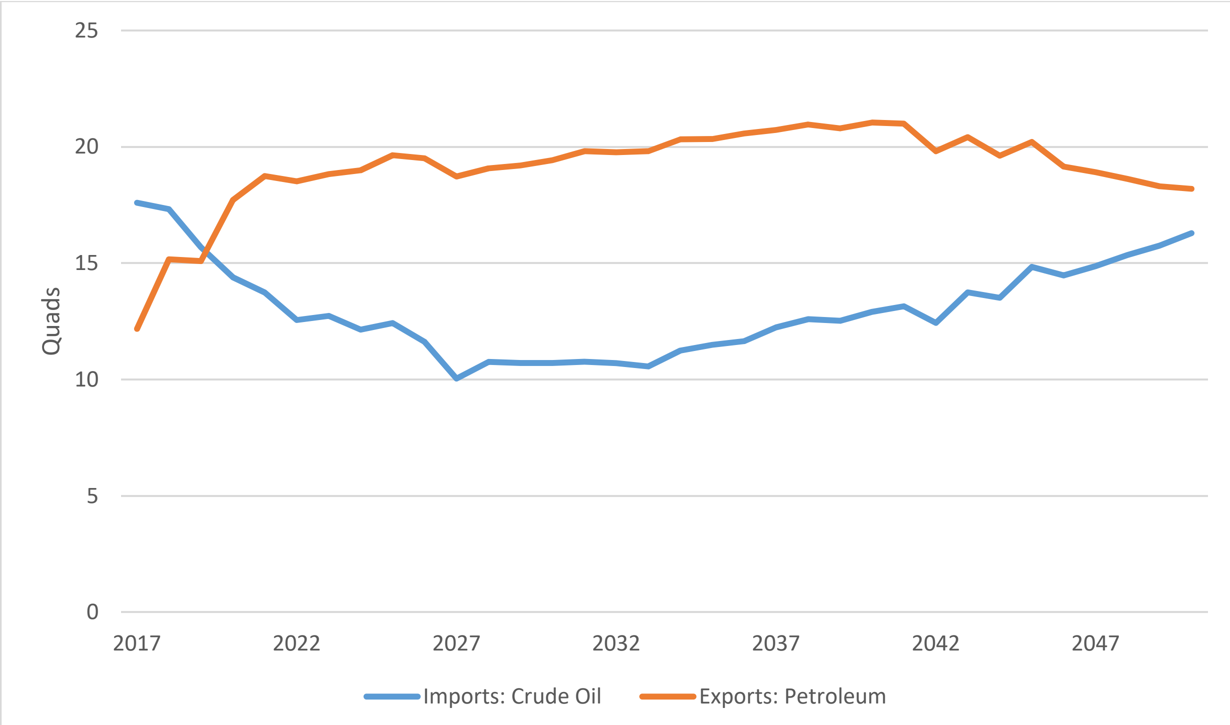


Table 17 below displays a summary of the sensitivity analysis scenarios. In all three growth scenarios, the project is still justified.

Table 17: Sensitivity Analysis Summary

	Import Growth Rate	Export Growth Rate	AAE Benefits	AAE Costs	Net Benefits	BCR
Scenario 1	0%	0%	$11,985,000	$3,567,000	$8,418,000	3.3
Scenario 2	0%	2.4%	$12,381,000	$3,567,000	$8,814,000	3.4
Scenario 3	0.3%	0%	$10,259,000	$3,567,000	$6,692,000	2.8

Multiport Analysis

Multiport analysis presents the results of an assessment of potential effects the deepening of San Francisco Bay to Stockton could have on other ports. The multiport analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput and sea, port and land based transportation options and costs. Since the purpose of a multiport analysis is to estimate potential changes in the with-project condition traffic forecasts, only the commodities affecting benefits and handled by alternative ports would be evaluated.

Multiport analysis calls for a systematic determination of alternative routing possibilities, regional port analyses and intermodal networks. Representatives from Contra Costa County and the oil refineries were contacted to gain additional knowledge regarding multiport analysis. The benefitting commodities are imported and exported directly to the facilities adjacent to the study channel. Therefore, transportation cost are expected to be lowest with goods transported on the Stockton Ship Channel. Los Angeles is the closest port with refineries and is over 400 miles away. The commodity movements are currently taking place and are expected to continue through the same channel.

The hinterland can be classified as captive since the imported and exporting benefitting commodity rely exclusively on the terminals that exist along the SF Bay to Stockton channel. Alternative ports are not expected to be used in the period of analysis that would affect traffic projections. It is concluded that deepening alone will not cause traffic to be diverted from or to other ports.

Socioeconomic and Regional Analysis

The socioeconomics of the community area are summarized in this section. The parameters used to describe the demographic and socioeconomic environment include recent trends in population for Alameda County, Contra Costa County, Marin County, San Francisco County, and San Mateo County that makes up the immediate economic study area of the San Francisco to Stockton Navigation Project.

Population

California is ranked as the largest state in the Union in terms of resident population as of 2016, with 37.3 million residents. Between the years 1990 and 2010, California's population increased by 25.2%, from 29.8 million to 37.3 million persons, as shown in Table 18, which is higher than the national growth over the same historical period. All counties within the immediate economic regions of San Francisco Bay have seen a growth in population according to 2010 census data.

Census data from 2010 show increases in population across the Bay Area. With a 21.6 percent growth rate, San Joaquin County was the fastest growing county in the Bay Area between 2000 and 2010, followed by Contra Costa County (10.6 percent), Solano County (4.8 percent), San Francisco County (3.7 percent), and Marin County (2.1 percent). San Francisco is the largest city in the Bay Area, with a population of more than 800,000, followed by Stockton (291,707), Concord (122,067), and Vallejo (115,942).

Table 18: Population

	Population			**Percent Change**		
Geography	**1990**	**2000**	**2010**	**1990-2000**	**2000-2010**	**1990-2010**
San Francisco County	723,959	776,733	805,235	7.3%	3.7%	11.2%
Marin County	230,096	247,289	252,409	7.5%	2.1%	9.7%
Contra Costa County	803,732	948,816	1,049,025	18.1%	10.6%	30.5%
Solano County	340,421	394,542	413,344	15.9%	4.8%	21.4%
San Joaquin County	480,628	563,598	685,306	17.3%	21.6%	42.6%
California	29,760,021	33,871,648	37,253,956	13.8%	10.0%	25.2%
United States	248,709,873	281,421,906	308,745,538	13.2%	9.7%	24.1%

Future population projections were retrieved from the California Department of Transportation database. The population projections for selected counties are shown in Table 19 below.

Table 19: Population Projections

	Population	Population Projections			Percent Change		
Geography	**2010**	**2020**	**2030**	**2040**	**2010-2020**	**2020-2030**	**2030-2040**
San Francisco County	805,235	891,887	937,307	966,226	10.76%	5.09%	3.09%
Marin County	252,409	268,343	276,771	283,676	6.31%	3.14%	2.49%
Contra Costa County	1,049,025	1,181,384	1,303,375	1,400,195	12.62%	10.33%	7.43%
Solano County	413,344	448,451	480,348	509,217	8.49%	7.11%	6.01%
San Joaquin County	685,306	786,738	883,911	973,872	14.80%	12.35%	10.18%
California	37,253,956	40,639,392	43,939,250	46,804,202	9.09%	8.12%	6.52%
United States	308,745,538	332,639,000	355,101,000	373,528,000	7.74%	6.75%	5.19%

Employment

California private sector annual employment in 2014 totaled 13.5 million, with average annual wage of $69,880 as shown in Tables 20 and 21, respectively. Of the major industry sectors within the State, the Health Care and Social Assistance sector employs the most persons, with 2,000,372 employees. Retail Trade and Accommodation and Food Services follow closely behind in total employed persons, with 1,623,371 and 504,176 employees, respectively.

County industry sectors yield employment distributions similar to the State level, with few exceptions. In San Francisco County, Professional and Technical Services is predominant compared to other counties in the Bay area and the State of California.

Table 20: California Private Sector Annual Employment, 2014

California Private Sector Annual Employment - 2014						
Industry	**San Joaquin County**	**Contra Costa County**	**Solano County**	**San Francisco County**	**Marin County**	**California**
Agriculture, Forestry, Fishing, and Hunting	15,588	787	1,788	144		415,444
Mining, Quarrying, and Oil and Gas Extraction	80	579	270	27		28,629
Utilities	1,255		551			57,627
Construction	8,897	21,213	8,368	16,741	5,969	669,766
Manufacturing	18,295	15,276	10,782	9,924	3,426	1,264,114
Wholesale Trade	11,109	9,184	4,326	13,896	2,804	709,154
Retail Trade	25,819	41,455	17,323	45,693	14,127	1,623,371

Transportation and Warehousing	13,668		3,369			446,430
Information	2,076	8,304	1,081	27,879	2,563	456,992
Finance and Insurance	5,003	18,191	3,460	37,175	4,623	515,504
Real Estate and Rental and Leasing	2,507	6,814	1,355	13,107	2,224	264,129
Professional and Technical Services	4,744	24,887	3,967	107,096	9,868	1,171,165
Management of Companies and Enterprises	1,812	8,439	801	20,881	2,163	225,792
Administrative and Waste Services	11,477	20,269	4,613	38,846	6,120	1,023,130
Education Services	4,258	6,388	1,532	18,173	3,451	317,066
Health Care and Social Assistance	29,781	53,885	21,522	64,801	15,770	2,000,372
Arts, Entertainment, and Recreation	2,395	5,968	3,470	13,260	2,722	276,312
Accommodation and Food Services	16,527	30,273	11,619	75,813	12,307	1,471,800
Other Services, Except Public Administration	6,104	11,852	3,610	27,266	5,478	504,176
Unclassified	499	1,019	274	2,682	487	60,740
Total	**181,894**	**284,783**	**104,081**	**533,404**	**94,102**	**13,501,713**

Table 21: California Average Annual Wage Earnings per Employee, 2014

California Average Annual Wage Earnings per Employee - 2014						
Industry	**San Joaquin County**	**Contra Costa County**	**Solano County**	**San Francisco County**	**Marin County**	**California**
Agriculture, Forestry, Fishing, and Hunting	$29,133	$31,234	$31,914	$44,314		$28,751
Mining, Quarrying, and Oil and Gas Extraction	$81,296	$152,629	$77,908	$192,224		$138,053
Utilities	$101,237		$130,209			$114,900
Construction	$51,002	$68,495	$66,574	$82,935	$62,553	$59,464
Manufacturing	$50,391	$97,310	$107,126	$98,581	$103,869	$81,368
Wholesale Trade	$54,615	$86,975	$61,557	$94,749	$87,640	$71,780
Retail Trade	$27,914	$32,314	$28,238	$46,042	$38,234	$33,175
Transportation and Warehousing	$48,572		$41,994			$50,140
Information	$54,435	$97,741	$51,194	$175,718	$104,017	$136,214

Finance and Insurance	$57,783	$97,375	$60,779	$230,075	$129,519	$108,336
Real Estate and Rental and Leasing	$37,246	$61,820	$39,402	$95,192	$64,791	$59,119
Professional and Technical Services	$53,330	$100,081	$54,110	$134,921	$92,565	$103,921
Management of Companies and Enterprises	$75,536	$137,355	$80,898	$178,209	$184,232	$118,880
Administrative and Waste Services	$27,231	$47,904	$37,184	$61,541	$48,566	$39,477
Education Services	$37,994	$37,170	$43,330	$50,908	$50,346	$48,787
Health Care and Social Assistance	$44,536	$60,518	$59,541	$45,530	$53,254	$46,848
Arts, Entertainment, and Recreation	$19,899	$22,950	$21,607	$64,872	$33,214	$53,678
Accommodation and Food Services	$15,100	$19,032	$16,318	$30,593	$23,287	$20,570
Other Services, Except Public Administration	$29,049	$34,901	$35,073	$45,842	$37,567	$35,023
Unclassified	$30,638	$49,596	$26,292	$65,269	$58,748	$49,119
Total Average	**$46,347**	**$68,633**	**$53,562**	**$96,529**	**$73,275**	**$69,880**

Wage Earnings by Sector

Of the private sector industries, Mining, Quarrying, and Oil and Gas Extraction sector employees are paid the highest in average annual earnings, slightly over $138,000, followed by Information sector employees, earning on average $136,214. The average annual earnings of Mining, Quarrying, and Oil and Gas Extraction sector employees nearly doubles the average annual wage earnings across all industry sectors. In December of 2014, the unemployment rate in California was 7 percent, higher than all but two other locations in the U.S. (Mississippi and Washington, D.C.). In October of 2015, California experienced the largest job growth in the country, adding nearly 41,200 new jobs and bumping its unemployment rate down to 5.8 percent.

Median Household Income for Selected Counties

Median household incomes for selected counties in California are shown in Table 22, with Marin County showing the highest median household income, followed by Contra Costa County, San Francisco County, Solano County, and San Joaquin County. Median household incomes for the Bay Area are higher than the State average of $61,094, except for San Joaquin County.

Table 22: California Median Household Income for Selected Counties

California Median Household Income for Selected Counties		
Geography	**Median Household Income**	**% of State Median Household Income**
San Francisco County	$75,604	123.8%
Marin County	$90,839	148.7%
Contra Costa County	$78,756	128.9%
Solano County	$67,177	110.0%
San Joaquin County	$53,380	87.4%
California	$61,094	100.0%

As shown in Table 23 below, the unemployment rates in the Bay Area counties were mostly lower than the State and National Averag

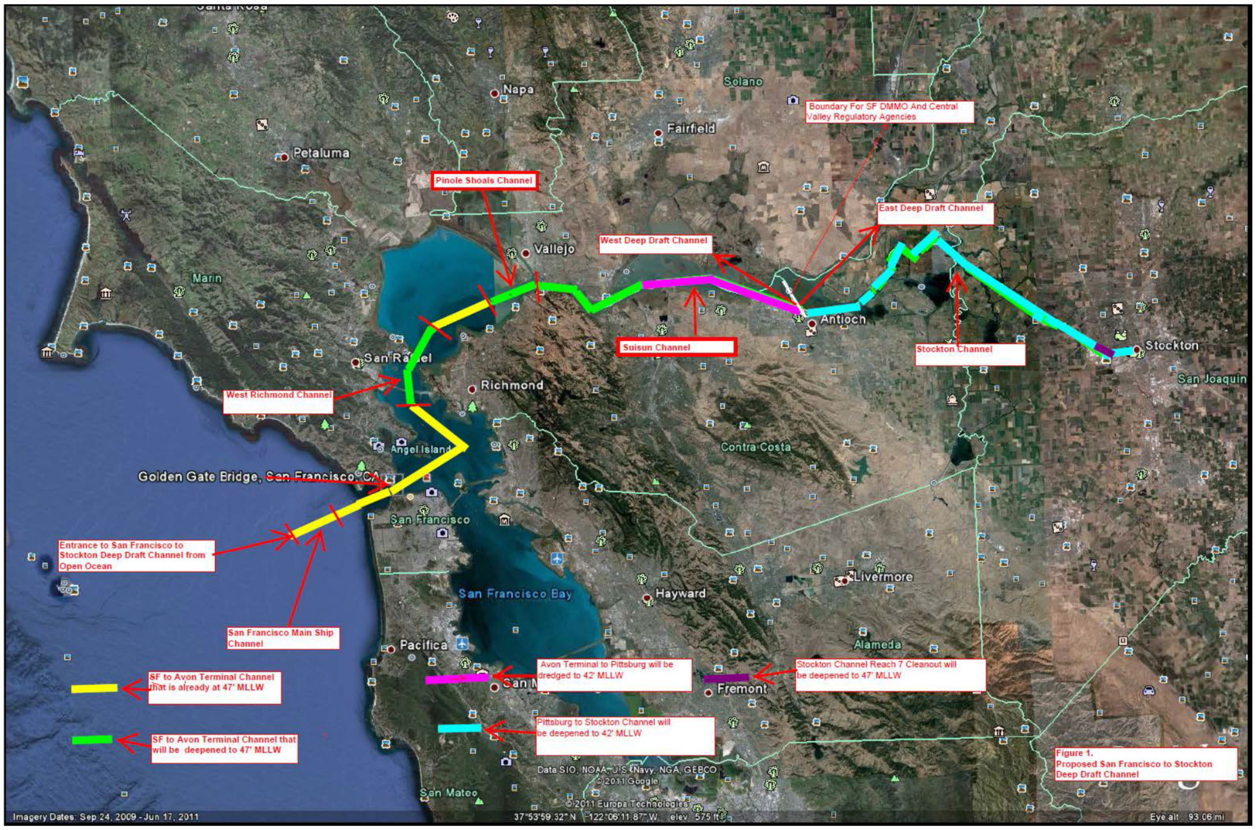
Table 23: California State Unemployment Rates for Selected Counties

California State Unemployment Rates for Selected Counties - 2015	
Geography	**Unemployment Rate**
San Francisco County	3.4%
Marin County	3.3%
Contra Costa County	4.7%
Solano County	5.6%
San Joaquin County	8.1%
California	5.8%
U.S.	5.5%

Social Characteristics

This section describes social characteristics of the Bay Area, each county within the region, and community study areas. The community study areas are illustrated in Figure 5 and are defined by a greater portion of the San Francisco Bay area. The social characteristics that are assessed in this section include population, race, age, education, income, poverty, and unemployment.

Figure 6: Study Area



The population growth trends from 1980 through 2010 for the San Francisco Bay area are shown in Table 24. The region as a whole has experienced a rapid rate of growth since 1980. According to 2010 U.S. Census data, the Bay Area has a 49.8 percent growth between 1980 and 2010, with a net population increase of 1,064,877 residents.

Table 24: Bay Area Population Growth, 1980-2010

Bay Area Population Growth, 1980-2010					
		Population			**Percent Increase 1980-2010**
Geography	**1980**	**1990**	**2000**	**2010**	
San Francisco County	678,974	723,959	776,733	805,235	18.6%
Marin County	222,592	230,096	247,289	252,409	13.4%
Contra Costa County	656,331	803,732	948,816	1,049,025	59.8%
Solano County	235,203	340,421	394,542	413,344	75.7%
San Joaquin County	347,342	480,628	563,598	685,306	97.3%
Bay Area	2,140,442	2,578,836	2,930,978	3,205,319	49.8%
California	23,667,902	29,760,021	33,871,648	37,253,956	57.4%
United States	226,542,199	248,709,873	281,421,906	308,745,538	36.3%

Population density varied extensively for the five counties from a low of 485 persons per square mile in Marin County to a high of 17,179 persons per square mile in San Francisco County.

As shown in Table 25, the Bay Area and the State of California have mostly higher percentages of minority populations than the United States according to the 2010 U.S. Census. In the Bay Area, San Francisco County has a higher percentage of minority populations than the other counties. In 2010, the Bay Area as a whole had more of a diverse racial composition compared to the U.S., where approximately 55 percent of the population identified as White, 8.3% of the population identified as Black or African American, 18.5 percent of the population identified as Asian, and 11.1 percent of the population identified as Other.

Table 25: Racial Composition

Racial Composition 2010		San Francisco County	Marin County	Contra Costa County	Solano County	San Joaquin County	Bay Area	California	U.S.
White	No.	390,387	201,963	614,512	210,751	349,287	1,766,900	21,453,934	223,553,265
	%	48.5%	80.0%	58.6%	51.0%	51.0%	55.1%	57.6%	72.4%
Black or African American	No.	48,870	6,987	97,161	60,750	51,744	265,512	2,299,072	38,929,319
	%	6.1%	2.8%	9.3%	14.7%	7.6%	8.3%	6.2%	12.6%
American Indian and Alaska Native	No.	4,024	1,523	6,122	3,212	7,196	22,077	362,801	2,932,248
	%	0.5%	0.6%	0.6%	0.8%	1.1%	0.7%	1.0%	0.9%
Asian	No.	267,915	13,761	151,469	60,473	98,472	592,090	4,861,007	14,674,252
	%	33.3%	5.5%	14.4%	14.6%	14.4%	18.5%	13.0%	4.8%
Native Hawaiian and Other Pacific Islander	No.	3,359	509	4,845	3,564	3,758	16,035	144,386	540,013
	%	0.4%	0.2%	0.5%	0.9%	0.5%	0.5%	0.4%	0.2%
Other	No.	53,021	16,973	112,691	43,236	131,054	356,975	6,317,372	19,107,368
	%	6.6%	6.7%	10.7%	10.5%	19.1%	11.1%	17.0%	6.2%
Two or More Races	No.	37,659	10,693	62,225	31,358	43,795	185,730	1,815,384	9,009,073
	%	4.7%	4.2%	5.9%	7.6%	6.4%	5.8%	4.9%	2.9%
Total Population	No.	805,235	252,409	1,049,025	413,344	685,306	3,205,319	37,253,956	308,745,538
	%	100%	100%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The age characteristics of the Bay Area are shown in Table 26. As a whole, the Bay Area in 2010 had a higher median age than the State of California and equaled the median age for the United States. San Francisco County, Marin County, and Contra Costa County all had median ages higher than or equal to the State and National median age. Solano County's median age was higher than the State level, but lower than the National level. San Joaquin County was the only area to have a median age lower than both State and National levels.

Table 26: Age Distribution, 2010

Age Distribution 2010		San Francisco County	Marin County	Contra Costa County	Solano County	San Joaquin County	Bay Area	California	U.S.
Under 18	No.	124,570	56,452	287,513	113,222	223,585	805,342	10,452,042	74,181,467
	%	15.5%	22.4%	27.4%	27.4%	32.6%	25.1%	28.1%	24.0%
18-64	No.	570,823	153,765	631,074	253,275	390,540	1,999,477	22,555,400	194,296,087
	%	70.9%	60.9%	60.2%	61.3%	57.0%	62.4%	60.5%	62.9%
65 or Above	No.	109,842	42,192	130,438	46,847	71,181	400,500	4,246,514	40,267,984
	%	13.6%	16.7%	12.4%	11.3%	10.4%	12.5%	11.4%	13.0%
Total Population	No.	805,235	252,409	1,049,025	413,344	685,306	3,205,319	37,253,956	308,745,538
	%	100%	100%	100%	100%	100%	100%	100%	100%
Median Age		38.5	37.2	38.5	36.9	32.7	37.2	35.2	37.2

The 2010 U.S. Census income and poverty data for the Bay Area and the State of California are summarized in Table 27. All counties had higher median household incomes than the State of California, with the exception of San Joaquin County at $59,900.

Table 27: Regional Income and Poverty Data

Regional Income and Poverty Data	San Francisco County	Marin County	Contra Costa County	Solano County	San Joaquin County	California	U.S.
Median Household Income	$75,604	$90,839	$78,756	$67,177	$59,900	$61,094	$53,046
Per Capita Income	$48,486	$56,791	$38,219	$28,929	$22,589	$29,527	$28,155
Percent of People Below Poverty Level	13.5%	7.7%	10.5%	13.0%	18.2%	15.9%	15.4%

Marin County had the highest median household income and per capita income, while San Joaquin County had the lowest median household income and per capita income. San Joaquin County had the highest percentage of people living below poverty level (18.2 percent) when compared to other counties in the region and to the State of California. San Francisco County, Marin County, Contra Costa County, and Solano County all had lower percentages of people living below poverty level compared to the State of California.

As shown in Table 28, all counties in the Bay Area had a higher percentage of people over the age of 25 that graduated high school or higher when compared to the State of California and the United States, except for San Joaquin County. San Francisco County, Marin County, and Contra Costa County had higher percentages of people over the age of 25 that earned a Bachelor's Degree or higher when compared to the State of California and the United States. Solano County and San Joaquin County had lower percentages of people over the age of 25 that earned a Bachelor's Degree or higher, at 24.3 percent and 18.1 percent, respectively.

Table 28: Education Attainment

Geography	High School Graduate or Higher - Persons 25 Years or Older	Bachelor's Degree or Higher - 25 Years and Older
San Francisco County	86.3%	52.4%
Marin County	92.4%	54.6%
Contra Costa County	88.8%	39.0%
Solano County	87.2%	24.3%
San Joaquin County	77.3%	18.1%
California	81.2%	30.7%
U.S.	86.0%	28.8%

Regional Economic Development Analysis

This report provides estimates of the economic impacts of Civil Works Budget Analysis for San Francisco to Stockton Navigation Project.

The U.S Army Corps of Engineers (USACE) Institute for Water Resources, the Louis Berger Group and Michigan State University has developed a regional economic impact modeling tool called RECONS (Regional ECONomic System) to provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Work program spending and stem-from effects for Ports, Inland Water Way, FUSRAP and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations. These multipliers were then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. The tool will be used as a means to document the performance of direct investment spending of the USACE as directed by the American Recovery and Reinvestment Act (ARRA). The Tool will also allow the USACE to evaluate project and program expenditures associated with the annual expenditure by the USACE.

Table 29 provides the project information while Table 30 provides the economic impact regions for the San Francisco to Stockton Navigation Project.

Table 29: Project Information

Project Name:	San Francisco to Stockton Navigation Project
Project ID:	22526
Division:	SPD
District:	SAN FRANCISCO DISTRICT
Type of Analysis:	Civil Works Budget Analysis
Business Line:	Navigation
Work Activity:	CWB - Navigation

Table 30: Economic Impact Regions

Regional Impact Area:	San Francisco Oakland Fremont CA MSA
Regional Impact Area ID:	9
Counties included	Alameda/Contra Costa/Marin/San Francisco/San Mateo/
State Impact Area:	California
National Impact:	Yes

The RED impact analysis was evaluated at three geographical levels: Local, State, and National for the 38-foot alternative. The local analysis represents the San Francisco to Stockton impact area. The State Level analysis includes the State of California. The National level includes the 48 contiguous United States.

Table 31 displays the overall spending profile that makes up the dispersion of the total project construction cost among the major industry sectors. The spending profile also identifies the geographical capture rate, also called Local Purchase Coefficient (LPC) in RECONS, of the cost components. The geographic capture rate is the portion of USACE spending on industries (sales) captured by industries located within the impact area. In many cases, IMPLAN's trade flows Regional Purchase Coefficients (RPC's) are utilized as a proxy to estimate where the money flows for each of the receiving industry sectors of the cost components within each of the impact areas.

Table 31: Input Assumptions (Spending and LPCs)

Category	Spending (%)	Spending Amount	Local LPC (%)	State LPC (%)	National LPC (%)
Dredging Fuel	6%	$3,623,400	85%	88%	90%
Metals and Steel Materials	4%	$2,554,200	28%	55%	90%
Textiles, Lubricants, and Metal Valves and Parts (Dredging)	2%	$1,247,400	13%	43%	65%
Pipeline Dredge Equipment and Repairs	5%	$3,088,800	22%	51%	100%
Aggregate Materials	3%	$1,722,600	61%	78%	97%
Switchgear and Switchboard Apparatus Equipment	0%	$178,200	20%	42%	80%
Hopper Equipment and Repairs	2%	$1,128,600	1%	10%	97%
Construction of Other New Nonresidential Structures	14%	$8,078,400	100%	100%	100%
Industrial and Machinery Equipment Rental and Leasing	7%	$4,336,200	75%	99%	100%
Planning, Environmental, Engineering and Design Studies and Services	5%	$2,732,400	100%	100%	100%
USACE Overhead	7%	$3,920,400	56%	60%	100%
Repair and Maintenance Construction Activities	4%	$2,435,400	100%	100%	100%
Industrial Machinery and Equipment Repair and Maintenance	11%	$6,237,000	73%	100%	100%
USACE Wages and Benefits	13%	$7,900,200	75%	100%	100%
Private Sector Labor or Staff Augmentation	15%	$9,088,200	100%	100%	100%
All Other Food Manufacturing	2%	$1,128,600	29%	75%	90%
Total	**100%**	**$59,400,000**	-	-	-

The USACE is planning on expending $59,400,000 on the project. Of this total project expenditure $44,268,102 will be captured within the regional impact area. The rest will be leaked out to the state or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity in that can be measured in jobs, income, sales and gross regional product as summarized in the following table and includes impacts to the region, the State impact area, and the Nation. Table 32 is the overall economic impacts for this analysis.

The labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income. The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues The GRP, which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income.

Table 32: Overall Summary Economic Impacts

Impact Areas		**Regional**	**State**	**National**
Total Spending		$59,400,000	$59,400,000	$59,400,000
Direct Impact				
	Output	$44,268,102	$52,211,881	$58,090,611
	Job	427.81	475.08	522.24
	Labor Income	$28,119,060	$32,385,718	$34,804,593
	GRP	$32,016,341	$37,382,072	$40,289,984
Total Impact				
	Output	$82,613,168	$107,813,402	$154,629,362
	Job	669.54	840.66	1,138.77
	Labor Income	$42,280,851	$51,368,682	$66,309,480
	GRP	$56,121,709	$70,500,608	$94,858,168

Tables 33, 34, and 35 present the economic impacts by industry sector both for each geographical region. Note that Labor -5001- is the largest impact area at the regional, state, and national levels, implying that all the labor demand can be met at the regional level.

Table 33: Economic Impact at Regional Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$2,707,634	0.33	$99,239	$432,406
171	Steel product manufacturing from purchased steel	$410,901	0.77	$110,719	$125,591
198	Valve and fittings other than plumbing manufacturing	$33,492	0.10	$7,934	$16,300
201	Fabricated pipe and pipe fitting manufacturing	$208,569	0.75	$57,810	$91,121
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$498,618	3.84	$180,080	$235,885
268	Switchgear and switchboard apparatus manufacturing	$11,919	0.03	$4,409	$6,725
290	Ship building and repairing	$5,320	0.02	$1,916	$2,278
319	Wholesale trade businesses	$1,009,772	5.19	$475,337	$798,537
322	Retail Stores - Electronics and appliances	$5,686	0.04	$3,165	$3,961
323	Retail Stores - Building material and garden supply	$213,842	2.27	$107,766	$151,451
324	Retail Stores - Food and beverage	$6,951	0.09	$3,732	$5,206
326	Retail Stores - Gasoline stations	$63,723	0.37	$28,688	$45,740
332	Transport by air	$3,376	0.01	$1,046	$1,731
333	Transport by rail	$35,879	0.11	$11,120	$19,106
334	Transport by water	$15,830	0.03	$4,927	$8,296
335	Transport by truck	$617,407	5.45	$246,506	$308,797
337	Transport by pipeline	$9,084	0.01	$6,440	$6,328
36	Construction of other new nonresidential structures	$8,078,400	45.04	$3,656,742	$4,441,541

365	Commercial and industrial machinery and equipment rental and leasing	$3,255,137	10.30	$945,648	$1,869,909
375	Environmental and other technical consulting services	$2,731,145	22.97	$1,982,938	$1,988,958
386	Business support services	$2,179,582	31.51	$1,508,667	$1,494,821
39	Maintenance and repair construction of nonresidential structures	$2,424,543	14.89	$1,193,475	$1,456,532
417	Commercial and industrial machinery and equipment repair and maintenance	$4,524,807	32.67	$2,919,281	$3,446,328
439	* Employment and payroll only (federal govt, non-military)	$5,925,150	40.55	$5,449,268	$5,925,150
5001	Labor	$9,088,200	209.86	$9,088,200	$9,088,200
69	All other food manufacturing	$203,133	0.61	$24,006	$45,442
	Total Direct Effects	$44,268,102	427.81	$28,119,060	$32,016,341
	Secondary Effects	$38,345,066	241.73	$14,161,791	$24,105,369
	Total Effects	**$82,613,168**	**669.54**	**$42,280,851**	**$56,121,709**

Table 34: Economic Impact at State Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$2,707,634	0.33	$99,239	$432,406
171	Steel product manufacturing from purchased steel	$1,001,381	2.01	$269,827	$306,071
198	Valve and fittings other than plumbing manufacturing	$368,436	1.14	$94,376	$184,086
201	Fabricated pipe and pipe fitting manufacturing	$943,202	3.57	$261,430	$412,071
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$588,450	4.53	$220,503	$284,882
268	Switchgear and switchboard apparatus manufacturing	$45,043	0.13	$16,663	$25,415
290	Ship building and repairing	$94,511	0.39	$34,032	$40,470
319	Wholesale trade businesses	$1,362,370	7.11	$641,318	$1,077,374
322	Retail Stores - Electronics and appliances	$5,688	0.04	$3,167	$3,963
323	Retail Stores - Building material and garden supply	$268,755	2.88	$135,439	$190,342
324	Retail Stores - Food and beverage	$7,880	0.11	$4,230	$5,901
326	Retail Stores - Gasoline stations	$97,292	0.57	$43,801	$69,836
332	Transport by air	$3,376	0.01	$1,046	$1,731
333	Transport by rail	$54,167	0.16	$16,932	$28,943
334	Transport by water	$15,830	0.03	$4,927	$8,296
335	Transport by truck	$839,182	7.41	$347,047	$429,699
337	Transport by pipeline	$18,843	0.02	$13,358	$13,126
36	Construction of other new nonresidential structures	$8,078,400	45.04	$3,656,742	$4,441,541

365	Commercial and industrial machinery and equipment rental and leasing	$4,289,115	13.71	$1,246,029	$2,463,877
375	Environmental and other technical consulting services	$2,731,145	22.97	$1,982,938	$1,988,958
386	Business support services	$2,355,222	34.27	$1,630,242	$1,615,280
39	Maintenance and repair construction of nonresidential structures	$2,431,824	14.94	$1,197,059	$1,460,906
417	Commercial and industrial machinery and equipment repair and maintenance	$6,237,000	46.02	$4,023,941	$4,750,423
439	* Employment and payroll only (federal govt, non-military)	$7,897,222	55.79	$7,262,952	$7,897,223
5001	Labor	$9,088,200	209.86	$9,088,200	$9,088,200
69	All other food manufacturing	$681,711	2.05	$90,279	$161,053
	Total Direct Effects	$52,211,881	475.08	$32,385,718	$37,382,072
	Secondary Effects	$55,601,521	365.58	$18,982,964	$33,118,536
	Total Effects	**$107,813,402**	**840.66**	**$51,368,682**	**$70,500,608**

Table 35: Economic Impact at National Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$2,713,009	0.34	$99,456	$433,390
171	Steel product manufacturing from purchased steel	$1,850,195	3.85	$498,544	$565,509
198	Valve and fittings other than plumbing manufacturing	$639,659	2.05	$164,374	$319,951
201	Fabricated pipe and pipe fitting manufacturing	$2,439,379	9.31	$676,130	$1,065,729
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$850,897	6.55	$342,362	$432,370
268	Switchgear and switchboard apparatus manufacturing	$111,418	0.33	$41,218	$62,867
290	Ship building and repairing	$1,079,692	4.50	$388,778	$462,330
319	Wholesale trade businesses	$1,380,842	7.24	$650,014	$1,091,982
322	Retail Stores - Electronics and appliances	$5,702	0.04	$3,175	$3,973
323	Retail Stores - Building material and garden supply	$318,908	3.55	$160,713	$225,862
324	Retail Stores - Food and beverage	$7,900	0.11	$4,241	$5,917
326	Retail Stores - Gasoline stations	$97,830	0.81	$44,043	$70,221
332	Transport by air	$3,453	0.01	$1,070	$1,770
333	Transport by rail	$70,455	0.21	$22,158	$37,786
334	Transport by water	$19,836	0.04	$6,175	$10,395
335	Transport by truck	$890,082	7.86	$370,123	$457,447
337	Transport by pipeline	$39,844	0.05	$28,246	$27,755
36	Construction of other new nonresidential structures	$8,078,400	45.04	$3,656,742	$4,441,541

365	Commercial and industrial machinery and equipment rental and leasing	$4,329,865	13.91	$1,257,867	$2,487,286
375	Environmental and other technical consulting services	$2,732,038	22.97	$1,983,586	$1,989,608
386	Business support services	$3,919,162	62.01	$2,712,774	$2,687,876
39	Maintenance and repair construction of nonresidential structures	$2,434,706	14.97	$1,198,478	$1,462,638
417	Commercial and industrial machinery and equipment repair and maintenance	$6,237,000	48.25	$4,023,941	$4,750,423
439	* Employment and payroll only (federal govt, non-military)	$7,900,199	55.82	$7,265,690	$7,900,200
5001	Labor	$9,088,200	209.86	$9,088,200	$9,088,200
69	All other food manufacturing	$851,941	2.56	$116,499	$206,959
	Total Direct Effects	$58,090,611	522.24	$34,804,593	$40,289,984
	Secondary Effects	$96,538,751	616.54	$31,504,887	$54,568,184
	Total Effects	**$154,629,362**	**1,138.77**	**$66,309,480**	**$94,858,168**

Total San Francisco to Stockton Navigation Project economic impact for the State of California (Table 34) is composed of $107,813,402 in sales, approximately 840 jobs, $51.4 million in labor income and a contribution of $70 million to GRP.

Table 36 represents the demographic data of the impact region. In 2008, the combined metropolitan impact area of San Francisco to Stockton had a population of 4,354,010 with an area of 2,532 square miles and a total personal income of $259 billion.

Table 36: Impact Region Definition (2008)

Regional Impact Area ID:	9
Regional Impact Area Name:	San Francisco Oakland Fremont CA MSA
Impact Area Type	Metropolitan Impact Area
State Impact Region::	California

County	FIPS	Area (sq. mi)	Population	Households	Total Personal Income (in millions)
Alameda	06001	744	1,516,873	544,601	$71,596
Contra Costa	06013	760	1,063,951	377,174	$59,044
Marin	06041	525	256,201	104,325	$22,352
San Francisco	06075	47	787,580	335,420	$56,037
San Mateo	06081	455	729,405	260,698	$50,014
Total		**2,532**	**4,354,010**	**1,622,218**	**$259,043**

Table 37 shows the impact region for 19 selected sectors. It displays the geographical capture amounts for the San Francisco-Oakland-Fremont MSA, which is that portion of USACE spending that is captured in the impact area. The labor income represents all forms of employment earnings (in IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income). The GRP is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. The total San Francisco-Oakland-Fremont MSA is composed of $590 billion in output (sales), $2.9 million employment, $201 billion in labor income and a contribution of $313 billion to GRP.

Table 37: Impact Region Definition (2008)

Regional Impact Area ID:	9
Regional Impact Area Name:	San Francisco Oakland Fremont CA MSA
Impact Area Type	Metropolitan Impact Area
State Impact Region::	California

Section	Output (millions)	Labor Income (millions)	GRP (millions)	Employment
Accommodations and Food Service	$14,797	$5,490	$8,522	195,211
Administrative and Waste Management Services	$14,548	$7,545	$9,792	166,043
Agriculture, Forestry, Fishing and Hunting	$678	$219	$294	5,302
Arts, Entertainment, and Recreation	$6,282	$2,423	$3,549	76,937
Construction	$26,668	$12,197	$13,381	159,427
Education	$12,107	$9,351	$10,535	178,454

Finance, Insurance, Real Estate, Rental and Leasing	$87,689	$26,962	$56,871	352,878
Government	$26,298	$19,428	$21,541	211,725
Health Care and Social Assistance	$26,228	$15,005	$17,653	228,988
Imputed Rents	$41,484	$5,238	$27,170	176,251
Information	$41,511	$9,514	$19,542	81,536
Management of Companies and Enterprises	$13,582	$6,721	$8,997	45,963
Manufacturing	$137,230	$16,610	$25,925	144,824
Mining	$2,572	$627	$1,570	4,214
Professional, Scientific, and Technical Services	$69,247	$37,306	$43,692	401,095
Retail Trade	$25,945	$10,851	$18,003	279,566
Transportation and Warehousing	$13,926	$5,583	$7,810	85,982
Utilities	$9,295	$1,761	$5,190	9,097
Wholesale Trade	$20,129	$7,722	$13,239	88,779
Total	**$590,215**	**$200,553**	**$313,277**	**2,892,273**

The following tables shows the top ten industries that typically benefit from the types of expenditures made for this project by the USACE. This analysis was conducted at the national level and thus it cannot be guaranteed that these industries would be present in the regional impact area as analyzed.

Table 38: Top Ten Industries Affected by Work Activity (2008)

Project:	San Francisco to Stockton Navigation Project
Business Line:	Navigation
Work Activity:	CWB - Navigation

Rank	**Industry (millions)**	**IMPLAN No.**	**% of Total Employment**
1	* Employment and payroll only (federal govt, non-military)	439	8 %
2	Business support services	386	7 %
3	Construction of other new nonresidential structures	36	6 %
4	Food services and drinking places	413	5 %
5	Commercial and industrial machinery and equipment repair and maintenance	417	4 %
6	Real estate establishments	360	3 %
7	Wholesale trade businesses	319	3 %
8	Employment services	382	3 %
9	Maintenance and repair construction of nonresidential structures	39	3 %
10	Offices of physicians, dentists, and other health practitioners	394	2 %
			43 %

Zero Emission Vehicle Regulation Assessment

Objective:

Briefly evaluate the impact of the California's Zero Emission Vehicle (ZEV) regulation on the demand for crude oil.

Background:

The purpose of Zero Emission Vehicle (ZEV) regulation, designed by the California Air Resources Board (CARB), is to reduce emission from mobile sources and attain health-based air quality standards.[1] In California, mobile sources account for approximately 40% of greenhouse gas emissions, contributing to ozone and particulate matter air pollution.[2]

In January 2018, Executive Order B-48-18 (2018 ZEV Action Plan) was signed, setting ambitious targets: 200 hydrogen fueling stations and 250,000 electric vehicle chargers to support 1.5 million ZEVs in California by 2025, and 5 million ZEVs by 2030.[3] To achieve this, the 2018 ZEV Action Plan outlines the following (notable) actions:[4]

1) Maintenance of incentives like ZEV Rebates and access to high occupancy vehicle (HOV) lanes (i.e. car-pool lanes)
2) Implementation of light-duty vehicle pilot projects for lower-income/disadvantaged consumers
3) Implementation of programs to expand ZEV use via statutory changes
4) Promotion of ZEV market growth outside of California (multi-state collaboration and international coordination)
5) Expansion of PEV (Plug-in Electric Vehicles) charging networks and hydrogen station network
6) Augmentation of local ZEV readiness and infrastructure development

Evaluation of marginal difference between gasoline car and PEV:

To evaluate the marginal difference between a gas car and PEV, the standard Ford Fusion and the Ford Fusion Energi (PEV version) were chosen as model vehicles. In effort to maximize ceteris paribus, the same model and make variations were chosen, with the only difference being the mechanism of energy consumption. The base, MSRP prices were used for comparison; the standard Ford Fusion was $22,840 and its PEV counterpart was $34,595. However, the latter is entitled to various incentives – approximately $4,750 – including tax credit, PG&E (clean fuel rebate), PEV charging rate reduction, and Ford Fusion Energi rebate.[5] In addition, to effectively charge the vehicle at 240 Volts, consumers will have to incur the cost of equipment and installation, which is approximately $2905. The final cost of the

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[1] "Zero Emission Vehicle (ZEV) Program," California Air Resources Board, last updated Oct 24 2018; https://arb.ca.gov/msprog/zevprog/zevprog.htm
[2] Ibid.
[3] "2018 ZEV Action Plan: Priorities Update," Office of Governor Edmund G. Brown Jr., Sept 2018; http://business.ca.gov/Portals/0/ZEV/2018-ZEV-Action-Plan-Priorities-Update.pdf
[4] Ibid.
[5] "Electric Vehicles: Tax Credits and Other Incentives," Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentives

Ford Fusion Energi was determined to be approximately $26,940.00. The PEV version is more expensive than the standard gasoline version by approximately $4,100.00.

To determine the cost to drive, the average gasoline price was set at $3.318 (which was the average gasoline price in California as of December 10, 2018).[6] The average kWh was set at $0.255, which was the average energy cost of peak, part-peak, and off-peak rates for the summer and winter.[7]

The standard Ford Fusion has a miles per gallon (MPG) rating of 21 in the city and 31 on the highway, with an average of 26 MPG. The PEV Ford Fusion Energy has a miles per gallon equivalent (MPGe) rating of 109 in the city and 97 on the highway, with an average of 103 MPGe. According to Ford, approximately 33.7 kWh equals one gallon of gasoline in terms of power output.[8] Given this, the cost of gasoline and cost of charge per year, based on 10,000 miles driven per year, were calculated to be $1,276.15 and $858.99, respectively (Figure 1). The difference between the two is $417.16, in favor of the PEV version. The assumption of 10,000 miles was chosen because it is the most standard lease mileage option – assumed to be the most common amount driven in a year.

Figure 1. Cost to drive

Standard Ford Fusion		**Ford Fusion Energi (PEV)**	
Final Upfront Cost	$22,840.00	Final Upfront Cost	$26,940.00
Gasoline Price in CA	$3.32	kWh Price in CA	$0.255
Average MPG	26	Average MPGe	103
Gallons per yr. (10,000mi)	384.615	kWh per yr. (10,000mi)	3370
Cost of Gas / yr.	$1,276.15	Cost of Charge per yr.	$858.99

Difference in Cost to Drive	$417.16
Difference of Vehicle Upfront Cost	$4,100.00

To make up for the large upfront cost difference through savings on the cost of driving over the years, it would take approximately 9.8 years to break even. However, the average length of vehicle ownership in America – according to Kelly Blue Book[9] – is approximately 5.95 years. This suggests that higher upfront

[6] "California: State Profile and Energy Estimates," U.S. Energy Information Administration https://www.eia.gov/state/?sid=CA

[7] Ibid.

[8] https://www.ford.com/

[9] KBB, "Average length of US vehicle ownership hit an all-time high," Feb 2012. https://www.kbb.com/car-news/all-the-latest/average-length-of-us-vehicle-ownership-hit-an-all_time-high/2000007854/

cost may not be justified for the average consumer. Furthermore, given that there is an opportunity cost to this initial upfront amount of $4,100.00 – which could only be redeemed in 9.8 years in the future, there may not be a great-enough incentive to make the switch to PEVs for the average consumer.

Evaluation of the target goal of the 2018 ZEV Action Plan:

To evaluate whether the target goal of the 2018 ZEV Action Plan is feasible, the current number of ZEVs, including battery electric and plug-in hybrid vehicles, with respect to the total number of vehicles in California was acquired for 2018 via the database provided by the California DMV.[10] As of January 2018, there were 174,203 pure battery vehicles; 1,010,715 hybrid gas vehicles; and 159,564 plug-in hybrid vehicles. The combined number of these ZEV types was 1,344,482. The total number of vehicles registered in the state of California was 29,785,667; hence, only 4.51% of vehicles were ZEV as of 2018 (Figure 2). However, it is worth noting that hybrid gas vehicles, although hybrids, may technically not be considered a ZEV.[11] If this class of vehicles was excluded, then only 1.12% of vehicles were ZEV as of 2018.

Figure 2. DMV Vehicle Registration by Type, January 2018

Number of Battery Electric Vehicles (BEV) in CA	174,203
Number of Hybrid Gas in CA	1,344,482
Number of Plug-in Hybrid Vehicles in CA	159,564
Total ZEVs in CA	1,344,482
Total Number of Vehicles in CA	29,785,667

Acquisition of historical vehicle sales and/or registration in California alone was unsuccessful in the allotted time of this endeavor. However, the historical data on vehicle sales for the entire United States, from 1951 to 2017, was obtained.[12] The year-to-year percent change was calculated; the average year-to-year percent change from 1951 to 2017 was 0.647%. Assuming similar percent change in California (big assumption), it can be projected that by year 2025 and 2030, there will be a total of 31.3 million and 32.3 million vehicles, respectively. Then, the goal of 1.5 million PEVs by 2025 would be 4.79% and that of 5 million by 2030 would be 15.48%.

[10] "California Motor Vehicle Fuel Types by City," State of California Department of Motor Vehicle, Chttps://www.dmv.ca.gov/portal/dmv/detail/pubs/media_center/statistics

[11] "The Zero Emission Vehicle (ZEV) Regulation," California Air Resources Board, https://arb.ca.gov/msprog/zevprog/factsheets/zev_regulation_factsheet_082418.pdf

[12] "U.S. Car Sales from 1951-2017," Statista, https://www.statista.com/statistics/199974/us-car-sales-since-1951/

Conclusion

It seems feasible to achieve the 2025 target goal if hybrid gas vehicles were included in their calculus. The initial efforts to push for increased sales of ZEVs began in 1990. In the last 28-year period, 1.3 million ZEVs if including gas hybrids and 333,767 ZEVs if excluding gas hybrids have been registered in California. With the aforementioned lack of incentive to make the switch for the average consumer, reaching the target seems unlikely unless a very aggressive implementation leads to a significant reduction in the upfront cost and cost to drive ZEVs.

Moreover, with the rise of 'Uber', 'Lyft', and car-sharing models like 'Zipcar', vehicle sales may see even less of a growth (plateau, if not even a decrease in the foreseeable future), which would also decrease the sales of ZEVs. In such scenario, the demand for crude oil will likely remain steady since drivers of these vehicles, who are eager to make a profit, would likely not invest in a higher upfront cost that would take close to 10 years to break even. Moreover, given the expected increased mileage driven per vehicle (with reduced overall vehicle on the road through car-sharing models), the length of vehicle ownership would also likely decrease, making ZEVs less favorable.

At present and near future, it is unlikely that the demand for crude oil will change drastically. The upfront cost is too high and the cost to drive throughout the lifespan of the vehicle remains not low enough (a consumer would need to drive the same vehicle for approximately 10 years to break even from the upfront cost). Moreover, with the rise of car-sharing business models, vehicle sales – including ZEVs – may not increase as rapidly as expected by the 2018 ZEV Action Plan.