Attachment 7 Economic Analysis – Flood Damage Reduction Costs and Benefits: Sunnydale Flood and Stormwater Management Sewer Improvement Project

PSP Requirements **Page**

Introduction

This attachment describes the flood damage reduction benefits provided by the Sunnydale flood and Stormwater Management Sewer Improvement Project (Sunnydale project). The auxiliary tunnel that will be installed as part of the Sunnydale project has a tributary drainage area of approximately 720 acres. Because the existing sewer system in this drainage area only has the capacity to convey approximately 40% of the peak flows generated from the 5-year storm event, much of the entire drainage area has been subject to repeated flooding. The area where flooding has occurred historically is shown in **Figure 1**. In total from 1987 through 2006, there were a total of 162 logged flooding complaints in the Sunnydale area[1].

Figure 1. General Location of Sunnydale Neighborhood Flooding Events

[1] San Francisco Planning Department, 2010."Mitigated Negative Declaration for the Sunnydale Sewer Improvement Project"

This project will increase reliability of the combined sewer system to:

- Ensure that the sewer system will contain flows from a 5-year design storm, leading to the improvement of hydraulic capacity to minimize potential flooding and maximize hydraulic grade line control.
- Address the increased storm activity associated with climate change and minimize potential flooding in the project area.
- Provide a dry weather (sanitary) flow bypass for future repair and rehabilitation work on the existing sewer.
- Reduce the volume of combined sewer discharges into San Francisco Bay.

Project Economic Costs

Capital costs for the project amount to $60,075,000 (2009 Dollars). Of this total, $3,214,000 are considered sunk costs and not included in this analysis. The initial costs of the project are $56,861,000, split among four years from 2010 through 2013. Once the sewer pipeline is in place and operational in 2013, a routine sewer inspection cost of $10,000 every 5 years and a sewer cleaning cost of $640,000 every 10 years is anticipated. The sewer cleaning cost is based on the San Francisco Public Utilities Commission's (SFPUC) estimates of cleaning costs for other similar sized sewers and is estimated at $90 per linear foot. Over the 75-year anticipated lifetime of the sewer, the present value costs amount to $50.6 million, as shown in **Table 1** in the following page.

Project Expected Flood Damage Reduction Benefits

Expected flood damage reduction benefits are based on an analysis of the extent and depth of flooding for 5-year[2], 10-year[3], and 25-year[4] design storms under without- and with-project conditions. Flood boundaries, flood depths, and impacted streets and properties were evaluated using San Francisco Public Utilities Commission's (SFPUC) citywide wastewater collection system simulation model.

The citywide model is a fully dynamic, continuous simulation hydraulic and hydrologic model developed in InfoWorks Collection System software. The model was initially developed in 2005 as part of San Francisco's Sewer System Master Plan and has continuously been updated and refined since that time through an ongoing process of database development, quality control reviews, calibration, and validation. The model is utilized by the SFPUC and the City's hydraulic engineers to analyze the expected performance of proposed improvement projects in San Francisco. Additional description of the model is provided in the report on Model Development, Validation and Baseline.[5]

For the flood damage analysis, the most current version of the citywide model was utilized to evaluate collection system performance during San Francisco's 5-, 10-, and 25-year, 24 hour design storms. After running the baseline model to establish pre-project conditions, the model was updated with the proposed projects and re-run to establish post-project conditions. In areas where the model predicted flooding, a digital terrain model of San Francisco's ground topography was utilized within the collection

[2] 5-year, 24-hour storm has a total depth of 3.19 inches and a peak 5-minute intensity of 2.90 inches/hour.
[3] 10-year, 24-hour storm has a total depth of 3.80 inches and a peak 5-minute intensity of 3.35 inches/hour.
[4] 25-year, 24-hour storm has a total depth of 3.96 inches and a peak 5-minute intensity of 3.83 inches/hour.
[5] SFPUC, 2007. Model Development, Validation and Baseline Report. Final Draft. October 2007.

system model to determine the spatial extent and depth of the flooding. The results of the hydraulic modeling were then used with DWR's F-RAM model to estimate expected annual flood damages under the without- and with-project conditions.

Table 1: Annual Cost of Sunnydale Flood and Stormwater Management Sewer Improvement Project

Annual Cost of Flood Damage Reduction Project (All costs in 2009 Dollars) Project: Sunnydale Flood and Stormwater Management Sewer Improvement Project									
	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost From Table 6 (A)	Admin	Operation	Maintenance	Replacement	Other	Total Costs	Discount Factor	Discounted Costs
2009	$0						$0	1.000	$0
2010	$7,865,000						$7,865,000	0.943	$7,419,811
2011	$32,112,000						$32,112,000	0.890	$28,579,566
2012	$11,523,000						$11,523,000	0.840	$9,674,933
2013	$5,361,000						$5,361,000	0.792	$4,246,414
2014							$0	0.747	$0
2015							$0	0.705	$0
2016							$0	0.665	$0
2017							$0	0.627	$0
2018				$10,000			$10,000	0.592	$5,919
2019							$0	0.558	$0
2020							$0	0.527	$0
2021							$0	0.497	$0
2022							$0	0.469	$0
2023				$650,000			$650,000	0.442	$287,496
2024							$0	0.417	$0
2025							$0	0.394	$0
2026							$0	0.371	$0
2027							$0	0.350	$0
2028				$10,000			$10,000	0.331	$3,305
2029							$0	0.312	$0
2030							$0	0.294	$0
2031							$0	0.278	$0
2032							$0	0.262	$0
2033				$650,000			$650,000	0.247	$160,536
2034							$0	0.233	$0
2035							$0	0.220	$0
2036							$0	0.207	$0
2037							$0	0.196	$0
2038				$10,000			$10,000	0.185	$1,846
2039							$0	0.174	$0
2040							$0	0.164	$0
2041							$0	0.155	$0
2042							$0	0.146	$0
2043				$650,000			$650,000	0.138	$89,642
2044							$0	0.130	$0
2045							$0	0.123	$0
2046							$0	0.116	$0
2047							$0	0.109	$0
2048				$10,000			$10,000	0.103	$1,031
2049							$0	0.097	$0
2050							$0	0.092	$0
2051							$0	0.087	$0
2052							$0	0.082	$0
2053				$650,000			$650,000	0.077	$50,056
2054							$0	0.073	$0
2055							$0	0.069	$0
2056							$0	0.065	$0
2057							$0	0.061	$0
2058				$10,000			$10,000	0.058	$575
2059							$0	0.054	$0
2060							$0	0.051	$0

Table continues on following page

2061							$0	0.048	$0
2062							$0	0.046	$0
2063				$650,000			$650,000	0.043	$27,951
2064							$0	0.041	$0
2065							$0	0.038	$0
2066							$0	0.036	$0
2067							$0	0.034	$0
2068				$10,000			$10,000	0.032	$321
2069							$0	0.030	$0
2070							$0	0.029	$0
2071							$0	0.027	$0
2072							$0	0.025	$0
2073				$650,000			$650,000	0.024	$15,608
2074							$0	0.023	$0
2075							$0	0.021	$0
2076							$0	0.020	$0
2077							$0	0.019	$0
2078				$10,000			$10,000	0.018	$179
2079							$0	0.017	$0
2080							$0	0.016	$0
2081							$0	0.015	$0
2082							$0	0.014	$0
2083				$650,000			$650,000	0.013	$8,715
2084							$0	0.013	$0
2085							$0	0.012	$0
2086							$0	0.011	$0
2087							$0	0.011	$0
Project Life								…	
								Total Present Value of Discounted Costs (Sum of Column (i))	$50,573,905
								Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries	

Comments:
(A) Column (a) excludes $3,214,000 of sunk project costs that are included in Table 6 Project Budget.
(B) Assumed Inspection Cost of $10,000 per inspection every 5 years
(C) Assumed cleaning costs of $640,000 for approximately 7,200 LF of sewer once every 10 years.

(1) The incremental change in O&M costs attributable to the project.

Hydraulic Modeling of 5-, 10-, and 25-Year Storm Events

The hydraulic modeling results for the three design storms are summarized in **Table 2**. Flood maps corresponding to the modeling results are shown in **Figures 2**, **3**, **and 4**. Expected impacts for the three design storms under without- and with-project conditions are as follows:

- Under the without-project condition, the 5-year design storm is predicted to inundate 30.8 acres of highly urbanized and densely populated area, impacting up to 160 residential properties, 8 commercial properties, 3 industrial properties and 6 cultural/educational properties. While most of these properties are predicted to experience flood depths of one-half foot or less, 28 may be flooded to depths of 2 feet, and 15 may be flooded to depths greater than 2 feet. Additionally, 2,880 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, no significant flooding is indicated by the hydraulic modeling.
- Under the without-project condition, the 10-year design storm is predicted to inundate 38.3 acres of highly urbanized and densely populated area, impacting up to 174 residential properties, 8 commercial properties, 4 industrial properties and 6 cultural/educational properties. Of these impacted properties, 32 may be flooded to depths of 2 feet, and 19 may be flooded to depths greater than 2 feet. Additionally, 3,100 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, no significant flooding is indicated by the hydraulic modeling.
- The 25-year design storm is predicted to inundate 42.5 acres of highly urbanized and densely populated area, impacting up to 188 residential properties, 8 commercial properties, 4 industrial

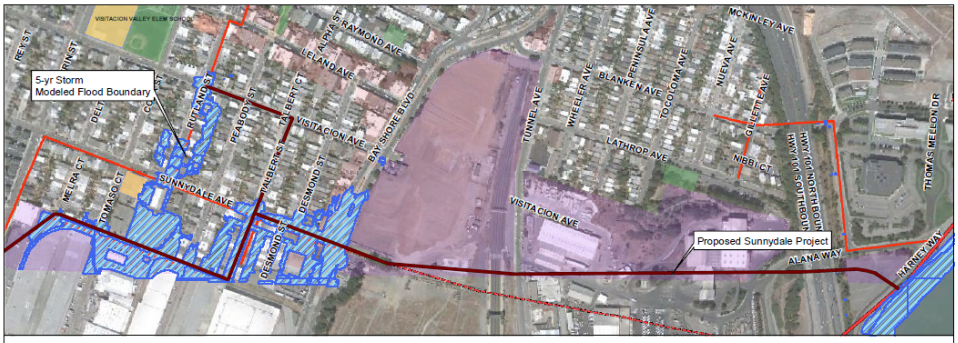
properties and 6 cultural/educational properties. Of these impacted properties, 58 may be flooded to depths of 2 feet, and 29 may be flooded to depths greater than 2 feet. Additionally, 3,320 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, no significant flooding is indicated by the hydraulic modeling.

Table 2: Summary of Hydraulic Modeling for Without- and With Project Conditions Under Three Design Storms

Flooding Parameter	5yr Storm		10 yr Storm		25yr Storm	
	Pre-Project	Post-Project	Pre-Project	Post-Project	Pre-Project	Post-Project
Flooded Area						
Total Flooded Area (acres)	30.8	0.001	38.3	0.002	42.5	0.004
Number of Lots with Flooding						
Residential	160	0	174	0	188	0
Cultural/Educational[(1)]	6	0	6	0	6	0
Commercial[(2)]	8	0	8	0	8	1
Industrial[(3)]	3	0	4	0	4	0
Totals (# of lots)	***177***	***0***	***192***	***0***	***206***	***1***
Number of Lots by Max Flood Depth						
Depth < 0.5 ft	134	0	141	0	119	1
Depth 0.5 to 2 ft	28	0	32	0	58	0
Depth > 2ft	15	0	19	0	29	0
Totals (# of lots)	***177***	***0***	***192***	***0***	***206***	***1***
Linear Feet of Street Flooding						
Tomaso Ct.	95	0	105	0	115	0
Peabody St.	110	0	145	0	185	0
Talbert St.	460	0	475	0	485	0
Desmond St.	400	0	425	0	445	0
Rutland St.	485	0	500	0	530	0
Sunnydale Ave.	710	0	800	0	880	0
Bayshore Blvd.	620	5	650	10	680	15
Totals (ft)	***2,880***	***5***	***3,100***	***10***	***3,320***	***15***

Notes:
(1) Cultural/Educational facilities in the flooded area consist of the four buildings (six lots) associated with the Church of Visitacion and Our Lady of Visitacion School.
(2) Commercial and mixed-use retail facilities in the flooded area include A. Silvestri statue store, Happy Donuts, Smog Test Station, etc.
(3) Industrial facilities in the flooded area include former Schlage Lock Site (site of the proposed Visitacion Valley Redevelopment Plan), TW Automotive, USPS Warehouse, and See's Candy Factory.

Figure 2: Sunnydale Project – Predicted Flood Boundary for 5-yr Storm



Modeling Prediction of 5 Year Storm Flood Boundary - Pre-Project Conditions

Modeling Prediction of 5 Year Storm Flood Boundary - Post-Project Conditions

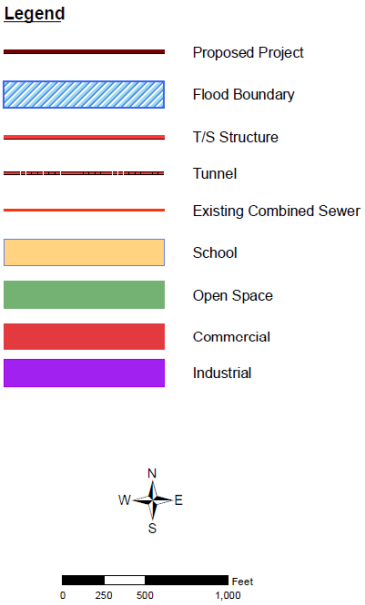


Figure 3: Sunnydale Project – Predicted Flood Boundary for 10-yr Storm

Modeling Prediction of 10 Year Storm Flood Boundary - Pre-Project Conditions

Modeling Prediction of 10 Year Storm Flood Boundary - Post-Project Conditions

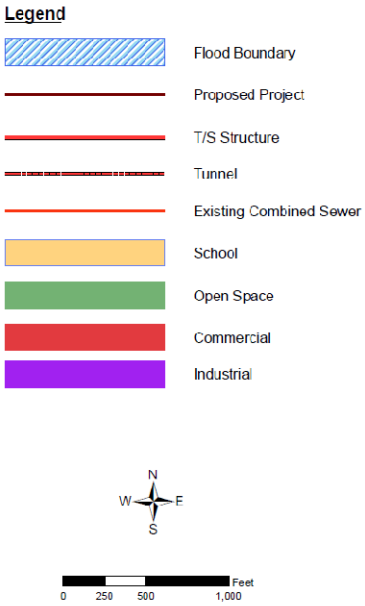
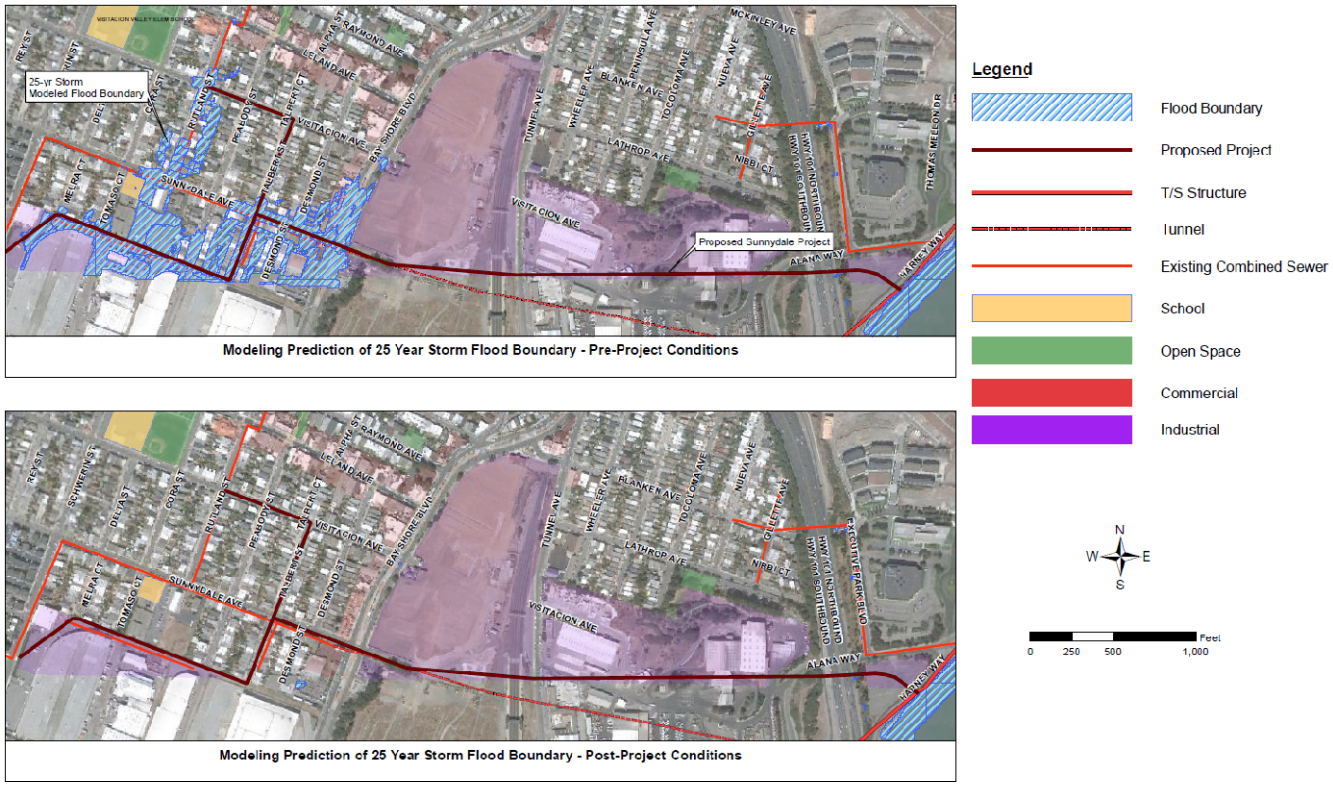


Figure 4: Sunnydale Project – Predicted Flood Boundary for 25-yr Storm



F-RAM Expected Annual Damages for Without- and With-Project Conditions

Expected annual flood damage for the without- and with-project conditions were estimated with the F-RAM model. Utilization of the F-RAM model required the following inputs for with and without-project conditions:

- Number of flooded residential properties for each design storm.
- Average flood depth of flooded residential properties for each design storm.
- Square feet of flooded commercial properties for each design storm.
- Square feet of flooded industrial properties for each design storm.
- Linear miles of flooded arterial, major, minor, and unsealed roads for each design storm.
- Ratio of depreciated value to replacement value for residential, commercial, and industrial structures.

F-RAM model inputs, other than the ratio of depreciated value to replacement value, were constructed from the hydraulic modeling results and are summarized in **Table 3**. The following should be kept in mind when reviewing Table 3:

- Flood depths are relative to ground level, per F-RAM input requirements. To calculate structure and content damages, the F-RAM model makes assumptions about average foundation height for residential, commercial, and industrial structures.

- The average flood depth is based on parcels experiencing positive amounts of flooding for a given design storm. Parcels within the flood zone not experiencing flooding were excluded from the calculation of flood depth. Likewise, the count of impacted residential properties and calculation of impacted commercial and industrial structure area are based only on parcels experiencing positive amounts of flooding for a given design storm. Parcels not experiencing positive depths of flooding were excluded from the property counts and area calculations.
- The square footage of inundated structures on commercial and industrial parcels was estimated using Google Earth Pro.
- F-RAM's medium structure value setting was used to calculate damages for commercial and industrial properties.
- The flooded streets listed in Table 2 were classified as arterial, major, or minor using the City's official road classifications. Any damages to unsealed roads on private commercial or industrial parcels were assumed to be covered by F-RAM's damage estimates for commercial and industrial properties and thus were not included in the tally of inundated roads miles.

Table 3: Summary of F-RAM Model Inputs

	Without-Project Condition			With-Project Condition		
	5-Yr	10-Yr	25-Yr	5-Yr	10-Yr	25-Yr
Residential						
No. of Flooded Properties	34	39	69	0	0	0
Average Flood Depth (ft)	2.50	2.60	2.10	0.00	0.00	0.00
Commercial						
Structure Area Flooded (Sqft)	32,843	51,149	68,394	0	0	0
Average Flood Depth (ft)	1.60	1.60	1.50	0.00	0.00	0.00
Industrial						
Structure Area Flooded (Sqft)	8,442	8,442	42,762	0	0	0
Average Flood Depth (ft)	3.20	3.20	2.00	0.00	0.00	0.00
Inundated Roads (mi)						
Arterial	0.117	0.123	0.129	0.001	0.002	0.003
Major	0.428	0.464	0.500	0.000	0.000	0.000
Minor	0.000	0.000	0.000	0.000	0.000	0.000
Unsealed	0.000	0.000	0.000	0.000	0.000	0.000

Two other model input assumptions require comment. The first concerns the ratio of depreciated value to replacement value. The second concerns F-RAM's default depth-to-damage curve for residential property.

1. F-RAM uses default assumptions for replacement cost per square foot to calculate structure and content damages for residential, commercial, and industrial properties. Because economic damages are to be based on depreciated value rather than replacement costs, F-RAM requires the user to enter the ratio of depreciated value to replacement value. However, there is no reliable data source for such an estimate. Depreciated book value would be meaningless in this context, for example, because structures are constantly being repaired and improved at varying rates. Thus, the depreciated value for structures of the same vintage should be expected to vary widely. Additionally, F-RAM's default replacement costs are low relative to costs of construction in the City of San Francisco. **Table 4** compares the F-RAM defaults to RSMean's 2010 dollars-per-square-foot construction costs for San Francisco. Given San Francisco's higher costs of construction, using the F-RAM defaults and setting the model's depreciation-value-to-replacement-cost ratio to 1.0 is equivalent to assuming the depreciation-value-to-replacement-cost ratios shown in the last column of the table, which are deemed to be sufficiently conservative for the estimation of flood damage reduction benefits.

Table 4: F-RAM Structure Replacement Costs Compared to Costs in Project Area

Building Type	F-RAM Default (2009 $)	RSMeans 2010 Estimate (2009 $)	Equivalent Depreciation Ratio
Residential Detached	$155	$300	0.52
Apartment Building	$155	$195	0.79
Commercial Office (2-4 stories)*	$142	$212	0.67
*F-RAM medium value estimate for commercial property.			

2. The F-RAM model uses depth-to-damage curves to estimate damages as a function of flood depth. Two separate curves are used for each building type, one to estimate structural damage and one to estimate contents damage. For residential structures, F-RAM can differentiate between structures with and without basements. By default, F-RAM assumes residential structures do not have basements. However, most of the residential structures in the flood zone for this project do have basements and basement flooding is expected to exacerbate damages to building contents. Therefore, residential content damages are calculated using F-RAM's depth-to-damage curve for residential structures with basements rather than the default setting, which assumes no basements.[6]

Calculated event damages for the three design storms under without- and with-project conditions are summarized in **Table 5**. Because the project is designed to reduce flooding associated with stormwater overflow, the damage amounts shown in Table 5 do not assume mitigation of flood damage due to advanced warning, as per F-RAM's model documentation and guidance.

[6]Since basement flooding is not anticipated to result in substantially worse structural damages, F-Ram's default (no basements) depth-to-damage curve for structural damage is used to calculate residential structural damage.

Table 5: F-RAM Damage Estimates for Three Design Storms

Event Damages (2009$)	Without-Project Condition			With-Project Condition		
	5-Yr	10-Yr	25-Yr	5-Yr	10-Yr	25-Yr
Residential						
Structural	$2,393,236	$2,745,183	$4,856,862	$0	$0	$0
Contents	$1,941,295	$2,226,779	$3,939,686	$0	$0	$0
Cleanup/External	$306,000	$351,000	$621,000	$0	$0	$0
Commercial						
Structural	$186,548	$290,526	$388,478	$0	$0	$0
Contents	$0	$0	$0	$0	$0	$0
Industrial						
Structural	$155,839	$155,839	$546,498	$0	$0	$0
Contents	$899,073	$899,073	$4,371,987	$0	$0	$0
Com/Ind Cleanup/External	$102,716	$133,910	$280,493	$0	$0	$0
Roads						
Arterial	$29,356	$30,777	$32,197	$237	$473	$710
Major	$42,803	$46,402	$50,000	$0	$0	$0
Indirect Damages	$1,514,217	$1,719,872	$3,771,800	$59	$118	$178
Total Estimated Damages	$7,571,083	$8,599,360	$18,859,001	$296	$592	$888

Figure 5 shows the loss-probability curves for the without- and with-project conditions from which F-RAM calculates expected annual damages (EAD). The expected annual flood damage reduction benefit is the area between the two loss-probability curves. This amount, shown in **Table 6**, is $2,386,509.

Figure 5: Sunnydale Project Flood Damage Loss-Probability Curves

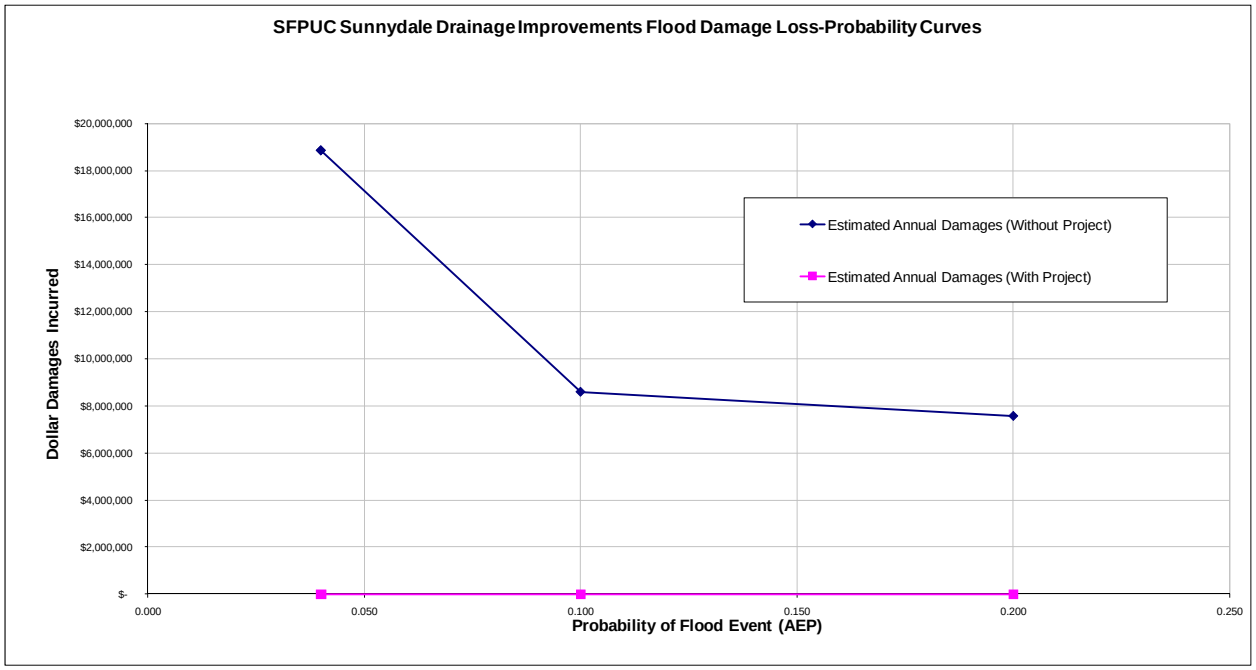


Table 6: Sunnydale Project Expected Annual Flood Damage Reduction

Expected Annual Damage	Dollar Amount (2009 $)
Without-Project Condition	$2,386,633
With-Project Condition	$124
Expected Annual Flood Damage Reduction	*$2,386,509*

Present Value of Expected Annual Flood Damage Reduction

The Sunnydale project is assumed to have a useful life of 75 years. This is the mid-point of SFPUC's 50 to 100 year useful life range assumed for sewer projects. It is worth noting that many of the sewers in operation in the City are over 100 years old. Thus the useful life assumption is conservative relative to historical experience. Flood damage reduction benefits are assumed to commence in 2013 when the project is scheduled to be operational. The present value of annual flood damage reduction benefits in 2009, summarized in **Table 7**, is $32,973,550.[7,8]

[7] Present value calculations are based on a 6% discount rate, per PSP requirements.
[8] Table 7 is substituted for Table 12 of Exhibit E of the PSP Application, which incorrectly calculates the present value of flood damage reduction benefits by assuming that project benefits commence in 2009, which clearly is

Table 7: Present Value of Annual Flood Damage Reduction

Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual	Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual
2009	1.000	$ -	$ -	2049	0.097	$ 2,386,509	$ 232,022
2010	0.943	$ -	$ -	2050	0.092	$ 2,386,509	$ 218,888
2011	0.890	$ -	$ -	2051	0.087	$ 2,386,509	$ 206,498
2012	0.840	$ -	$ -	2052	0.082	$ 2,386,509	$ 194,810
2013	0.792	$ 2,386,509	$ 1,890,338	2053	0.077	$ 2,386,509	$ 183,783
2014	0.747	$ 2,386,509	$ 1,783,338	2054	0.073	$ 2,386,509	$ 173,380
2015	0.705	$ 2,386,509	$ 1,682,395	2055	0.069	$ 2,386,509	$ 163,566
2016	0.665	$ 2,386,509	$ 1,587,165	2056	0.065	$ 2,386,509	$ 154,308
2017	0.627	$ 2,386,509	$ 1,497,325	2057	0.061	$ 2,386,509	$ 145,573
2018	0.592	$ 2,386,509	$ 1,412,571	2058	0.058	$ 2,386,509	$ 137,333
2019	0.558	$ 2,386,509	$ 1,332,614	2059	0.054	$ 2,386,509	$ 129,560
2020	0.527	$ 2,386,509	$ 1,257,183	2060	0.051	$ 2,386,509	$ 122,226
2021	0.497	$ 2,386,509	$ 1,186,022	2061	0.048	$ 2,386,509	$ 115,308
2022	0.469	$ 2,386,509	$ 1,118,888	2062	0.046	$ 2,386,509	$ 108,781
2023	0.442	$ 2,386,509	$ 1,055,555	2063	0.043	$ 2,386,509	$ 102,623
2024	0.417	$ 2,386,509	$ 995,807	2064	0.041	$ 2,386,509	$ 96,815
2025	0.394	$ 2,386,509	$ 939,440	2065	0.038	$ 2,386,509	$ 91,334
2026	0.371	$ 2,386,509	$ 886,264	2066	0.036	$ 2,386,509	$ 86,165
2027	0.350	$ 2,386,509	$ 836,099	2067	0.034	$ 2,386,509	$ 81,287
2028	0.331	$ 2,386,509	$ 788,772	2068	0.032	$ 2,386,509	$ 76,686
2029	0.312	$ 2,386,509	$ 744,125	2069	0.030	$ 2,386,509	$ 72,345
2030	0.294	$ 2,386,509	$ 702,004	2070	0.029	$ 2,386,509	$ 68,250
2031	0.278	$ 2,386,509	$ 662,268	2071	0.027	$ 2,386,509	$ 64,387
2032	0.262	$ 2,386,509	$ 624,781	2072	0.025	$ 2,386,509	$ 60,743
2033	0.247	$ 2,386,509	$ 589,416	2073	0.024	$ 2,386,509	$ 57,304
2034	0.233	$ 2,386,509	$ 556,053	2074	0.023	$ 2,386,509	$ 54,061
2035	0.220	$ 2,386,509	$ 524,579	2075	0.021	$ 2,386,509	$ 51,001
2036	0.207	$ 2,386,509	$ 494,885	2076	0.020	$ 2,386,509	$ 48,114
2037	0.196	$ 2,386,509	$ 466,873	2077	0.019	$ 2,386,509	$ 45,390
2038	0.185	$ 2,386,509	$ 440,446	2078	0.018	$ 2,386,509	$ 42,821
2039	0.174	$ 2,386,509	$ 415,515	2079	0.017	$ 2,386,509	$ 40,397
2040	0.164	$ 2,386,509	$ 391,996	2080	0.016	$ 2,386,509	$ 38,111
2041	0.155	$ 2,386,509	$ 369,807	2081	0.015	$ 2,386,509	$ 35,953
2042	0.146	$ 2,386,509	$ 348,875	2082	0.014	$ 2,386,509	$ 33,918
2043	0.138	$ 2,386,509	$ 329,127	2083	0.013	$ 2,386,509	$ 31,998
2044	0.130	$ 2,386,509	$ 310,497	2084	0.013	$ 2,386,509	$ 30,187
2045	0.123	$ 2,386,509	$ 292,922	2085	0.012	$ 2,386,509	$ 28,479
2046	0.116	$ 2,386,509	$ 276,341	2086	0.011	$ 2,386,509	$ 26,867
2047	0.109	$ 2,386,509	$ 260,699	2087	0.011	$ 2,386,509	$ 25,346
2048	0.103	$ 2,386,509	$ 245,943	**Total Benefits:**		**$ 178,988,158**	**$ 32,973,550**

impossible. The present value shown in Table 7 is transferred to Table 20 of Exhibit E of the PSP Application. This modification was discussed with and approved by Lorraine Marsh of DWR on March 29, 2011.

Expected Annual Costs of Flood-Related Traffic Delay

Table 8 summarizes traffic flows on streets within the flood zone in the Sunnydale/Visitacion neighborhood expected to be impacted by flooding under the three design storms. The average volume of traffic per hour is approximately 1,700 vehicles per day, with average hour vehicle occupancy in excess of 1,900 persons.[9] The economic cost per hour of traffic delay, measured in terms of lost consumer surplus, is estimated to exceed $26,000.[10]

Table 8: Sunnydale Area Traffic Volumes

Primary Street	Cross Street	Volume (Vehicles per day)	Avg Hour Volume	Avg Hour Occupancy	Cost Per Hour of Delay
Visitacion*	Rutland	3,985	166	189	$2,629
Sunnydale	Rutland	3,985	166	189	$2,629
Sunnydale	Sawyer	2,268	95	108	$1,496
Bayshore Blvd	Sunnydale	21,594	900	1,026	$14,245
Bus Routes**		9,754	406	406	$5,644
TOTAL		**41,586**	**1,733**	**1,918**	**$26,643**
*Visitacion and Rutland volume estimated based on Sunnydale Volume					
*Volume for bus routes expressed in passengers per day.					

The cost of traffic delay due to localized flooding is a function of the average amount of delay caused. It is anticipated that some vehicles will experience significant delays while others will be able to take alternative routes and experience little or no delay. For the purpose of calculating impacts, the following average delay times shown in **Table 9** were assumed.

Table 9: Average Traffic Delay Times for Three Design Storms

Design Storm	Without Project		With Project	
	Avg Traffic Delay (hrs)	Economic Cost	Avg Traffic Delay (hrs)	Economic Cost
5-year	0.50	$13,322	0.0	$0
10-year	1.00	$26,643	0.0	$0
25-year	1.50	$39,965	0.0	$0

Figure 6 shows the loss-probability curves for the without- and with-project conditions from which expected annual costs of traffic delay were calculated. The expected annual benefit of avoided traffic delay is the area between the two loss-probability curves. This amount, shown in **Table 10**, is $3,996.

[9] Based on an average vehicle occupancy of 1.14, per San Francisco Planning Department, Downtown Plan: Annual Monitoring Report 2009.

[10] Based on the U.S. Department of Transportation's recommended value of $13.89/hr (2009 $) for travel time for surface modes of transportation. The estimate is a weighted average of personal and business travel using the following distribution of travel by trip purpose: 94.4% personal, 5.6% business. U.S. Department of Transportation, "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis," February 11, 2003.

Figure 6: Sunnydale Project Traffic Delay Loss-Probability Curves

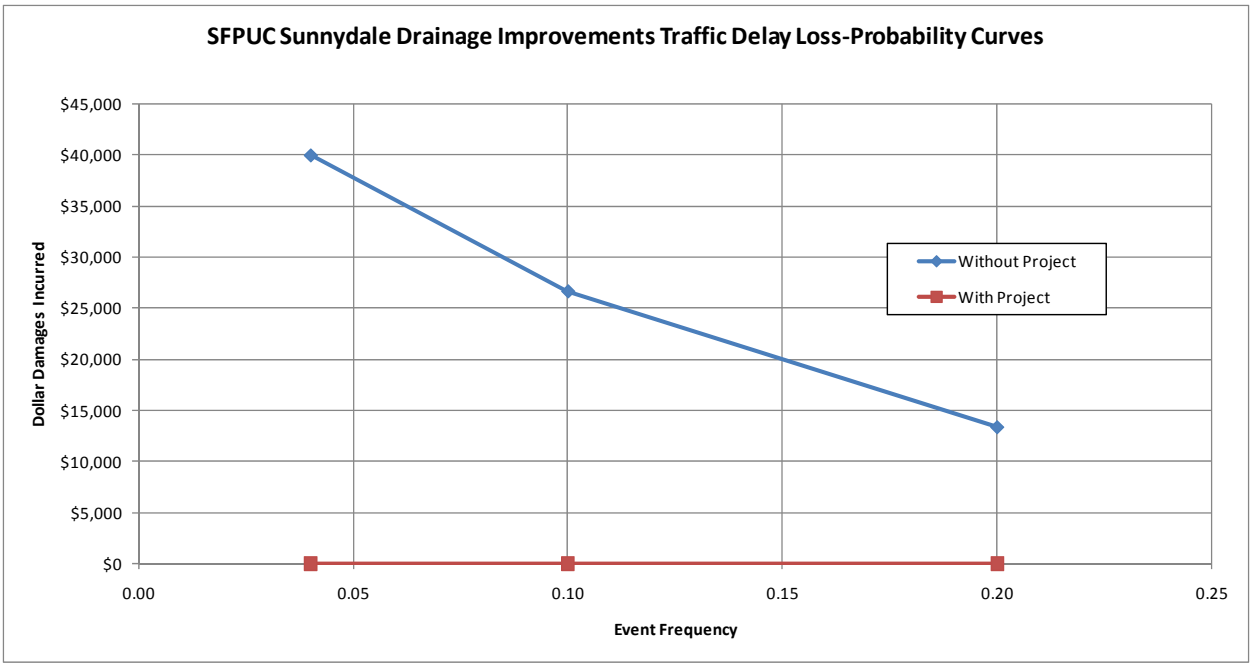


Table 10: Sunnydale Project Expected Annual Traffic Delay Reduction

Expected Annual Cost of Traffic Delay	Dollar Amount (2009 $)
Without-Project Condition	$3,996
With-Project Condition	$0
Expected Annual Traffic Delay Reduction Benefit	*$3,996*

Present Value of Expected Annual Traffic Delay Reduction Benefits

Traffic delay reduction benefits are assumed to commence in 2013 when the project is scheduled to be operational. The present value of annual traffic delay reduction benefits in 2009, summarized in **Table 11**, is $55,218.[11]

[11] The present value shown in Table 11 is transferred to Table 20 of Exhibit E of the PSP Application.

Table 11: Present Value of Traffic Delay Reduction Benefits

Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual	Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual
2009	1.000	$ -	$ -	2049	0.097	$ 3,996	$ 389
2010	0.943	$ -	$ -	2050	0.092	$ 3,996	$ 367
2011	0.890	$ -	$ -	2051	0.087	$ 3,996	$ 346
2012	0.840	$ -	$ -	2052	0.082	$ 3,996	$ 326
2013	0.792	$ 3,996	$ 3,166	2053	0.077	$ 3,996	$ 308
2014	0.747	$ 3,996	$ 2,986	2054	0.073	$ 3,996	$ 290
2015	0.705	$ 3,996	$ 2,817	2055	0.069	$ 3,996	$ 274
2016	0.665	$ 3,996	$ 2,658	2056	0.065	$ 3,996	$ 258
2017	0.627	$ 3,996	$ 2,507	2057	0.061	$ 3,996	$ 244
2018	0.592	$ 3,996	$ 2,366	2058	0.058	$ 3,996	$ 230
2019	0.558	$ 3,996	$ 2,232	2059	0.054	$ 3,996	$ 217
2020	0.527	$ 3,996	$ 2,105	2060	0.051	$ 3,996	$ 205
2021	0.497	$ 3,996	$ 1,986	2061	0.048	$ 3,996	$ 193
2022	0.469	$ 3,996	$ 1,874	2062	0.046	$ 3,996	$ 182
2023	0.442	$ 3,996	$ 1,768	2063	0.043	$ 3,996	$ 172
2024	0.417	$ 3,996	$ 1,668	2064	0.041	$ 3,996	$ 162
2025	0.394	$ 3,996	$ 1,573	2065	0.038	$ 3,996	$ 153
2026	0.371	$ 3,996	$ 1,484	2066	0.036	$ 3,996	$ 144
2027	0.350	$ 3,996	$ 1,400	2067	0.034	$ 3,996	$ 136
2028	0.331	$ 3,996	$ 1,321	2068	0.032	$ 3,996	$ 128
2029	0.312	$ 3,996	$ 1,246	2069	0.030	$ 3,996	$ 121
2030	0.294	$ 3,996	$ 1,176	2070	0.029	$ 3,996	$ 114
2031	0.278	$ 3,996	$ 1,109	2071	0.027	$ 3,996	$ 108
2032	0.262	$ 3,996	$ 1,046	2072	0.025	$ 3,996	$ 102
2033	0.247	$ 3,996	$ 987	2073	0.024	$ 3,996	$ 96
2034	0.233	$ 3,996	$ 931	2074	0.023	$ 3,996	$ 91
2035	0.220	$ 3,996	$ 878	2075	0.021	$ 3,996	$ 85
2036	0.207	$ 3,996	$ 829	2076	0.020	$ 3,996	$ 81
2037	0.196	$ 3,996	$ 782	2077	0.019	$ 3,996	$ 76
2038	0.185	$ 3,996	$ 738	2078	0.018	$ 3,996	$ 72
2039	0.174	$ 3,996	$ 696	2079	0.017	$ 3,996	$ 68
2040	0.164	$ 3,996	$ 656	2080	0.016	$ 3,996	$ 64
2041	0.155	$ 3,996	$ 619	2081	0.015	$ 3,996	$ 60
2042	0.146	$ 3,996	$ 584	2082	0.014	$ 3,996	$ 57
2043	0.138	$ 3,996	$ 551	2083	0.013	$ 3,996	$ 54
2044	0.130	$ 3,996	$ 520	2084	0.013	$ 3,996	$ 51
2045	0.123	$ 3,996	$ 491	2085	0.012	$ 3,996	$ 48
2046	0.116	$ 3,996	$ 463	2086	0.011	$ 3,996	$ 45
2047	0.109	$ 3,996	$ 437	2087	0.011	$ 3,996	$ 42
2048	0.103	$ 3,996	$ 412	**Total Benefits:**		**$ 299,737**	**$ 55,218**

Distribution of Benefits

Flood damage reduction benefits would directly benefit property owners and residents of the portions of the Sunnydale neighborhood within the existing flood zones. Traffic delay reduction benefits are expected to be more widely distributed, though neighborhood residents and workforce are likely to benefit the most.

Uncertainty of Benefits

Estimated flood damage reduction benefits have moderately high certainty. Results from the hydraulic modeling are consistent with historical flooding and therefore are deemed reasonably certain. Flood event damages are based on F-RAM modeling assumptions and depth-to-damage curves.

Estimated traffic delay reduction benefits have moderately high certainty. Historical traffic volumes are based on traffic count data compiled by the City from 1997 through 2008 and is deemed plausibly certain; the extent of delay caused by the three design storms was approximated.

Adverse Effects

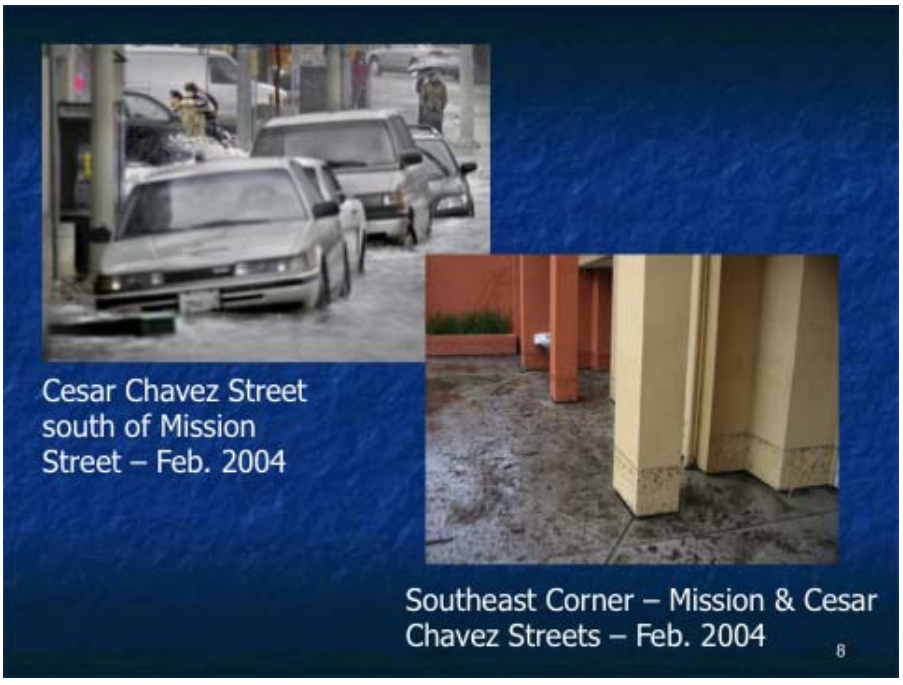
No known adverse effects are associated with the benefits described in this attachment.

Attachment 7 Economic Analysis – Flood Damage Reduction Costs and Benefits: Cesar Chavez Street Flood and Stormwater Management Sewer Improvement Project

Introduction

This attachment describes the flood damage reduction benefits provided by the Cesar Chavez Street Flood and Stormwater Management Sewer Improvement Project (Cesar Chavez project). The section of Cesar Chavez Street between Mission Street and Highway 101 has received numerous flooding complaints and damage claims made against the City over the past several years (**Figure 1**). This section of Cesar Chavez follows the alignment of what was formerly Precita Creek (a tributary to Islais Creek), a historical creek that has since been filled in and paved over. The fact that the street alignment used to be a creek creates unique drainage challenges in this area. Moreover, hydraulic analysis of this area has shown that the Cesar Chavez sewer and other major sewers in this area are hydraulically inadequate.

Figure 1: Flooding along Cesar Chavez Street during the February 2004 Flood Event



The Cesar Chavez project will increase reliability of the combined sewer system to:

- Ensure that the sewer system will contain flows from a 5-year design storm, leading to the improvement of hydraulic capacity to minimize potential flooding and maximize hydraulic grade line control.
- Address increased storm activity associated with climate change and minimize potential flooding in the project area.
- Reduce "wear and tear" of the sewer system through the reduction of stormwater discharges into the system.

Project Economic Costs

Capital costs for the project amount to $26,323,000 (2009 Dollars). Of this total, $2,192,000 are considered sunk costs and not included in this analysis. The initial costs of the project are $24,131,000, split among three years from 2011 through 2013. Once the sewer pipeline is in place and operational in 2013, a routine sewer inspection cost of $10,000 every 5 years and a sewer cleaning cost of $610,000 every 10 years is anticipated. The sewer cleaning cost is based on the San Francisco Public Utilities Commission's (SFPUC) estimates of cleaning costs for other similar sized sewers and is estimated at approximately $90 per linear foot. Over the 75-year anticipated lifetime of the sewer, the present value costs amount to $21.3 million, as shown in **Table 1** in the following page.

Project Expected Flood Damage Reduction Benefits

Expected flood damage reduction benefits are based on an analysis of the extent and depth of flooding for 5-year[1], 10-year[2], and 25-year[3] design storms under without- and with-project conditions. Flood boundaries, flood depths, and impacted streets and properties were evaluated using SFPUC's citywide wastewater collection system simulation model.

The citywide model is a fully dynamic, continuous simulation hydraulic and hydrologic model developed in InfoWorks Collection System software. The model was initially developed in 2005 as part of San Francisco's Sewer System Master Plan and has continuously been updated and refined since that time through an ongoing process of database development, quality control reviews, calibration, and validation. The model is utilized by the SFPUC and the City's hydraulic engineers to analyze the expected performance of proposed improvement projects in San Francisco. Additional description of the model is provided in the report on Model Development, Validation and Baseline.[4]

For the flood damage analysis, the most current version of the citywide model was utilized to evaluate collection system performance during San Francisco's 5-, 10-, and 25-year, 24 hour design storms. After running the baseline model to establish pre-project conditions, the model was updated with the proposed projects and re-run to establish post-project conditions. In areas where the model predicted flooding, a digital terrain model of San Francisco's ground topography was utilized within the collection system model to determine the spatial extent and depth of the flooding.

[1] 5-year, 24-hour storm has a total depth of 3.19 inches and a peak 5-minute intensity of 2.90 inches/hour.
[2] 10-year, 24-hour storm has a total depth of 3.80 inches and a peak 5-minute intensity of 3.35 inches/hour.
[3] 25-year, 24-hour storm has a total depth of 3.96 inches and a peak 5-minute intensity of 3.83 inches/hour.
[4] SFPUC, 2007. Model Development, Validation and Baseline Report. Final Draft. October 2007.

The results of the hydraulic modeling were used with DWR's F-RAM model to estimate expected annual flood damages to impacted structures and roads under the without- and with-project conditions. Flooding within and around the Cesar Chavez traffic corridor also is expected to result in disruption of traffic flows and significant traffic delays. The expected costs of traffic delays under without-project and with-project conditions for the three design storms are also estimated.

Table 1: Annual Cost of Cesar Chavez Street Flood and Stormwater Management Sewer Improvement Project

Annual Cost of Flood Damage Reduction Project
(All costs in 2009 Dollars)
Project: Cesar Chavez Street Flood and Stormwater Management Sewer Improvement Project

	Initial Costs	Operations and Maintenance Costs [1]						Discounting Calculations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
YEAR	Grand Total Cost From Table 6 (A)	Admin	Operation	Maintenance	Replacement	Other	Total Costs	Discount Factor	Discounted Costs
2009	$0						$0	1.000	$0
2010	$0						$0	0.943	$0
2011	$10,030,000						$10,030,000	0.890	$8,926,664
2012	$11,957,000						$11,957,000	0.840	$10,039,328
2013	$2,144,000						$2,144,000	0.792	$1,698,249
2014							$0	0.747	$0
2015							$0	0.705	$0
2016							$0	0.665	$0
2017							$0	0.627	$0
2018				$10,000			$10,000	0.592	$5,919
2019							$0	0.558	$0
2020							$0	0.527	$0
2021							$0	0.497	$0
2022							$0	0.469	$0
2023				$620,000			$620,000	0.442	$274,227
2024							$0	0.417	$0
2025							$0	0.394	$0
2026							$0	0.371	$0
2027							$0	0.350	$0
2028				$10,000			$10,000	0.331	$3,305
2029							$0	0.312	$0
2030							$0	0.294	$0
2031							$0	0.278	$0
2032							$0	0.262	$0
2033				$620,000			$620,000	0.247	$153,127
2034							$0	0.233	$0
2035							$0	0.220	$0
2036							$0	0.207	$0
2037							$0	0.196	$0
2038				$10,000			$10,000	0.185	$1,846
2039							$0	0.174	$0
2040							$0	0.164	$0
2041							$0	0.155	$0
2042							$0	0.146	$0
2043				$620,000			$620,000	0.138	$85,505
2044							$0	0.130	$0
2045							$0	0.123	$0
2046							$0	0.116	$0
2047							$0	0.109	$0
2048				$10,000			$10,000	0.103	$1,031
2049							$0	0.097	$0
2050							$0	0.092	$0
2051							$0	0.087	$0
2052							$0	0.082	$0
2053				$620,000			$620,000	0.077	$47,746
2054							$0	0.073	$0
2055							$0	0.069	$0
2056							$0	0.065	$0
2057							$0	0.061	$0
2058				$10,000			$10,000	0.058	$575
2059							$0	0.054	$0
2060							$0	0.051	$0

Table continues on following page

2061							$0	0.048	$0
2062							$0	0.046	$0
2063				$620,000			$620,000	0.043	$26,661
2064							$0	0.041	$0
2065							$0	0.038	$0
2066							$0	0.036	$0
2067							$0	0.034	$0
2068				$10,000			$10,000	0.032	$321
2069							$0	0.030	$0
2070							$0	0.029	$0
2071							$0	0.027	$0
2072							$0	0.025	$0
2073				$620,000			$620,000	0.024	$14,887
2074							$0	0.023	$0
2075							$0	0.021	$0
2076							$0	0.020	$0
2077							$0	0.019	$0
2078				$10,000			$10,000	0.018	$179
2079							$0	0.017	$0
2080							$0	0.016	$0
2081							$0	0.015	$0
2082							$0	0.014	$0
2083				$620,000			$620,000	0.013	$8,313
2084							$0	0.013	$0
2085							$0	0.012	$0
2086							$0	0.011	$0
2087							$0	0.011	$0
Project Life								…	
								Total Present Value of Discounted Costs (Sum of Column (i))	$21,287,883
								Transfer to Table 20, column (c), Exhibit F: Proposal Costs and Benefits Summaries	

Comments:
(A) Column (a) excludes $2,192,000 of sunk project costs that are included in Table 6 Project Budget.
(B) Assumed Inspection Cost of $10,000 per inspection every 5 years
(C) Assumed cleaning costs of $610,000 for approximately 6,900 LF of sewer once every 10 years.

(1) The incremental change in O&M costs attributable to the project.

Hydraulic Modeling of 5-, 10-, and 25-Year Storm Events

The hydraulic modeling results for the three design storms are summarized in **Table 2**. Flood maps corresponding to the modeling results are shown in **Figures 2, 3, and 4**. Expected impacts for the three design storms under without- and with-project conditions are as follows:

- Under the without-project condition, the 5-year design storm is predicted to inundate 9.8 acres of highly urbanized and densely populated area, impacting up to 92 residential properties, 13 commercial properties, 5 industrial properties and 7 cultural/educational properties. While most of these properties are predicted to experience flood depths of one-half foot or less, 17 may be flooded to depths of 2 feet, and 3 may be flooded to depths greater than 2 feet. Additionally, 3,726 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, no significant flooding is indicated by the hydraulic modeling.
- Under the without-project condition, the 10-year design storm is predicted to inundate 15.7 acres of highly urbanized and densely populated area, impacting up to 183 residential properties, 23 commercial properties, 7 industrial properties and 8 cultural/educational properties. Of these impacted properties, 74 may be flooded to depths of 2 feet, and 15 may be flooded to depths greater than 2 feet. Additionally, 5,751 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, the number of potentially impacted properties is reduced from 224 to 37 and none are predicted to experience flood depths greater than half a foot. The amount of street flooding is reduced by 86%.

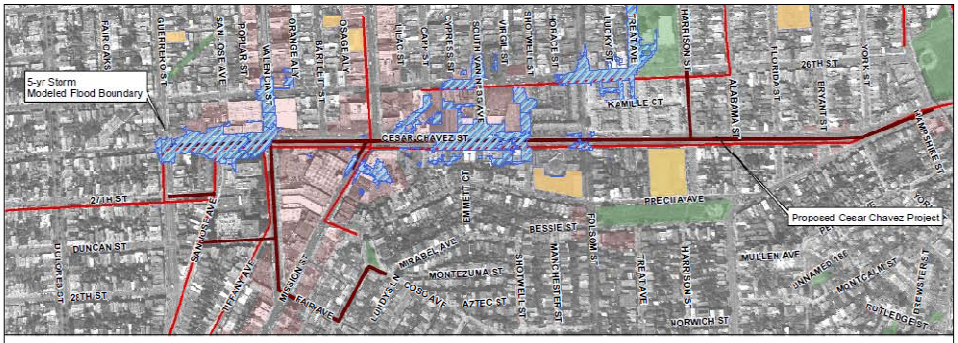
- The 25-year design storm is predicted to inundate 18.5 acres of highly urbanized and densely populated area, impacting up to 220 residential properties, 25 commercial properties, 8 industrial properties and 9 cultural/educational properties. Of these impacted properties, 74 may be flooded to depths of 2 feet, and 38 may be flooded to depths greater than 2 feet. Additionally, 6,485 linear feet of arterial and major roads are expected to be impacted. Under the with-project condition, the number of potentially impacted properties is reduced from 266 to 151 and the amount of street flooding is reduced by 59%.

Table 2: Summary of Hydraulic Modeling for Without- and With Project Conditions Under Three Design Storms

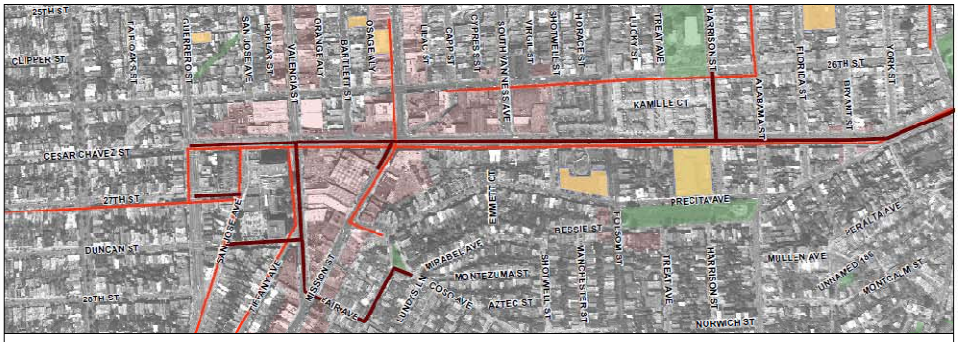
Flooding Parameter	5 yr Storm		10 yr Storm		25 yr Storm	
	Without-Project	With-Project	Without-Project	With-Project	Without-Project	With-Project
Flooded Area						
Total Flooded Area (acres)	9.8	0.0	15.7	2.2	18.5	7.9
Number of Lots with Flooding						
Residential	92	0	183	28	220	130
Open Space[1]	2	0	3	1	4	2
Cultural/Educational[2]	7	0	8	4	9	6
Commercial[3]	13	0	23	3	25	11
Industrial	5	0	7	1	8	2
Totals (# of lots)	***119***	***0***	***224***	***37***	***266***	***151***
Number of Lots by Max Flood Depth						
Depth < 0.5 ft	99	0	135	37	154	79
Depth 0.5 to 2 ft	17	0	74	0	74	38
Depth > 2ft	3	0	15	0	38	34
Totals (# of lots)	***119***	***0***	***224***	***37***	***266***	***151***
Linear Feet of Street Flooding						
Cesar Chavez	1246	0	1606	700	2025	1590
Mission Street	115	0	1100	0	1145	685
Valencia Street	295	0	375	0	445	0
South Van Ness	170	0	250	0	295	0
Treat Ave	670	0	720	0	720	0
26th Street	625	0	730	0	805	0
Precita Ave	0	0	200	0	200	190
Folsom Street	75	0	125	0	145	0
Shotwell Street	265	0	295	130	315	175
Capp Street	265	0	350	0	390	0
Totals (ft)	***3,726***	***0***	***5,751***	***830***	***6,485***	***2,640***

Notes:
(1) Open space and parks in the area of flooding include Garfield Square, etc.
(2) Cultural and educational facilities in the area of flooding include Flynn Elementary School, St. Anthony's Immaculate Conception School and St. Luke's Hospital, etc.
(3) Commercial and mixed-use retail activities in area of flooding include Salvation Army, Olympian Gas Station, etc.

Figure 2: Cesar Chavez Project – Predicted Flood Boundary for 5-yr Storm



Modeling Prediction of 5 Year Storm Flood Boundary - Pre-Project Conditions



Modeling Prediction of 5 Year Storm Flood Boundary - Post-Project Conditions

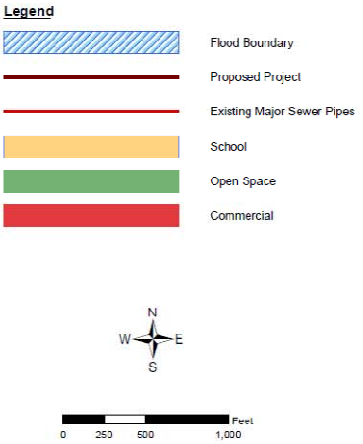
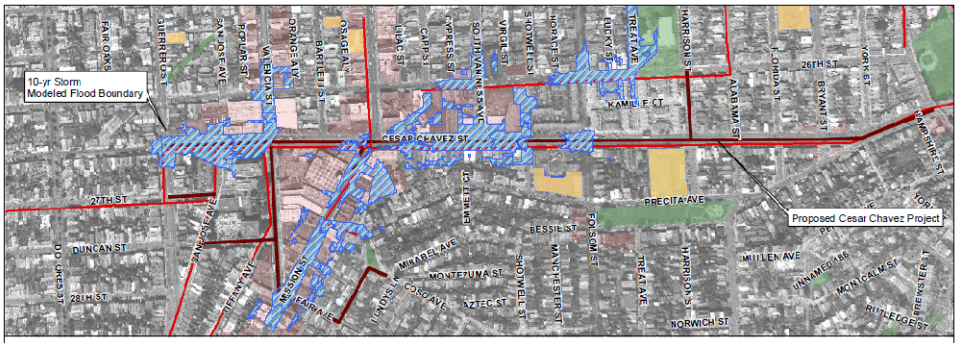
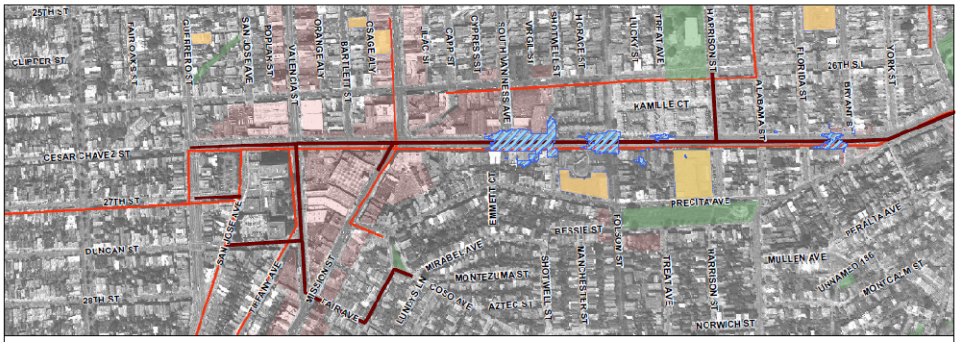


Figure 3: Cesar Chavez Project – Predicted Flood Boundary for 10-yr Storm



Modeling Prediction of 10 Year Storm Flood Boundary - Pre-Project Conditions



Modeling Prediction of 10 Year Storm Flood Boundary - Post-Project Conditions

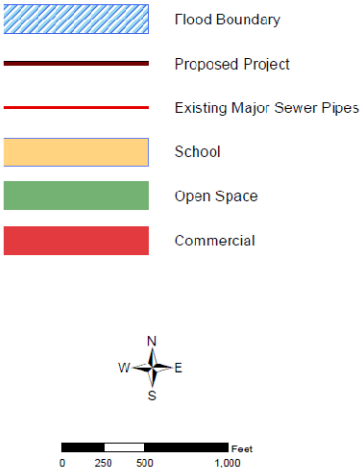
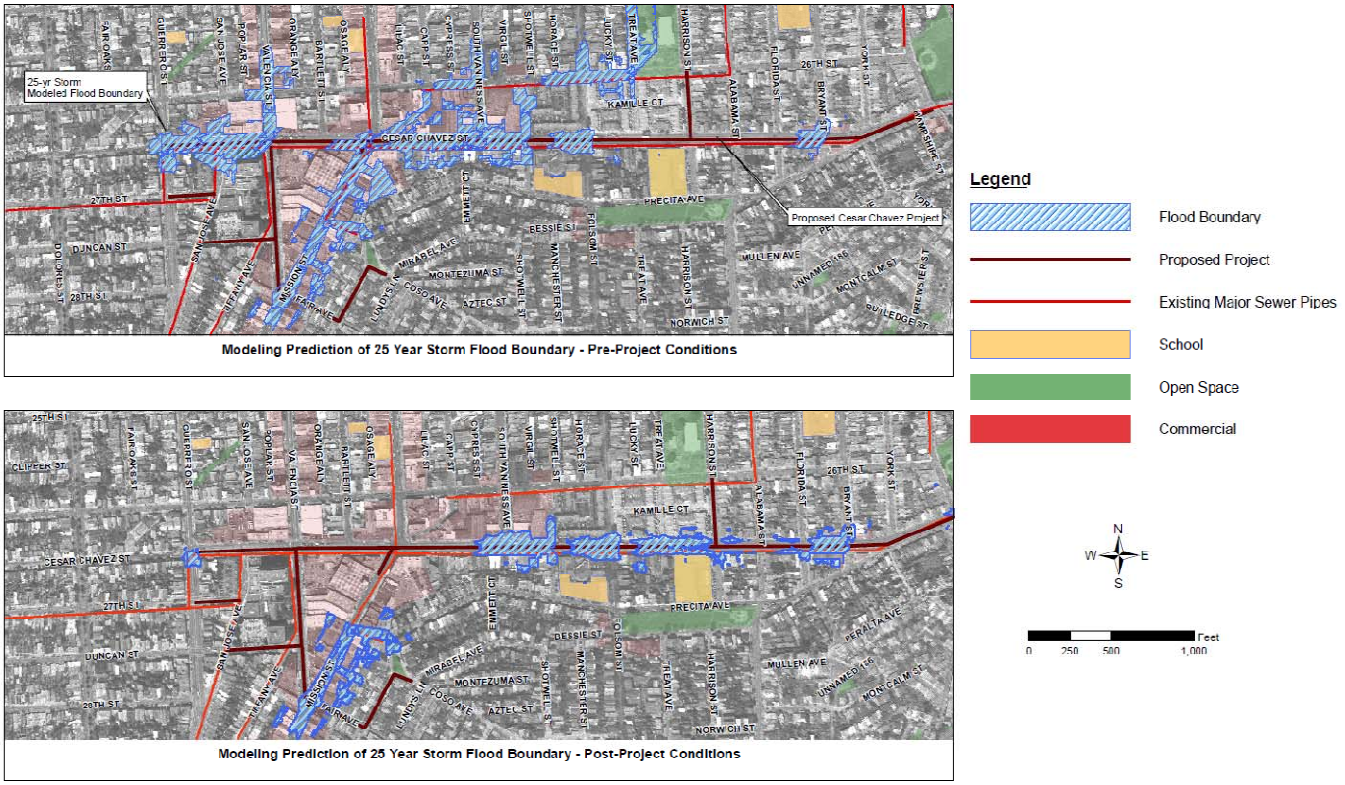


Figure 4: Cesar Chavez Project – Predicted Flood Boundary for 25-yr Storm



F-RAM Expected Annual Damages for Without- and With-Project Conditions

Expected annual flood damage for the without- and with-project conditions were estimated with the F-RAM model. Utilization of the F-RAM model required the following inputs for with and without-project conditions:

- Number of flooded residential properties for each design storm.
- Average flood depth of flooded residential properties for each design storm.
- Square feet of flooded commercial properties for each design storm.
- Square feet of flooded industrial properties for each design storm under without- and with-project conditions.
- Linear miles of flooded arterial, major, minor, and unsealed roads for each design storm.
- Ratio of depreciated value to replacement value for residential, commercial, and industrial structures.

F-RAM model inputs, other than the ratio of depreciated value to replacement value, were constructed from the hydraulic modeling results and are summarized in **Table 3**. The following should be kept in mind when reviewing Table 3:

- Flood depths are relative to ground level, per F-RAM input requirements. To calculate structure and content damages, the F-RAM model makes assumptions about average foundation height for residential, commercial, and industrial structures.
- The average flood depth is based on parcels experiencing positive amounts of flooding for a given design storm. Parcels within the flood zone not experiencing flooding were excluded from the calculation of flood depth. Likewise, the count of impacted residential properties and calculation of impacted commercial and industrial structure area are based only on parcels experiencing positive amounts of flooding for a given design storm. Parcels not experiencing positive depths of flooding were excluded from the property counts and area calculations.
- The square footage of inundated structures on commercial and industrial parcels was estimated using Google Earth Pro.
- F-RAM's medium structure value setting was used to calculate damages for commercial and industrial properties.
- The flooded streets listed in Table 2 were classified as arterial, major, or minor using the City's official road classifications. Any damages to unsealed roads on private commercial or industrial parcels were assumed to be covered by F-RAM's damage estimates for commercial and industrial properties and thus were not included in the tally of inundated roads miles.

Table 3: Summary of F-RAM Model Inputs

	Without-Project Condition			With-Project Condition		
	5-Yr	10-Yr	25-Yr	5-Yr	10-Yr	25-Yr
Residential						
No. of Flooded Properties	11	64	82	0	0	57
Average Flood Depth (ft)	1.72	1.87	1.87	0.00	0.00	2.48
Commercial						
Structure Area Flooded (Sqft)	107,120	168,136	192,116	0	0	41,340
Average Flood Depth (ft)	1.78	1.75	1.91	0.00	0.00	2.21
Industrial						
Structure Area Flooded (Sqft)	3,367	25,290	25,290	0	0	9,016
Average Flood Depth (ft)	3.16	2.10	2.26	0.00	0.00	1.36
Inundated Roads (mi)						
Arterial	0.290	0.560	0.656	0.000	0.133	0.431
Major	0.416	0.529	0.572	0.000	0.025	0.069
Minor	0.000	0.000	0.000	0.000	0.000	0.000
Unsealed	0.000	0.000	0.000	0.000	0.000	0.000

Two other model input assumptions require comment. The first concerns the ratio of depreciated value to replacement value. The second concerns F-RAM's default depth-to-damage curve for residential property.

1. F-RAM uses default assumptions for replacement cost per square foot to calculate structure and content damages for residential, commercial, and industrial properties. Because economic damages are to be based on depreciated value rather than replacement costs, F-RAM requires the user to enter the ratio of depreciated value to replacement value. However, there is no reliable data source for such an estimate. Depreciated book value would be meaningless in this context, for example, because structures are constantly being repaired and improved at varying rates. Thus, the depreciated value for structures of the same vintage should be expected to vary widely. Additionally, F-RAM's default replacement costs are low relative to costs of construction in the City of San Francisco. **Table 4** compares the F-RAM defaults to RSMean's 2010 dollars-per-square-foot construction costs for San Francisco. Given San Francisco's higher costs of construction, using the F-RAM defaults and setting the model's depreciation-value-to-replacement-cost ratio to 1.0 is equivalent to assuming the depreciation-value-to-replacement-cost ratios shown in the last column of the table, which are deemed to be sufficiently conservative for the estimation of flood damage reduction benefits.

Table 4: F-RAM Structure Replacement Costs Compared to Costs in Project Area

Building Type	F-RAM Default (2009 $)	RSMeans 2010 Estimate (2009 $)	Equivalent Depreciation Ratio
Residential Detached	$155	$300	0.52
Apartment Building	$155	$195	0.79
Commercial Office (2-4 stories)*	$142	$212	0.67
*F-RAM medium value estimate for commercial property.			

2. The F-RAM model uses depth-to-damage curves to estimate damages as a function of flood depth. Two separate curves are used for each building type, one to estimate structural damage and one to estimate contents damage. For residential structures, F-RAM can differentiate between structures with and without basements. By default, F-RAM assumes residential structures do not have basements. However, most of the residential structures in the flood zone for this project do have basements and basement flooding is expected to exacerbate damages to building contents. Therefore, residential content damages are calculated using F-RAM's depth-to-damage curve for residential structures with basements rather than the default setting, which assumes no basements.[5]

Calculated event damages for the three design storms under without- and with-project conditions are summarized in **Table 5**. Because the project is designed to reduce flooding associated with stormwater overflow, the damage amounts shown in Table 5 do not assume mitigation of flood damage due to advanced warning, as per F-RAM's model documentation and guidance.

[5]Since basement flooding is not anticipated to result in substantially worse structural damages, F-Ram's default (no basements) depth-to-damage curve for structural damage is used to calculate residential structural damage.

Table 5: F-RAM Damage Estimates for Three Design Storms

Event Damages (2009$)	Without-Project Condition			With-Project Condition		
	5-Yr	10-Yr	25-Yr	5-Yr	10-Yr	25-Yr
Residential						
Structural	$445,295	$2,590,810	$3,319,475	$0	$0	$4,012,190
Contents	$531,696	$3,093,504	$3,963,552	$0	$0	$3,254,523
Cleanup/External	$99,000	$576,000	$738,000	$0	$0	$513,000
Commercial						
Structural	$608,443	$955,012	$1,091,219	$0	$0	$528,326
Contents	$0	$0	$0	$0	$0	$645,731
Industrial						
Structural	$62,146	$323,210	$323,210	$0	$0	$51,210
Contents	$358,537	$2,585,679	$2,585,679	$0	$0	$0
Com/Ind Cleanup/External	$201,177	$383,466	$424,329	$0	$0	$173,861
Roads						
Arterial	$72,491	$139,962	$164,063	$0	$33,144	$107,718
Major	$41,572	$52,936	$57,197	$0	$2,462	$6,913
Indirect Damages	$605,089	$2,675,145	$3,166,681	$0	$8,902	$2,323,368
Total Estimated Damages	$3,025,447	$13,375,724	$15,833,404	$0	$44,508	$11,616,840

Figure 5 shows the loss-probability curves for the without- and with-project conditions from which F-RAM calculates expected annual damages (EAD). The expected annual flood damage reduction benefit is the area between the two loss-probability curves. This amount, shown in **Table 6**, is $1,512,929.

Figure 5: Cesar Chavez Project Flood Damage Loss-Probability Curves

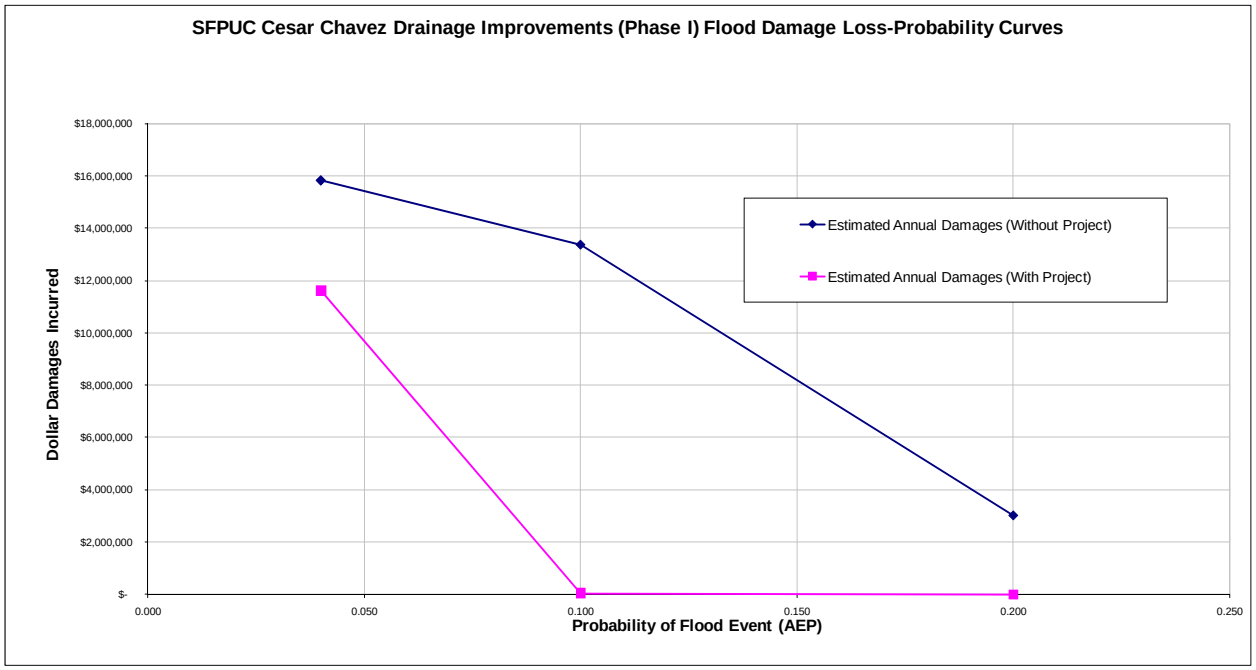


Table 6: Cesar Chavez Project Expected Annual Flood Damage Reduction

Expected Annual Damage	Dollar Amount (2009 $)
Without-Project Condition	$2,329,669
With-Project Condition	$816,739
Expected Annual Flood Damage Reduction	*$1,512,929*

Present Value of Expected Annual Flood Damage Reduction

The Cesar Chavez project is assumed to have a useful life of 75 years. This is the mid-point of SFPUC's 50 to 100 year useful life range assumed for sewers. It is worth noting that many of the sewers in operation in the City are over 100 years old. Thus the useful life assumption is conservative relative to historical experience. Flood damage reduction benefits are assumed to commence in 2013 when the project is scheduled to be operational. The present value of annual flood damage reduction benefits in 2009, summarized in **Table 7**, is $20,903,608.[6,7]

[6] Present value calculations are based on a 6% discount rate, per PSP requirements.
[7] Table 7 is substituted for Table 12 of Exhibit E of the PSP Application, which incorrectly calculates the present value of flood damage reduction benefits by assuming that project benefits commence in 2009, which clearly is

Table 7: Present Value of Annual Flood Damage Reduction

Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual	Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual
2009	1.000	$ -	$ -	2049	0.097	$ 1,512,929	$ 147,090
2010	0.943	$ -	$ -	2050	0.092	$ 1,512,929	$ 138,764
2011	0.890	$ -	$ -	2051	0.087	$ 1,512,929	$ 130,910
2012	0.840	$ -	$ -	2052	0.082	$ 1,512,929	$ 123,500
2013	0.792	$ 1,512,929	$ 1,198,382	2053	0.077	$ 1,512,929	$ 116,509
2014	0.747	$ 1,512,929	$ 1,130,549	2054	0.073	$ 1,512,929	$ 109,914
2015	0.705	$ 1,512,929	$ 1,066,555	2055	0.069	$ 1,512,929	$ 103,693
2016	0.665	$ 1,512,929	$ 1,006,184	2056	0.065	$ 1,512,929	$ 97,823
2017	0.627	$ 1,512,929	$ 949,230	2057	0.061	$ 1,512,929	$ 92,286
2018	0.592	$ 1,512,929	$ 895,500	2058	0.058	$ 1,512,929	$ 87,063
2019	0.558	$ 1,512,929	$ 844,812	2059	0.054	$ 1,512,929	$ 82,134
2020	0.527	$ 1,512,929	$ 796,992	2060	0.051	$ 1,512,929	$ 77,485
2021	0.497	$ 1,512,929	$ 751,879	2061	0.048	$ 1,512,929	$ 73,099
2022	0.469	$ 1,512,929	$ 709,320	2062	0.046	$ 1,512,929	$ 68,962
2023	0.442	$ 1,512,929	$ 669,170	2063	0.043	$ 1,512,929	$ 65,058
2024	0.417	$ 1,512,929	$ 631,292	2064	0.041	$ 1,512,929	$ 61,376
2025	0.394	$ 1,512,929	$ 595,559	2065	0.038	$ 1,512,929	$ 57,902
2026	0.371	$ 1,512,929	$ 561,848	2066	0.036	$ 1,512,929	$ 54,624
2027	0.350	$ 1,512,929	$ 530,045	2067	0.034	$ 1,512,929	$ 51,532
2028	0.331	$ 1,512,929	$ 500,043	2068	0.032	$ 1,512,929	$ 48,615
2029	0.312	$ 1,512,929	$ 471,738	2069	0.030	$ 1,512,929	$ 45,863
2030	0.294	$ 1,512,929	$ 445,036	2070	0.029	$ 1,512,929	$ 43,267
2031	0.278	$ 1,512,929	$ 419,846	2071	0.027	$ 1,512,929	$ 40,818
2032	0.262	$ 1,512,929	$ 396,081	2072	0.025	$ 1,512,929	$ 38,508
2033	0.247	$ 1,512,929	$ 373,661	2073	0.024	$ 1,512,929	$ 36,328
2034	0.233	$ 1,512,929	$ 352,510	2074	0.023	$ 1,512,929	$ 34,272
2035	0.220	$ 1,512,929	$ 332,557	2075	0.021	$ 1,512,929	$ 32,332
2036	0.207	$ 1,512,929	$ 313,733	2076	0.020	$ 1,512,929	$ 30,502
2037	0.196	$ 1,512,929	$ 295,975	2077	0.019	$ 1,512,929	$ 28,775
2038	0.185	$ 1,512,929	$ 279,221	2078	0.018	$ 1,512,929	$ 27,147
2039	0.174	$ 1,512,929	$ 263,416	2079	0.017	$ 1,512,929	$ 25,610
2040	0.164	$ 1,512,929	$ 248,506	2080	0.016	$ 1,512,929	$ 24,160
2041	0.155	$ 1,512,929	$ 234,440	2081	0.015	$ 1,512,929	$ 22,793
2042	0.146	$ 1,512,929	$ 221,169	2082	0.014	$ 1,512,929	$ 21,503
2043	0.138	$ 1,512,929	$ 208,650	2083	0.013	$ 1,512,929	$ 20,285
2044	0.130	$ 1,512,929	$ 196,840	2084	0.013	$ 1,512,929	$ 19,137
2045	0.123	$ 1,512,929	$ 185,698	2085	0.012	$ 1,512,929	$ 18,054
2046	0.116	$ 1,512,929	$ 175,187	2086	0.011	$ 1,512,929	$ 17,032
2047	0.109	$ 1,512,929	$ 165,271	2087	0.011	$ 1,512,929	$ 16,068
2048	0.103	$ 1,512,929	$ 155,916	**Total Benefits:**		**$ 113,469,682**	**$ 20,903,608**

impossible. The present value shown in Table 7 is transferred to Table 20 of Exhibit E of the PSP Application. This modification was discussed with and approved by Lorraine Marsh of DWR on March 29, 2011.

Expected Annual Costs of Flood-Related Traffic Delay

Table 8 summarizes traffic flows on Cesar Chavez and other streets expected to be impacted by flooding under the three design storms. The average volume of traffic per hour is approximately 9,900 vehicles per day, with average hour vehicle occupancy in excess of 11,000 persons.[8] The economic cost per hour of traffic delay, measured in terms of lost consumer surplus, is estimated to exceed $150,000.[9]

Table 8: Cesar Chavez Area Traffic Volumes

Primary Street	Cross Street	Volume (Vehicles per day)	Avg Hour Volume	Avg Hour Occupancy	Cost Per Hour of Delay
Cesar Chavez	Guerrero	12,711	530	604	$8,385
Cesar Chavez	Harrison	43,963	1,832	2,088	$29,002
Cesar Chavez	Mission	31,106	1,296	1,478	$20,520
Cesar Chavez	South Van Ness	42,452	1,769	2,016	$28,005
Cesar Chavez	Valencia	16,934	706	804	$11,171
Guerrero	Cesar Chavez	28,096	1,171	1,335	$18,534
Hampshire	Cesar Chavez	1,134	47	54	$748
Mission	Cesar Chavez	18,688	779	888	$12,328
Valencia	Cesar Chavez	19,719	822	937	$13,008
York	Cesar Chavez	1,094	46	52	$722
Bus Routes*		22,387	933	933	$12,955
TOTAL		**215,897**	**9,929**	**11,188**	**$155,378**

*Volume for bus routes expressed in passengers per day.

The cost of traffic delay due to localized flooding is a function of the average amount of delay caused. It is anticipated that some vehicles will experience significant delays due to street closures while others will be able to take alternative routes and experience little or no delay. For the purpose of calculating impacts, the following average delay times shown in **Table 9** were assumed.

Table 9: Average Traffic Delay Times for Three Design Storms

Design Storm	Without Project		With Project	
	Avg Traffic Delay (hrs)	Economic Cost	Avg Traffic Delay (hrs)	Economic Cost
5-year	0.50	$77,689	0.0	$0
10-year	1.00	$155,378	0.0	$0
25-year	1.50	$233,066	0.5	$77,689

[8] Based on an average vehicle occupancy of 1.14, per San Francisco Planning Department, Downtown Plan: Annual Monitoring Report 2009.

[9] Based on the U.S. Department of Transportation's recommended value of $13.89/hr (2009 $) for travel time for surface modes of transportation. The estimate is a weighted average of personal and business travel using the following distribution of travel by trip purpose: 94.4% personal, 5.6% business. U.S. Department of Transportation, "Revised Departmental Guidance: Valuation of Travel Time in Economic Analysis," February 11, 2003.

Figure 6 shows the loss-probability curves for the without- and with-project conditions from which expected annual costs of traffic delay were calculated. The expected annual benefit of avoided traffic delay is the area between the two loss-probability curves. This amount, shown in **Table 10**, is $20,976.

Figure 6: Cesar Chavez Project Traffic Delay Loss-Probability Curves

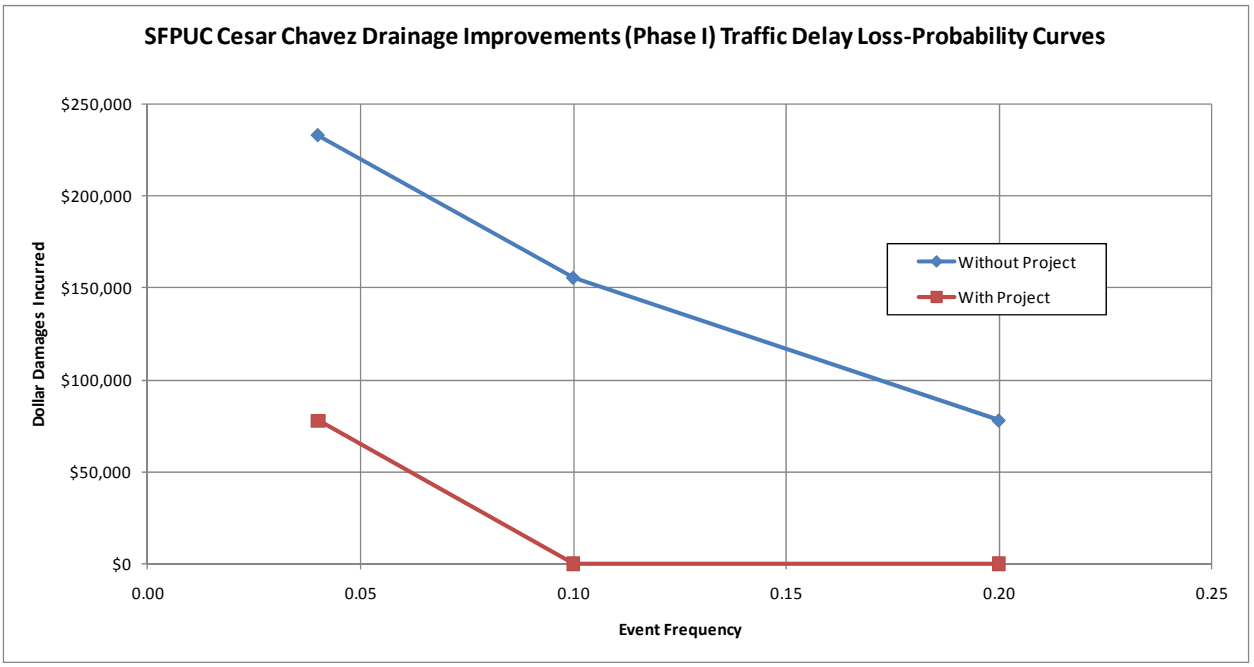


Table 10: Cesar Chavez Project Expected Annual Traffic Delay Reduction

Expected Annual Cost of Traffic Delay	Dollar Amount (2009 $)
Without-Project Condition	$23,307
With-Project Condition	$2,331
Expected Annual Traffic Delay Reduction Benefit	*$20,976*

Present Value of Expected Annual Traffic Delay Reduction Benefits

Traffic delay reduction benefits are assumed to commence in 2013 when the project is scheduled to be operational. The present value of annual traffic delay reduction benefits in 2009, summarized in **Table 11**, is $289,818.[10]

[10] The present value shown in Table 11 is transferred to Table 20 of Exhibit E of the PSP Application.

Table 11: Present Value of Traffic Delay Reduction Benefits

Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual	Year	Discount Factor	Avoided Flood Damage Annual	Avoided Flood Damage PV Annual
2009	1.000	$ -	$ -	2049	0.097	$ 20,976	$ 2,039
2010	0.943	$ -	$ -	2050	0.092	$ 20,976	$ 1,924
2011	0.890	$ -	$ -	2051	0.087	$ 20,976	$ 1,815
2012	0.840	$ -	$ -	2052	0.082	$ 20,976	$ 1,712
2013	0.792	$ 20,976	$ 16,615	2053	0.077	$ 20,976	$ 1,615
2014	0.747	$ 20,976	$ 15,674	2054	0.073	$ 20,976	$ 1,524
2015	0.705	$ 20,976	$ 14,787	2055	0.069	$ 20,976	$ 1,438
2016	0.665	$ 20,976	$ 13,950	2056	0.065	$ 20,976	$ 1,356
2017	0.627	$ 20,976	$ 13,161	2057	0.061	$ 20,976	$ 1,280
2018	0.592	$ 20,976	$ 12,416	2058	0.058	$ 20,976	$ 1,207
2019	0.558	$ 20,976	$ 11,713	2059	0.054	$ 20,976	$ 1,139
2020	0.527	$ 20,976	$ 11,050	2060	0.051	$ 20,976	$ 1,074
2021	0.497	$ 20,976	$ 10,424	2061	0.048	$ 20,976	$ 1,013
2022	0.469	$ 20,976	$ 9,834	2062	0.046	$ 20,976	$ 956
2023	0.442	$ 20,976	$ 9,278	2063	0.043	$ 20,976	$ 902
2024	0.417	$ 20,976	$ 8,753	2064	0.041	$ 20,976	$ 851
2025	0.394	$ 20,976	$ 8,257	2065	0.038	$ 20,976	$ 803
2026	0.371	$ 20,976	$ 7,790	2066	0.036	$ 20,976	$ 757
2027	0.350	$ 20,976	$ 7,349	2067	0.034	$ 20,976	$ 714
2028	0.331	$ 20,976	$ 6,933	2068	0.032	$ 20,976	$ 674
2029	0.312	$ 20,976	$ 6,540	2069	0.030	$ 20,976	$ 636
2030	0.294	$ 20,976	$ 6,170	2070	0.029	$ 20,976	$ 600
2031	0.278	$ 20,976	$ 5,821	2071	0.027	$ 20,976	$ 566
2032	0.262	$ 20,976	$ 5,491	2072	0.025	$ 20,976	$ 534
2033	0.247	$ 20,976	$ 5,181	2073	0.024	$ 20,976	$ 504
2034	0.233	$ 20,976	$ 4,887	2074	0.023	$ 20,976	$ 475
2035	0.220	$ 20,976	$ 4,611	2075	0.021	$ 20,976	$ 448
2036	0.207	$ 20,976	$ 4,350	2076	0.020	$ 20,976	$ 423
2037	0.196	$ 20,976	$ 4,104	2077	0.019	$ 20,976	$ 399
2038	0.185	$ 20,976	$ 3,871	2078	0.018	$ 20,976	$ 376
2039	0.174	$ 20,976	$ 3,652	2079	0.017	$ 20,976	$ 355
2040	0.164	$ 20,976	$ 3,445	2080	0.016	$ 20,976	$ 335
2041	0.155	$ 20,976	$ 3,250	2081	0.015	$ 20,976	$ 316
2042	0.146	$ 20,976	$ 3,066	2082	0.014	$ 20,976	$ 298
2043	0.138	$ 20,976	$ 2,893	2083	0.013	$ 20,976	$ 281
2044	0.130	$ 20,976	$ 2,729	2084	0.013	$ 20,976	$ 265
2045	0.123	$ 20,976	$ 2,575	2085	0.012	$ 20,976	$ 250
2046	0.116	$ 20,976	$ 2,429	2086	0.011	$ 20,976	$ 236
2047	0.109	$ 20,976	$ 2,291	2087	0.011	$ 20,976	$ 223
2048	0.103	$ 20,976	$ 2,162	**Total Benefits:**		**$ 1,573,198**	**$ 289,818**

Distribution of Benefits

Flood damage reduction benefits would directly benefit property owners and residents of the portions of the Cesar Chavez neighborhood within the existing flood zones. Given the importance of Cesar Chavez Street as a primary traffic corridor, traffic delay reduction benefits are expected to be more widely distributed across City residents.

Uncertainty of Benefits

Estimated flood damage reduction benefits have moderately high certainty. Results from the hydraulic modeling are consistent with historical flooding and therefore are deemed reasonably certain. Flood event damages are based on F-RAM modeling assumptions and depth-to-damage curves.[11]

Estimated traffic delay reduction benefits have moderately high certainty. Historical traffic volumes are based on traffic count data compiled by the City from 1997 through 2008 and is deemed plausibly certain; the extent of delay caused by the three design storms was approximated.

Adverse Effects

No known adverse effects are associated with the benefits described in this attachment.

[11] Since 1998, 17 flood-related damage claims have been filed against the City, ranging in value from $125 to $210,000 per claim. An unknown number of claims have been filed against private insurance policies. The F-RAM model estimates average damages of about $98,000 per residential property, which is about the midpoint of the range of claims filed with the City.