Lowell Creek Flood Diversion

Seward, Alaska

Appendix D: Economics

May 2021

U.S. Army Corps of Engineers
Alaska District

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Integrated Feasibility Report and Environmental Assessment

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Prepared By:

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1 BACKGROUND INFORMATION

1.1 INTRODUCTION

1.1.1 General

This Appendix presents an economic evaluation of the riverine flood risk reduction measures for the Lowell Creek Flood Diversion Integrated Feasibility Report and Environmental Assessment (IFR/EA). The evaluation area includes the downstream community of Seward, Alaska. The report was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the User's Manual for the Hydrologic Engineering Center Flood Damage Analysis Model (HEC-FDA).

This Appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing conditions and the project's costs. The damages and costs were calculated using Fiscal Year (FY) 2021 price levels. Costs were annualized using the FY 2021 Federal discount rate of 2.5% and a period of analysis of 50 years with the year 2025 as the base year. The expected annual damage (EAD) and benefit estimates were compared to the annual construction costs and the associated Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) costs for each of the project measures.

1.1.2 NED Benefit Categories Considered

The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project measure generally result from the reduction of actual or potential damages caused by inundation. Inundation reduction includes the reduction of physical damages to structures, contents, and vehicles and indirect losses to the national economy.

1.1.3 Physical Flood Damage Reduction

Physical flood damage reduction benefits include the decrease in potential damages to residential and commercial structures, their contents, and the privately owned vehicles associated with these structures.

1.1.4 Emergency Cost Reduction Benefits

Emergency costs are those costs incurred by a community during and immediately following a major storm. The cost of debris removal from inundated residential and non-residential structures was the only emergency cost reduction benefit considered for this analysis.

1.1.5 Flood Fighting Cost Reduction Benefits

Flood fighting costs are those costs incurred by the City of Seward in combating the heavy sediment load exiting the tunnel outfall before entering Resurrection Bay. The flood-fighting efforts are to save the only bridge that connects portions of the study area to Seward.

1.1.6 NED Benefit Categories NOT Considered

The NED benefit categories not addressed in this Economic Appendix include the following:

- Costs associated with evacuation and reoccupation activities before, during, and following a flood event incurred by property owners and governments
- Indirect losses to the national economy as a result of disruptions in the production of goods and services by industries affected by the storm or riverine flooding
- The increased cost of operations for industrial facilities following a flood event relative to normal business operations
- Costs associated with local tourism being impacted by a flood event

1.1.7 Regional Economic Development

When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the Regional Economic Development (RED) account. The input-output macroeconomic model RECONS (Regional Economic System) is used in this Appendix to address the impacts of the construction spending associated with the project alternatives.

1.1.8 Other Social Effects

The other social effects (OSE) account includes impacts on life safety, vulnerable populations, local economic vitality, and community optimism. Impacts on these topics are a natural outcome of civil works projects and are most commonly qualitatively discussed in the OSE account. HEC-LifeSim was utilized in this study to quantify the loss of life for a given alternative to determine if life safety risk decreases or is induced as a result of Federal investment. The life safety analysis included a Semi Quantitative Risk Assessment (SQRA), which informed the design and optimization of the recommended plan.

1.2 DESCRIPTION OF THE STUDY AREA

1.2.1 Geographic Location

The Lowell Creek study area includes the town of Seward and extends from the Lowell Creek Diversion Dam down into Resurrection Bay. The Lowell Creek measures for the study area were analyzed in this Economics Appendix. An inventory of residential and non-residential structures was developed using Kenai Peninsula Borough tax assessment data. The structure inventory within the Kenai Peninsula is shown in Figure 1.

The study area was further divided into 6 study area reaches. Dividing the study area into reaches was done to reduce the variability within the hydraulic data that represented an alluvial fan floodplain. Structures located within each reach were assigned that reach code in HEC-FDA. The study area reach boundaries are shown in Figure 2. Of particular note is Reach 6, which included the area from the diversion dam to the canyon exit. This area receives the highest depth and velocity flows during an overtopping event and includes an apartment complex for the elderly and a hospital.

Figure 1. Lowell Creek Structure Inventory (Seward, AK)

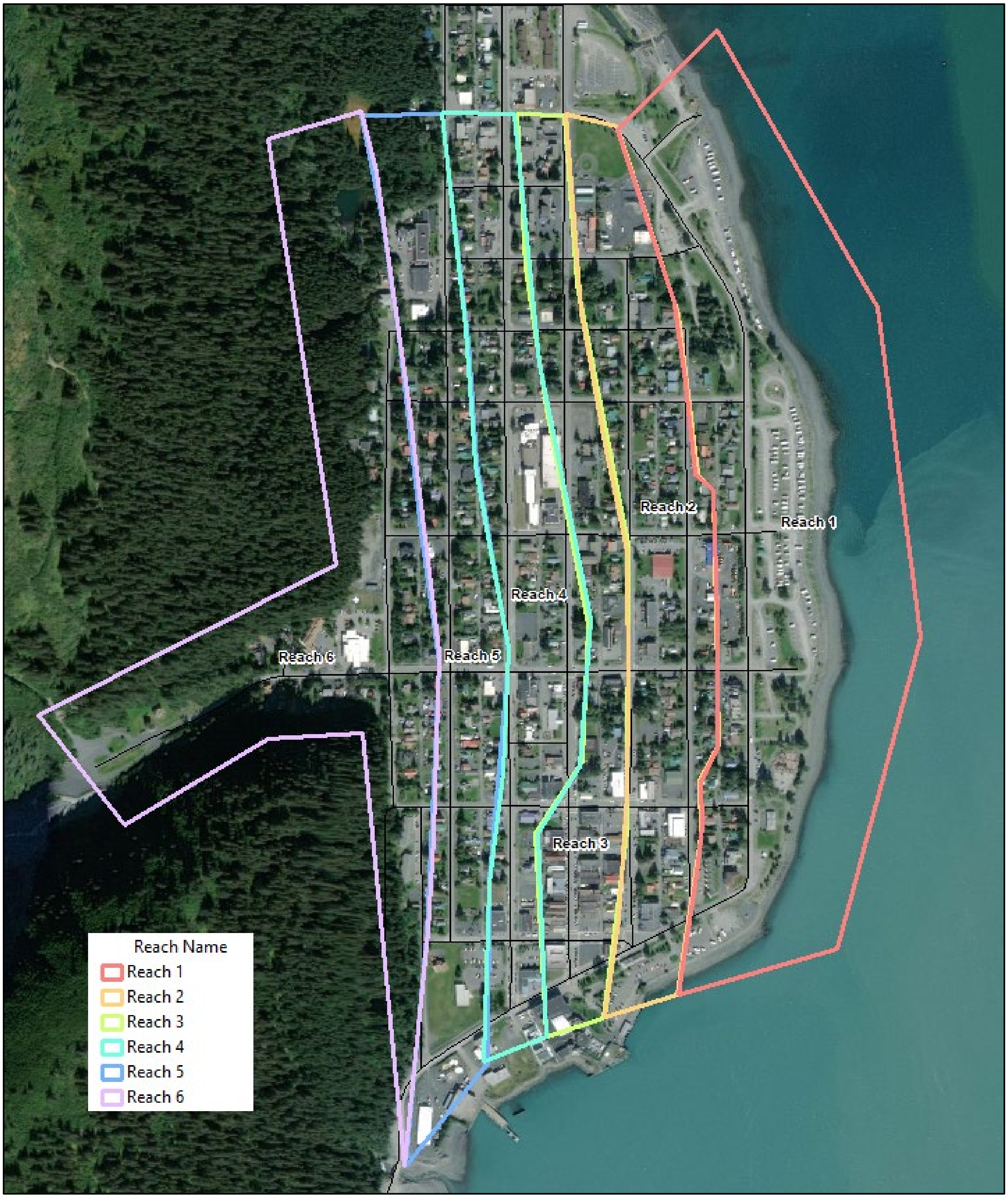

Figure 2. Study Reaches

Table 1 presents a structure count by reach, split between residential and non-residential types, which includes commercial, industrial, and public structures. The study area has a total of 564 structures located across the 6 study area reaches. Reach 1 of the study area includes 65 mobile home structures that are parked for greater than or equal to 66% of the year. Research performed for the SQRA determined that the perception of the flood hazard by the local population is minimal, and therefore evacuation of the mobile homes before an event would be unlikely.

Table 1. Structure Count by Reach

Reach	Residential Count	Non-Residential Count
1	99	1
2	86	14
3	51	49
4	61	39
5	89	11
6	61	3

1.2.2 Existing Flood Damage Reduction Infrastructure

The Lowell Creek study area includes the Lowell Creek Diversion Dam and Tunnel that runs through Bear Mountain and empties into Resurrection Bay. The economic analysis assumed that the tunnel could handle floods up to the 2% Annual Exceedance Probability (AEP) event. The estimate level of risk reduction of 2% is based on tunnel capacity estimates developed and refined in 1988, 1992, and again in 2012 during an inundation study that re-evaluated the hydraulics of the tunnel. Additional information on flood frequency and tunnel diameters can be found in Section 6.6 of this appendix and in Section 3.6 of Appendix C (Hydraulic and Structural Design). The economic analysis also assumed the tunnel will be properly maintained and operated and therefore does not have any fragility curves associated with it that would lead to failure prior to its maximum level of performance.

1.3 SOCIOECONOMICS

1.3.1 Demographics

In 2019, the State of Alaska Department of Labor and Workforce Development (DLWD) estimated Seward's population to be 2,545. However, there are multiple census-designated places outside Seward's city limits that are still located within the greater Seward area, adding an additional 2,500 people to the local population.

The population of the City of Seward is approximately 68% White, 17% American Indian or Alaska Native, 3% African American, 2% Asian, and 8% two or more races in combination. Other small groups (less than 1%) include Pacific Islanders. The population is 61% male and 39% female. The median age of the population is 37 years.

1.3.2 Employment and Income

According to the DLWD, 59% of resident workers were employed during 2016 (the last year for which statistics are available). The largest industry is Trade, Transportation, and Utilities with significant employment in Leisure and Hospitality, Education and Health Services, and State and Local Government.

Median household income in Seward is approximately $76,400, compared to the median annual income of approximately $61,900 across the entire United States. Approximately 11.9% of local residents have incomes lower than the Federal poverty threshold.

1.3.3 Existing Infrastructure and Facilities

Infrastructure at risk on the Seward Creek alluvial fan includes all Seward schools, the Seward Long Term Care Facility, Seward Sanitary Landfill, major businesses, the Seward Military Resort, and several highly developed subdivisions including Forest Acres. According to the Seward-Bear Creek Flood Service Area Flood Hazard Mitigation Plan, there is only one access and evacuation route to this highly populated area.

1.3.4 Cultural and Subsistence Activities

Present-day Seward is primarily non-Native, but there is still a strong cultural tie to the outdoors, including both food gathering activities such as fishing, hunting, and berry picking, as well as non-food gathering activities such as hiking, camping, skiing, and motorized recreation activities.

1.3.5 Population Projections

The DLWD projects the Kenai Peninsula Borough as a whole to gain approximately 6,700 residents over the next 25 years. The degree to which this increase occurs specifically in the greater Seward area is dependent upon several factors. The city’s relative proximity to Anchorage, access to marine recreation, and rural lifestyle while maintaining common services and conveniences makes it an attractive location for some future development. However, a significantly large increase in development and population is not expected. Because of this relatively stable environment, the prevailing economic and political conditions are not expected to change significantly over the period of analysis.

1.3.6 Recreational Demand

The Alaska Statewide Comprehensive Outdoor Recreation Plan (SCORP) for 2016-2021 divides the state into three administrative areas including Southeast, Railbelt, and Rural. The Seward area is located in the Railbelt region. The plan did not quantify surplus demand for additional recreation facilities in this region. However, trail improvements were the highest rated facility need in the area, and restrooms were a close second. The recreation facilities included in this project would address this need.

The Seward area is a recreational destination for many residents of Southcentral Alaska and visitors from outside of the area. Multiple salmon streams, world-class halibut fishing, unparalleled wildlife viewing opportunities, access to state and National parks, the Seward Small Boat Harbor, the southern terminus of the Alaska Railroad, and the Alaska Sea Life Center Research Aquarium all draw visitors to the area.

There is very little information about current visitation numbers to the project area. The project area does not lie within an established park or recreation area and visitation information is not available from established recreation facilities or informal recreation sites in the area.

1.4 SCOPE OF THE STUDY

1.4.1 Problem Description

The study area is characterized as an alluvial fan of Lowell Creek. Alluvial fans are depositional landforms, located at the base of mountain ranges where a steep mountain stream emerges onto lesser valley slopes. Sediments deposited on alluvial fans are generally coarse-grained, composed of sand, gravels, and boulders. Lowell Creek is a unique alluvial fan. The river no longer actively flows over the fan but instead is diverted through Bear Mountain, and the entire alluvial fan is developed with the only available conveyance being overland flooding through the city.

The City of Seward was rapidly developed after the tunnel and diversion dam construction was completed in the fall of 1940. The economic problem of the study area is two-fold. The first issue is the risk of inundation from events that exceed the tunnel capacity, which is approximately 2% AEP. The second economic problem is sedimentation of the diversion outlet and the City of Seward’s ability to manage sediment through flood-fighting efforts. These two problems are interrelated, as high sediment loads can increase the stage of flood flows.

1.4.2 Project Alternatives

The suite of alternatives carried through to the final array included:

- Improve Existing Flood Diversion System (Alternative 2)
- Enlarge Existing Flood Diversion System to Convey Larger Flow (Alternative 3)
- Construct New Flood Diversion System (Alternative 4)
- Construct Debris Retention Basin (Alternative 5)
- Floodplain Relocation (Alternative 6)

The Economic Appendix only includes basic descriptions of measures carried through to the final array (4th planning iteration). A full description of measures included in the focused array (3rd planning iteration) and the final array can be found in the IFR/EA Main Report.

1.4.3 Improve Existing Flood Diversion System

Alternative 2 would refurbish the existing tunnel without enlarging the tunnel. This alternative would extend the outfall of the tunnel to Resurrection Bay, leading to a reduction in flood fighting activities associated with sediment deposition.

1.4.4 Enlarge Existing Flood Diversion System to Convey Large Flow

Alternative 3 would increase the size of the existing tunnel from 14-feet (ft) in diameter up to 24-ft in diameter to pass flood events exceeding the 0.2% AEP frequency event. This alternative would also extend the outfall of the tunnel to Resurrection Bay, leading to a reduction in flood fighting activities associated with sediment deposition. Enlarging the existing flood diversion system would require significant delays in flood risk reduction due to limited construction windows because construction activities could only take place during low-flow conditions.

1.4.5 Construct New Flood Diversion System

Alternative 4 would construct a new flood diversion tunnel (14–24 ft in diameter) and include a landslide mitigation feature. The new tunnel would have an extended outfall into Resurrection Bay, leading to a reduction in flood fighting activities associated with sediment deposition. This alternative provides for utilization of both tunnels, which would improve operation, maintenance, and rehabilitation efforts by having a dedicated tunnel to divert flow. The construction timeline could be expedited under this condition since existing flows would not have to be rerouted to complete construction.

1.4.6 Construct Debris Retention Basin

Alternative 5 would construct an upstream retention basin that would gather sediment flowing through Lowell Creek and retain the sediment during the duration of the flood event. The retention basin would have to be cleaned regularly to maintain effectiveness. This alternative would not have a measurable impact on flood damage reduction benefits since sedimentation impacts the probability of tunnel blockage and impact velocity of sediment laden flood flows, but not necessarily flood depths, which are the only variable used by the HEC-FDA model to compute flood damages. The debris retention basis would lead to a reduction in flood fighting activities associated with sediment deposition.

1.4.7 Nonstructural Acquisition and Relocation

Nonstructural alternatives may potentially include the implementation of an early warning system, evacuation plan, relocation of buildings and critical infrastructure, and the removal of trees from the upstream watershed. Currently, there is no system or plan to monitor the tunnel or diversion dam, and the flashy system can be overwhelmed quickly with little to no warning to the downstream residents within Seward. Additionally, trees could be removed from the upstream watershed to reduce the likelihood of a surge release event that results from debris blocking the stream and temporarily impounding water.

Located less than 0.1 miles from the diversion dam sits an apartment complex for the elderly and a hospital. These structures sit at the edge of the Lowell Creek Canyon and experience the full force of depth and velocity flows resulting from an event that overtops the diversion dam. Alternative 6 involves different nonstructural configurations that include relocating the entire valley and floodway along Jefferson Street, to just relocating the valley, to relocating the valley but excluding either/or the hospital and elderly apartment complex.

While these measures do not significantly reduce flood damages, it does reduce the potential for life loss. The structures included in the valley and along Jefferson Street represent between approximately 61% of existing condition life loss across all hydraulic frequencies. The location of the valley's critical infrastructure relative to the diversion dam is shown in Figure 3.

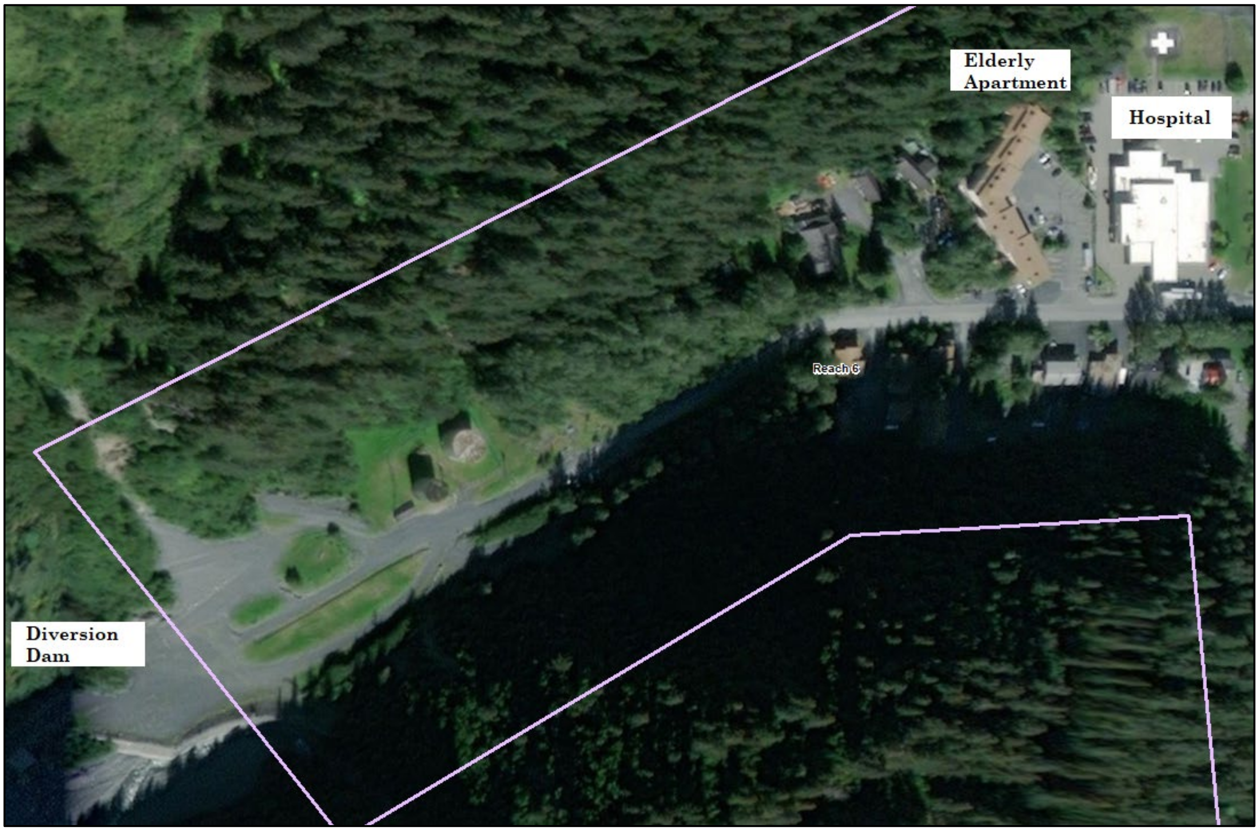

Figure 3. Seward Critical Infrastructure

2 ECONOMIC AND ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.1 HEC-FDA MODEL

2.1.1 Model Overview

The HEC-FDA Version 1.4.2 Corps-certified model was used to calculate the damages and benefits. The economic and engineering inputs necessary for the model to calculate damages for the project base year (2025) include the existing condition structure inventory, contents-to-structure value ratios (CSVR), vehicles, first floor and ground elevations, depth-damage relationships, and without project and with-project stage-probability relationships.

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations.

The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships. For this study, there is not a gage on Lowell Creek, and therefore the hydraulic engineer interpolated values from nearby Spruce Creek. Spruce Creek has 43 years of recorded gage data and was scaled to fit the Lowell Creek Basin using the 2016 USGS method presented in Scientific Investigations Report 2016-5024, titled “Estimated Flood Magnitude and Frequency at Gaged and Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, Based on Data through Water Year 2012." Spruce Creek basin and the Lowell Creek basin are both located on the same coastal mountain range in close proximity and are of a similar slope and size, it is expected that the rainfall-runoff characteristics of these basin are quite similar and that the method of scaling the gaged data to the ungagged basin produces a good estimate of the Lowell Creek's basin response. Appendix C (Hydraulics) concludes that it is reasonable to evaluate the flow frequency relationship uncertainty as having a 25 year period of record rather than 43 years to account for the remaining uncertainty of the conversion process.

2.2 ECONOMIC INPUTS TO THE HEC-FDA MODEL

2.2.1 Structure Inventory

A structured inventory of residential and non-residential structures for the Lowell Creek study area was obtained using Kenai Peninsula Borough tax assessment data. The structure inventory was imported into Geographic Information System (GIS) software using the tax assessor’s shapefile. Each structure point was geospatially relocated to the structure building footprint to ensure an accurate ground surface elevation and flood depth extraction. Assessed values were multiplied by a factor provided by the Borough’s tax assessor to obtain a proxy for depreciated replacement value.

2.2.1.1 Windshield Survey

A vehicle-based windshield survey was conducted in March 2017 to record structural attributes such as foundation height, effective age, condition, story count, exterior wall types, and foundation types. The windshield survey sampled 100% of the structures that could not be properly surveyed using Google Street View. The windshield survey sampled a total of 489 structures. The remaining 75 mobile homes were assumed to have similar attributes to those of national averages. The structure count by occupancy type and the associated average and standard deviation of the foundation heights from the survey is shown in Table 2.

Table 2. Windshield Survey Results

Occupancy Type	Occupancy Code	Number of Structures	Average. Foundation (ft)	Standard Deviation (ft)
One story res with basement	Oreswbsmt	27	1.86	1.17
One story res without basement	Oreswoutbsmt	178	1.05	0.86
Two+ story res with basement	Treswbsmt	24	1.63	1.30
Two+ story res without basement	Treswoutbsmt	98	1.43	1.18
Mobile home	MobHome	75	2.00	0.00
Apartment building	Apt1	41	1.11	0.92
Public building	Pub2	11	0.30	0.35
Retail shop	Retail	87	0.63	0.91
School	School*	23	0.69	1.16

*Note: The Alaska Vocational Technical Center is made up of multiple buildings, each independently analyzed, which explains the high structure count for schools.

2.2.2 Structure Value Uncertainty

The uncertainty surrounding the residential structure values includes the depreciation percentage applied based on the effective age and condition of the structures, as well as the four exterior wall types utilized in RS Means. A triangular probability distribution was developed for residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Good Condition
- Most Likely Depreciation – Effective Age: 20 Years & Average Condition
- Maximum Depreciation – Effective Age: 30 Years & Poor Condition

Effective age for this uncertainty analysis was defined as the average observed age of a structure as recorded during the windshield survey. These values were then converted to a percentage of the most-likely value with the most-likely value equal to 100% of the average value for each exterior wall type and occupancy category. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

The uncertainty surrounding the non-residential structure values was based on the depreciation percentage applied to the average replacement cost per square calculated from the six exterior wall types. A triangular probability distribution was developed for non-residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Masonry on Masonry/Steel
- Most Likely Depreciation – Effective Age: 20 Years & Masonry on Wood
- Maximum Depreciation – Effective Age: 30 Years & Frame

These values were then converted to a percentage of the most-likely value with the most-likely value being equal to 100% and the minimum and maximum values equal to percentages of the most-likely value. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values for each non-residential occupancy category. The minimum and maximum percentages of the most-likely structure values assigned to the various structure categories are shown in Table 3.

Table 3. RS Means Structure Value Uncertainty Factors

RS Means Occupancy Type	RS Means Cost per Square Ft Factor		
	Minimum	Most Likely	Maximum
Non-Residential	0.80	1.00	1.23
1 Story Res	0.69	1.00	1.16
2 Story Res	0.69	1.00	1.16
Mobile Home	0.48	1.00	1.47

2.2.3 Residential and Non-Residential CSVRs

Based on Economic Guidance Memorandum (EGM), 04-01, dated 10 October 2003, a CSVR of 100% was applied to all of the residential structures in the structure inventory and the error associated with CSVR was set to zero. The EGM states that the 100% CSVR is to be used with the generic depth-damage relationships developed for residential structures, which were also used for this study.

The CSVRs applied to the non-residential structure occupancies were taken from an extensive survey of business owners in coastal Louisiana for three large coastal storm risk management evaluations previously conducted by the U.S. Army Corps of Engineers (USACE). These interviews included a sampling from the eight non-residential content categories from each of the three evaluation areas. A total of 210 non-residential structures were used to develop CSVRs for each of the non-residential categories.

2.2.4 CSVR Uncertainty

For each of the occupancy types, a mean CSVR and a standard deviation was calculated and entered into the HEC-FDA model using the information gathered from the survey performed for the three large coastal storm risk management evaluations. A normal probability density function was used to describe the uncertainty surrounding the CSVR for each content category. The expected CSVR percentage values and standard deviations for each of the occupancy types are shown in Table 4.

Table 4. CSVRs and Uncertainty

Type	Average	Standard Deviation
1-Story Res	100%	0%
2-Story Res	100%	0%
Mobile Home	114%	79%
Pub2	57%	90%
School	57%	90%
Retail	124%	111%

2.2.5 Vehicle Inventory and Values

Based on the 2017 Census information for the Kenai Peninsula area, there is an average of 2 vehicles associated with each household (owner-occupied housing or rental unit). Given that a large portion of Seward's population is seasonal during the warmer months, it was probabilistically determined 1 of the 2 vehicles had the potential to not be within the study area during a flood event. According to Edmunds, the average value of a used car was $19,700 as of June 2018. An average vehicle value of $20,090 was assigned to each residential automobile structure record in the HEC-FDA model, which includes price indexing to represent FY2021 values.

If an individual structure contained more than one housing unit, then the adjusted vehicle value was assigned to each housing unit in a residential or multi-family structure category. Only vehicles associated with residential structures were included in the analysis. Vehicles associated with non-residential properties were not included in the evaluation.

2.2.6 Vehicle Value Uncertainty

The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The average value of a used car, $20,090, was used as the most-likely value. The average value of a new vehicle, $33,560, before taxes, license, and shipping charges was used as the maximum value. In contrast, the average 10-year depreciation value of a vehicle, $3,000, was used as the minimum value. The percentages were developed for most-likely, minimum, and the maximum values with the most-likely equal to 100%, and the minimum and the maximum values as percentages of the most-likely value (minimum=16%, most-likely=100%, maximum=180%). These percentages were entered into the HEC-FDA model as a triangular probability distribution to represent the uncertainty surrounding the vehicle value for both residential and non-residential vehicles.

2.2.7 Elevation Data

Elevation data associated with the ground surface, foundation heights, and first floors of structures are critical to the economic analysis and feasibility of studies.

2.2.7.1 Ground Surface Elevations

Topographical data based on Light Detection and Ranging (LiDAR) data using vertical datum North American Vertical Datum of 1988 was obtained by the Alaska District GIS department in a 5-meter resolution raster format. The 5-meter LiDAR data was used to assign ground elevations to structures and vehicles in the study area.

2.2.7.2 First Floor Elevations

The ground elevation was added to the height of the foundation of the structure above the ground in order to obtain the first-floor elevation of each structure in the study area. Vehicles were assigned to the ground elevation of the adjacent residential structures and did not include adjustments for foundation heights.

2.2.8 Elevation Uncertainty

There are two sources of uncertainty surrounding the first-floor elevations: the use of the LiDAR data for the ground elevations, and the methodology used to determine the structure foundation heights above ground elevation. The error surrounding the LiDAR data was determined to be plus or minus 0.5895 ft at the 95% level of confidence. This uncertainty was normally distributed with a mean of zero and a standard deviation of 0.3 ft.

The uncertainty surrounding the foundation heights for the residential and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for the four structure groups was computed for each structure category. The distribution of the foundation height uncertainty for each occupancy type is displayed in Table 4.

The standard deviations for the ground elevations and foundation heights were combined, which resulted in a 1.21 ft standard deviation for one-story residential structures with basements (Oreswbsmt) structures and 1.22 ft for two-story residential structures without basements (Treswoutbsmt), as examples. The calculations used to combine the uncertainty surrounding the ground elevations with uncertainty surrounding the foundation height to derive the uncertainty surrounding the first-floor elevations of residential, commercial, and public structures are displayed in Table 5.

Table 5. First Floor Stage Uncertainty Standard Deviation (SD) Calculation

Ground - LiDAR (conversion cm to inches to ft)		
+/- 18 cm @ 95% confidence		18cm
	x	0.393
z = (x - u)/ std. dev.		7.074in
	÷	12
1.96 = (0.5895 - 0)/ SD 0.3007 = SD		0.5895ft

First Floor Combined Std. Dev (shown in ft)								
Residential					Comm-ercial	Public		Note
Ores-wbsmt	Ores-woutbsmt	Tres-wbsmt	Tres-woutbsmt	Apt1	Retail	Pub2	School	
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	ground SD
0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	ground SD^2
1.17	0.86	1.3	1.18	0.92	0.35	0.91	1.16	1st floor SD
1.37	0.74	1.69	1.39	0.85	0.12	0.83	1.35	1st floor SD^2
1.46	0.83	1.78	1.48	0.94	0.21	0.92	1.44	Sum of Squared
1.21	**0.91**	**1.33**	**1.22**	**0.97**	**0.46**	**0.96**	**1.20**	**Square root of Sum of Squared**

Notes: SD = Standard Deviation

2.2.9 Debris Removal Costs

Debris removal costs are typically discussed in the Other Benefit Categories section of the Economic Appendix. However, since debris removal costs were included as part of the HEC-FDA structure records for the individual residential and non-residential structures in the Lowell Creek study area, these costs are being treated as an economic input. The HEC-FDA model does not report debris removal costs separately from the total expected annual without project and with-project damages.

Following Hurricanes Katrina and Rita, interviews were conducted by the New Orleans District with experts in the fields of debris collection, processing, and disposal to estimate the cost of debris removal following a storm event. Information obtained from these interviews was used to assign debris removal costs for each residential and non-residential structure in the Lowell Creek structure inventory. The experts provided a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2-ft, 5-ft, and 12-ft depths of flooding. A prototypical structure size in square ft was used for the residential occupancy categories and the non-residential occupancy categories.

The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structural occupancy types, 100% damage was reached at 12 ft of flooding. The debris clean-up values provided in the report were expressed in 2010 price levels for the New Orleans area. These values were converted to 2021 price levels for the Lowell Creek area using the indexes provided by Gordian's 2020 edition of "Square Foot Costs with RS Means Data." The debris removal costs were included as the "other" category on the HEC-FDA structure records for the individual residential and non-residential structures and used to calculate the expected annual without project and with-project debris removal and cleanup costs.

2.2.10 Debris Removal Costs Uncertainty

The uncertainty surrounding debris percentage values at 2-ft, 5-ft, and 12-ft depths of flooding were based on the range of values provided by the four experts in the fields of debris collection, processing, and disposal. The questionnaires used in the interview process were designed to elicit information from the experts regarding the cost of each stage of the debris cleanup process by structure occupancy type. The range of responses from the experts were used to calculate a mean value and standard deviation value for the cleanup costs percentages provided at 2-ft, 5-ft, and 12-ft depths of flooding. The mean values and the standard deviation values were entered into the HEC-FDA model as a normal probability distribution to represent the uncertainty surrounding the costs of debris removal for residential and non-residential structures. The depth-damage relationships containing the damage percentages at the various depths of flooding and the corresponding standard deviations representing the uncertainty are shown within the depth-damage tables.

2.2.11 Depth-Damage Relationships

The USACE generic depth-damage relationships for one-story and two-story residential structures with no basement from EGM, 01-03, dated 4 December 2000, were used in the analysis. The mobile home depth-damage relationships were based on the relationships developed by a panel of insurance experts as part of the New Orleans District Morganza to the Gulf feasibility study. The vehicle depth-damage functions were based on the generic depth-damage curves from EGM, 09-04, generic depth-damage relationships for vehicles, dated 22 June 2009. The generic vehicle curves for sedans were used for vehicles associated with residential structures.

Since site-specific non-residential depth-damage relationships were not available for the Lowell Creek study area, depth-damage relationships developed for the 2011 Fargo-Moorhead Feasibility Study were utilized. These curves were developed for study areas with freshwater riverine flooding characteristics similar to the Lowell Creek basin. The ideal depth-damage relationship curves would have incorporated the increase in damages due to sedimentation. Still, such a relationship could not be established for this study, and as a result, the economic damages reported from HEC-FDA are likely understated.

Depth-damage relationships indicate the percentage of the total structure value that would be lost at various depths of flooding. For residential and non-residential structures, damage percentages were provided at each 1-ft increment from 2 ft below the first-floor elevation to 16 ft above the first-floor elevation for the structural components and the content components.

2.2.12 Uncertainty Surrounding Depth-Damage Relationships

A normal distribution with a standard deviation for each damage percentage provided at the various increments of flooding was used to determine the uncertainty surrounding the generic depth-damage relationships used for residential structures and vehicles. For non-residential structures and mobile homes, a triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding. A minimum, maximum, and most-likely damage estimate was provided by a panel of experts for each depth of flooding.

The damage relationships for structures, contents, vehicles, and debris removal, contain the damage percentages at each depth of flooding along with the uncertainty surrounding the damage percentages, are shown in Section 8.

2.3 ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.3.1 Stage-Probability Relationships

Stage-probability relationships were provided for the existing without project condition (2021) using modified hydraulic models from previous studies. HEC-RAS version 5.0 or later was utilized to model the hydraulic conditions of Lowell Creek. Given the uncertain flow path, and large overbank flow areas, a 2D hydraulic model was set up in HEC-RAS to represent the hydraulic conditions of the alluvial floodplain.

The hydraulic model provided water surface profiles for eight AEP events including the 0.50 (2-year), 0.20 (5-year), 0.10 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.004 (250-year), and 0.002 (500-year). The without project water surface profiles assume the Lowell Creek tunnel and diversion dam are in operation and contain 2,600 cubic feet per section (cfs), or approximately the 2% AEP event. In events larger than the 2% AEP, the diversion dam is overtopped, and flows follow Jefferson Street into Seward, eventually dumping into Resurrection Bay.

To account for the sedimentation of Lowell Creek in the hydraulic analysis, the hydraulic engineer applied a bulking factor of 1.11 to increase the amount of cfs and stage modeled within HEC-FDA. The bulking factor is the only assumption utilized in the economic analysis to account for increased depth and velocities as a result of rocks, boulders, and other sedimentation forms. See Appendix C: Hydraulic and Structural Design for additional information on bulking factors.

2.3.2 Uncertainty Surrounding the Stage-Probability Relationships

The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships. For this study, there is not a gage on Lowell Creek, and therefore the hydraulic engineer interpolated values from nearby Spruce Creek. Spruce Creek has 43 years of recorded gage data and was scaled to fit the Lowell Creek Basin using the 2016 USGS method presented in Scientific Investigations Report 2016-5024, titled “Estimated Flood Magnitude and Frequency at Gaged and Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada, Based on Data through Water Year 2012." Spruce Creek basin and the Lowell Creek basin are both located on the same coastal mountain range in close proximity and are of a similar slope and size, it is expected that the rainfall-runoff characteristics of these basin are quite similar and that the method of scaling the gaged data to the ungagged basin produces a good estimate of the Lowell Creek's basin response. Appendix C concludes it is reasonable to evaluate the flow frequency relationship uncertainty of a 25 year period of record rather than 43 years to account for the remaining uncertainty of the conversion process.

2.3.3 Uncertainty Surrounding Sea-Level Change

The conclusion of the sea level change analysis (documented in Appendix C) is that there is minimal impact to potential FRM benefits of the project. The hydraulic engineer looked at three scenarios considered equally likely. In the year 2100, sea level change was estimated to be -0.62 feet for the low case, 0.42 feet for the intermediate case and 3.71 feet for the high case. Using the high case as a reference, the maximum high tide would be +19.4 feet MLLW. For reference, the Sea Life Center is at +21 feet MLLW. Low spots in the campground near Resurrection Bay are at about +17.5 feet MLLW. Therefore, it is not expected that a change in sea-level will have an effect on the NED or OSE conclusions of this report.

2.3.4 Use of HEC-GeoFDA

The Geospatial Preprocessor for Flood Damage Reduction Analysis (GeoFDA) program was utilized for the Lowell Creek study. GeoFDA preprocesses hydraulic and economic data in a GIS format so that HEC-FDA can read non-native hydraulic data formats. For the Lowell Creek study, the alluvial fan could not be properly modeled using traditional cross-section data that HEC-FDA requires. Instead, hydraulic data was provided in a two-dimensional depth grid format in GIS. The GeoFDA model extracted depth of flooding data from the grid to each structure point and then treated it as a station within FDA. GeoFDA has been officially released by the Hydrologic Engineering Center and does not have to comply with traditional model certifications, given that it is a preprocessor.

3 NED FLOOD DAMAGE AND BENEFIT CALCULATIONS

3.1 HEC-FDA Model Calculations

The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 6 study area reaches for which a structure inventory had been created. A range of possible values, with a maximum and a minimum value for each economic variable (first-floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships.

The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships. For this study, there was not a gage on Lowell Creek, and therefore the hydraulic engineer interpolated values from nearby Spruce Creek. To represent the uncertainty of interpolating from a nearby gage, a gage record of 25 years was recommended by the hydraulic engineer.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

3.2 Stage-Damage Relationships with Uncertainty

The HEC-FDA model used the economic and engineering inputs to generate a stage-damage relationship for each structure category in each study area reach. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed in the model for stage-damage relationships. The sum of all sampled values was divided by the number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage.

3.3 Without Project EAD

The model used a Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the EAD with confidence bands (uncertainty). For the without project alternative, the EAD was totaled for each study area reach to obtain the total without project EAD under base year (2025) conditions. The number and type of structures that are damaged the AEP events for the year 2025 under without project conditions are shown in Table 6. It is assumed that the tunnel is functional up to the 2% AEP event, and therefore damages are shown at the 2% AEP frequency, but not at more frequent events.

Table 6. Total Economic Damage by Probability Events in 2025 ($1,000s)

AEP	Residential	Non-Residential	Total
0.50 (2 yr.)	-	-	-
0.20 (5 yr.)	-	-	-
0.10 (10 yr.)	-	-	-
0.04 (25 yr.)	-	-	-
0.02 (50 yr.)	10,951	15,346	26,297
0.01 (100 yr.)	14,869	20,011	34,880
0.005 (200 yr.)	19,257	25,048	44,305
0.002 (500 yr.)	30,712	40,557	71,269

The total EAD by damage category for the existing condition and with project condition measures are shown in Table 7. Both enlarging and construction new flood diversion tunnels reduce EAD below $10,000. A debris retention basin does not reduce EAD relative to the existing condition, which improves the existing flood diversion system and construction.

Table 7. EAD by Damage Category ($1,000's)

Alternative	Plan	Vehicle	Commercial	Public	Resid-ential	Total
Without	Without Project	231	407	346	305	1,289
Alt. 2	Improve Existing Flood Diversion System	231	407	346	305	1,289
Alt. 3A	Enlarge Existing Flood Diversion System – 18-ft Tunnel	0	3	5	2	10
Alt. 3B	Enlarge Existing Flood Diversion System – 24-ft Tunnel	0	3	5	2	10
Alt. 4A	Construct New Flood Diversion System – 18-ft Tunnel	0	3	5	2	10
Alt. 4B	Construct New Flood Diversion System – 24-ft Tunnel	0	3	5	2	10
Alt. 4C	Construct New Flood Diversion System – 16-ft Tunnel	0	3	5	2	10
Alt. 4D	Construct New Flood Diversion System – 14-ft Tunnel	0	3	5	2	10
Alt. 5	Debris Retention Basin	231	407	346	305	1,289
Alt. 6A	Nonstructural Relocations (Entire Floodway)	223	337	285	247	1,092
Alt. 6B	Nonstructural Relocations (Entire Valley)	226	407	290	243	1,166
Alt. 6C	Nonstructural Relocations (Entire Valley, No Hospital)	226	407	341	200	1,174
Alt. 6D	Nonstructural Relocations (Entire Valley, No Hospital/Apt)	226	407	341	204	1,178

EAD can also be presented as damages reduced. The EAD reduced for each of the alternatives is shown in Table 8. Despite tunnel capacities varying significantly, the EAD reduced for Alternative 3 and Alternative 4 is $1,279,120 for every plan since even the smallest scaled plan (Alt 3A) provides with project condition risk reduction up to a

0.004% AEP flood frequency. While Alt 3A still cannot pass the PMF flow, it's level of risk reduction far exceeds the level of frequency that HEC-FDA can process, which is known to be the 0.01% AEP event. Given HEC-FDA's inability to differentiate with project conditions that exceed 0.01% AEP events, Alternative 3 and Alternative 4 have equal damages reduced.

While the HEC-FDA model cannot process damages beyond the 0.01% AEP event, the HEC-LifeSim model has the capability and estimates that total damages increase approximately 87% between the 1% AEP and PMF events. Damages within HEC-LifeSim plateau at the PMF event, which is approximately the 0.0018% AEP event. An increase in damages by 87% for the PMF event would result in approximately an additional $400 in damages reduced and therefore increase total damages reduced to $1,279,520 for the larger tunnel diameters relative to the smaller tunnels. No changes were made to expected annual damages reduced computed by HEC-FDA as a result of the increased risk reduction exceeding 0.01% AEP events.

Table 8. EAD Reduced by Measure ($1,000's)

2025				
Alternative	**Plan**	**Total Without Project**	**Total With Project**	**Damages Reduced**
Without	Without Project	1,289.12	1,289.12	0.00
Alternative 2	Improve Existing Flood Diversion System	1,289.12	1,289.12	0.00
Alternative 3A	Enlarge Existing Flood Diversion System – 18-ft Tunnel	1,289.12	10.00	1,279.12
Alternative 3B	Enlarge Existing Flood Diversion System – 24-ft Tunnel	1,289.12	10.00	1,279.12
Alterative 4A	Construct New Flood Diversion System – 18-ft Tunnel	1,289.12	10.00	1,279.12
Alterative 4B	Construct New Flood Diversion System – 24-ft Tunnel	1,289.12	10.00	1,279.12
Alterative 4C	Construct New Flood Diversion System – 16-ft Tunnel	1,289.12	10.00	1,279.12
Alterative 4D	Construct New Flood Diversion System – 14-ft Tunnel	1,289.12	10.00	1,279.12
Alterative 5	Debris Retention Basin	1,289.12	1,289.12	0.00
Alternative 6A	Floodplain Relocations (Entire Floodway)	1,289.12	1,092.42	196.70
Alternative 6B	Floodplain Relocations (Entire Valley)	1,289.12	1,166.43	122.69
Alternative 6C	Floodplain Relocations (Entire Valley, Hospital Remains)	1,289.12	1,174.44	114.68
Alternative 6D	Floodplain Relocations (Entire Valley, Hospital/Apt Remain)	1,289.12	1,178.36	110.76

3.4 Expected Annual Flood Fight Cost Reductions

The current design of the Lowell Creek Tunnel leads to discharge from the tunnel to flow past Lowell Point Road into Resurrection Bay. Since the tunnel has been completed, the City of Seward has built Lowell Point Road to connect the City of Seward with Lowell Point, which is a popular destination for recreational vehicles and campers. The only road leading to Lowell Point is the one that is impacted by outflows from Lowell Creek Tunnel. As a result, the City of Seward flood fights the outfall to maintain accessibility to Lowell Point and maintain a place for the outfall to dump. Without proper maintenance of the outfall, sediment would quickly deposit and lead to performance issues.

To estimate the costs of flood fight activities, three economists interviewed the City of Seward's Public Works Director and his team in the fall of 2019. The interview resulted in the ability to fill out a table that shows the amount of heavy machinery, human labor, fuel, and bridge repair costs that are associated with various frequency rain events. Flood fighting begins with as little as 3 inches of rain over 24 hours, which is expected to occur at least 4 times per year and results in approximately $40,000 of flood fight costs for the City. The City also explained the maximum extent of flood fight efforts, which is limited by the amount of space the city can fit heavy machinery. The maximum flood fight effort is a 0.8 AEP event, which is expected to lead to close to $628,000 in flood fight costs for the City. The costs dramatically increase as the city must also pay for all of the sediment to be trucked away, which can take up to 7 days of constant loads after a 0.8 AEP flood event concludes. Post-interview, historical photos were analyzed from the 1986 flood event, which was approximately a 0.04 AEP flood event and concluded a 60,000 cubic yard sediment load that would take Seward approximately 40 days to clean up assuming the current rate of truck availability. This estimate of $1.2M in costs for a 0.04 AEP event acts as the upper bound for the flood fight costs avoided analysis.

Expected annual reductions in flood fight costs were calculated by computing the average annual value of flood fighting in the existing condition and under a condition where flood fighting would only be required for events that exceed the tunnel capacity and overtop the diversion dam. The difference in average annual values between these conditions yielded average annual damage (AAD) reduced to $580,000. Alternative 2 (improving the existing tunnel with a modified outfall) and Alternative 5 (debris retention basin) reduce sedimentation at the outfall of the tunnel enough to qualify for this benefit category. Calculations showing how this figure was quantified can be found in Section 8.

4 OSE ACCOUNT LIFE SAFETY CALCULATIONS

4.1 HEC-LifeSim Model Calculations

The HEC-LifeSim model was utilized to evaluate the potential for loss of life in the study area. Life Loss was aggregated at the study area level and was not broken down into reaches, as was conducted for the HEC-FDA modeling results. The HEC-LifeSim model contains both economic variables (first-floor elevation, structure and content values, and depth-damage relationships), and evacuation effectiveness variables (warning issuance delay, first alert warning, protective action initiation, hazard communication delay, submergence criteria, stability criteria, etc.). Each of the HEC-LifeSim assumptions previously listed is subject to uncertainty and can play a significant role in the HEC-LifeSim output. Each scenario was computed within the model, sampling values for each parameter from these distributions, until the model reached the specified amount of iterations, in this case, 1,000 resulting in an output distribution that represents the range of possible consequences for each scenario.

The HEC-LifeSim model computes loss of life for selected hydraulic scenarios. In the case of Lowell Creek, multiple hydraulic scenarios were run for Alternative 2, Alternative 3, and Alternative 4. These scenarios included the 10%, 1%, 0.01%, 0.001%, and 0.0000063% (Probable Maximum Flood (PMF)) AEP events. Further hydraulic scenarios were run for events where the diversion tunnel was blocked or for conditions where surge flow events were present. The HEC-LifeSim model results are organized using standardized incremental risk methodology, meaning the loss of life associated with hydraulic scenarios with an operational tunnel are subtracted from hydraulic scenarios with the tunnel is blocked.

4.2 The Life Safety Story

The Lowell Creek Dam’s location relative to the town of Seward, Alaska, provides unique hydraulic and consequence modeling conditions. During the PMF, the diversion dam will be overtopped, and floodwaters will rapidly flow through a narrow canyon less than a quarter of a mile in length before reaching a group of structures that includes a hospital and apartment complex for the elderly. If the PMF flood is combined with a surge release, floodwaters will reach the Lowell Canyon structures within minutes, supporting flood depths between 7 and 12 ft, with velocities exceeding 16 ft per second. Of the 16 structures in the canyon, 14 are likely to collapse from the combined depth and velocity forces. As the flood wave exits the canyon, its depths and velocities remain destructive throughout its path along Jefferson Street, leading to several more collapsed structures before dissipating into Resurrection Bay.

If a structure collapses from floodwaters, it does not guarantee that there are fatalities within the model. The evacuation process in HEC-LifeSim models human behavior by estimating when Seward will receive an evacuation warning and how households will react to such a warning. Historical flooding data from Seward has shown that water will pond behind the Lowell Creek Dam at an expedient rate, providing limited opportunities for emergency staff to identify the hazard and warn the town of Seward. As a result of these assumptions, the town of Seward has a chance to receive the warning but is inundated before any successful town-wide evacuations can finish occurring. In HEC-LifeSim, Seward residents in structures that have not mobilized are considered to have sheltered in place. However, they are still subject to the limitations of the structure's story height or stability criteria (potential for collapse). Residents that have evacuated may find themselves in even worse conditions, given the rapid onset of life-threatening flows combined with the flood-prone position of being stuck in a car rather than sheltered within a building.

In the case of the two structures with the highest life loss (Seward hospital & apartment), both structures have their stability criteria exceeded, meaning any occupants within the structure are subject to higher fatality rates. Vertical evacuation (moving to a higher floor) is not effective in the case of a collapsed structure. In order to ensure life loss was not overestimated, the apartment building was split into two structures given its size, and subsequent model runs resulted in less life loss as half of the building no longer collapsed. More information regarding detailed life loss results can be found in Appendix H: Risk Assessment.

The alternatives presented within the Economic Appendix can limit the potential for life loss resulting from hydraulic scenarios that block the tunnel and/or overtop the dam. HEC-LifeSim has been run for the alternatives, and the reduction in incremental risk is presented along with traditional NED metrics such as net benefits.

4.3 Population at Risk

The population at risk (PAR) is defined as the number of people downstream of a dam that would be subject to inundation risk. In HEC-LifeSim, PAR is calculated as a function of both inundation extents (spatial) and warning issuance time (temporal). PAR changes per LifeSim iteration. The population in each structure is linearly interpolated between 2 AM and 2 PM, depending on when the warning is issued. [redacted]

The primary difference between the tunnel open and tunnel blocked condition is the quantity of flow routing through the diversion tunnel. The tunnel's capacity is approximately 2,600 cfs, or the 2% AEP event, which is why there are not any structures or PAR for the tunnel open scenario for the 10% and 1% AEP events. In the surge scenario, there are additional flows during the 10% and 1% AEP scenarios that exceed the tunnel's capacity and therefore lead to overtopping events.

[redacted]

4.4 Incremental Life Loss Results

[redacted] For Alternative 2, improving the existing tunnel, incremental life loss is not significantly reduced since the alternative does not create more capacity within the tunnel. Alternatives 3 and 4, on the other hand, increase the total capacity of the tunnel to over 8,400 cfs, which significantly reduces life loss within the tunnel open (non-fail) condition and tunnel blocked (fail) condition.

[redacted]

[redacted]

4.5 Total Life Loss Reduced Results

While incremental life loss helps show the difference between the tunnel flowing as designed versus a rarer condition where the tunnel is blocked, total life loss helps show the benefit of investing in an alternative from a total life loss reduced perspective. [redacted] Alternative 2 only rehabilitates the tunnel without increasing capacity for flows, leading to zero reduction in loss of life for both tunnels open and tunnel blocked conditions.

Alternative 3 performs well in reducing total life loss in both conditions but lags behind Alternative 4 during the tunnel blocked condition during non-surge flows. During the tunnel open condition, both Alternative 3 and Alternative 4 perform nearly equal, with Alternative 4 only showing an advantage during the 0.001% event with a surge.

[redacted]

4.6 Nonstructural Life Loss Summary

The HEC-LifeSim model was run for the four different nonstructural measures (Alt 6A, B, C, D) previously identified in this Economic Appendix. [redacted]

[redacted]

4.7 Average Annual Life Loss Results

The final life safety metric to be used to evaluate alternatives is average annual life loss (AALL). This metric considers the hazard, which includes the frequency of the hydraulic scenario, and performance, which includes how well the diversion dam will perform during the hydraulic scenario. [redacted]

[redacted]

5 PROJECT COSTS

5.1 Construction Schedule

To compute interest during construction (IDC), the construction of the project alternatives is expected to begin in the year 2021. It will continue for four years for the new tunnel construction alternatives (Alt 4), 7 years for rehabilitating the existing tunnel (Alt 3) due to limited winter construction periods, and three months for nonstructural measures according to Planning Bulletin 2019-03.

5.2 Structural Costs

Structural cost estimates for the final array were developed by the Alaska District Cost Engineering Branch and were commensurate with a class 4 cost estimate. An abbreviated cost risk analysis was completed to determine the contingencies used for all structural measures.

Interest during construction was calculated for each of the structural alternatives and assumed the construction period as identified in Section 5.1. Interest during construction was calculated using an end of year payment schedule and 2.5% discount rate.

5.3 Annual Project Costs

Life cycle cost estimates were provided for the nonstructural measures in FY21 price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction and gross investment cost at the end of the installation period. The FY 2021 Federal interest rate of 2.5% was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis.

Operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs associated with the final array of measures was computed for each alternative. Alternative 2, 3, and 4 are assumed to be maintained and rehabilitated based on historic costs dating back to the tunnel's construction. Additional maintenance costs were added to dredge Resurrection Bay, where the proposed extended tunnel outfall will outlet sediment, and also to add an upstream stream gage. The maintenance included for Alternative 5 includes removing sediment build up from the retention basin. There are no costs for any alternative associated with wetland mitigation, real estate, or cultural resources. A breakdown of costs associated with each of the project measures is shown in Tables 18–20. OMRR&R for Alternative 6 includes expected future maintenance costs associated with the existing tunnel.

Table 18. Summary of Costs for Structural Measures (Part 1) ($)

Item	Alternative 2	Alternative 3A	Alternative 3B	Alterative 4A
	Improve Existing Flood Diversion System	Enlarge Existing Flood Diversion System – 18-ft Tunnel	Enlarge Existing Flood Diversion System – 24-ft Tunnel	Construct New Flood Diversion System – 18-ft Tunnel
Construction First Cost	53,061,221	157,282,815	314,846,026	122,928,162
LERRD (Utility Relocations)	350,000	350,000	350,000	350,000
Interest During Construction	730,000	13,587,000	27,199,000	5,164,000
Total Cost	54,141,221	171,219,815	342,395,026	128,442,162
Average Annual Construction	1,908,914	6,036,878	12,072,183	4,528,621
Average Annual OMRR&R	841,000	1,012,000	1,141,000	1,077,000
Total Average Annual Cost	2,750,000	7,049,000	13,213,000	5,606,000
LERRD = Lands, Easements, Rights of Way, Relocations, and Disposal Area				

Table 19. Summary of Costs for Structural Measures (Part 2) ($)

Item	Alterative 4B	Alterative 4C	Alterative 4D	Alterative 5
	Construct New Flood Diversion System – 24-ft Tunnel	Construct New Flood Diversion System – 16-ft Tunnel	Construct New Flood Diversion System – 14-ft Tunnel	Debris Retention Basin
Construction First Cost	172,606,683	122,600,000	121,600,000	15,800,000
LERRD (Utility Relocations)	350,000	350,000	350,000	-
Interest During Construction	7,251,000	5,151,000	5,109,000	436,000
Total Cost	180,207,683	128,101,000	127,059,000	16,236,000
Average Annual Construction	6,353,773	4,516,592	4,479,853	572,450
Average Annual OMRR&R	1,215,000	1,077,000	1,077,000	617,000
Total Average Annual Cost	7,569,000	5,594,000	5,557,000	1,189,000
LERRD = Lands, Easements, Rights of Way, Relocations, and Disposal Area				

Table 20. Summary of Costs for Nonstructural Measures ($)

Item	Alternative 6A	Alternative 6B	Alternative 6C	Alternative 6D
	Floodplain Relocations (Entire Floodway)	Floodplain Relocations (Entire Valley)	Floodplain Relocations (Entire Valley, No Hospital)	Floodplain Relocations (Entire Valley, No Hospital/Apt)
Construction First Cost	405,600,000	126,200,000	59,000,000	48,000,000
LERRD (Utility Relocations)	-	-	-	-
Interest During Construction	1,253,850	390,128	182,389	148,385
Total Cost	406,853,850	126,590,128	59,182,389	48,148,385
Average Annual Construction	14,344,876	4,463,322	2,086,656	1,697,618
Average Annual OMRR&R	980,000	980,000	980,000	980,000
Total Average Annual Cost	15,325,000	5,443,000	3,067,000	2,678,000
LERRD = Lands, Easements, Rights of Way, Relocations, and Disposal Area				

6 RESULTS OF THE ECONOMIC ANALYSIS

6.1 NET BENEFIT ANALYSIS

6.1.1 Calculation of Net Benefits

The expected annual benefits attributable to the final array of alternatives were compared to the annual costs to develop a benefit-to-cost ratio for the measures. The net benefits for the measures were calculated by subtracting the annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project measures.

Net benefit calculations for the with-project condition were computed differently by alternative. Alternatives 3 and 4 assumed that the with project condition would be able to pass highly infrequent events, and therefore limited residual damages remained. Alternatives 2 and 5 do not reduce structural damages downstream of the diversion dam and therefore were not run through HEC-FDA as a with project condition. The comparison of the net benefits for each of the alternatives is shown in Table 21 through Table 23.

Table 21. Structural Economic Benefits (1 of 2) (Damages Reduced)

Damage Category	Alternative 2	Alternative 3A	Alternative 3B	Alterative 4A
	Improve Existing Flood Diversion System	Enlarge Existing Flood Diversion System – 18-ft Tunnel	Enlarge Existing Flood Diversion System – 24-ft Tunnel	Construct New Flood Diversion System – 18-ft Tunnel
Structural	-	571,653	571,653	571,653
Contents	-	625,167	625,167	625,167
Vehicle	-	52,777	52,777	52,777
Debris Removal	-	39,404	39,404	39,404
Flood Fight Costs Avoided	580,000	580,000	580,000	580,000
Total Average Annual Benefits	580,000	1,869,000	1,869,000	1,869,000
Total Average Annual Cost	2,750,000	7,049,000	13,213,000	5,606,000
Net Benefits	(2,170,000)	(5,180,000)	(11,344,000)	(3,737,000)
BCR	0.21	0.27	0.14	0.33

Table 22. Structural Economic Benefits (2 of 2) (Damages Reduced)

Damage Category	Alterative 4B	Alterative 4C	Alterative 4D	Alterative 5
	Construct New Flood Diversion System – 24-ft Tunnel	Construct New Flood Diversion System – 16-ft Tunnel	Construct New Flood Diversion System – 14-ft Tunnel	Debris Retention Basin
Structural	571,653	571,653	571,653	-
Contents	625,167	625,167	625,167	-
Vehicle	52,777	52,777	52,777	-
Debris Removal	39,404	39,404	39,404	-
Flood Fight Costs Avoided	580,000	580,000	580,000	580,000
Total Average Annual Benefits	1,869,000	1,869,000	1,869,000	580,000
Total Average Annual Cost	7,569,000	5,594,000	5,557,000	1,189,000
Net Benefits	(5,700,000)	(3,725,000)	(3,688,000)	(609,000)
BCR	0.25	0.33	0.34	0.49

Table 23. Nonstructural Economic Benefits (Damages Reduced)

Damage Category	Alternative 6A	Alternative 6B	Alternative 6C	Alternative 6D
	Floodplain Relocations (Entire Floodway)	Floodplain Relocations (Entire Valley)	Floodplain Relocations (Entire Valley, No Hospital)	Floodplain Relocations (Entire Valley, No Hospital/Apt)
Structural	87,234	54,411	50,863	49,120
Contents	95,400	59,505	55,624	53,719
Vehicle	8,054	5,023	4,696	4,535
Debris Removal	6,013	3,751	3,506	3,386
Flood Fight Costs Avoided	-	-	-	-
Total Average Annual Benefits	196,700	122,690	114,689	110,760
Total Average Annual Cost	15,325,000	5,443,000	3,067,000	2,678,000
Net Benefits	(15,128,300)	(5,320,310)	(2,952,311)	(2,567,240)
BCR	0.01	0.02	0.04	0.04

Table 24 displays the recommended plan that would reduce flood damage [redacted] for more than 250 structures. [redacted]

Table 24. Economic Benefits of the Recommended Plan

Alternative 4A	Expected Annual Benefits and Costs
Structure, Contents, Vehicles, and Debris Removal	$1,289,000
Flood Fight Costs Avoided	$580,000
Total Annual Benefits	$1,869,000
First Costs	$122,928,162
Interest During Construction	$5,164,000
Annual Operation & Maintenance Costs	$1,077,000
Total Annual Costs	$5,606,000
B/C Ratio	0.33
Expected Annual Net Benefits	($3,737,000)

[redacted]

6.2 CE/ICA Life Safety Analysis

Alternatives 3, 4, and 6 were each analyzed within HEC-LifeSim for its impact on reducing life loss relative to the existing condition, both for tunnel open and blocked, and with and without surge releases. The Alaska District Geotech Section used RMC-DAMRAE to summarize the hydraulic frequencies, life loss, and failure probabilities to develop AALL and residual risk reduction statistics that could be used in combination with average annual costs within the CE/ICA. The CE/ICA model produces an efficient frontier that organizes each measure into either a best buy (optimized), cost-effective, or not cost effective.

[redacted]

[redacted]

[redacted]

[redacted]

6.3 Calculation of Final Project Benefits and Costs

The cost estimate for the recommended plan (4A) was certified by the Cost Engineering Mandatory Center of Expertise during the final agency technical review of the study, resulting in a certified cost. The certified cost was only developed for the recommended plan, and therefore Table 26 below shows the refined benefit to cost analysis for the recommended plan. It is assumed that the proportional cost increase shown in Table 26 relative to the previous cost identified in Table 24 would be consistent across all structural measures and therefore there is no reason to reassess alternatives.

Table 26. Total Life Loss Reduced of the Recommended Plan

	Alterative 4A (Final)
	Construct New Flood Diversion System – 18' Tunnel
Construction Cost	139,345,000
LERRD	7,000
PED	18,212,000
Construction Management	27,660,000
Total Construction First Cost	185,225,000
Interest During Construction	7,782,000
Total Cost	193,007,000
Average Annual Construction	6,805,000
Average Annual OMRR&R	1,041,000
Total Average Annual Cost	7,846,000
Total Average Annual Benefits	1,869,000
Net Benefits	(5,977,000)
BCR	0.24

6.4 Risk Analysis

The risk analysis is a section of the report that discusses the risk and uncertainty associated with the HEC-FDA model and the economic benefits. The HEC-FDA model was utilized for the existing condition and with project alternatives to an extent previously described in Section 5.1.

6.5 Benefit Exceedance Probability Relationship

Based on the information and inputs available at this point in the study, there is a high likelihood that the net benefits associated with the structural alternatives presented will remain negative. The cost estimates have been conservative, combined with the fact that the alternatives with the highest reduction in damages assume that nearly all damage in rare frequency events will be fully mitigated.

The exception to this statement is that the sedimentation issue that the study area experiences is currently underrepresented in the economic analysis. The risks that remain from this is that proper quantification of the sedimentation issue could lead to additional NED benefits. A sensitivity analysis could be performed using existing depth-damage relationships to determine what escalation of damages would have to occur to justify one of the alternatives that reduce structural damages. With this said, it is highly likely that even with aggressive depth-damage relationships showing high damages at low stages, the NED analysis would still result in average annual costs exceeding AADs reduced.

6.6 Residual Risk

The flood risk that remains in the floodplain after the proposed alternatives are implemented is known as the residual flood risk. For Lowell Creek, the residual risk depends on the alternative selected. For the recommended plan, Alternative 4A, risk to life safety is limited to extremely remote events that exceed 0.0003% AEP event. The risk to infrastructure and structural damage is also greatly reduced and would only occur in events that the tunnel or diversion dam did not perform as designed. Incorporation of a fragility curve in HEC-FDA would be one way to quantify the residual risk associated with infrastructure that may not perform as designed.

Quantifying the residual risk for the recommended plan (Alt 4A), is challenging because the HEC-FDA model is constrained to hydraulic events less than the 0.01% AEP event (10,000-YR) and therefore benefits associated with the PMF for remote events are too infrequent to be computed in HEC-FDA. Regardless, the residual risk associated with economic damages is extremely low for the recommended plan.

6.7 Project Performance

Project performance can best be described by translating each of the with project conditions relative to tunnel diameter to a level of risk reduction through the lens of Annual Exceedance Probability (AEP). Table 27 shows the level of risk reduction for various with project conditions, as well as the existing and PMF frequencies. The table helps show that even the smallest alternative analyzed (tunnel enlargement) provides a minimum level of risk reduction of 0.004% AEP, which is beyond the probabilities that HEC-FDA has the capability of computing. As a result, a probability distribution of the benefits could not be displayed along with the probability that the net benefits are negative. Given that all tunnel conditions exceed a minimum level of risk reduction of 0.004% AEP, it can be concluded that there is a high probability that net benefits will remain negative and that the risk and uncertainty associated with the expected annual damages has no potential to increase the net benefits above zero.

Table 27. Hydraulic Frequencies with Tunnel Alternatives

AEP	Return Period	CFS (Best Est.)	Level of Risk Reduction
1E-08	100,000,000	21,000	Alt 4B (24Ft New Tunnel)
4E-08	23,404,255	19,000	Alt 3B (24ft Enlargement)
1E-07	10,000,000	15,500	
1E-06	1,000,000	12,100	
3E-06	287,129	11,300	Alt 4A (18Ft New Tunnel)
1E-05	100,000	9,200	
2E-05	52,910	8,800	PMF
4E-05	27,586	8,500	Alt 3A (18ft Enlargement)
1E-04	10,000	6,800	
0.001	1,000	4,900	
0.01	100	3,200	
0.02	50	2,800	Existing Tunnel
0.05	20	2,300	
0.1	10	1,900	
0.2	5	1,500	

ER 1105-2-101, Risk Assessment for Flood Risk Management Studies, provides the requirement to describe project performance by AEP, assurance (conditional non-exceedance probability), and Long-Term Exceedance Probability. Project performance describing these attributes is computed within HEC-FDA and is based on a target stage. Table 26 shows the project performance table consistent with ER 1105-2-101 for the existing condition and the with-project condition (Alt 4A, the recommended plan).

As previously referenced in the report, the existing condition tunnel is expected to provide approximately a 2% AEP level of risk reduction, and the project performance table reflects this condition in estimating the existing condition has a 50% chance of containing the 1% AEP flood event. In the with-project condition, the second tunnel provides a level of risk reduction that exceeds the 0.002% AEP hydraulic event, and therefore shows a 100% chance of containing each of the hydraulic frequencies and a 0% chance of long-term risk.

All of the with-project alternatives run through HEC-FDA (Alt 3A, 3B, 4A, and 4B) provide a minimum risk reduction of at least 0.002% AEP and therefore separate tables were not shown since they all provide risk reduction that exceeds the 0.2% AEP hydraulic event. Alternative 2 and 5 were not run through HEC-FDA and therefore project performance cannot be reported for those alternatives. These alternatives were not run through HEC-FDA because they did not provide any reductions in stages and therefore there were no quantifiable damage reduction benefits.

Table 28. Lowell Creek Project Performance

Alternative	Target Stage Annual Exceedance Probability			Long-Term Risk (% over years)			Conditional Non-Exceedance Probability (% by AEP)					
	Target Stage	Median	Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Existing Condition (Tunnel Operational)	64.5	0.01	0.02	16	41	58	100	92	68	50	0	0
Alt 4A (New Flood Diversion System – 18-*ft* Tunnel)	121	0.00	0.00	0	0	0	100	100	100	100	100	100

Even though the with-project conditions are shown to reduce the level of risk to an extremely remote event, risk can never fully be eliminated and uncertainty remains in the tunnel design and final metric of performance will not be known until further into the study when design and implementation of the with-project condition is completed. HEC-FDA only samples hydraulic events up to the 0.01% event, and therefore the model is not capturing the damages associated with more remote events that potentially could overwhelm the with-project condition.

6.8 Compliance with Section 308 of WRDA 1990

Section 308 of the Water Resource Development Act (WRDA) 1990 limits structures built or substantially improved after 1 July 1991, in designated floodplains not elevated to the 1% AEP flood elevation from being included in the benefit base of the economic analysis. The economic analysis complies with Section 308 of WRDA 1990 since it includes no structures that have been built or substantially improved in the designated floodplain. Reach 2, 3, 4, 5, and 6 are all outside of the designated floodplain. Portions of Reach 1 are inside the designated floodplain, but the only structures impacted are temporary recreational vehicles and mobile homes that are not designated as a built structure. The Federal Emergency Management Agency (FEMA) flood insurance rate map for Seward and the designation of the AE Zone near the edge of the study area impacts only personal property and not built structures is shown in Figure 6.

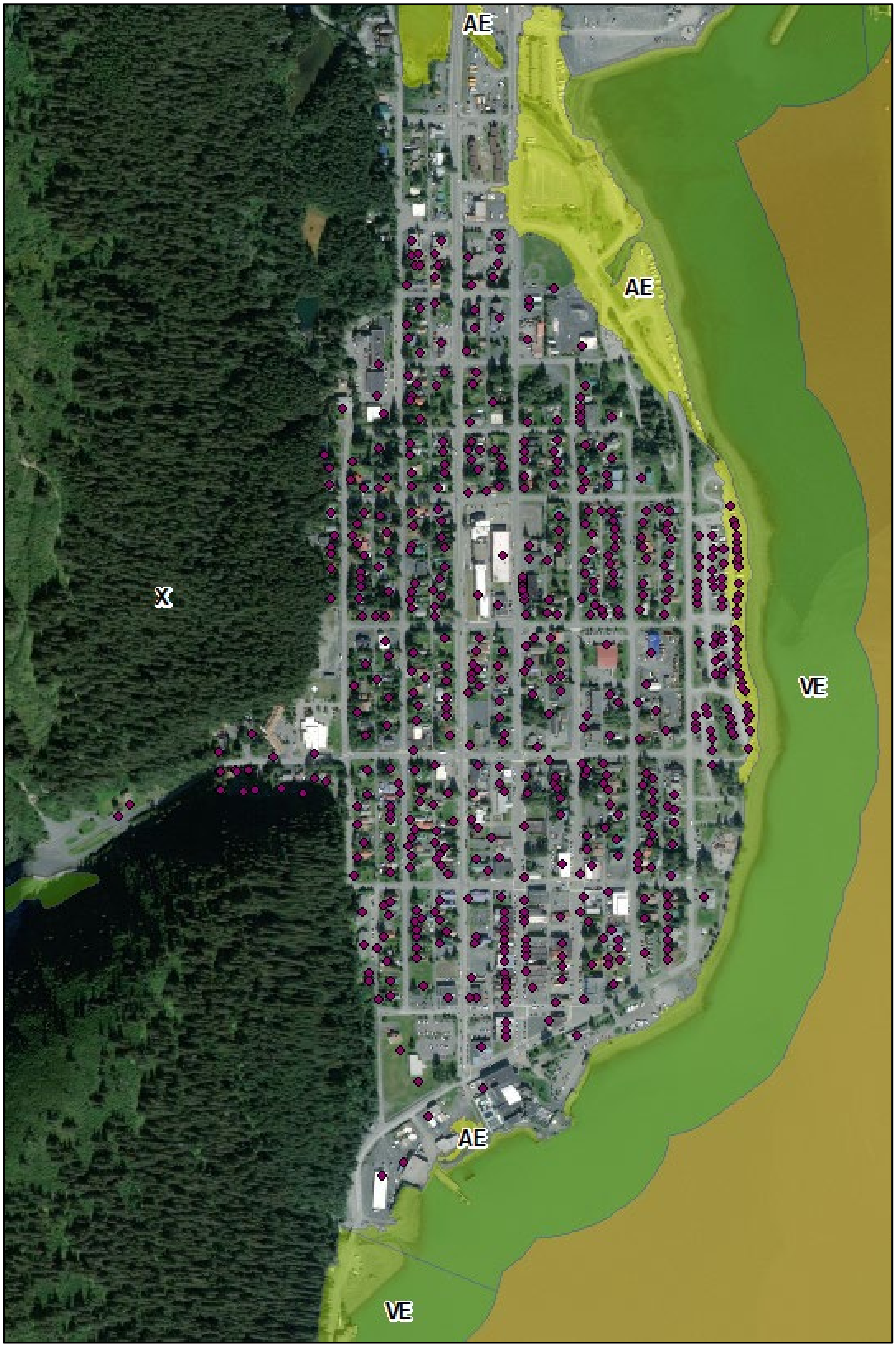

Figure 6. Seward FEMA Flood Insurance Rate Map

6.9 Surge Flow Sensitivity Analysis

The current condition of the economic analysis for Lowell Creek assumes that there is no potential for surge flows within the HEC-FDA output that computes AAD. To model surge flows, the economics team examined the joint probability for surge flow defined by two variables with the potential to change:

1. Stage increase as a result of surge flow
2. The associated decrease in the frequency of the surge flows occurring

The first condition was incorporated in HEC-FDA by overlaying the structure inventory in GIS with the max depth grid for the 10% (10YR) AEP frequency for the with and without surge conditions. The flood depths were extracted to each structure to determine what the change in flood stage would be with and without the surge flows. This same procedure was followed for the 1% (100YR) AEP frequency. Increases in flood stage for the 1% (100YR) AEP frequency averaged between 0.5 and 1.5 ft depending on the location of flooding.

To independently model the first condition, the water surface profiles for each structure were modified as if the increased stage associated with surge flow were the existing condition, with no change to the frequency of the surge flow occurring. Isolating increased stages to represent surge flow resulted in a condition where the Lowell Creek diversion tunnel could no longer retain flows from events exceeding the 10% (10YR) AEP frequency. This change in modeling conditions leads to a spike in AAD from $899,840 (existing condition) to $8,193,360 (surge condition with no frequency Δ). The order of magnitude jump in AADs occurred due to highly frequent flood events (10%, 4%, 2%, etc.) now being able to inundate the town of Seward. Where in events without surge, these frequencies would ordinarily be contained by the Lowell Creek diversion tunnel.

Damages associated with the first condition (surge condition with no frequency Δ) were high enough to justify structural alternatives. Therefore, a decrease in frequency associated with surge flows needed to be added to the HEC-FDA model to account for the likelihood of the flows occurring. Exact surge flow-frequencies could not be incorporated into HEC-FDA. Therefore, the second modeling condition assumed the joint probability of a surge flow during a 10% (10YR) AEP frequency event could not occur at a rate more frequent than a 1% (100YR) AEP frequency.

To model the second condition (surge condition with frequency Δ), the HEC-FDA model was modified to change the Lowell Creek diversion tunnel capacity to be able to pass surge flows up to the 1% (100YR) AEP frequency event. By adjusting the stage-frequency curve, the HEC-FDA model resulted in a condition where damages associated with surge flow events can only occur at frequencies larger than the 1% (100YR AEP) frequency event. This change in modeling conditions resulted in a smaller increase in AADs from $899,840 (existing condition) to $1,021,150 (surge condition with frequency Δ).

Both conditions are visually explained in Figure 7. The flood stage on the Y-axis and flows frequency on the X-axis (defined as the return interval, 10-YR for 10% AEP, etc.) is shown in Figure 7. The blue line represents the existing condition, where there are no increases in stage and, therefore, no additional AAD. The red line represents the first surge condition with an increase in stage from surge flow, but no change in frequency. As shown in the figure, nearly all of the increased AADs come from flows occurring before the 1% (100YR AEP) frequency (red box). The dashed black line represents the second surge condition where an increase in stage from surge flow, and a decrease in frequency only leads to an increase in AADs for events less frequent than the 1% (100YR AEP) frequency (black box).

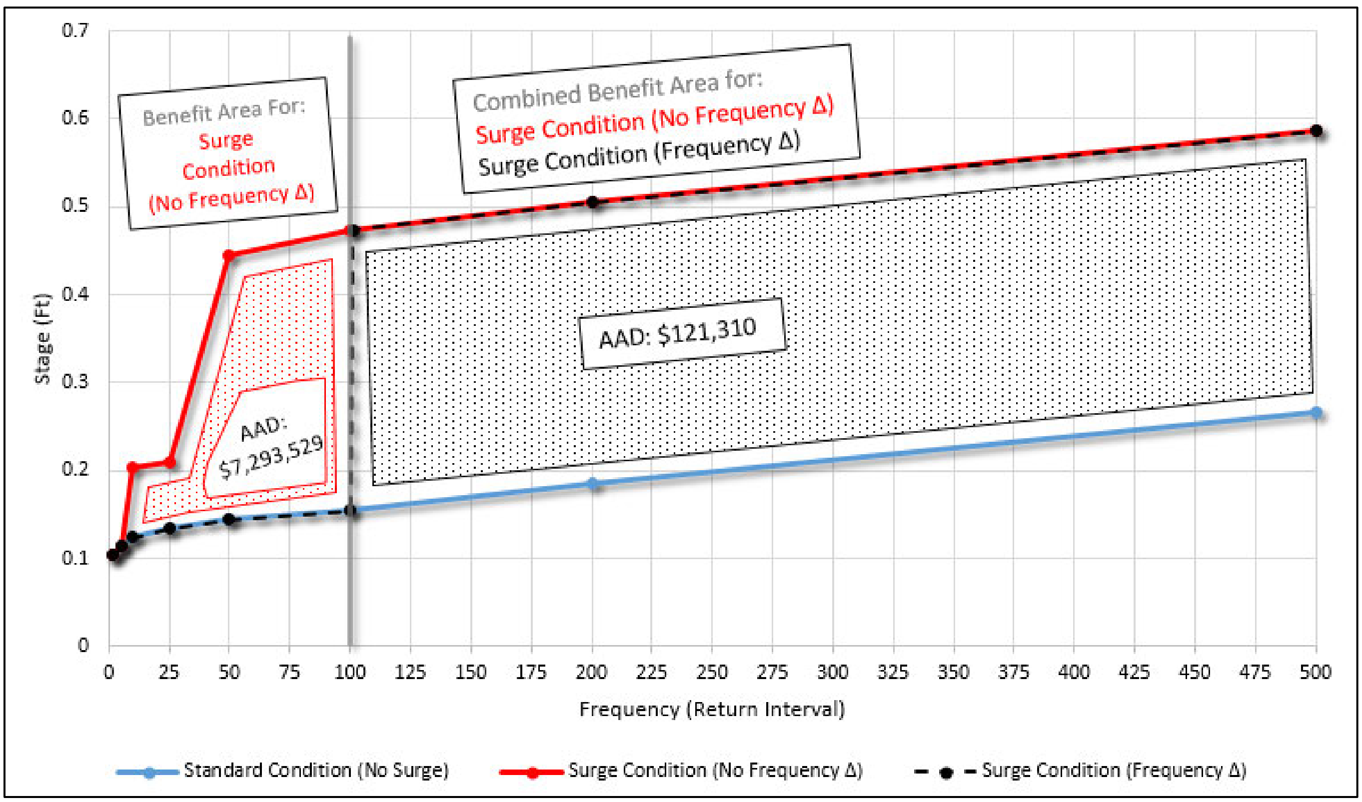

Figure 7. Surge Flow Stage-Frequency Curve

7 RED ACCOUNT

When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project alternatives. The RECONS model utilizes a total construction cost of a project that is attributable to contracts being awarded to complete the construction of the project. This cost excludes USACE labor associated with planning, engineering, and design, as well as economic costs like interest during construction. The costs also include real estate and cultural resources costs since the disbursement of Federal funds are expected to be spent within the region of the study area. An example of this would be using Uniform Relocation Act funding to pay a tenant to temporarily relocate to a hotel while their home is being elevated. Tables 28-51 present to RECONS model results for each alternative evaluated. The Tables for each alternative show both Impacts to Local, State, and National Economy and Local Impacts to Specific Industries.

The total cost input into the RECONS model for the recommended plan (4A) was $122,928,000, which again excludes pre-construction engineering and design (PED), construction management, and IDC. A flood risk management construction spending profile was utilized. Of this total expenditure, $89,730,000 will be captured within the local area. The remainder of the expenditures will be captured within the state and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The RED effects are shown for the local, state, and national impact areas. In summary, the expenditures $122,928,000 support a total of 1,498 full-time equivalent jobs, $83,281,000 in labor income, $90,403,000 in the gross regional product, and $146,576,000 in economic output in the local impact area. More broadly, these expenditures support 2,407 full-time equivalent jobs, $163,206,000 in labor income, $196,345,000 in the gross regional product, and $339,749,000 in economic output in the nation.

Table 29. Alt 2: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$38,731,280	491.4	$28,412,981	$25,299,554
Secondary Impact		$24,537,577	155.3	$7,534,921	$13,722,468
Total Impact	$38,731,280	$63,268,856	646.6	$35,947,902	$39,022,022
State					
Direct Impact		$29,990,022	304.1	$25,613,876	$17,244,831
Secondary Impact		$27,660,766	151.3	$8,984,833	$16,125,696
Total Impact	$41,663,491	$57,650,789	455.4	$34,598,710	$33,370,527
National					
Direct Impact		$50,384,114	574.9	$40,184,947	$32,592,250
Secondary Impact		$96,266,359	464.0	$30,262,122	$52,158,742
Total Impact	$50,384,114	$146,650,473	1,038.9	$70,447,069	$84,750,992

Table 30. Alt 2: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$17,510,203	214.7	$12,088,104	$6,759,634
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$12,527	0.0	$18	$57
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$6,933	0.0	$1,961	$3,520
400	Wholesale - Other nondurable goods merchant wholesalers	$215,067	0.5	$76,197	$138,572
401	Wholesale - Wholesale electronic markets and agents and brokers	$17,548	0.5	$33,305	$13,417
414	Air transportation	$9,325	0.0	$2,508	$4,717
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$8,906	0.0	$1,197	$1,923
417	Truck transportation	$163,654	1.0	$56,413	$70,387
444	Insurance carriers, except direct life	$104,563	0.1	$14,064	$54,518
453	Commercial and industrial machinery and equipment rental and leasing	$2,644,683	5.5	$487,488	$1,937,934
457	Architectural, engineering, and related services	$358,554	2.2	$133,521	$163,576
463	Environmental and other technical consulting services	$434,419	4.8	$271,034	$260,027
470	Office administrative services	$1,989,796	31.4	$707,813	$636,171
544	Employment and payroll of Federal govt, non-military	$3,581,632	19.0	$2,865,892	$3,581,632
5001	Private Labor	$11,673,468	211.6	$11,673,468	$11,673,468
	Direct Impact	**$38,731,280**	**491.4**	**$28,412,981**	**$25,299,554**
	Secondary Impact	**$24,537,577**	**155.3**	**$7,534,921**	**$13,722,468**
	Total Impact	**$63,268,856**	**646.6**	**$35,947,902**	**$39,022,022**

Table 31. Alt 3A: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$114,806,342	1,456.4	$84,221,085	$74,992,339
Secondary Impact		$72,733,704	460.2	$22,334,833	$40,675,815
Total Impact	$114,806,342	$187,540,046	1,916.7	$106,555,919	$115,668,154
State					
Direct Impact		$88,895,713	901.4	$75,924,046	$51,116,721
Secondary Impact		$81,991,389	448.3	$26,632,631	$47,799,405
Total Impact	$123,497,933	$170,887,103	1,349.8	$102,556,676	$98,916,126
National					
Direct Impact		$149,347,398	1,704.0	$119,115,268	$96,609,175
Secondary Impact		$285,350,461	1,375.4	$89,702,265	$154,607,709
Total Impact	$149,347,398	$434,697,859	3,079.4	$208,817,533	$251,216,883

Table 32. Alt 3A: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$51,903,329	636.4	$35,831,273	$20,036,748
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$37,132	0.0	$53	$168
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$20,550	0.1	$5,811	$10,433
400	Wholesale - Other nondurable goods merchant wholesalers	$637,496	1.6	$225,861	$410,752
401	Wholesale - Wholesale electronic markets and agents and brokers	$52,017	1.4	$98,722	$39,771
414	Air transportation	$27,642	0.1	$7,433	$13,981
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$26,399	0.0	$3,547	$5,701
417	Truck transportation	$485,100	2.8	$167,219	$208,639
444	Insurance carriers, except direct life	$309,945	0.4	$41,688	$161,601
453	Commercial and industrial machinery and equipment rental and leasing	$7,839,306	16.4	$1,444,999	$5,744,379
457	Architectural, engineering, and related services	$1,062,817	6.4	$395,779	$484,868
463	Environmental and other technical consulting services	$1,287,696	14.3	$803,391	$770,765
470	Office administrative services	$5,898,106	93.2	$2,098,081	$1,885,723
544	Employment and payroll of Federal govt, non-military	$10,616,590	56.2	$8,495,010	$10,616,590
5001	Private Labor	$34,602,219	627.2	$34,602,219	$34,602,219
	Direct Impact	**$114,806,342**	**1456.4**	**$84,221,085**	**$74,992,339**
	Secondary Impact	**$72,733,704**	**460.2**	**$22,334,833**	**$40,675,815**
	Total Impact	**$187,540,046**	**1916.7**	**$106,555,919**	**$115,668,154**

Table 33. Alt 3B: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$229,817,356	2,915.5	$168,592,316	$150,118,370
Secondary Impact		$145,597,074	921.3	$44,709,484	$81,424,145
Total Impact	$229,817,356	$375,414,430	3,836.7	$213,301,800	$231,542,515
State					
Direct Impact		$177,949,906	1,804.5	$151,983,445	$102,324,570
Secondary Impact		$164,128,948	897.5	$53,312,741	$95,684,025
Total Impact	$247,216,031	$342,078,854	2,702.0	$205,296,186	$198,008,595
National					
Direct Impact		$298,961,045	3,411.0	$238,442,890	$193,390,579
Secondary Impact		$571,209,631	2,753.3	$179,564,446	$309,491,044
Total Impact	$298,961,045	$870,170,676	6,164.3	$418,007,335	$502,881,624

Table 34. Alt 3B: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$103,899,188	1274.0	$71,726,424	$40,109,217
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$74,329	0.1	$105	$335
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$41,136	0.2	$11,633	$20,885
400	Wholesale - Other nondurable goods merchant wholesalers	$1,276,129	3.1	$452,124	$822,236
401	Wholesale - Wholesale electronic markets and agents and brokers	$104,126	2.8	$197,620	$79,614
414	Air transportation	$55,333	0.2	$14,879	$27,987
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$52,846	0.1	$7,100	$11,412
417	Truck transportation	$971,066	5.7	$334,736	$417,650
444	Insurance carriers, except direct life	$620,442	0.7	$83,450	$323,490
453	Commercial and industrial machinery and equipment rental and leasing	$15,692,588	32.7	$2,892,574	$11,499,000
457	Architectural, engineering, and related services	$2,127,528	12.9	$792,263	$970,601
463	Environmental and other technical consulting services	$2,577,688	28.6	$1,608,215	$1,542,904
470	Office administrative services	$11,806,726	186.5	$4,199,903	$3,774,808
544	Employment and payroll of Federal govt, non-military	$21,252,107	112.5	$17,005,165	$21,252,107
5001	Private Labor	$69,266,124	1255.4	$69,266,124	$69,266,124
	Direct Impact	**$229,817,356**	**2915.5**	**$168,592,316**	**$150,118,370**
	Secondary Impact	**$145,597,074**	**921.3**	**$44,709,484**	**$81,424,145**
	Total Impact	**$375,414,430**	**3836.7**	**$213,301,800**	**$231,542,515**

Table 35. Alt 4A: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$89,729,654	1,138.3	$65,825,012	$58,612,064
Secondary Impact		$56,846,774	359.7	$17,456,326	$31,791,160
Total Impact	$89,729,654	$146,576,428	1,498.0	$83,281,338	$90,403,224
State					
Direct Impact		$69,478,580	704.5	$59,340,262	$39,951,501
Secondary Impact		$64,082,340	350.4	$20,815,372	$37,358,773
Total Impact	$96,522,776	$133,560,920	1,055.0	$80,155,634	$77,310,274
National					
Direct Impact		$116,726,046	1,331.8	$93,097,399	$75,507,221
Secondary Impact		$223,022,507	1,075.0	$70,108,959	$120,837,368
Total Impact	$116,726,046	$339,748,553	2,406.8	$163,206,359	$196,344,589

Table 36. Alt 4A: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$40,566,293	497.4	$28,004,792	$15,660,202
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$29,021	0.0	$41	$131
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$16,061	0.1	$4,542	$8,154
400	Wholesale - Other nondurable goods merchant wholesalers	$498,250	1.2	$176,527	$321,033
401	Wholesale - Wholesale electronic markets and agents and brokers	$40,655	1.1	$77,158	$31,084
414	Air transportation	$21,604	0.1	$5,809	$10,927
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$20,633	0.0	$2,772	$4,456
417	Truck transportation	$379,142	2.2	$130,694	$163,067
444	Insurance carriers, except direct life	$242,245	0.3	$32,582	$126,303
453	Commercial and industrial machinery and equipment rental and leasing	$6,126,998	12.8	$1,129,374	$4,489,658
457	Architectural, engineering, and related services	$830,670	5.0	$309,331	$378,960
463	Environmental and other technical consulting services	$1,006,430	11.2	$627,910	$602,410
470	Office administrative services	$4,609,806	72.8	$1,639,806	$1,473,832
544	Employment and payroll of Federal govt, non-military	$8,297,651	43.9	$6,639,479	$8,297,651
5001	Private Labor	$27,044,195	490.2	$27,044,195	$27,044,195
	Direct Impact	**$89,729,654**	**1138.3**	**$65,825,012**	**$58,612,064**
	Secondary Impact	**$56,846,774**	**359.7**	**$17,456,326**	**$31,791,160**
	Total Impact	**$146,576,428**	**1498.0**	**$83,281,338**	**$90,403,224**

Table 37. Alt 4B: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$125,991,781	1,598.3	$92,426,640	$82,298,749
Secondary Impact		$79,820,058	505.1	$24,510,888	$44,638,809
Total Impact	$125,991,781	$205,811,839	2,103.4	$116,937,529	$126,937,557
State					
Direct Impact		$97,556,712	989.3	$83,321,230	$56,096,959
Secondary Impact		$89,979,708	492.0	$29,227,415	$52,456,442
Total Impact	$135,530,182	$187,536,419	1,481.3	$112,548,645	$108,553,401
National					
Direct Impact		$163,898,128	1,870.0	$130,720,520	$106,021,686
Secondary Impact		$313,151,800	1,509.4	$98,441,844	$169,670,944
Total Impact	$163,898,128	$477,049,928	3,379.4	$229,162,364	$275,692,630

Table 38. Alt 4B: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$56,960,205	698.4	$39,322,269	$21,988,904
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$40,749	0.1	$58	$184
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$22,552	0.1	$6,378	$11,450
400	Wholesale - Other nondurable goods merchant wholesalers	$699,606	1.7	$247,866	$450,771
401	Wholesale - Wholesale electronic markets and agents and brokers	$57,085	1.6	$108,340	$43,646
414	Air transportation	$30,335	0.1	$8,157	$15,343
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$28,971	0.0	$3,893	$6,257
417	Truck transportation	$532,363	3.1	$183,511	$228,966
444	Insurance carriers, except direct life	$340,142	0.4	$45,749	$177,345
453	Commercial and industrial machinery and equipment rental and leasing	$8,603,080	17.9	$1,585,784	$6,304,047
457	Architectural, engineering, and related services	$1,166,366	7.1	$434,339	$532,108
463	Environmental and other technical consulting services	$1,413,155	15.7	$881,665	$845,860
470	Office administrative services	$6,472,751	102.3	$2,302,494	$2,069,447
544	Employment and payroll of Federal govt, non-military	$11,650,951	61.7	$9,322,668	$11,650,951
5001	Private Labor	$37,973,470	688.3	$37,973,470	$37,973,470
	Direct Impact	**$125,991,781**	**1598.3**	**$92,426,640**	**$82,298,749**
	Secondary Impact	**$79,820,058**	**505.1**	**$24,510,888**	**$44,638,809**
	Total Impact	**$205,811,839**	**2103.4**	**$116,937,529**	**$126,937,557**

Table 39. Alt 4C: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$89,490,117	1,135.3	$65,649,290	$58,455,596
Secondary Impact		$56,695,019	358.7	$17,409,725	$31,706,292
Total Impact	$89,490,117	$146,185,136	1,494.0	$83,059,015	$90,161,889
State					
Direct Impact		$69,293,104	702.7	$59,181,850	$39,844,849
Secondary Impact		$63,911,269	349.5	$20,759,805	$37,259,043
Total Impact	$96,265,104	$133,204,373	1,052.1	$79,941,655	$77,103,891
National					
Direct Impact		$116,414,441	1,328.2	$92,848,872	$75,305,651
Secondary Impact		$222,427,139	1,072.1	$69,921,801	$120,514,788
Total Impact	$116,414,441	$338,841,580	2,400.3	$162,770,672	$195,820,439

Table 40. Alt 4C: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$40,458,000	496.1	$27,930,032	$15,618,396
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$28,944	0.0	$41	$131
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$16,018	0.1	$4,530	$8,133
400	Wholesale - Other nondurable goods merchant wholesalers	$496,920	1.2	$176,056	$320,176
401	Wholesale - Wholesale electronic markets and agents and brokers	$40,546	1.1	$76,952	$31,001
414	Air transportation	$21,546	0.1	$5,794	$10,898
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$20,578	0.0	$2,765	$4,444
417	Truck transportation	$378,130	2.2	$130,345	$162,631
444	Insurance carriers, except direct life	$241,598	0.3	$32,495	$125,966
453	Commercial and industrial machinery and equipment rental and leasing	$6,110,642	12.7	$1,126,359	$4,477,672
457	Architectural, engineering, and related services	$828,452	5.0	$308,505	$377,949
463	Environmental and other technical consulting services	$1,003,743	11.1	$626,234	$600,802
470	Office administrative services	$4,597,500	72.6	$1,635,428	$1,469,898
544	Employment and payroll of Federal govt, non-military	$8,275,500	43.8	$6,621,755	$8,275,500
5001	Private Labor	$26,972,000	488.9	$26,972,000	$26,972,000
	Direct Impact	**$89,490,117**	**1135.3**	**$65,649,290**	**$58,455,596**
	Secondary Impact	**$56,695,019**	**358.7**	**$17,409,725**	**$31,706,292**
	Total Impact	**$146,185,136**	**1494.0**	**$83,059,015**	**$90,161,889**

Table 41. Alt 4D: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$88,760,182	1,126.0	$65,113,814	$57,978,797
Secondary Impact		$56,232,580	355.8	$17,267,721	$31,447,677
Total Impact	$88,760,182	$144,992,761	1,481.8	$82,381,535	$89,426,474
State					
Direct Impact		$68,727,907	696.9	$58,699,127	$39,519,850
Secondary Impact		$63,389,970	346.6	$20,590,475	$36,955,135
Total Impact	$95,479,907	$132,117,877	1,043.6	$79,289,602	$76,474,985
National					
Direct Impact		$115,464,894	1,317.4	$92,091,540	$74,691,413
Secondary Impact		$220,612,888	1,063.4	$69,351,476	$119,531,796
Total Impact	$115,464,894	$336,077,783	2,380.8	$161,443,016	$194,223,209

Table 42. Alt 4D: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$40,128,000	492.0	$27,702,218	$15,491,003
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$28,707	0.0	$41	$130
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$15,888	0.1	$4,493	$8,066
400	Wholesale - Other nondurable goods merchant wholesalers	$492,867	1.2	$174,620	$317,564
401	Wholesale - Wholesale electronic markets and agents and brokers	$40,216	1.1	$76,325	$30,748
414	Air transportation	$21,371	0.1	$5,747	$10,809
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$20,410	0.0	$2,742	$4,408
417	Truck transportation	$375,046	2.2	$129,282	$161,305
444	Insurance carriers, except direct life	$239,627	0.3	$32,230	$124,938
453	Commercial and industrial machinery and equipment rental and leasing	$6,060,800	12.6	$1,117,172	$4,441,150
457	Architectural, engineering, and related services	$821,695	5.0	$305,988	$374,866
463	Environmental and other technical consulting services	$995,556	11.1	$621,126	$595,901
470	Office administrative services	$4,560,000	72.0	$1,622,089	$1,457,908
544	Employment and payroll of Federal govt, non-military	$8,208,000	43.5	$6,567,744	$8,208,000
5001	Private Labor	$26,752,000	484.9	$26,752,000	$26,752,000
	Direct Impact	**$88,760,182**	**1126.0**	**$65,113,814**	**$57,978,797**
	Secondary Impact	**$56,232,580**	**355.8**	**$17,267,721**	**$31,447,677**
	Total Impact	**$144,992,761**	**1481.8**	**$82,381,535**	**$89,426,474**

Table 43. Alt 5: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$11,532,984	146.3	$8,460,512	$7,533,429
Secondary Impact		$7,306,536	46.2	$2,243,668	$4,086,129
Total Impact	$11,532,984	$18,839,520	192.5	$10,704,180	$11,619,558
State					
Direct Impact		$8,930,106	90.6	$7,627,025	$5,134,980
Secondary Impact		$8,236,526	45.0	$2,675,407	$4,801,736
Total Impact	$12,406,106	$17,166,632	135.6	$10,302,432	$9,936,717
National					
Direct Impact		$15,002,840	171.2	$11,965,842	$9,704,970
Secondary Impact		$28,665,161	138.2	$9,011,129	$15,531,270
Total Impact	$15,002,840	$43,668,001	309.3	$20,976,971	$25,236,239

Table 44. Alt 5: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$5,214,000	63.9	$3,599,466	$2,012,811
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$3,730	0.0	$5	$17
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$2,064	0.0	$584	$1,048
400	Wholesale - Other nondurable goods merchant wholesalers	$64,040	0.2	$22,689	$41,262
401	Wholesale - Wholesale electronic markets and agents and brokers	$5,225	0.1	$9,917	$3,995
414	Air transportation	$2,777	0.0	$747	$1,404
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$2,652	0.0	$356	$573
417	Truck transportation	$48,731	0.3	$16,798	$20,959
444	Insurance carriers, except direct life	$31,136	0.0	$4,188	$16,234
453	Commercial and industrial machinery and equipment rental and leasing	$787,505	1.6	$145,159	$577,057
457	Architectural, engineering, and related services	$106,766	0.7	$39,758	$48,708
463	Environmental and other technical consulting services	$129,357	1.4	$80,705	$77,428
470	Office administrative services	$592,500	9.4	$210,765	$189,432
544	Employment and payroll of Federal govt, non-military	$1,066,500	5.7	$853,375	$1,066,500
5001	Private Labor	$3,476,000	63.0	$3,476,000	$3,476,000
	Direct Impact	**$11,532,984**	**146.3**	**$8,460,512**	**$7,533,429**
	Secondary Impact	**$7,306,536**	**46.2**	**$2,243,668**	**$4,086,129**
	Total Impact	**$18,839,520**	**192.5**	**$10,704,180**	**$11,619,558**

Table 45. Alt 6A: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$296,061,921	3,755.8	$217,188,840	$193,389,803
Secondary Impact		$187,565,249	1,186.8	$57,596,937	$104,894,553
Total Impact	$296,061,921	$483,627,171	4,942.7	$274,785,778	$298,284,356
State					
Direct Impact		$229,243,744	2,324.6	$195,792,483	$131,819,499
Secondary Impact		$211,438,913	1,156.2	$68,680,072	$123,264,826
Total Impact	$318,475,744	$440,682,657	3,480.8	$264,472,555	$255,084,325
National					
Direct Impact		$385,136,193	4,394.2	$307,173,755	$249,135,172
Secondary Impact		$735,860,095	3,546.9	$231,323,673	$398,701,452
Total Impact	$385,136,193	$1,120,996,288	7,941.1	$538,497,428	$647,836,624

Table 46. Alt 6A: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$133,847,999	1641.2	$92,401,476	$51,670,649
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$95,755	0.1	$136	$432
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$52,994	0.2	$14,986	$26,905
400	Wholesale - Other nondurable goods merchant wholesalers	$1,643,971	4.0	$582,448	$1,059,244
401	Wholesale - Wholesale electronic markets and agents and brokers	$134,141	3.6	$254,583	$102,562
414	Air transportation	$71,283	0.2	$19,168	$36,054
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$68,078	0.1	$9,147	$14,702
417	Truck transportation	$1,250,974	7.3	$431,223	$538,037
444	Insurance carriers, except direct life	$799,283	1.0	$107,504	$416,735
453	Commercial and industrial machinery and equipment rental and leasing	$20,215,957	42.2	$3,726,355	$14,813,572
457	Architectural, engineering, and related services	$2,740,786	16.6	$1,020,632	$1,250,376
463	Environmental and other technical consulting services	$3,320,703	36.9	$2,071,781	$1,987,644
470	Office administrative services	$15,210,000	240.3	$5,410,519	$4,862,892
544	Employment and payroll of Federal govt, non-military	$27,378,000	144.9	$21,906,882	$27,378,000
5001	Private Labor	$89,231,998	1617.3	$89,231,998	$89,231,998
	Direct Impact	**$296,061,921**	**3755.8**	**$217,188,840**	**$193,389,803**
	Secondary Impact	**$187,565,249**	**1186.8**	**$57,596,937**	**$104,894,553**
	Total Impact	**$483,627,171**	**4942.7**	**$274,785,778**	**$298,284,356**

Table 47. Alt 6B: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$92,117,886	1,168.6	$67,577,001	$60,172,074
Secondary Impact		$58,359,799	369.3	$17,920,941	$32,637,309
Total Impact	$92,117,886	$150,477,685	1,537.9	$85,497,942	$92,809,383
State					
Direct Impact		$71,327,812	723.3	$60,919,653	$41,014,844
Secondary Impact		$65,787,946	359.7	$21,369,391	$38,353,109
Total Impact	$99,091,812	$137,115,758	1,083.0	$82,289,044	$79,367,953
National					
Direct Impact		$119,832,810	1,367.2	$95,575,266	$77,516,910
Secondary Impact		$228,958,442	1,103.6	$71,974,969	$124,053,558
Total Impact	$119,832,810	$348,791,251	2,470.8	$167,550,235	$201,570,468

Table 48. Alt 6B: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$41,646,000	510.6	$28,750,163	$16,077,012
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$29,793	0.0	$42	$134
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$16,489	0.1	$4,663	$8,371
400	Wholesale - Other nondurable goods merchant wholesalers	$511,512	1.3	$181,225	$329,577
401	Wholesale - Wholesale electronic markets and agents and brokers	$41,737	1.1	$79,212	$31,912
414	Air transportation	$22,179	0.1	$5,964	$11,218
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$21,182	0.0	$2,846	$4,574
417	Truck transportation	$389,233	2.3	$134,172	$167,407
444	Insurance carriers, except direct life	$248,692	0.3	$33,449	$129,665
453	Commercial and industrial machinery and equipment rental and leasing	$6,290,073	13.1	$1,159,433	$4,609,154
457	Architectural, engineering, and related services	$852,779	5.2	$317,564	$389,047
463	Environmental and other technical consulting services	$1,033,217	11.5	$644,622	$618,444
470	Office administrative services	$4,732,500	74.8	$1,683,450	$1,513,060
544	Employment and payroll of Federal govt, non-military	$8,518,500	45.1	$6,816,195	$8,518,500
5001	Private Labor	$27,764,000	503.2	$27,764,000	$27,764,000
	Direct Impact	**$92,117,886**	**1168.6**	**$67,577,001**	**$60,172,074**
	Secondary Impact	**$58,359,799**	**369.3**	**$17,920,941**	**$32,637,309**
	Total Impact	**$150,477,685**	**1537.9**	**$85,497,942**	**$92,809,383**

Table 49. Alt 6C: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$43,066,207	546.3	$31,593,051	$28,131,160
Secondary Impact		$27,283,900	172.6	$8,378,253	$15,258,330
Total Impact	$43,066,207	$70,350,106	719.0	$39,971,304	$43,389,490
State					
Direct Impact		$33,346,600	338.2	$28,480,662	$19,174,927
Secondary Impact		$30,756,647	168.2	$9,990,444	$17,930,534
Total Impact	$46,326,600	$64,103,246	506.3	$38,471,106	$37,105,462
National					
Direct Impact		$56,023,263	639.2	$44,682,573	$36,240,077
Secondary Impact		$107,040,793	516.0	$33,649,154	$57,996,513
Total Impact	$56,023,263	$163,064,056	1,155.1	$78,331,726	$94,236,590

Table 50. Alt 6C: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$19,470,000	238.7	$13,441,043	$7,516,194
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$13,929	0.0	$20	$63
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$7,709	0.0	$2,180	$3,914
400	Wholesale - Other nondurable goods merchant wholesalers	$239,138	0.6	$84,725	$154,081
401	Wholesale - Wholesale electronic markets and agents and brokers	$19,513	0.5	$37,033	$14,919
414	Air transportation	$10,369	0.0	$2,788	$5,245
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$9,903	0.0	$1,331	$2,139
417	Truck transportation	$181,971	1.1	$62,727	$78,265
444	Insurance carriers, except direct life	$116,267	0.1	$15,638	$60,620
453	Commercial and industrial machinery and equipment rental and leasing	$2,940,684	6.1	$542,049	$2,154,834
457	Architectural, engineering, and related services	$398,684	2.4	$148,465	$181,884
463	Environmental and other technical consulting services	$483,041	5.4	$301,369	$289,130
470	Office administrative services	$2,212,500	35.0	$787,033	$707,373
544	Employment and payroll of Federal govt, non-military	$3,982,500	21.1	$3,186,652	$3,982,500
5001	Private Labor	$12,980,000	235.3	$12,980,000	$12,980,000
	Direct Impact	**$43,066,207**	**546.3**	**$31,593,051**	**$28,131,160**
	Secondary Impact	**$27,283,900**	**172.6**	**$8,378,253**	**$15,258,330**
	Total Impact	**$70,350,106**	**719.0**	**$39,971,304**	**$43,389,490**

Table 51. Alt 6D: RECONS Impacts to Local, State, and National Economy

Area	Local Capture	Output	Jobs (FTE's)	Labor Income	Value Added
Local					
Direct Impact		$35,036,914	444.5	$25,702,821	$22,886,367
Secondary Impact		$22,197,071	140.5	$6,816,206	$12,413,557
Total Impact	$35,036,914	$57,233,985	584.9	$32,519,027	$35,299,924
State					
Direct Impact		$27,129,437	275.1	$23,170,708	$15,599,941
Secondary Impact		$25,022,357	136.8	$8,127,819	$14,587,553
Total Impact	$37,689,437	$52,151,794	411.9	$31,298,527	$30,187,494
National					
Direct Impact		$45,578,248	520.0	$36,351,924	$29,483,452
Secondary Impact		$87,084,035	419.8	$27,375,583	$47,183,604
Total Impact	$45,578,248	$132,662,283	939.8	$63,727,506	$76,667,056

Table 52. Alt 6D: RECONS Local Impacts to Specific Industries

Direct Impacts		Output	Jobs (FTE's)	Labor Income	Value Added
56	Construction of other new nonresidential structures	$15,840,000	194.2	$10,935,086	$6,114,870
203	Cement manufacturing	$0	0.0	$0	$0
215	Iron and steel mills and ferroalloy manufacturing	$11,332	0.0	$16	$51
269	All other industrial machinery manufacturing	$0	0.0	$0	$0
331	Switchgear and switchboard apparatus manufacturing	$0	0.0	$0	$0
395	Wholesale - Machinery, equipment, and supplies	$6,271	0.0	$1,774	$3,184
400	Wholesale - Other nondurable goods merchant wholesalers	$194,553	0.5	$68,929	$125,354
401	Wholesale - Wholesale electronic markets and agents and brokers	$15,875	0.4	$30,128	$12,138
414	Air transportation	$8,436	0.0	$2,268	$4,267
415	Rail transportation	$0	0.0	$0	$0
416	Water transportation	$8,057	0.0	$1,082	$1,740
417	Truck transportation	$148,044	0.9	$51,032	$63,673
444	Insurance carriers, except direct life	$94,590	0.1	$12,722	$49,318
453	Commercial and industrial machinery and equipment rental and leasing	$2,392,421	5.0	$440,989	$1,753,085
457	Architectural, engineering, and related services	$324,353	2.0	$120,785	$147,973
463	Environmental and other technical consulting services	$392,983	4.4	$245,181	$235,224
470	Office administrative services	$1,800,000	28.4	$640,298	$575,490
544	Employment and payroll of Federal govt, non-military	$3,240,000	17.2	$2,592,530	$3,240,000
5001	Private Labor	$10,560,000	191.4	$10,560,000	$10,560,000
	Direct Impact	**$35,036,914**	**444.5**	**$25,702,821**	**$22,886,367**
	Secondary Impact	**$22,197,071**	**140.5**	**$6,816,206**	**$12,413,557**
	Total Impact	**$57,233,985**	**584.9**	**$32,519,027**	**$35,299,924**

8 SUPPLEMENTAL TABLES

Supplemental Table 1. Lowell Creek Flood Diversion IFR/EA. Depth – Damage Relationships for Structures, Contents, and Vehicles, including Debris Removal.

Residential - Oreswbsmt
One Story, With Basement

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-8.0	0.0	0.0
-7.0	0.7	1.3
-6.0	0.8	1.1
-5.0	2.4	0.9
-4.0	5.2	0.9
-3.0	9.0	0.9
-2.0	13.8	0.9
-1.0	19.4	0.8
0.0	25.5	0.9
1.0	32.0	1.0
2.0	38.7	1.1
3.0	45.5	1.4
4.0	52.2	1.6
5.0	58.6	1.9
6.0	64.5	2.1
7.0	69.8	2.4
8.0	74.2	2.5
9.0	77.7	2.7
10.0	80.1	2.8
11.0	81.1	2.9

Depth in Structure	Contents Percent Damage	Contents Standard Deviation
-9.0	0.0	0.0
-8.0	0.1	1.6
-7.0	0.8	1.2
-6.0	2.1	0.9
-5.0	3.7	0.8
-4.0	5.7	0.8
-3.0	8.0	0.8
-2.0	10.5	0.7
-1.0	13.2	0.7
0.0	16.0	0.7
1.0	18.9	0.8
2.0	21.8	1.0
3.0	24.7	1.2
4.0	27.4	1.4
5.0	30.0	1.6
6.0	32.4	1.8
7.0	34.5	2.0
8.0	36.3	2.1
9.0	37.7	2.3
10.0	38.6	2.4
11.0	39.1	2.5

Residential - Treswbsmt
Two Story, With Basement

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-9.0	0.0	0.0
-8.0	1.7	2.7
-7.0	1.7	2.7
-6.0	1.9	2.1
-5.0	2.9	1.8
-4.0	4.7	1.7
-3.0	7.2	1.6
-2.0	10.2	1.5
-1.0	13.9	1.4
0.0	17.9	1.3
1.0	22.3	1.4
2.0	27.0	1.5
3.0	31.9	1.8
4.0	36.9	2.0
5.0	41.9	2.3
6.0	46.9	2.6
7.0	51.8	2.9
8.0	56.4	3.1
9.0	60.8	3.4
10.0	64.8	3.7
11.0	68.4	4.2
12.0	71.4	5.0
13.0	73.7	6.2
14.0	75.4	7.8

Depth in Structure	Contents Percent Damage	Contents Standard Deviation
-8.0	0.0	0.0
-7.0	1.0	2.3
-6.0	2.3	1.8
-5.0	3.7	1.5
-4.0	5.2	1.4
-3.0	6.8	1.3
-2.0	8.4	1.2
-1.0	10.1	1.1
0.0	11.9	1.1
1.0	13.8	1.1
2.0	15.7	1.2
3.0	17.7	1.4
4.0	19.8	1.7
5.0	22.0	1.9
6.0	24.3	2.2
7.0	26.7	2.4
8.0	29.1	2.6
9.0	31.7	2.8
10.0	34.4	3.0
11.0	37.2	3.5
12.0	40.0	4.1
13.0	43.0	5.1
14.0	46.1	6.4
15.0	49.3	8.1

Residential - Oreswoutbsmt
One Story, No Basement

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-2.0	0.0	0.0
-1.0	2.5	2.7
0.0	13.4	2.0
1.0	23.3	1.6
2.0	32.1	1.6
3.0	40.1	1.8
4.0	47.1	1.9
5.0	53.2	2.0
6.0	58.6	2.1
7.0	63.2	2.2
8.0	67.2	2.3
9.0	70.5	2.4
10.0	73.2	2.7
11.0	75.4	3.0
12.0	77.2	3.3
13.0	78.5	3.7
14.0	79.5	4.1
15.0	80.2	4.5
16.0	80.7	4.9

Depth in Structure	Contents Percent Damage	Contents Standard Deviation
-2.0	0.0	0.0
-1.0	2.4	2.1
0.0	8.1	1.5
1.0	13.3	1.2
2.0	17.9	1.2
3.0	22.0	1.4
4.0	25.7	1.5
5.0	28.8	1.6
6.0	31.5	1.6
7.0	33.8	1.7
8.0	35.7	1.8
9.0	37.2	1.9
10.0	38.4	2.1
11.0	39.2	2.3
12.0	39.7	2.6
13.0	40.0	2.9
14.0	40.0	3.2
15.0	40.0	3.5

Residential - Treswoutbsmt
Two Story, No Basement

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-2.0	0.0	0.0
-1.0	3.0	4.1
0.0	9.3	3.4
1.0	15.2	3.0
2.0	20.9	2.8
3.0	26.3	2.9
4.0	31.4	3.2
5.0	36.2	3.4
6.0	40.7	3.7
7.0	44.9	3.9
8.0	48.8	4.0
9.0	52.4	4.1
10.0	55.7	4.2
11.0	58.7	4.2
12.0	61.4	4.2
13.0	63.8	4.2
14.0	65.9	4.3
15.0	67.7	4.6
16.0	69.2	5.0

Depth in Structure	Contents Percent Damage	Contents Standard Deviation
-2.0	0.0	0.0
-1.0	1.0	3.5
0.0	5.0	2.9
1.0	8.7	2.6
2.0	12.2	2.5
3.0	15.5	2.5
4.0	18.5	2.7
5.0	21.3	3.0
6.0	23.9	3.2
7.0	26.3	3.3
8.0	28.4	3.4
9.0	30.3	3.5
10.0	32.0	3.5
11.0	33.4	3.5
12.0	34.7	3.5
13.0	35.6	3.5
14.0	36.4	3.6
15.0	36.9	3.8
16.0	37.2	4.2

Debris Depth	Debris Percent Damage	Debris Variance Lower	Debris Variance Upper
0.5	5.8	5.2	6.4
1.0	7.5	6.8	8.3
2.0	9.1	8.2	10.0
3.0	10.7	9.6	11.8
4.0	12.4	11.2	13.6
5.0	14.0	12.6	15.4
6.0	15.7	14.1	17.3
7.0	17.3	15.6	19.0

Note: the same Debris Depth-Damage Relationships were used for all residential structures

Supplemental Table 2. Lowell Creek Flood Diversion IFR/EA. Depth – Damage Relationships for Structures, Contents, and Vehicles.

Residential - Apartment One Story, No Basement		
Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-1.0	0 0	0.0
0.0	1 0	0.5
1.0	12 5	1.6
2.0	20.4	1.6
3.0	25 9	1.8
4.0	31.7	1.9
5.0	33 5	2.0
6.0	37 5	2.1
7.0	39.4	2.2
8.0	42 2	2.4
9.0	45 0	2.4

Public - Pub2 One Story, No Basement		
Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-8.0	0.0	0 0
-1.0	0.0	0 0
0.0	0.0	0 0
1.0	10.0	2 0
2.0	14.0	2 8
3.0	26.0	5 2
5.0	29.0	5 8
10.0	46.0	9 2
15.0	50.0	10 0

Public - School One Story, No Basement		
Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-8 0	0.0	0 0
-1 0	0.4	0.0
0 0	0.6	0.0
1 0	15.3	0 5
2 0	26.1	0.7
3 0	33.0	1 3
5 0	44.0	1.4
10 0	60.0	2 3
15 0	75.0	2 5

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-1.0	0 0	0.0
0.0	0 0	0.5
1.0	21.7	2.1
2.0	30.4	3.8
3.0	39 0	4.4
4.0	45 0	5.1
5.0	47 9	5.7
6.0	51 9	6.3
7.0	55.7	6.7
8.0	59 3	7.1
9.0	60.6	7.6

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-8.0	0 0	0 0
-1.0	0.0	0 0
0.0	0.0	0 0
1.0	33 0	6.6
2.0	40 0	8 0
3.0	50 0	10 0
5.0	50 0	10 0
10.0	50 0	10 0
15.0	50 0	10 0

Depth in Structure	Contents Lower Percent	Contents Percent Damage
-8 0	0.0	0 0
-1 0	0.0	0 0
0 0	0.0	0 0
1 0	25.5	0.1
2.0	39.0	0.1
3.0	50.0	0 2
5.0	62.0	0 2
10.0	80.0	0.4
15.0	100.0	0.4

Supplemental Table 3. Lowell Creek Flood Diversion IFR/EA. Depth-Damage Relationships for Structures, Contents, and Vehicles.

Residential - Mobile Home One Story, No Basement				Commercial - Retail One Story, No Basement				Auto Vehicles			
Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Percent Damage	Structure Percent Damage	Structure Higher Percent
-2.0	0 0	0.0	0.0	-2.0	0.0	0 0	0.0	0 0	0.0	0 0	0.0
-1.0	1.1	0.0	9.9	-1.0	0.0	0 0	0.0	0 5	0.0	0 0	0 0
0.0	17 2	10.2	38.9	0.0	0.2	0.1	0.3	1 0	100.0	100 0	100 0
1.0	45.4	40.5	49.4	1.0	7.6	5.7	9.5	1 5	100.0	100 0	100 0
2.0	49 2	44.6	53.8	2.0	8.3	6 2	10.4	2 0	100.0	100 0	100 0
3.0	49 2	44.6	53.8	3.0	11.4	8.6	14.2	3 0	100.0	100 0	100 0
4.0	51.7	47.2	86.8	4.0	15.0	12 8	17.2	4 0	100.0	100.0	100 0
5.0	57.1	52.7	56.2	5.0	15.8	13.4	18.2	5 0	100.0	100.0	100 0
6.0	57 9	53.5	61.5	6.0	15.8	13.4	18.2	6 0	100.0	100.0	100 0
7.0	57 9	53.5	62.3	7.0	15.8	13.4	18.2	7 0	100.0	100.0	100 0
8.0	66 3	62.2	62.3	8.0	22.2	18 9	25.5	8 0	100.0	100.0	100 0
9.0	66 3	62.2	70.4	9.0	26.6	22.6	30.1	9 0	100.0	100.0	100 0
10.0	66 3	62.2	70.4	10.0	28.7	24.4	30.1	10 0	100.0	100.0	100 0
11.0	66 3	62.2	70.4	11.0	28.7	27 3	30.1	11 0	100.0	100.0	100 0
12.0	66 3	62.2	70.4	12.0	28.7	27 3	30.1	12 0	100.0	100.0	100 0
13.0	66 3	62.2	70.4	13.0	32.4	30.1	34.0	13 0	100.0	100.0	100 0
14.0	66 3	62.2	70.4	14.0	39.7	37.7	41.7	14 0	100.0	100.0	100 0
15.0	66 3	62 2	70.4	15.0	41.2	39.1	43.3	15 0	100.0	100.0	100 0
								16 0	100.0	100.0	100 0

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-2.0	0 0	0 0	0.0	-2.0	0.0	0 0	0.0
-1.0	0.0	0 0	0.0	-1.0	0.0	0 0	0.0
0.0	0.0	0 0	0.0	0 0	0.0	0 0	0.0
1.0	38.8	26.7	49.7	1 0	35.3	15 3	55.3
2.0	53.7	34 2	61.4	2 0	48.2	28 2	68.2
3.0	75.2	43.4	86.8	3 0	54.1	34.1	74.1
4.0	77.2	57.1	86.8	4 0	54.3	34 3	74.3
5.0	84.5	66 3	90.9	5 0	54.8	34 8	74.8
6.0	84.5	67.4	90.9	6 0	54.8	34 8	74.8
7.0	84.5	67.4	90.9	7 0	54.8	34 8	74.8
8.0	84.5	67.4	90.9	8 0	54.8	34 8	74.8
9.0	84.5	67.4	90.9	9 0	54.8	34 8	74.8
10.0	84.5	76 3	90.9	10 0	98.9	78 9	100.0
11.0	84.5	76 3	90.9	11 0	99.9	79 9	100.0
12.0	84.5	76 3	90.9	12 0	100.0	80 0	100.0
13.0	84.5	76 3	90.9	13 0	100.0	80 0	100.0
14.0	84.5	76 3	90.9	14 0	100.0	80 0	100.0
15.0	84.5	76 3	90.9	15 0	100.0	80 0	100.0

Supplemental Table 4. Lowell Creek Flood Diversion IFR/EA. Flood Flight AADs Reduced.

Flood Fight Without Project Condition		
YEAR	FREQUENCY	VALUE
	-	1,199,000
500	0.002	1,199,000
250	0.004	1,199,000
100	0.010	1,199,000
25	0.040	1,199,000
10	0.100	627,080
5	0.200	627,800
1.25	0.800	627,800
1.11	0.900	285,480
1.02	0.980	105,800
1.01	0.990	61,860
0.25	4.000	40,140
AVERAGE ANNUAL VALUE =		**758,000**

Flood Fight With Project Condition		
YEAR	FREQUENCY	VALUE
	-	1,199,000
500	0.002	1,199,000
250	0.004	1,199,000
100	0.010	1,199,000
50	0.020	40,140
10	0.100	40,140
5	0.200	40,140
1.25	0.800	40,140
1.11	0.900	40,140
1.02	0.980	40,140
1.01	0.990	40,140
0.25	4.000	40,140
AVERAGE ANNUAL VALUE =		**178,000**
AA DAMAGES REDUCED =		**580,000**

9 REFERENCES