# 1 Bridge Management System

| Category | Subcategory | Grade |
|---|---|---|
| Overall Grade | | C |
| Physical Health | | |
| | Overall Condition | A |
| | Risk-Based Condition | A |
| Financial Health | | |
| | Catch Up | F |
| | Keep Up | F |

## 1.1 Background

### *1.1.1 What Services Do the Assets Provide?*

Bridges are integral pieces of the transportation infrastructure. The primary function of bridges is to safely convey traffic across a waterway or other barrier.

The City owns and manages 44 bridges total, which are further divided between vehicle and trail bridges. The City owns and manages 32 vehicle bridges (including culverts) and 12 trail bridges which serve a mixture of pedestrians, bicyclists, and equestrians.

*Figure 1-1 Vehicle Bridge*

*Figure 1-2 Vehicle Bridge - Culvert*

*Figure 1-3 Trail Bridge*

### *1.1.2 Who is Responsible?*

The City is responsible for the inspection, maintenance, and replacement of all 12 trail bridges and vehicle bridges with a span of less than 20 feet (approximately 8 bridges). The City is also responsible for routine maintenance and repairs of bridges over 20 feet (approximately 24 bridges), but Caltrans is responsible for the inspection and may provide partial funding for major repairs or replacement.

The locations of City owned and maintained bridges are shown in the following figures. More information about the bridges will be included in the Asset Inventory section of the report.

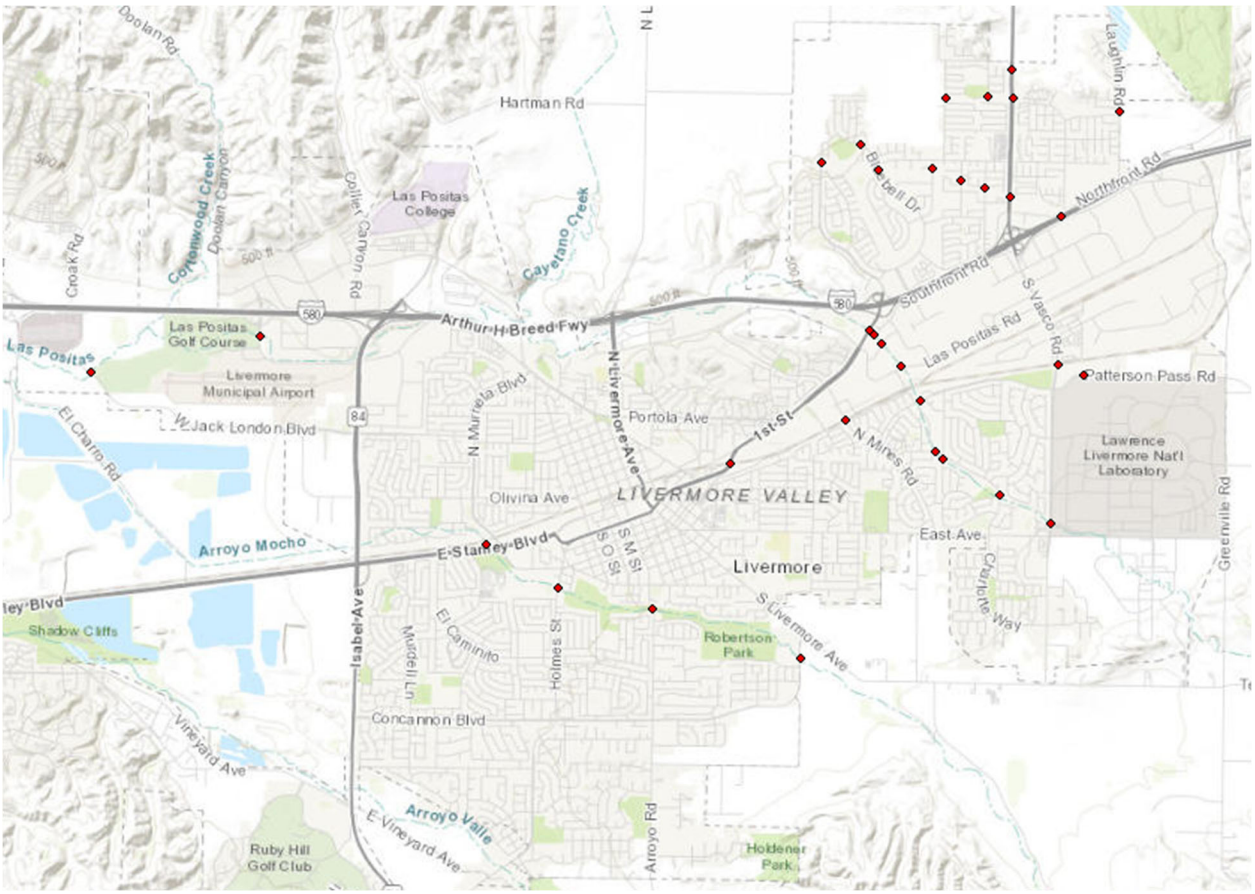


*Figure 1-4 Map of Livermore Vehicle Bridges*

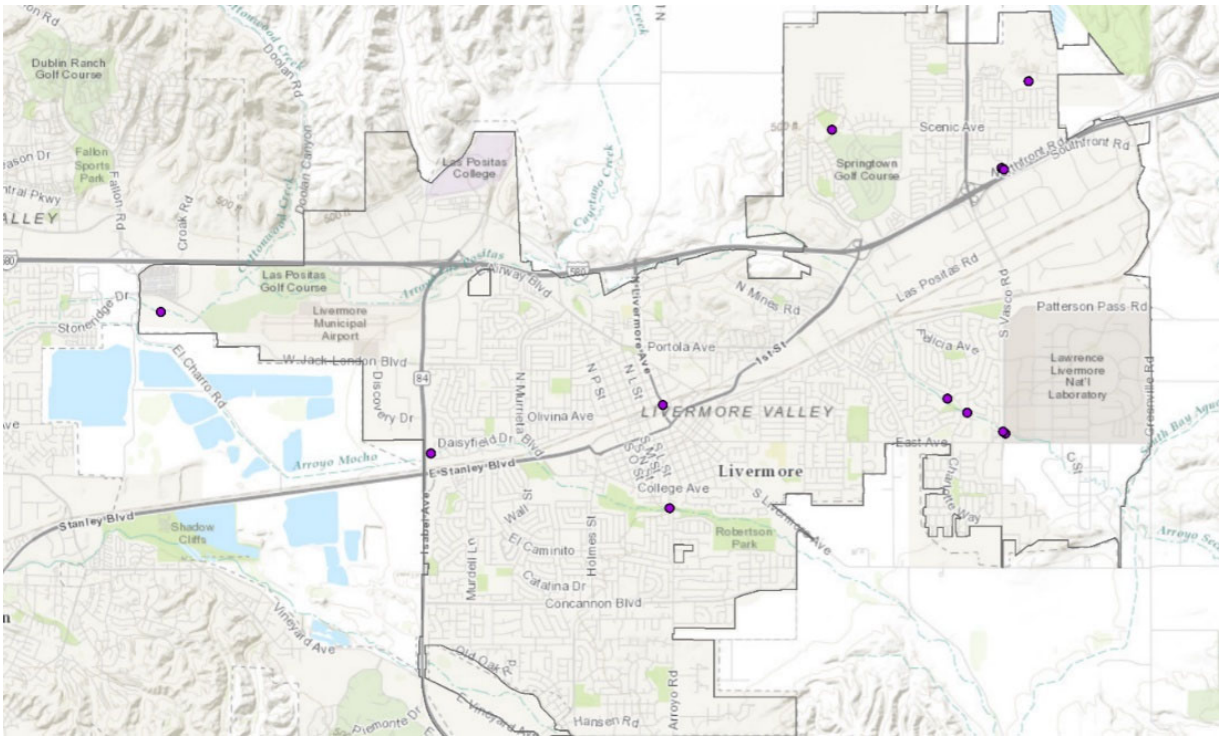


*Figure 1-5 Map of Livermore Trail Bridges*

The City is not responsible for Caltrans owned/maintained bridges which span I-580, except for the pavement on the surface of these bridges which is included in a separate management system. All bridges at the Las Positas Golf Course are included in the Las Positas Golf Course AMP and are not included in this report. The City also is not responsible for Livermore Area Recreation and Park District (LARPD) owned and maintained trail bridges. The locations of the LARPD trail bridges are as follows:

- Along Concannon Blvd across Arroyo Mocho
- Wetmore Road Trail
- Arroyo Mocho Trail to Chateau Way
- Sycamore Trail across Arroyo Valle
- Sycamore Trail across Arroyo Valle near Arroyo Road

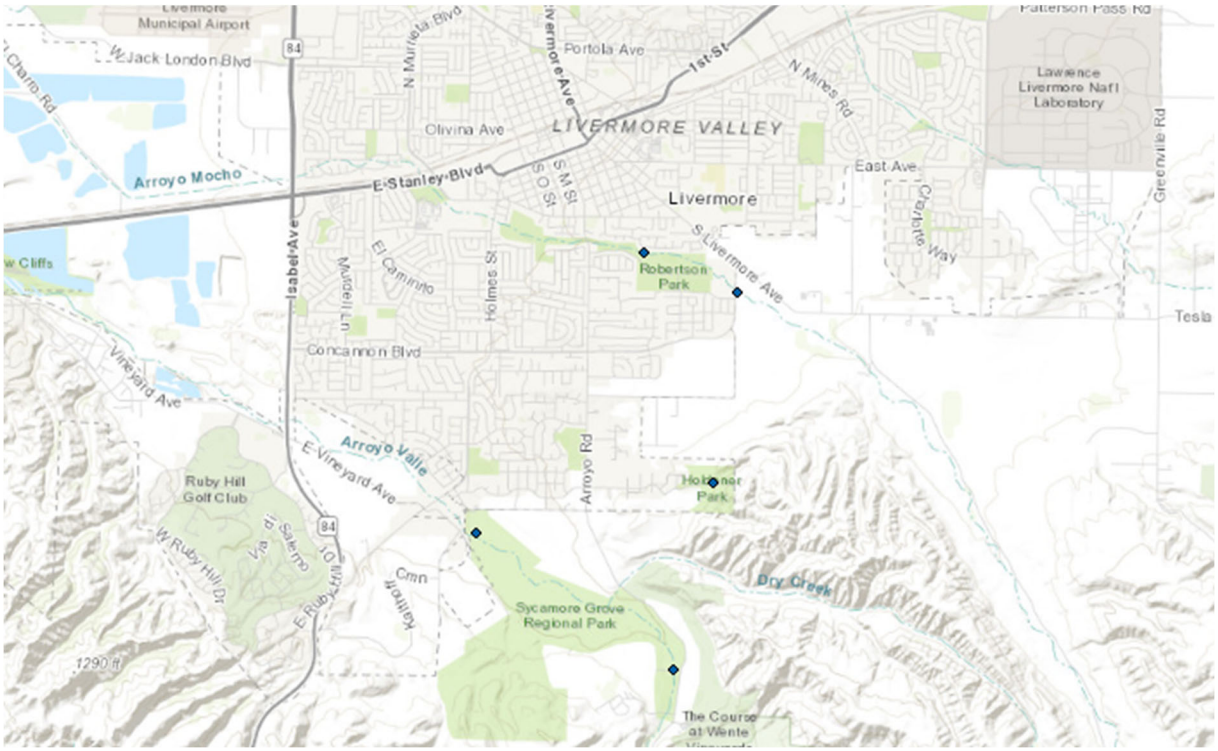


*Figure 1-6 LARPD Trail Bridges*

## 1.2 Asset Register

### *1.2.1 Asset Definition*

An asset is defined as something with value that is owned and managed by the City. In the bridge management system, each major component of the bridge was considered an asset. The following images show examples of some of the bridge components that were considered assets.

*Figure 1-7 Superstructure – Deck*

*Figure 1-8 Substructure – Culvert*

*Figure 1-9 Superstructure – Truss*

*Figure 1-10 Superstructure – Guardrail*

### *1.2.2 Asset Class*

Assets are grouped into classes to more efficiently model and manage the assets. An asset class generally refers to a group of assets that behave similarly (e.g., useful life, refurbishment work). Grouping the assets into these classes allows easier modeling of life cycle behavior. A full list of asset classes developed during this phase of the asset

management program is included in Appendix A.

### *1.2.3 Asset Hierarchy*

The asset hierarchy for the Bridge Management System is organized first by bridge type (i.e., vehicle or trail), then by bridge. After the bridge location, the asset classes are organized by superstructure and substructure.

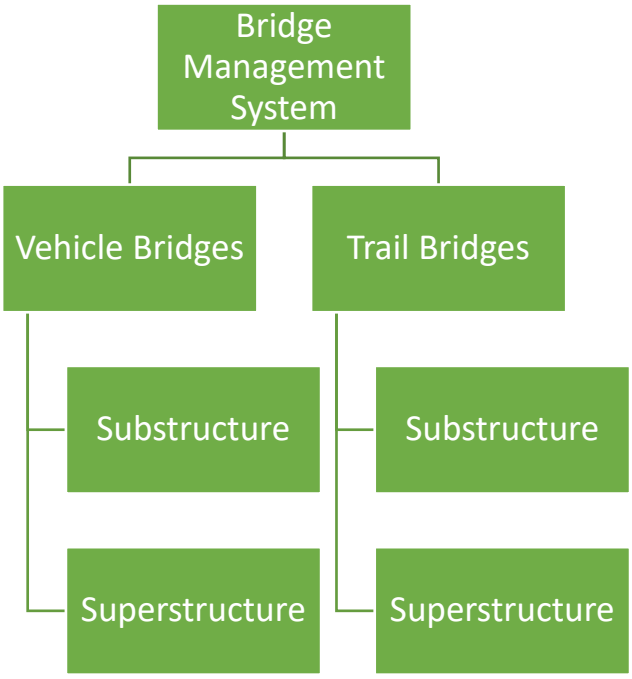


*Figure 1-11 Bridge Hierarchy*

The following tables give a general overview of some examples of the asset classes included in the substructure and superstructure categories.

*Table 1-1 Vehicle Bridge Hierarchy*

| **Superstructure** | |
|---|---|
| • Deck<br>• Guardrail | • Parapet<br>• Truss |
| **Substructure** | |
| • Abutment<br>• Culvert | • Wall (Inlet, Outlet, End, Support, Wing) |

*Table 1-2 Trail Bridge Hierarchy*

| **Superstructure** | |
|---|---|
| • Deck<br>• Guardrail | • Parapet<br>• Truss |

| Substructure | |
|---|---|
| • Abutment<br>• Culvert | • Wall (Inlet, Outlet, End, Support, Wing) |

### *1.2.4 Asset Inventory*

Once the asset definition, hierarchy, and classes were set, the asset register was compiled. This process involved consolidation of existing data and data collected from on-site asset inventory work. The following tables list the vehicle and trail bridges included in the Bridge Management System.

*Table 1-3 City Owned/Maintained Vehicle Bridge List*

| Vehicle Bridge Number | Bridge Description |
|---|---|
| 33C0070 | Arroyo Mocho - Stanley Blvd |
| 33C0129 | Arroyo Seco - South Vasco Rd |
| 33C0191 | Arroyo Las Positas - Bluebell Rd |
| 33C0192 | Altamont Creek - Bluebell Rd |
| 33C0193 | Altamont Creek - Broadmoor St |
| 33C0194 | Arroyo Seco - Charlotte Wy South |
| 33C0195 | Arroyo Mocho - Arroyo Rd |
| 33C0198 | Arroyo Las Positas - Airway Blvd |
| 33C0379 | Arroyo Seco - Lucille St |
| 33C0380 | Arroyo Seco - Charlotte Wy North |
| 33C0381 | Arroyo Seco - Patterson Pass Rd |
| 33C0382 | Arroyo Seco - Las Positas Rd |
| 33C0383 | Arroyo Seco - Arroyo Vista |
| 33C0385 | Vasco Rd |
| 33C0395 | Arroyo Las Positas - W. Jack London Blvd |
| 33C0397 | Arroyo Las Positas - Springtown Blvd |
| 33C0413 | Arroyo Las Positas - Patterson Pass Rd |
| 33C0414 | Altamont Creek - Laughlin Rd |
| 33C0415 | Arroyo Seco - Southfront Rd |
| 33C0416 | North Mines Rd Overpass |
| 33C0424 | Arroyo Seco - First St |
| 33C0425 | East First St - First St |
| 33C0426 | Arroyo Mocho - Holmes St |
| 33C0485 | Concannon Blvd - Arroyo Mocho |
| COLV001 | Altamont Creek - Pasatiempo St Vehicle Bridge |
| COLV002 | Altamont Creek - Vasco Rd Vehicle Bridge |
| COLV003 | Arroyo Las Positas - Arrowhead Ave Vehicle Bridge |

| Vehicle Bridge Number | Bridge Description |
|---|---|
| COLV004 | Arroyo Las Positas - Central Ave Vehicle Bridge |
| COLV005 | Arroyo Las Positas - Heather Ln Vehicle Bridge |
| COLV006 | Arroyo Las Positas - Northfront Rd Vehicle Bridge |
| COLV007 | Arroyo Las Positas - Vasco Rd Vehicle Bridge |
| COLV008 | North Altamont Creek - Vasco Rd Vehicle Bridge |

*Table 1-4 City Owned/Maintained Trail Bridge List*

| Trail Bridge Number | Bridge Description |
|---|---|
| COLP001 | Altamont Creek Trail Bridge |
| COLP002 | Arroyo Road Trail Bridge |
| COLP003 | Big Trees Park btwn Susan Ln/Cheryl |
| COLP004 | Charlotte Bridge - Arroyo Seco School |
| COLP005 | El Charro Trail Bridge |
| COLP006 | Northfront Park - North Side Trail Bridge |
| COLP007 | Northfront Park - South Side Trail Bridge |
| COLP008 | Livermore Avenue Trail Bridge |
| COLP009 | Vasco Road West Side Trail Bridge |
| COLP010 | Vasco Road East Side Trail Bridge |
| COLP011 | Springtown Open Space Trail Bridge |
| COLC001 | Rockrose Culverts Trail Bridge |

There are 377 assets in the Bridge Management System; of these, 282 assets are located on vehicle bridges and 95 are on trail bridges. In future versions of the bridge asset inventory, the identification of assets may be adjusted to more closely align with how the bridges will be managed; more information about this will be included in the Next Steps section of this report.

### *1.2.5 Asset Replacement Cost*

Each asset in the asset register was assigned an estimated replacement cost. As part of the asset replacement costs, an additional markup was added to help account for project costs (e.g., design, engineering, permit fees). For most of the City's asset management systems, this markup was approximately 30%; for the bridges, however, a higher markup of approximately 50% was used to more accurately model the bridge costs based on historical records and City staff estimates. As summarized in this report, the replacement cost by bridge represents the sum of replacement costs of the assets within the bridge.

The total replacement cost of all the bridge assets is $168.6 million in 2017 dollars including 50% project delivery costs, including $160.3 million for the vehicle bridges and $8.3 million for the trail bridges. The following tables give an overview of the bridge replacement costs.

Table 1-5 Vehicle Bridge Replacement Cost

| Bridge Number | Bridge Description | Replacement Cost |
|---|---|---|
| 33C0070 | Arroyo Mocho - Stanley Blvd | $ 11,245,000 |
| 33C0129 | Arroyo Seco - South Vasco Rd | $ 2,340,000 |
| 33C0191 | Arroyo Las Positas - Bluebell Rd | $ 3,920,000 |
| 33C0192 | Altamont Creek - Bluebell Rd | $ 2,545,000 |
| 33C0193 | Altamont Creek - Broadmoor St | $ 1,810,000 |
| 33C0194 | Arroyo Seco - Charlotte Wy South | $ 2,680,000 |
| 33C0195 | Arroyo Mocho - Arroyo Rd | $ 9,900,000 |
| 33C0198 | Arroyo Las Positas - Airway Blvd | $ 7,650,000 |
| 33C0379 | Arroyo Seco - Lucille St | $ 1,350,000 |
| 33C0380 | Arroyo Seco - Charlotte Wy North | $ 1,800,000 |
| 33C0381 | Arroyo Seco - Patterson Pass Rd | $ 3,750,000 |
| 33C0382 | Arroyo Seco - Las Positas Rd | $ 3,720,000 |
| 33C0383 | Arroyo Seco - Arroyo Vista | $ 3,605,000 |
| 33C0385 | Vasco Rd - Vasco Rd | $ 18,905,000 |
| 33C0395 | W. Jack London Blvd - Arroyo Las Positas | $ 4,435,000 |
| 33C0397 | Arroyo Las Positas - Springtown Blvd | $ 8,555,000 |
| 33C0413 | Arroyo Las Positas - Patterson Pass Rd | $ 2,910,000 |
| 33C0414 | Altamont Creek - Laughlin Rd | $ 1,350,000 |
| 33C0415 | Arroyo Seco - Southfront Rd | $ 5,410,000 |
| 33C0416 | North Mines Rd - North Mines Rd | $ 18,710,000 |
| 33C0424 | Arroyo Seco - First St | $ 8,450,000 |
| 33C0425 | East First St - First St | $ 15,075,000 |
| 33C0426 | Arroyo Mocho - Holmes St | $ 8,220,000 |
| 33C0485 | Concannon Blvd - Arroyo Mocho | $ 4,160,000 |
| COLV001 | Altamont Creek - Pasatiempo St Vehicle Bridge | $ 615,000 |
| COLV002 | Altamont Creek - Vasco Rd Vehicle Bridge | $ 1,152,000 |
| COLV003 | Arroyo Las Positas - Arrowhead Ave Vehicle Bridge | $ 500,000 |
| COLV004 | Arroyo Las Positas - Central Ave Vehicle Bridge | $ 455,000 |
| COLV005 | Arroyo Las Positas - Heather Ln Vehicle Bridge | $ 480,000 |
| COLV006 | Arroyo Las Positas - Northfront Rd Vehicle Bridge | $ 2,610,000 |
| COLV007 | Arroyo Las Positas - Vasco Rd Vehicle Bridge | $ 845,000 |
| COLV008 | North Altamont Creek - Vasco Rd Vehicle Bridge | $ 1,150,000 |

*Table 1-6 Trail Bridge Replacement Cost*

| Bridge Number | Bridge Description | Replacement Cost |
|---|---|---|
| COLP001 | Altamont Creek Trail Bridge | $ 60,000 |
| COLP002 | Arroyo Road Trail Bridge | $ 600,000 |
| COLP003 | Big Trees Park between Susan Ln/Cheryl | $ 525,000 |
| COLP004 | Charlotte Bridge - Arroyo Seco School | $ 300,000 |
| COLP005 | El Charro Trail Bridge | $ 680,000 |
| COLP006 | Northfront Park - North Side Trail Bridge | $ 1,420,000 |
| COLP007 | Northfront Park - South Side Trail Bridge | $ 1,420,000 |
| COLP008 | Livermore Avenue Trail Bridge | $ 1,700,000 |
| COLP009 | Vasco Road West Side Trail Bridge | $ 500,000 |
| COLP010 | Vasco Road East Side Trail Bridge | $ 500,000 |
| COLP011 | Springtown Open Space Trail Bridge | $ 500,000 |
| COLC001 | Rockrose Culverts Trail Bridge | $ 120,000 |

### *1.2.6 Installation and Consumption Profile*

The installation profile gives an indication of the age of the bridges. Installation year was determined based on historical data. Exact installation year from records for certain assets was incorporated whenever possible. The following figure shows the installation profile for the Bridge Management System. The graph shows the City's historical investments represented in 2017 dollars.

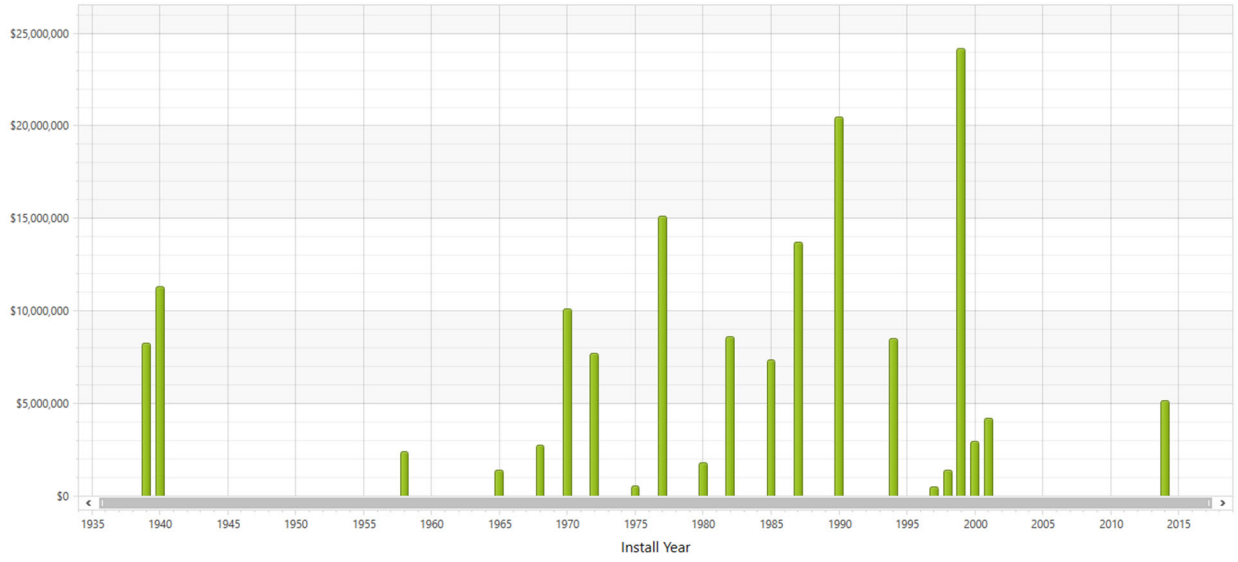


*Figure 1-12 Installation Profile*

More important than the installation data is the estimated current state or consumption of the assets. Consumption represents the percentage of an asset's expected life that it has used up or consumed. As illustrated in the following

figure, most bridge assets have consumed approximately 70% or less of their useful lives. Although 70% may seem high, these assets may be in relatively good condition with years of life left, as explained in the next section. Another reason for the high consumption peak in the 70% was that many assets received a condition score of 3 (Good or As Expected Based on Age). An exponential decay curve was utilized to represent the deterioration of the asset, which roughly translated a condition assessment score of 3 to be 70% consumed. Discussion on the condition assessment rating scale is presented in the following section. The following figure shows the consumption profile represented in 2017 dollars.

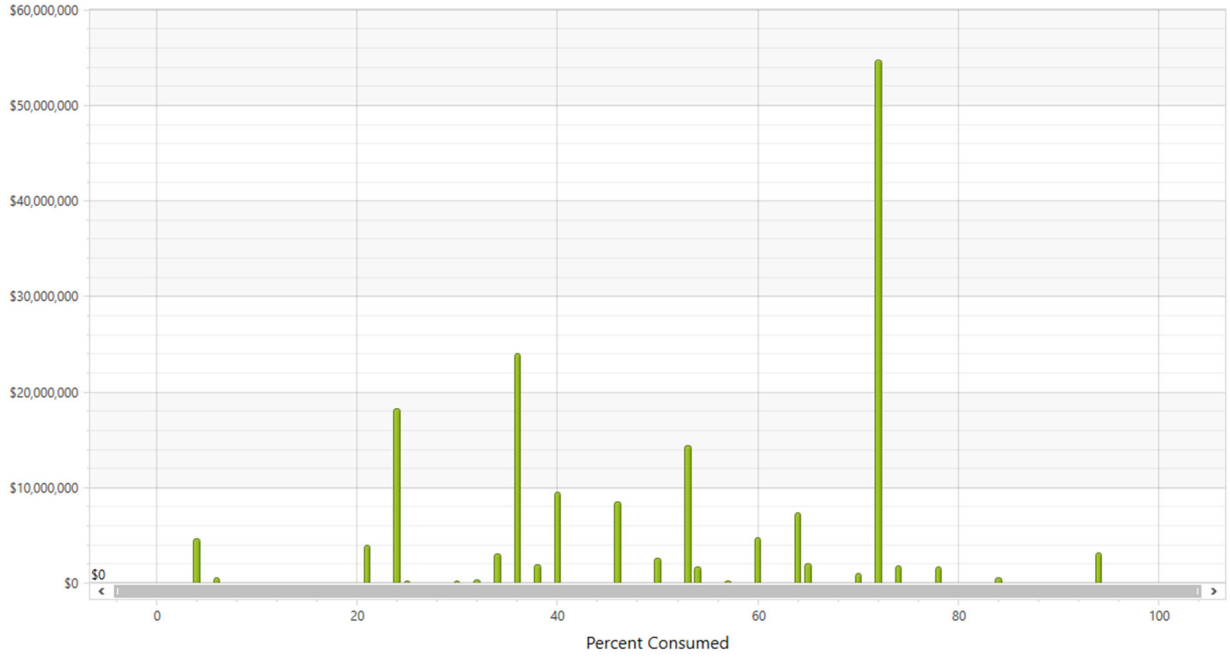


*Figure 1-13 Consumption Profile*

### *1.2.7 Condition Assessment*

Condition is one of the best indicators for estimation of immediate or future repair and replacement work. During the asset inventory field visits, the asset condition was assessed and recorded. The condition scores were based on visual inspection. It accounts for the external factors related to safety, service level, functionality, and/or remaining useful life. It does not reflect the condition of the internal, non-visible components of the asset. The condition was assessed based on the following condition scale. Condition information for each asset is available in the City's IRIS database. This information would be too lengthy to include in this report.

*Table 1-7 Condition Scale*

| Condition Score | Description |
|---|---|
| **1** | New or nearly new |
| **2** | Very good |
| **3** | Good or as expected based on age |
| **4** | Poor or recommended replacement within near-term |
| **5** | Failed or nearing failure, needs immediate attention |

The City is responsible for the inspection, maintenance, and replacement of vehicle bridges with a span of less than 20 ft, and the City is also responsible for inspection, maintenance, and replacement of trail bridges. It is important to note that CalTrans performs a condition assessment of vehicle bridges with a span of over 20 ft every 5 years. Based on these assessments, the City is responsible for annual maintenance, while the City can apply for partial funding from CalTrans for major repairs or replacement.

During the on-site inventory process, condition assessment took place for vehicle bridges not inspected by CalTrans (i.e., with a span of less than 20 feet) and for all trail bridges. A sample of the condition assessment on a trail bridge is presented below. The following figure displays the Altamont Creek Trail Bridge and some of the images recorded during inventory and condition assessment.

*Figure 1-14 Condition Score Examples*

The image on the left shows the overview of the bridge and the images on the right highlight some of the condition issues that were found during inspection. The image on the upper right shows the wearing of the Portland cement concrete (PCC) deck surface. The deck is 80 square feet, 75 square feet is in good condition but the wear is concentrated on about 5 square feet, making this small area considered to be in fair condition. The bottom images show the minor to moderate rusting on the metal railing. Out of 16 total feet of railing, about 4 feet is in good condition, 4 feet is in fair condition, and 8 feet is in poor condition (bottom right image).

It would be recommended that the lower rail at the ends should be re-weld and the railings should be re-painted. The cracks at the post bases of the deck need to be epoxied and the vertical cracks in the AC at approaches should be re-sealed. Lastly, sediment under the bridge should be removed to maximize channel hydraulic capability.

As mentioned previously, Caltrans performs a condition assessment of vehicle bridges with a span of over 20 feet typically on a two-year cycle in accordance with the National Bridge Inspection (NBI) Standards. The City is responsible for routine maintenance and repairs of these bridges. For bridges that are listed in the NBI and require major repairs or replacement, the City can apply for Federal funding administered by Caltrans through the Federal

Highway Administration (FHWA) Highway Bridge Program (HBP). The HBP program will pay for approximately 88.53% of the eligible design and repair or replacement cost. The following information for bridges over 20 foot span was provided by City staff for reference.

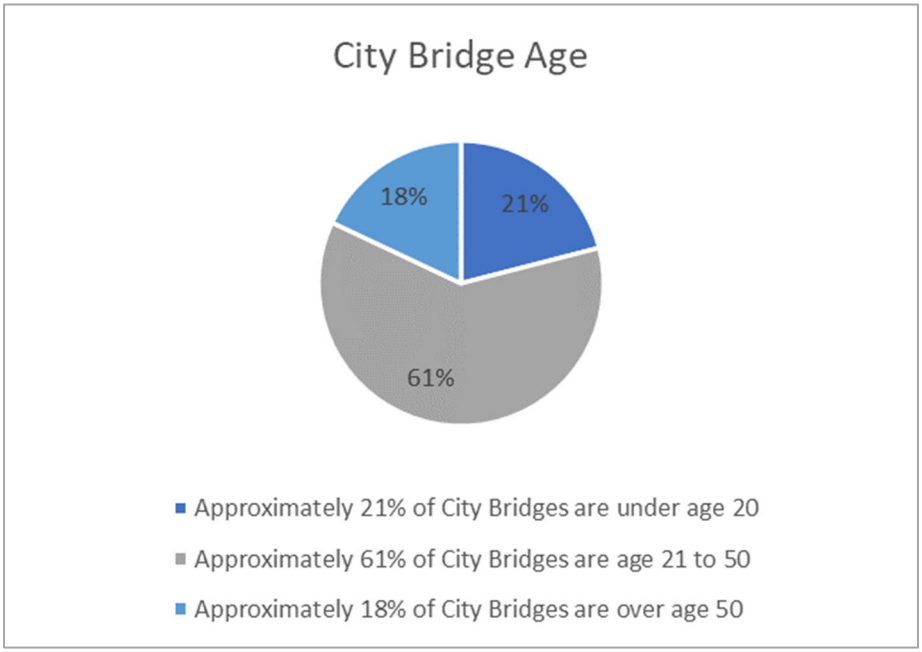


*Figure 1-15 Bridges Over 20' Span Age*

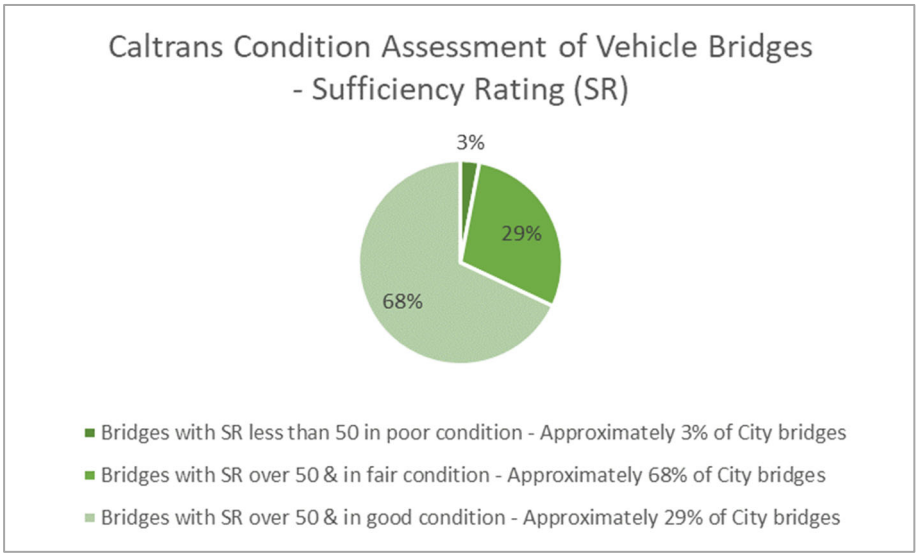


*Figure 1-16 Caltrans Condition Assessment of Vehicle Bridges over 20' Span*

## 1.3 Risk Analysis

### *1.3.1 Probability of Failure*

For most of the bridge assets, Probability of Failure (PoF) was determined by the condition score assigned during visual inspection. In cases where the assets were not visible or where visual assessment was not a good

representation of the asset's condition, PoF was calculated based on age by comparing the installation year and estimated useful life based on the City's historical usage, manufacturer's estimation, and/or other reputable resources (e.g., research results, ENR, neighboring cities). PoF information for each asset is available in the City's IRIS database. This information is too lengthy to include in this report.

### *1.3.2 Consequence of Failure*

The figure below presents the multi-tier logic Consequence of Failure (CoF) rating methodology developed for the Bridge Management System. In the first tier, a criticality level was assessed at the bridge level based on the level of usage, which was rated by road class. The criticality was then assessed at the asset level based on how integral the asset class' function was to the bridge overall. CoF information for each asset is available in the City's IRIS database. This information would be too lengthy to include in this report.

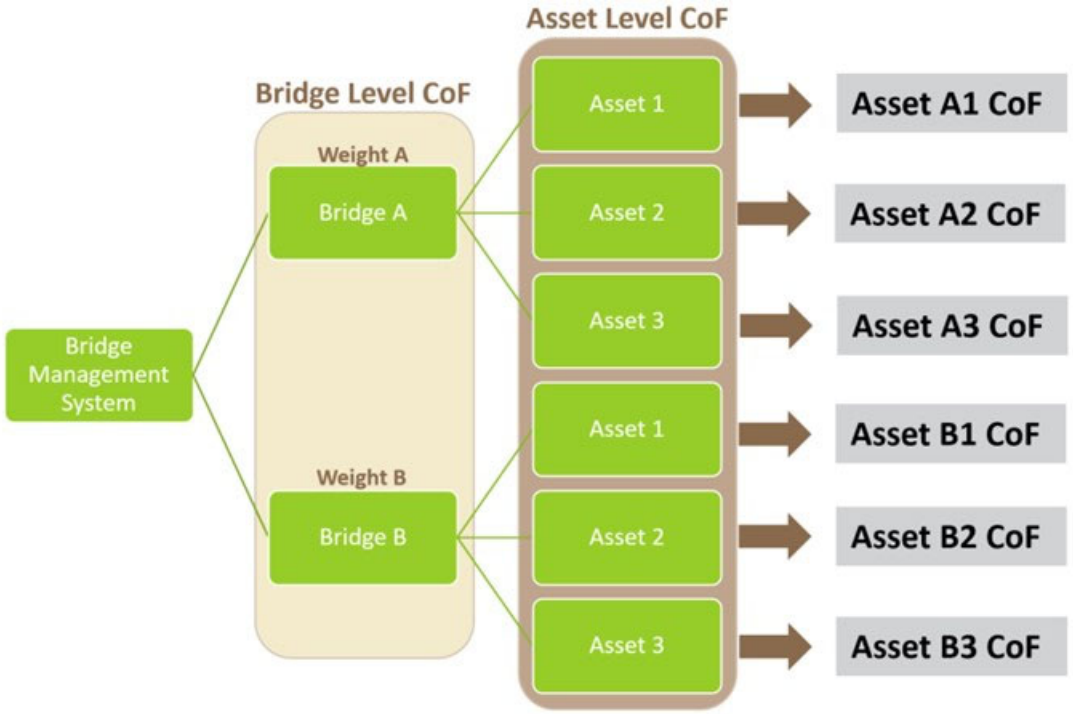


*Figure 1-17 Multi-Tier Logic of CoF Rating Methodology*

#### 1.3.2.1 Bridge and Asset Criticality Ratings

The bridges are prioritized based on a two-tier system where the first tier CoF rating is based on the bridge usage (higher usage equals higher CoF) and the second tier CoF rating is based on the importance of each major component of the bridge. Bridges were assigned CoF scores of Medium-Low or higher due to safety issues related to bridges as shown in the following table.

*Table 1-8 Bridge-Level Criticality*

| CoF Level | Bridge Usage |
|---|---|
| Very High | Roadway Bridges on Arterials |
| High | Roadway Bridges on Collectors, Trail Bridges with High Usage |
| Medium | Roadway Bridges on Residential Streets, Other Trail Bridges |
| Medium-Low | Trail Bridges with Adjacent Redundancy |

Once the bridge level CoF was assigned, CoF scores were assigned at the asset level. The more integral the asset was to the bridge, the higher the CoF score. Bridge assets were given CoF scores of Medium-Low and higher due to safety issues associated with bridges.

*Table 1-9 Asset-Level Criticality*

| CoF Level | Components |
|---|---|
| Very High | Structural Components, Deck, Abutments, Culverts |
| High | Walls, Guardrails, Parapets, Railing |
| Medium | Approach, Lighting, Pavers |
| Medium-Low | Fencing, Gates |

### *1.3.3 Risk Analysis Results*

The following figure shows the resulting overall risk profile for City-owned and managed bridge assets. This profile incorporates both the PoF and CoF scores to prioritize the assets. Each box shows a summary of the number of assets and the total replacement cost for those assets. The asset in the red zone of the risk matrix is part of the bridge across Altamont Creek along Bluebell Road, and is the highest risk asset with both a high probability and high consequence of failure. This bridge will need rehabilitation in the near future in order to lower the risk. As illustrated in the matrix, no assets were given low CoF scores (i.e., CoF 2 or less) due to the safety issues associated with bridges.


*Figure 1-18 Bridge Risk Matrix*

## 1.4 Future Needs

### *1.4.1 Life Cycle Cost Logic*

Life cycle cost logic, also known as management strategies, were developed for the bridge assets. Each asset class was assigned a management strategy that includes the rehabilitation and replacement activities to best characterize the life cycle investment needs for the asset. The bridge management strategies are based on an estimated 75-year overall useful life, while culvert management strategies are based on an estimated 50-year overall useful life. Both useful lives are based on the assumption that rehabilitation takes place as scheduled. The management strategies are summarized in Appendix B.

### *1.4.2 Long-Range Replacement and Rehabilitation Profile*

The following figures show the replacement and rehabilitation needs (including the 50% for project delivery costs) for which the City is responsible over a 30-year span in 2017 dollars. Utilizing a deterministic model (i.e. assets fail at the end of their useful lives), the average annual replacement and rehabilitation needs over the 30-year planning horizon is approximately $4.3 million.

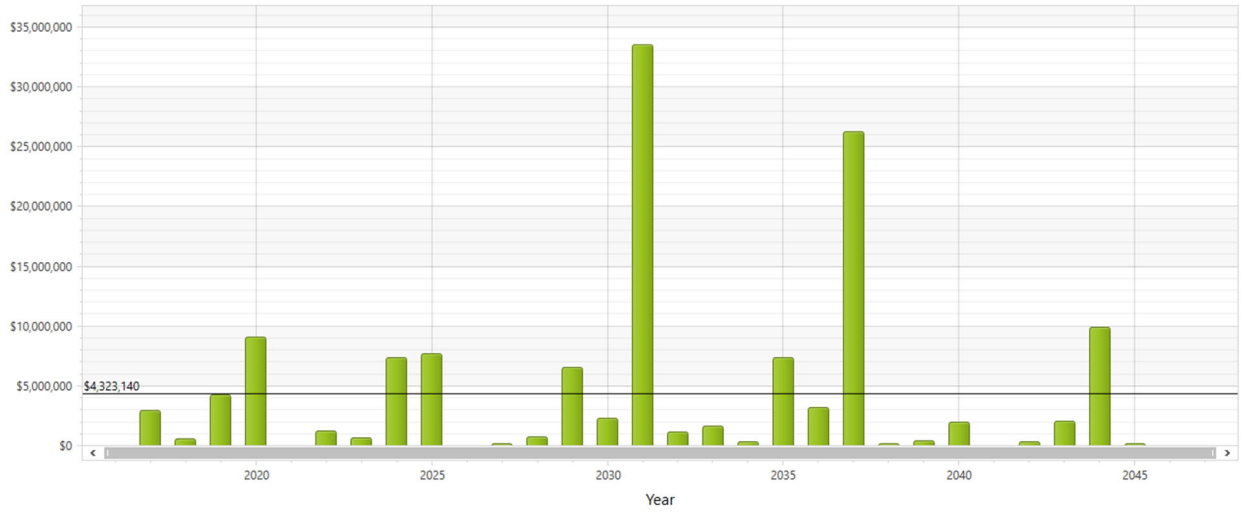


*Figure 1-19 Bridge 30-Year Replacement and Rehabilitation Profile (Deterministic)*

The following figures show a breakdown of the rehabilitation and replacement by bridge type. The vehicle bridges will need approximately $4.1 million each year, while trail bridges will need an average annual investment of approximately $254,000.

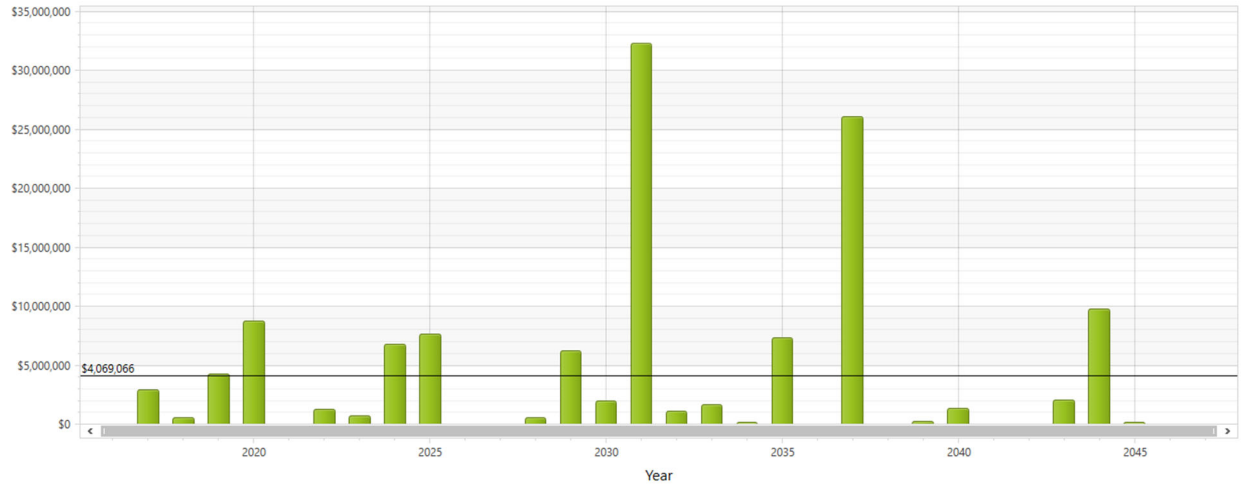


*Figure 1-20 Vehicle Bridge 30-Year Replacement and Rehabilitation Profile (Deterministic)*

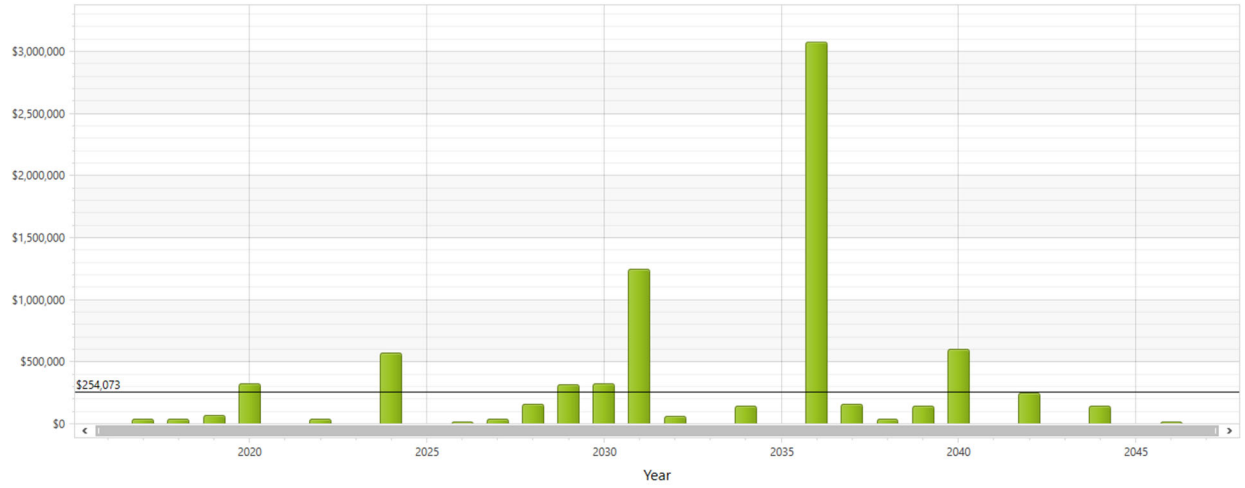


*Figure 1-21 Trail Bridge 30-Year Replacement and Rehabilitation Profile (Deterministic)*

The 30-year life cycle cost analysis was repeated utilizing a probabilistic model. In this model, asset failures were smoothed representing a more realistic expectation where assets may fail sooner or later than the expected useful lives; as such, this scenario may present a more realistic estimate of the future asset failures and funding needs. The probabilistic analysis incorporates the concept of randomness in that early or late asset failures are distributed randomly using the assigned standard deviation (i.e., 20%). The probabilistic model predicts the annual replacement and rehabilitation needs to be approximately $3.1 million.

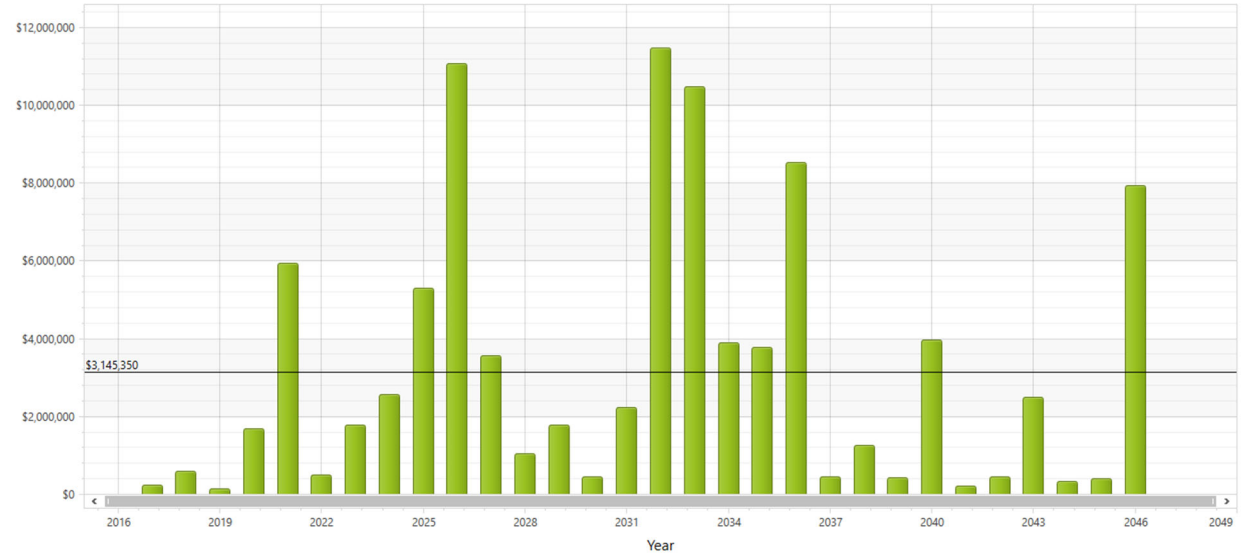


*Figure 1-22 Bridge 30-Year Replacement and Rehabilitation Profile (Probabilistic)*

Both analyses above represented results in 2017 dollars. Expecting the cost of construction will increase with time, a second model run was performed using a 3% annual inflation factor was utilized. With 3% inflation over the 30-year planning horizon, the projected annual investment need for the deterministic model increases from $4.3 million per year to $6.8 million per year. Similarly, for the probabilistic model, the annual investment need increases from

$3.1 million per year to $5.0 million per year. The results of these analyses are presented the following figures.

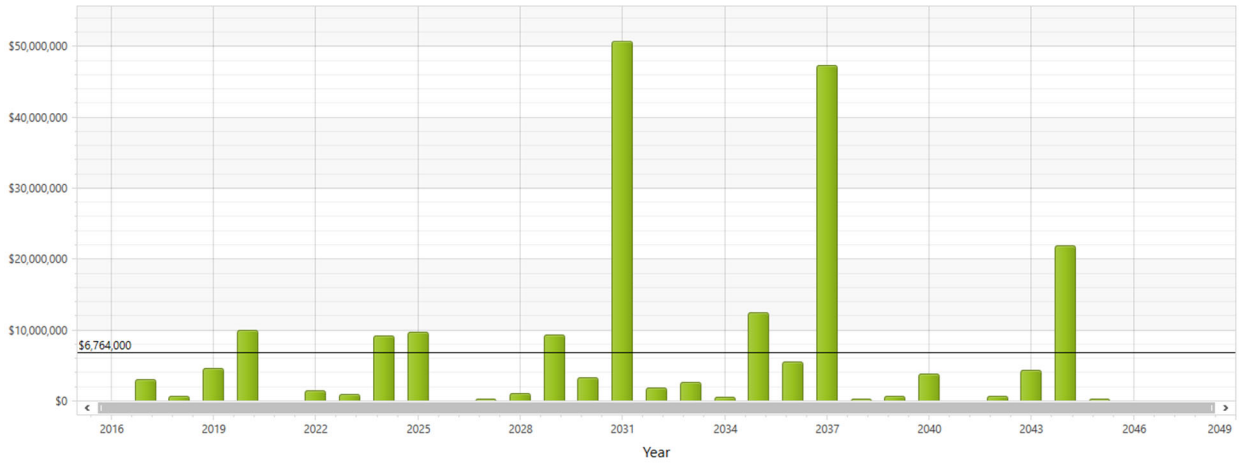


*Figure 1-23 Bridge 30-Year Replacement and Rehabilitation Profile (Deterministic, 3% Inflation)*

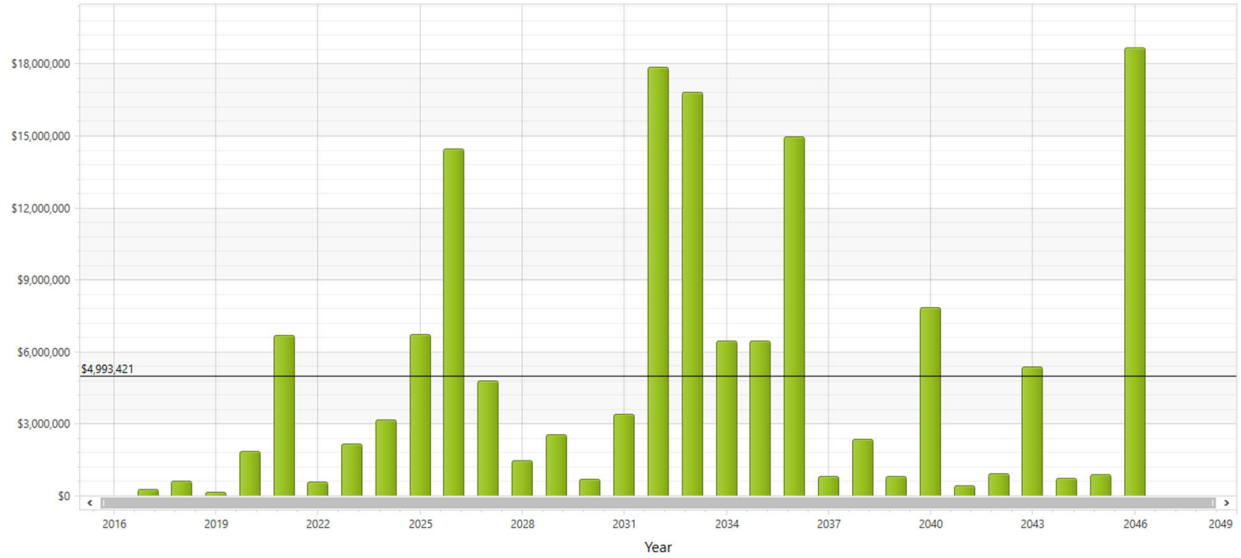


*Figure 1-24 Bridge 30-Year Replacement and Rehabilitation Profile (Probabilistic, 3% Inflation)*

The following table summarizes the 30-year replacement and rehabilitation needs for the Bridge Management System.

*Table 1-10 Replacement and Rehabilitation Profile Summary*

| Analysis Type | R&R Average |
|---|---|
| Deterministic | $4.3 M/yr |
| Probabilistic | $3.1 M/yr |
| Deterministic with 3% Inflation | $6.8 M/yr |
| Probabilistic with 3% Inflation | $5.0 M/yr |

### *1.4.3 Keep Up and Catch Up*

When discussing replacement and rehabilitation, Catch Up describes all replacement and rehabilitation needs (e.g., assets fully consumed, assets with condition score of 4 or 5) in the current year. Keep Up describes all replacement and rehabilitation needs in the remainder of a given planning horizon after the City has addressed the Catch Up needs. In the Catch Up and Keep Up analysis, the deterministic 30-year replacement and rehabilitation analysis is re-examined by bringing the high-risk assets (Catch Up needs) to the beginning of the planning horizon. The remaining replacement and rehabilitation needs are represented by the Keep Up. The following table displays the total Catch Up and the Keep Up for a 30-year planning horizon, both represented in 2017 dollars with 50% project delivery costs.

*Table 1-11 Catch Up and Keep Up*

| | Cost |
|---|---|
| **Catch Up** | $2.1 million |
| **Keep Up** | $4.3 million average per year |

Overall, the Catch Up and Keep Up analysis provides a view of the future needs if the City were to focus solely on high-risk assets before addressing the other Keep Up needs. If the City were to fund the Catch Up ($2.1 million) in the immediate future, the Keep Up represents the annual average for the remaining R&R needs in the 30-year planning horizon. As such, the Keep Up annual average should only be used as the future funding need estimate if the City has the budget to address all Catch Up needs in the immediate future. Otherwise, the replacement and rehabilitation analyses in Section 1.4.3 should be used as the basis for future planning.

## 1.5 Level of Service

### *1.5.1 Preferred Level of Service*

The preferred level of service would be for the City to follow the rehabilitation and replacement cycles as outlined in the life cycle cost logic section of this report (i.e., full service, replace and rehabilitate all assets on schedule regardless of priority). Due to the City's limited budget, the City may prioritize which bridge assets to rehabilitate or replace, but overall, all bridge assets should be rehabilitated and replaced on schedule under this preferred level of service.

As shown in Table 1-11, the estimated annual budget over a 30-year horizon for the preferred level of service is

approximately $4.3 million or $6.8 million with 3% inflation.

### *1.5.2 Minimum Level of Service*

Because bridges provide a critical public service, there is no minimum level of service for the Bridge Management System.

## 1.6 Management System Score

### *1.6.1 Physical Health*

The physical health of the Bridge Management System was judged based on the ratio of poor condition assets and the red zone, high risk assets (as identified in Section 1.3) to the overall replacement cost of all system assets. These scores were used to assess the overall grade of the management system. For these scores, the lower the percentage of poor condition (Overall Condition) and high risk (Risk-Based Condition) scores, the better.

*Table 1-12 Bridge Management System Physical Health Values and Scores*

| Category | Score | Grade |
|---|---|---|
| Overall Condition | 2% | A |
| Risk-Based Condition | 1% | A |

As shown in the table, the estimated physical health of the Bridge Management System is in good physical health.

### *1.6.2 Financial Health*

The financial health of the Bridge Management System was judged based on the ratio of the Catch Up and Keep Up values to the 2017 annual rehabilitation and replacement budget of approximately $10,000. The scores for each category are presented below. These scores were used to assess the overall grade of the management system.

*Table 1-13 Bridge Management System Financial Health Scores*

| Category | Score | Grade |
|---|---|---|
| Catch Up Score | <1% | F |
| Keep Up Score | <1% | F |

As shown in the table, the estimated financial health of the system is poor, with a score of F indicating the City's catchup needs. While the assets are currently in good condition as shown with a score of A in the physical health score (Table 1-12), the poor catch up score means that there is insufficient funding dedicated to bridge rehabilitation and replacement to improve the condition of the current high-risk asset. The system also received a keep up grade of F; this implies that the system will not likely have the funding to keep up once it has caught up. This is due to the high cost of replacing a bridge versus the relatively low annual rehabilitation budget for bridges. In the future, it will be important to review bridges that need major rehabilitation or replacement well in advance of failure and begin planning for the financing of the rehabilitation or replacement work.

## 1.7 Confidence Level

Confidence level factor weights are based on the City's specific goals for this phase of the asset management program development. Factors that were focused on during this phase of the asset management program development, such as asset inventory and condition assessment, were given higher weight. One of the City's particular goals was also to encourage buy-in on the part of its staff and stakeholders, so the Community Asset Management Program (CAMP) committee review was added to the general asset management program as a factor. On the other hand, factors that will be improved in future phases of the program development were given lower weight.

*Table 1-14 Bridge Confidence Level*

| Confidence Level Factor | Confidence Level Rating Score | Weighting Factor | Weighted Confidence Level Rating Score |
|---|---|---|---|
| **Asset Inventory** | 70% | 20% | 14% |
| **Data Quality** | 70% | 15% | 11% |
| **Condition Assessment** | 70% | 20% | 14% |
| **Asset Valuation** | 85% | 10% | 9% |
| **Life-cycle Cost Logic** | 70% | 10% | 7% |
| **Risk** | 85% | 10% | 9% |
| **Staff Review** | 70% | 5% | 4% |
| **CAMP Committee Review** | 100% | 10% | 10% |
| **Total Score** | | | 76% |

*Asset Inventory (Unweighted Score - 70%)*

On-site inventory collection and verification took place for each bridge. Further use of the asset management system will determine whether the asset level was defined at the appropriate level.

*Data Quality (Unweighted Score - 70%)*

On-site inventory collection and verification took place for each bridge. Further verification with staff will take place in the future to make sure that all necessary attributes were collected.

*Condition Assessment (Unweighted Score - 70%)*

On-site inventory condition assessment took place for the bridges. Further verification with staff, including review of rehabilitation needs, will take place in the future.

*Asset Valuation (Unweighted Score - 85%)*

Overall replacement costs were estimated for each bridge with City staff input. As bridges are replaced in the future, the costs will be updated in the bridge management system.

*Life-cycle Cost Logic (Unweighted Score - 70%)*

Life-cycle cost logic was assigned to the assets based on overall bridge life estimates. Further review of activities may be needed if asset inventory is adjusted in the future.

*Risk (Unweighted Score - 85%)*

A robust CoF methodology was developed that incorporates the criticality of the bridge as well as the asset.

*Staff Review (Unweighted Score - 70%)*

Staff was involved in the development of the bridge management system, particularly in the replacement cost estimate and replacement and rehabilitation cycles. Continued review of the inventory and condition assessment should happen regularly.

*CAMP Committee Review (Unweighted Score - 100%)*

The CAMP committee reviewed, analyzed, and provided input on the results throughout the asset management plan process.

### 1.8 Next Steps

*Asset Classes and Asset Inventory*

As mentioned previously, review with City staff has revealed that further updates to the asset definitions will need to take place in the future to better model how the bridges are managed and to fully align with the current City staff's expectations. The following bridge asset classes and categories have been provided by City Staff. By adjusting the asset register to align with City staff definitions, the future replacement and rehabilitation will even more fully capture the management of these assets in accordance with the asset management concept of continuous improvement.

*Table 1-15 Culver Components with Traffic and Pedestrian Safety Elements*

| Culvert Components | | |
|---|---|---|
| • Pavement<br>• Road Embankment<br>• Headwall<br>• Wing Wall | • Apron<br>• Crown<br>• Culvert Pipe<br>• Culvert Inlet | • Culvert Outlet<br>• Culvert Foundation<br>• Energy Dissipator |
| **Traffic and Pedestrian Safety Elements** | | |
| • Barriers<br>• Railing | • Signage<br>• Traffic Striping | • Lighting |

*Table 1-16 Bridge Components*

| Bridge Components | | | |
|---|---|---|---|
| Superstructure | Substructure | Foundation | Traffic and Safety Elements |
| • Deck Slab<br>• Deck Beam<br>• Girders<br>• Truss<br>• Approach Slab<br>• Sidewalk, Curb & Gutter | • Piers<br>• Abutments<br>• Wing Walls<br>• Spandrels<br>• Caps<br>• Bearings | • Piles<br>• Spread Footing | • Barriers<br>• Parapets<br>• Bridge Railings<br>• Pedestrian and Bicycle Railings<br>• Signage<br>• Traffic Striping<br>• Lighting |

## Appendix A – Asset Classes

The following table shows the asset classes for the Bridge Management System.

| Asset Classes – Bridges |
|---|
| Abutment |
| Approach |
| Beam |
| Column Supports |
| Culvert |
| Deck |
| End Wall |
| Fencing |
| Gate |
| Girder |
| Guardrail |
| Head Wall |
| Inlet Wall |
| Lighting |
| Outlet Wall |
| Parapet |
| Pavers |
| Pier |
| Piles |
| Pillar |
| Railing |
| Reinforced Concrete Box |
| Supporting Wall |
| Truss |
| Wing Wall |

## Appendix B – Management Strategy

The following tables show the management strategies applied to the assets. The bridge management strategies are based on an estimated 75-year overall useful life, while culvert management strategies are based on an estimated 50-year overall useful life. Both useful lives are based on the assumption that rehabilitation takes place as scheduled.

**Vehicle Bridge Management Strategy**

| Asset Class/Type | Useful Life (Years) | Rehab | Rehab Frequency (Years) | Rehab Cost (% of Replacement Cost) |
|---|---|---|---|---|
| RCB - Concrete | 50 | Rehabilitation | 25 | 50% |
| Culvert - CMP | 50 | | | |
| Culvert - Concrete | 50 | Rehabilitation | 25 | 50% |
| End Wall - Concrete | 50 | Rehabilitation | 30 | 30% |
| Inlet Wall | 50 | Rehabilitation | 30 | 30% |
| Outlet Wall | 50 | Rehabilitation | 30 | 30% |
| Wing Wall | 50 | Rehabilitation | 30 | 30% |
| Abutment | 50 | Rehabilitation | 30 | 30% |
| Parapet - Concrete | 50 | | | |
| Pillar | 75 | | | |
| Supporting Wall | 75 | Rehabilitation | 30 | 30% |
| Railing - Concrete | 75 | | | |
| Girder - Concrete | 75 | Rehabilitation | 30 | 30% |
| Pier | 75 | | | |
| Piles | 75 | | | |
| Guardrail | 75 | Rehabilitation | 20 | 20% |
| Head Wall - Concrete | 75 | | | |
| Deck - AC | 25 | Rehabilitation | 10 | 15% |
| Deck - PCC | 75 | Rehabilitation | 10 | 15% |
| Pavers | 40 | | | |
| Fencing - Chainlink | 30 | | | |
| Gate - Chainlink | 30 | | | |
| Light Standard | 25 | | | |
| Railing - Block | 50 | | | |
| Railing - Chainlink | 30 | | | |
| Railing - Steel | 30 | Paint | 10 | 20% |
| Railing - Wood | 30 | | | |
| Wall | 75 | | | |

**Trail Bridge Management Strategy**

| Asset Class/Type | Useful Life (Years) | Rehab | Rehab Frequency (Years) | Rehab Cost (% of Replacement Cost) |
|---|---|---|---|---|
| RCB - Concrete | 50 | Rehabilitation | 25 | 50% |
| Abutment - Concrete | 50 | | | |
| Base - Concrete | 50 | | | |
| Beam - Steel | 50 | | | |
| Culvert - RCP | 50 | | | |
| Column Supports | 50 | | | |
| End Wall - Concrete | 50 | | | |
| Wing Wall - Concrete | 50 | | | |
| Truss | 70 | | | |
| Deck - Concrete | 70 | Rehabilitation | 10 | 15% |
| Approach - AC | 25 | Rehabilitation | 10 | 15% |
| Approach - PCC | 50 | Rehabilitation | 10 | 15% |
| Deck - AC | 25 | Rehabilitation | 10 | 15% |
| Deck - Wood | 10 | | | |
| Gate - Chainlink | 30 | | | |
| Lighting | 15 | | | |
| Girder - Concrete | 70 | | | |
| Railing - Chainlink | 30 | | | |
| Railing - Corrosion Resistant Steel | 70 | | | |
| Railing - Metal | 20 | | | |
| Railing - Steel | 40 | Paint | 10 | 20% |