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CITY OF
CHULA VISTA

City of Chula Vista

Urban Forestry Management System
Asset Management Plan

Horizon Scanning and Scenario Planning

2016

Table of Contents

1 Introduction 1

1.1 Asset Management Program Goal 2
1.2 Asset Management Program Methodology 3
1.3 Asset Management Definition 4
1.4 Asset Management Plan 4

2 Asset Register 5

2.1 Asset Definition 5
2.2 Asset Hierarchy 6
2.3 Asset Class 6
2.4 Asset Inventory 6
2.5 Asset Valuation versus Asset Replacement Cost 9
2.6 Asset Valuation 10
2.7 Asset Replacement Cost 13
2.8 Condition Assessment 14

3 Risk Analysis 17

3.1 Probability of Failure 17
3.2 Consequence of Failure 18
3.3 Risk 21

4 Future Needs 24

4.1 Immediate Needs 24
4.2 Life Cycle Cost Logic 25
4.3 Preservation and Restoration Profile 28

5 Confidence Level 34

5.1 Next Steps 36
5.1.1 Asset Inventory, Data Quality, and Condition Assessment 36
5.1.2 Level of Service and Resources 36

6 Appendix A – Species Rating 37

Figures

Figure 1-1 Map of Chula Vista Urban Forestry System 2
Figure 2-1 Urban Forestry Asset Hierarchy 6
Figure 2-2 Urban Forestry Asset Value 13
Figure 2-3 Urban Forestry Replacement Cost 14
Figure 3-1 Map of Probability of Failure 18
Figure 3-2 Map of Consequence of Failure 20
Figure 3-3 Urban Forestry Risk Matrix 21
Figure 3-4 Map of Risk 22
Figure 4-1 Urban Forestry Immediate Needs Map 24
Figure 4-2 Urban Forestry System High Risk Immediate Needs 25
Figure 4-3 Preservation and Restoration Profile 29

Figure 4-4 Preservation Profile 30
Figure 4-5 10-Year Preservation and Restoration Profile 31
Figure 4-6 20-Year Preservation and Restoration Profile 32
Figure 4-7 30-Year Preservation and Restoration Profile 32

Tables

Table 2-1 Urban Forestry Asset Inventory 7
Table 2-2 Urban Forestry Asset Inventory by Type 7
Table 2-3 Vacant Site Planting Projection 8
Table 2-4 Vacant Site Planting Priority 8
Table 2-5 Urban Forestry Inventory by Diameter 9
Table 2-6 Urban Forestry Inventory by Height 9
Table 2-7 Diameter Assumptions 10
Table 2-8 Species Rating Sample 11
Table 2-9 Location Rating 12
Table 2-10 Condition Rating Matrix 15
Table 2-11 Condition Assessment Results 16
Table 3-1 Condition Rating Score Logic 19
Table 3-2 High Risk Asset Replacement Cost 23
Table 4-1 Urban Forestry Replacement Cost Logic 26
Table 4-2 Vacant Site and Stump Cost Logic 26
Table 4-3 Urban Forestry Maintenance Cost Logic 27
Table 4-4 Eucalyptus Size Logic 27
Table 4-5 Vacant Site and Stump Maintenance Cost Logic 27
Table 5-1 Confidence Level Logic 34
Table 5-2 Urban Forestry Confidence Level 35

1 Introduction

The City of Chula Vista (City) is currently enhancing its asset management practices to promote effective use of financial and physical resources and to develop a proactive approach to managing its infrastructure assets. As part of this effort, the City embarked on developing a comprehensive citywide Asset Management Program (AM Program) that includes the following asset management systems:

- Wastewater Management System
- Urban Forestry Management System
- Building Management System
- Drainage Management System
- Parks Management System
- Roadway Management System
- Fleet Management System

The AM Program began with the Wastewater Management System as the pilot asset management program. The Wastewater Management System helped to educate the City staff on asset management processes and practices and acted as a template for other asset management systems. The Wastewater Management System demonstrated the benefits of asset management, and the City decided to expand its asset management improvement efforts to its other systems, listed above.

In addition to the above asset management systems, the City plans to include the following asset management systems to develop a comprehensive citywide asset management program:

- Fleet Management System
- Open Space Management System
- General Government Management System

This document, Urban Forestry Management System Asset Management Plan, will only focus on the urban forestry assets.

The City has currently inventoried and assessed 33,983 trees that it owns and manages in its Urban Forestry Management System. Concerned about the ongoing maintenance needs of its trees and the liability presented by aging and dying trees, the City decided to conduct a comprehensive survey of its urban forestry system and to develop an asset management plan to gain better understanding of its current and future needs and to proactively manage its trees.

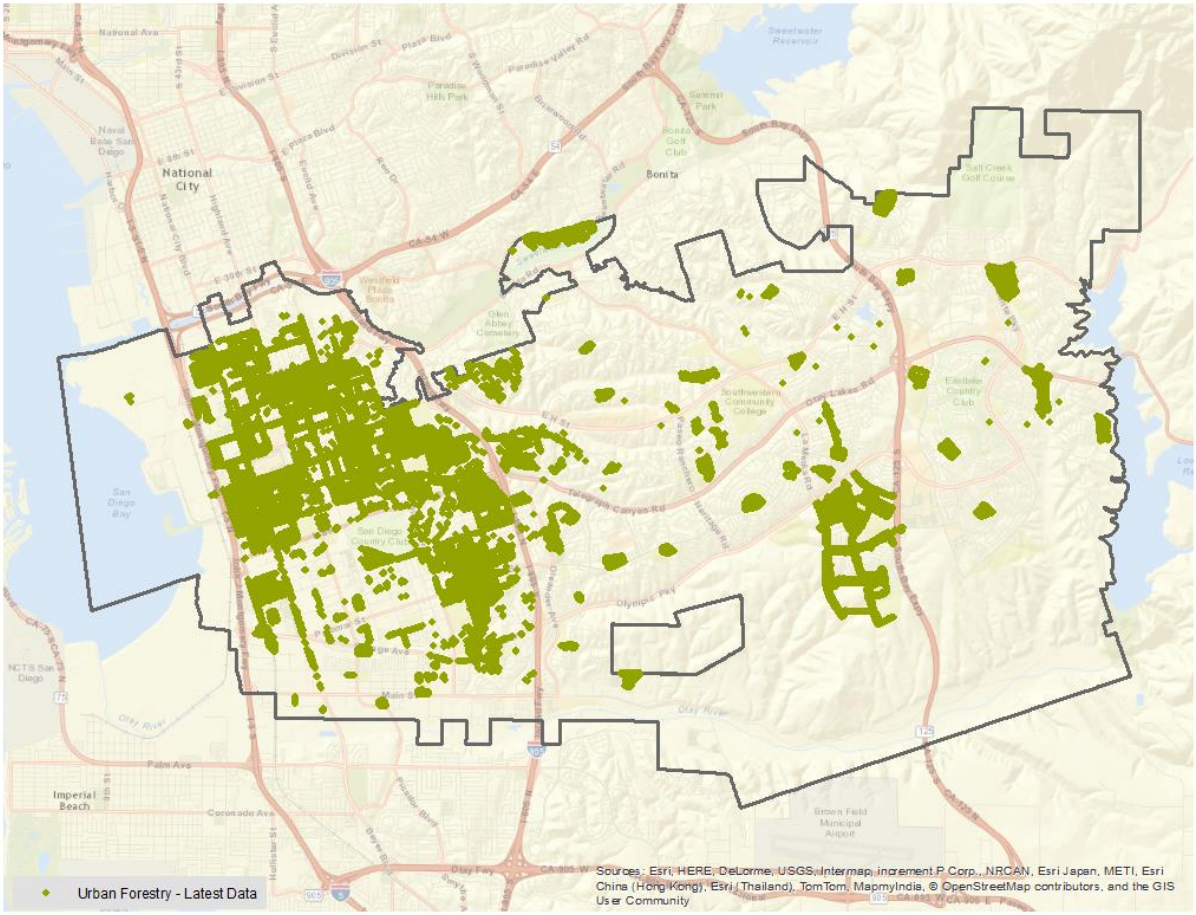


Figure 1-1 Map of Chula Vista Urban Forestry System

It is estimated that the City owns more than 50,000 trees; however, only the 33,978 trees, stumps, and vacant sites that have been inventoried and assessed are covered in this document. As part of the asset management continuous improvement effort, the City will continue to inventory and assess the condition of its urban forestry assets.

1.1 Asset Management Program Goal

The goal of the City's AM Program was to shift from reactive to proactive planning and management of its infrastructure assets. Specifically, the City wanted to do the following:

- Gain better understanding of the current state of the infrastructure and its future needs
- Proactively identify the asset rehabilitation and replacement needs and plan the budget and resources accordingly
- Understand the probability and consequence of failure of each asset so that the City can manage high-risk assets before failure and minimize the City's overall risk profile
- Minimize the life-cycle cost by incorporating the latest technological advances in infrastructure management to develop efficient and effective preservation and restoration strategies
- Develop a consistent and defendable methodology for prioritizing work and budget expenditure

- Focus on high benefit-to-cost ratio to ensure the budget is spent in the right place, for the right reason, at the right time, and at the right cost
- Be transparent by involving the City Council and the Public in the development of the asset management program and the associated decisions

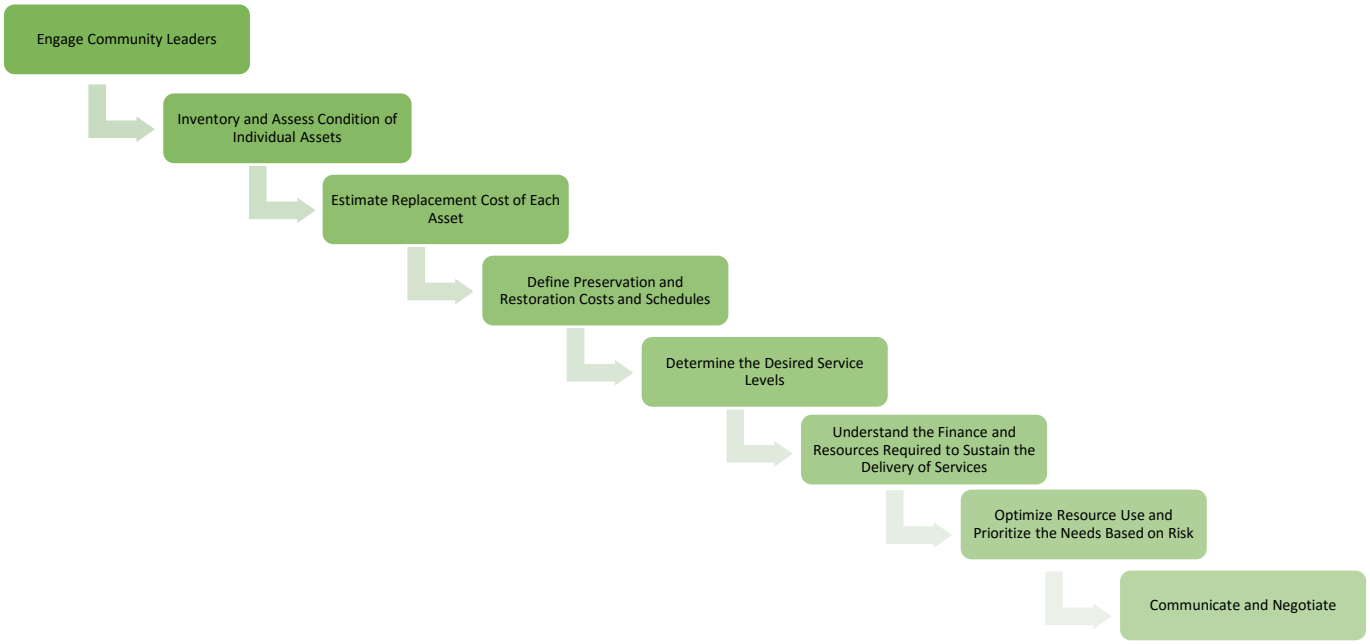
In essence, the City wanted to gain better understanding of the current and future asset needs, asset risk profile, appropriate levels of service, cost to provide services, and financial requirements to sustain the delivery of services. The City then wanted to communicate this improved understanding of the infrastructure status to the public and the decision makers.

Key objectives of the City's AM Program were to identify answers to the following questions for each asset management system:

- *Catch Up* – What levels of work, resources, and budget are required to bring the asset to the required conditional state to meet the safety, regulatory, and level of service requirements?
- *Keep Up* – Once the asset is caught up, what levels of work, resources, and budget are required to keep up the level of service?
- *Moving Forward* – What levels of work, resources, and budget are required to sustain the level of service?

1.2 Asset Management Program Methodology

The following diagram illustrates the methodology the City implemented to develop the AM Program.



In order to promote education, communication, and transparency, the City established two committees: the Asset Management Program Advisory Committee (AMPAC) and the Asset Management Program Technical Advisory Committee (AMPTAC). Members of the AMPAC are residents, business owners, community leaders, and stakeholders. AMPAC visited various asset management systems and observed and discussed the issues associated

with each asset management system. AMPAC oversaw the City's overall AM Program methodology and helped to guide and reach consensus.

AMPTAC is a technical committee formed within AMPAC to further engage the public in the understanding and review of the asset management methodologies and logic used to define the preservation and restoration costs and schedules.

A comprehensive inventory of assets took place for each asset management system. Where accessible, assets were visited and their conditions were assessed. Based on the condition, actions required to restore the asset were identified, and the cost and timing were estimated. Through assessment of risk (probability and consequence of failures), activities were prioritized and communicated regarding urgency and the financial and resource requirements.

1.3 Asset Management Definition

The City defined asset management as

"Delivering an established level of service while managing individual assets to minimize the life-cycle cost within the ambits of an acceptable level of risk."

The City's asset management definition formed the fundamental basis of the City's AM Program.

1.4 Asset Management Plan

An asset management plan is a long-range planning document that provides a framework for understanding the assets an organization owns, services it provides, risks it assumes, and financial investments it requires. An asset management plan can help an organization move from reactive to proactive management of its physical and financial resources. This transition requires answers to the following questions:

- What is an asset? What is not an asset?
- Which assets need to be managed?
- What are the conditions of the assets?
- What maintenance and capital work are required? When and how much?
- How long until the assets need to be renewed?
- Which assets are critical?
- What levels of service must be provided?
- Are the current maintenance practices sufficient to sustain the service level?
- How should the assets be managed to provide services in the most efficient way?
- How can the asset data and maintenance system be updated to better facilitate maintenance practices?
- How much funding is necessary to sustain the delivery of services?
- Are there adequate resources to provide the services?

The answers to these questions help in the development of an asset management plan. An asset management plan is meant to grow and change with both the organization and the system for which it is written. In the spirit of continuous improvement, recommendations for future improvement activities were also developed and presented.

2 Asset Register

The asset register is the key component to developing an asset management plan. It establishes the data foundation of the asset management plan by consolidating all data pertaining to the assets in the asset management system.

The initial step in developing an asset register was to consolidate all previously existing asset data in the City's various information systems (e.g., GIS, Lucity, Excel spreadsheets) into the asset register, creating a centralized database. Once the data was gathered, a data gap analysis was performed to determine which assets or asset attributes (e.g., size, material) were missing from the register. This data gap analysis built a foundation for the data collection and reconciliation part of the project. Each asset that was safely accessible was visited and assessed for condition and missing attributes.

The development of the asset register required establishing the following key components:

- **Asset Definition** – Helps to define "what is an asset" versus "what is not an asset". With the asset definition established, the City is able to separate assets from components and filter assets depending on how they should be managed.
- **Asset Hierarchy** - Organizes the thousands of assets in the asset register. With the asset hierarchy, the City is able to easily find and support asset management decisions at any level within the asset hierarchy.
- **Asset Classes** – Groups the assets to allow the City to characterize the life-cycle behavior of the assets in the register. An asset class is developed by grouping assets with similar characteristics – such as type, function, useful life, material, and size – together. Asset classes are used to help model the life-cycle costs of the assets.

2.1 Asset Definition

An Urban Forestry Asset Management System asset is defined as an asset that is owned and managed by the City with a value that requires the asset to be capitalized. In the case of urban forestry, each tree was considered an asset. The Urban Forestry Management System comprises many types of trees, including the following:

- Palm
- Eucalyptus
- Pine
- Oak
- California pepper
- Chinese flame

2.2 Asset Hierarchy

The asset hierarchy allows for easy navigation in the asset register. The following figure presents an overview of the asset hierarchy established for the City's Urban Forestry Asset Management System.

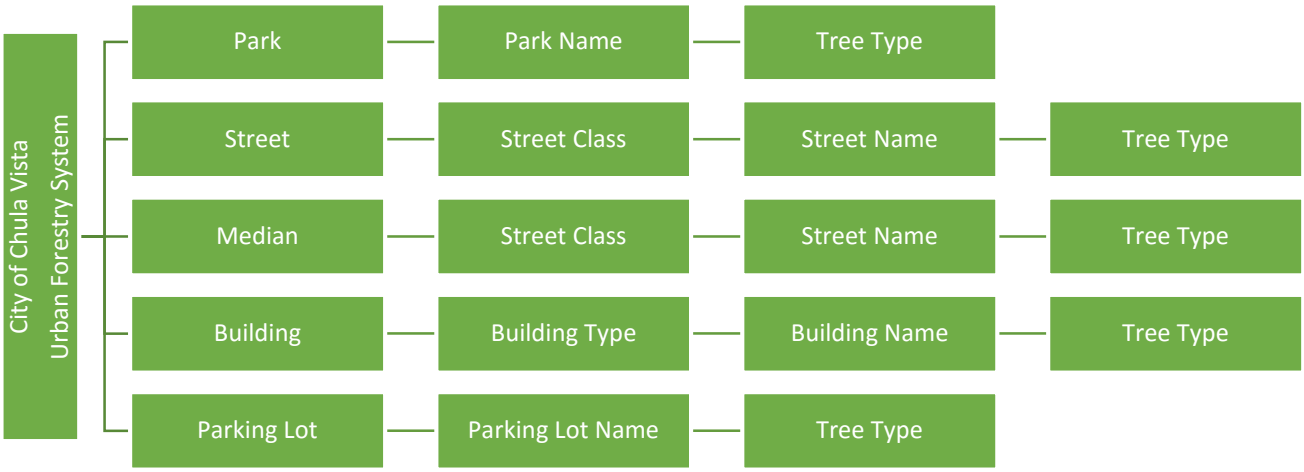


Figure 2-1 Urban Forestry Asset Hierarchy

At the higher levels, the Urban Forestry Management System assets are categorized by their general location (i.e., park, street, road median, building, and parking lot). The next level in the hierarchy gives a more exact description of the specific location, such as the class of the street on which the asset is located (e.g., arterial, collector, residential) or the name of the location (e.g., park name, building name). The last stage of the hierarchy shows the tree type.

2.3 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. Grouping the assets into these classes allows easier modeling of life-cycle behavior.

In the case of the Urban Forestry Management System, the asset classes were defined in terms of each tree's scientific classification. The asset register identifies approximately 265 different asset classes.

2.4 Asset Inventory

Once the asset definition, hierarchy, and classes were set, the City began compiling the asset register. West Coast Arborists, Inc. performed on-site assessments and recorded the related asset attributes (e.g., species, size).

The following tables present a summary of the urban forestry asset inventory. The total number of trees, stumps, and vacant sites inventoried was 33,978. The assets were categorized by location type (i.e., park, street, median, building, parking lot) in the City's GIS.

Table 2-1 Urban Forestry Asset Inventory shows the urban forestry asset inventory by location type. As is shown in the table, 69% of the trees are located along streets. Parks contain the second highest percentage of the total tree count at 24%. The remaining trees are near buildings, in road medians, or in parking lots.

Table 2-1 Urban Forestry Asset Inventory

Location	Quantity	Percent of Total
Park	8,045	24%
Street	23,573	69%
Median	622	2%
Building	1,539	5%
Parking Lot	199	1%

The following table offers an overview of the urban forestry asset inventory broken down by type. This table presents the top asset types and is not a comprehensive list of all tree types. The asset register identifies approximately 270 asset types.

Table 2-2 Urban Forestry Asset Inventory by Type

Type	Quantity
Vacant Site	9,115
California pepper	1,774
Queen palm	1,546
Mexican fan palm	1,308
Chinese flame tree	1,276
Fern pine	1,080
Sugar gum	997
Chinese pistache	767
Evergreen pear	726
Canary Island pine	713
Jacaranda	650
Other	14,026

As is shown in the asset inventory, vacant sites represent the highest number of assets. A vacant site actually refers to a spot in which a tree will be planted in the future; currently, there is no existing tree in any vacant site. In order to plan for the future, these vacant site assets were added as assets that are planned for planting. The City has provided an anticipated schedule of trees to be planted in vacant sites. Life-cycle analyses will begin based on the anticipated planting year of the tree.

The projected planting at these vacant sites was distributed over the next 12 years, as presented in the following table.

Table 2-3 Vacant Site Planting Projection

Year	Number of Vacant Sites to be Filled
2016	328
2017	800
2018	800
2019	800
2020	800
2021	800
2022	800
2023	800
2024	800
2025	800
2026	800
2027	787

The vacant site planting was prioritized based on the following table. In accordance with the priority, park vacant sites will be filled first, while recreation center and library vacant sites will be filled latest.

Table 2-4 Vacant Site Planting Priority

Location	Description	Priority
Parks	Decorative, high traffic, presence of targets*	1
City Streets, Arterial	High traffic, presence of targets*	2
City Streets, Collector	Some traffic, presence of targets*	3
City Streets, Residential	Some traffic, presence of targets*	4
Public Office Buildings (e.g., P.D., Civic Center)	Medium traffic, presence of targets*, functional people spaces	5
Recreation Centers, Library	Low traffic, presence of targets*	6

* *A target is a person or property, located in the vicinity of the asset, which is at risk for injury or damage in the case of the asset's critical failure, which presents a liability to the City.*

Size information for the urban forestry assets was recorded based on specific ranges. For instance, the diameter of each asset was estimated within certain ranges as presented in Table 2-5 below. Approximately one quarter of the total number of inventoried trees had a diameter between 0 and 6 inches. Approximately 23% of the trees had a diameter between 7 and 12 inches. Diameter estimations were not applicable for some assets, such as vacant sites and some stumps.

Table 2-5 Urban Forestry Inventory by Diameter

Diameter Range (in)	Quantity	Percent of Total System
0-6	8,650	25%
07-12	7,711	23%
13-18	4,594	14%
19-24	2,241	7%
25-30	834	2%
> 30	823	2%
N/A (e.g., vacant sites, stumps)	9,125	27%

Height was recorded based on similar ranges as presented in the table below. As is shown in the table, approximately one third of the total inventoried trees were between 1 and 15 feet tall. Approximately 25% of the trees were between 16 and 30 feet tall. Around 27% of the trees did not have a recorded height; these assets are generally vacant sites and stumps.

Table 2-6 Urban Forestry Inventory by Height

Height (ft)	Quantity	Percent of Total System
01-15	10,524	31%
16-30	8,544	25%
31-45	3,024	9%
46-60	1,472	4%
> 60	1,132	3%
N/A (e.g., vacant sites, stumps)	9,282	27%

2.5 Asset Valuation versus Asset Replacement Cost

In a typical asset management plan, the valuation and replacement cost are synonymous. Valuation is represented as summation of replacement cost for all assets. Urban Forestry presents a unique challenge because the value and the replacement cost are not calculated the same way.

A tree fluctuates in value during its lifetime. As the tree grows, it can add value to the surrounding area by providing shade and other benefits. As it ages and begins to die, however, its value decreases. In addition, it is generally impossible to replace an old tree with one that is the exact size of the current tree. It is much more common to

replace a large old tree with a younger, smaller tree simply because this is what a local nursery can provide.

For example, a dead tree presents no value; in fact, it generally presents a liability to the City. This is recorded in data form as a value of $0. The cost to replace the tree, however, is significantly more than $0. Separate valuation and replacement cost methodologies were developed for the Urban Forestry Management System.

2.6 Asset Valuation

The value of each tree was calculated using the following formula:

Value = Basic Tree Cost x Species Rating x Condition Rating x Location Rating

The factors in the value calculations are explained in the following sections.

Basic Tree Cost

The basic tree cost is based on the size of the tree. The basic tree cost was calculated using the following formula:

Basic Tree Cost = Replacement Cost + Base Price x (Adjusted Trunk Area Value – Adjusted Trunk Replacement Value)

Replacement Cost

The replacement cost was based on the average largest transplantable-sized tree that a nursery in the area of the City could provide. The estimated replacement cost in this case is $500.

Base Price

The base price is a preassigned price per square inch.

Adjusted Trunk Area Value

Adjusted Trunk Area value is the area of the trunk cross section based on the measurement of the diameter of the tree trunk at 4.5 feet above the ground, called diameter at standard height (DSH). The diameter for each tree was assigned a range during the inventory process. For estimation purposes, the following values were used for the diameter in this formula. In most cases, the diameter value used was the mean average of the diameter range.

Table 2-7 Diameter Assumptions

Estimated Diameter Range (in)	Diameter Value Used (in)
0-6	3
07-12	9.5
13-18	15.5
19-24	21.5
25-30	27.5
>30	40

Adjusted Trunk Replacement Value

Adjusted Trunk replacement value is the area of the trunk cross section based on the measurement of the diameter at 4.5 feet above the ground, called diameter at standard height (DSH), of the average largest transplantable-sized tree that a nursery can provide in Chula Vista. This average diameter was estimated to be 4 inches.

Species Rating

A rating was assigned to each species in order to differentiate between the general robustness of the plants. The factors that were considered in the development of the species ratings are as follows:

- Hardiness – resistance to cold
- Durability – resistance to damage
- Longevity – length of expected life
- Biotic Tolerance – resistance to damage done by other living organisms

The following table presents a sample of the ratings assigned to each species. For a full list of the species ratings assigned to the Urban Forestry System, please refer to Appendix A.

Table 2-8 Species Rating Sample

Species	Species Rating
Eucalyptus	0.8
Pine	0.9
Pepper	0.5
Queen Palm	0.7
Pear	0.8
Fan Palm	0.7
Sycamore	0.9
Elm	0.8
Magnolia	0.9
Oak	1
Oleander	0.6

Condition Rating

The condition scores assigned to each asset during on-site inspection were factors in the overall valuation of the asset. These condition ratings were translated into a rating on a scale of 0 to 1. More information on the condition assessment can be found in Section 2.8.

Location Rating

A location rating was assigned to each asset based on where it is located.

Table 2-9 Location Rating

Location	Description	Location Rating
Parks	Decorative, high traffic, presence of targets*	1
City Streets, Arterial	High traffic, presence of targets*	0.9
City Streets, Collector	Some traffic, presence of targets*	0.8
City Streets, Residential	Some traffic, presence of targets*	0.7
Public Office Buildings	Medium traffic, presence of targets*, functional people spaces	0.6
Recreation Centers	Low traffic, presence of targets*	0.5
Libraries	Low traffic, presence of targets*	0.5

* *A target is a person or property, located in the vicinity of the asset, which is at risk for injury or damage in the case of the asset's critical failure, which presents a liability to the City.*

Medians and parking lots received a location rating based on the street class on which they were located. For example, trees on medians in arterial streets received a location rating of 0.9. If a recreation center was adjacent to a park, the park location rating was used.

As is shown in the table above, the location rating for each asset is based on a number of factors. Traffic and presence of targets are major factors in assigning location ratings. A target is a person or property, located in the vicinity of the asset, which is at risk for injury or damage in the case of the asset's critical failure. This scenario presents a liability to the City. Assets in parks were assigned a high location rating because of the high number of targets, such as people and automobiles, in those locations.

Vacant Sites and Stumps

The value of vacant sites and stumps was estimated to be $0. Although stumps may add value to their surroundings, such as providing wildlife habitats in parks, their value has not been quantified at the time of this report.

Overall Valuation

The overall valuation of the Urban Forestry Management System is determined by aggregating the asset-by-asset values. The total valuation for the Urban Forestry Management System is approximately $138 million. The figure below presents the valuation broken down by location type.

As is shown in Urban Forestry Asset Value figure, street trees have the highest value at $67.5 million. Park trees have the next highest value at just under $61 million. Building trees are valued at approximately $5 million. Median trees have an approximate value of $3 million, while parking lot trees are valued at just under $1 million.

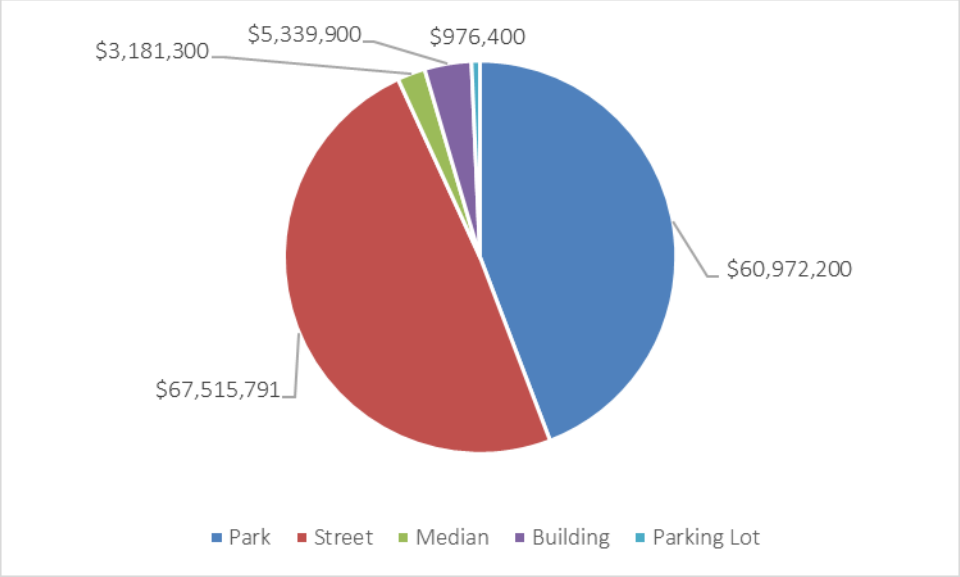


Figure 2-2 Urban Forestry Asset Value

2.7 Asset Replacement Cost

As mentioned in Section 2.6, the replacement cost was based on the average largest transplantable-sized tree that a nursery in the area of the City could provide. This cost could include dead tree removal or stump removal and the labor for planting a new tree. Replacement cost is further explained in Section 4.2.

The overall replacement cost of the Urban Forestry Management System is determined by aggregating the asset-by-asset replacement costs. The total replacement cost for the Urban Forestry Management System is approximately $48 million. This number is much lower than the total valuation; this is expected because the value of the current trees is higher than the younger, smaller trees with which they would be replaced.

Figure 2-3 presents the replacement cost for the entire Urban Forestry Management System by location type. As is shown in the figure, street tree replacement makes up the largest portion of the replacement cost at $34 million. Park trees have the next highest replacement cost, at just under $10 million. Median, building, and parking lot tree replacement costs total approximately $3.7 million.

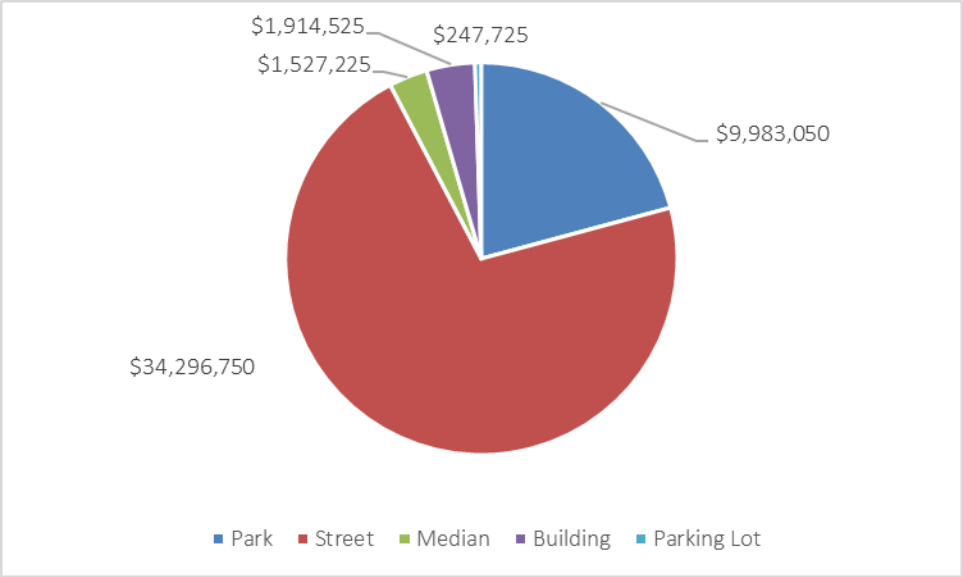


Figure 2-3 Urban Forestry Replacement Cost

2.8 Condition Assessment

Condition is one of the best indicators for estimation of immediate or future restoration work. During the asset inventory field visits, each asset's condition was assessed and recorded. Assets were visually assessed by West Coast Arborists, Inc. Where condition was much worse than expected, it was recommended that the City investigate the cause to prevent further abnormal deterioration of the asset's condition.

The table below describes the methodology used to assess the condition of the trees. Several aspects of each asset were examined during condition assessment. For the tree structure, the [visible] root condition and formation, trunk condition, and branch assembly and arrangement were considered. For the tree health, crown indicators were considered, such as vigor, density, leaf size, quality, and stem shoot extensions. As is shown in the table, a tree in good condition was given a condition rating of 1. The worse the condition, the lower the condition rating, all the way down to 0 for a dead tree. A dead tree is a tree that fails to meet the minimum requirements for a Very Poor rating.

Table 2-10 Condition Rating Matrix

Condition	Tree Structure	Tree Health	Condition Score	Condition Rating (for Value Calculation)
Good	Root plate undisturbed and clear of any obstructions. Root flare has normal development. No visible trunk defects or cavities. Branch spacing/structure and attachments are free of any defects.	Perfect specimen with excellent form and vigor, well-balanced crown. Trunk is sound and solid. No apparent pest problems. Normal to exceeding shoot length on new growth. Leaf size and color normal for the species. Exceptional life expectancy for the species.	1	1
Fair	Root plate appears normal; only minor damage may be found. Possible signs of root dysfunction around trunk flare. Minor trunk defects from previous injury, with good closure; less than 15% of bark section missing. Good branch habit, minor dieback with some signs of previous pruning. Codominant stem formation may be present. Minor corrections required.	Imperfect crown density in few parts of the tree, 10% or less, lacking natural symmetry. Less than half normal growth rate and minor deficiency in leaf development. Few pest issues or damage, controllable. Normal branch and stem development with healthy growth. Typical life expectancy for the species.	2	0.9
Poor	Root plate reveals previous damage or disturbance and dysfunctional roots may be visible around main stem. Evidence of trunk damage or cavities with decay or defects present. More than 15% of bark sections missing on trunk. Codominant stems are present. Branching habit and attachments indicate poor pruning or damage, which requires moderate corrections.	Crown decline and dieback up to 25% of the crown. Overall poor symmetry. Leaf color somewhat chlorotic with smaller leaves. Shoot extensions indicate some stunting and stressed growing conditions. Obvious signs of pest problems. Some decay areas found in main stem and branches. Below average life expectancy.	3	0.75
Very Poor	Root plate disturbance and defects indicate major damage with girdling roots around the trunk flare. Trunk reveals more than 30% of bark section missing. Branches have poor attachments, with several scaffolding branches/lateral limbs dead or broken. Crown reveals signs of severe damage or topping, with major corrective actions required.	Lacking full crown, more than 25% decline and dieback, especially affecting larger branches. Stunting obvious with little evidence of growth on smaller stems. Leaf size and color reveal overall stress in the plant. Insect or disease infestation may be severe. Extensive decay or hollow. Life expectancy is low.	4	0.5
Dead			5	0

Table 2-11 below shows the results of the condition assessment. As is shown in the table, the majority of the assets are in good or fair condition. Although many of the trees are in good condition, the trees in poor condition and the dead trees are important to monitor and manage.

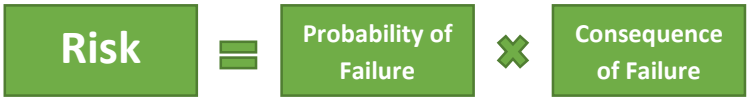
Table 2-11 Condition Assessment Results

Condition	Quantity	Percent of Total
Good	13,643	40%
Fair	8,379	25%
Poor	2,338	7%
Dead	269	1%
Vacant Site/Stump	9,349	28%

3 Risk Analysis

Risk is a key component of asset management. Risk is used for effective prioritization of limited resources. The two main components of risk are Probability of Failure (PoF) and Consequence of Failure (CoF). PoF provides an indication of timing to failure. CoF provides an indication of the impact of a failure.

The following formula is used to calculate risk:



The components of the risk calculation are described in detail in the following sections.

3.1 Probability of Failure

The Probability of Failure score indicates the projected time until the asset fails to function at the established levels of service. The PoF score for each asset was based on the condition rating given to the asset. PoF was calculated on a score of 0 (low probability of failure) to 1 (extremely high probability of failure).

In the case of urban forestry, Probability of Failure is more accurately referred to as Likelihood of Failure. Likelihood of Failure is a term developed to describe the dynamic nature of the living assets in the Urban Forestry Management System.

This condition assessment data translated to the PoF scores for the urban forestry system assets. Figure 3-1 Map of Probability of Failure shows a map of the urban forestry assets by PoF level.

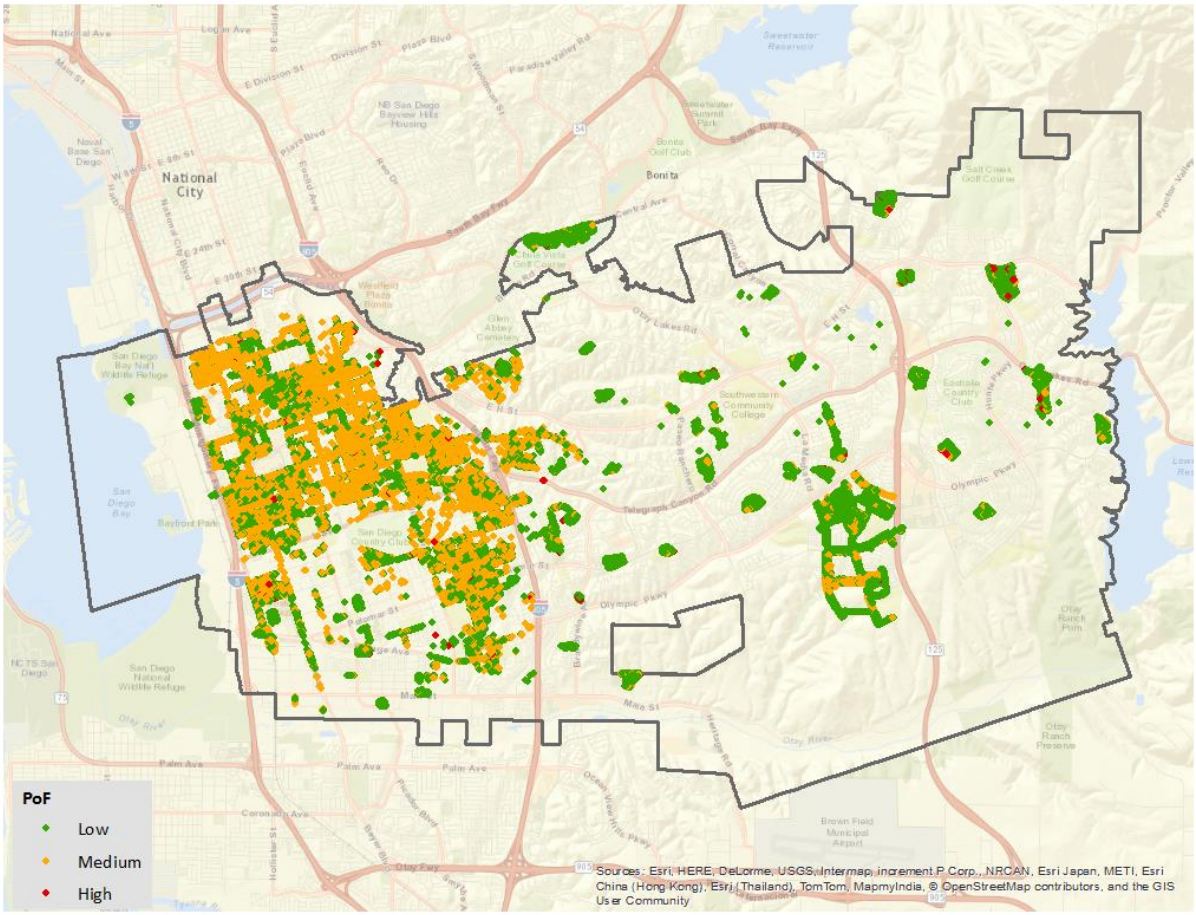


Figure 3-1 Map of Probability of Failure

As is shown in the map, many of the trees with medium to high probability of failure are located on the west side of the City. This is expected, as the west side is the older area of the City, and the trees there are expected to be older. The east side of the City shows a higher number of trees with low PoF scores, which is as expected because they have been planted more recently.

3.2 Consequence of Failure

CoF is a numerical measurement of the criticality of the asset, that is, the possible consequence of the failure of an urban forest asset (i.e., tree or tree part). The impact of failure was assessed with respect to the triple bottom line factors of sustainability: economic, social, and environmental.

In the Urban Forestry Management System, CoF can be seen as a measurement of the consequences of a tree either falling or breaking in such a way that would cause injury to persons, damage to property, or disruption of activities. The impact of a failure in the City's urban forest can be catastrophic; a falling tree branch could cause property damage, major injury, or even death, and may result in a lawsuit against the City.

The CoF logic presented in Table 3-1 determines the probable consequence of failure for each asset based on location.

Table 3-1 Condition Rating Score Logic

Location	Description	CoF
Parks	Decorative, high traffic, constant occupancy, presence of targets*	5
City Streets, Arterial	High traffic, frequent occupancy, presence of targets*	4
City Streets, Collector	Some traffic, frequent occupancy, presence of targets*	3
City Streets, Residential	Some traffic, presence of targets*	2
Public Office Buildings	Medium traffic, presence of targets*, functional people spaces	2
Recreation Centers	Low traffic, presence of targets*	1
Libraries	Low traffic, presence of targets*	1

* *A target is a person or property, located in the vicinity of the asset, which is at risk for injury or damage in the case of the asset's critical failure, which presents a liability to the City.*

As is shown in the table above, the CoF for each asset is based on a number of factors. The presence of targets and visibility of failures are major factors in assigning CoF scores. A target is a person or property, located in the vicinity of the asset, which is at risk for injury or damage in the case of the asset's critical failure, which presents a liability to the City. Assets in parks were assigned a high CoF because of the high number of targets, such as people and automobiles, in those locations.

High traffic areas received a higher criticality rating because of their constant occupancy and the possibility of a significant to severe consequence of a tree failure in those areas.

The following map summarizes the CoF findings for the Urban Forestry System.

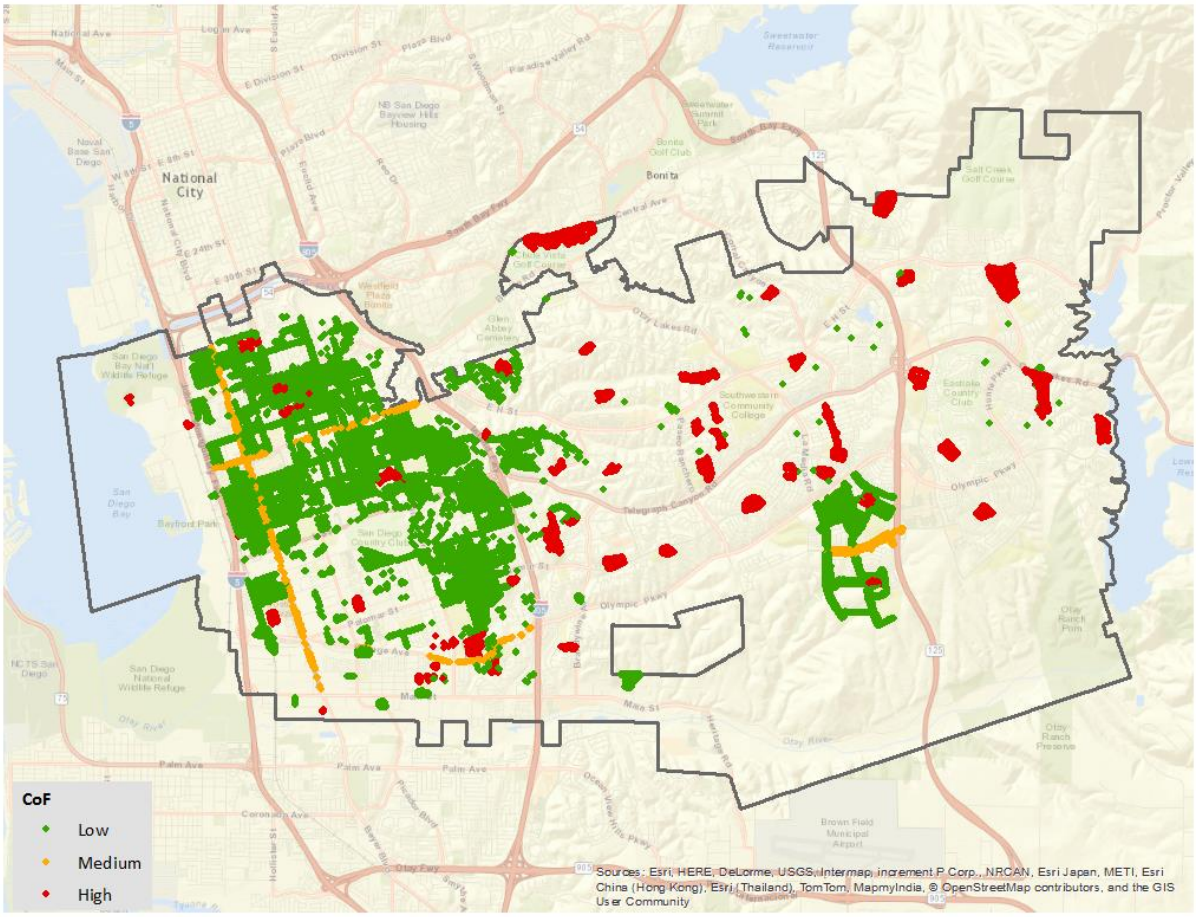


Figure 3-2 Map of Consequence of Failure

As is shown in the map above, high CoF trees appear more frequently on the east side of the City. This is because many of the trees that have been inventoried on the east side of the City are located in city parks and thus were assigned a high CoF score. Although some trees on the west side of the City are in medium to high traffic areas, many of the trees on the west side of the City are in areas with lower presence of targets and lower traffic, which resulted in low CoF ratings.

3.3 Risk

The following figure shows the resulting risk profile for the Urban Forestry System. This profile incorporates both the PoF and CoF scores to prioritize the assets.

Figure 3-3 shows the risk matrix for the Urban Forestry System. This matrix gives a visual representation of the risk the assets pose. The risk is color-coded depending on the CoF and PoF scores. Each section of the risk matrix presents the replacement cost and number of assets in that risk range. The City has been most concerned about the assets in the red zone (i.e., Catch Up). These assets have the highest probability and impact of failure. The assets in the red zone also include the backlog work (i.e., activities from previous years that has yet to take place). The total replacement cost for the red zone assets is approximately $550,000.

Figure 3-3 Urban Forestry Risk Matrix

The figure below shows a map representing the risk levels of the trees.

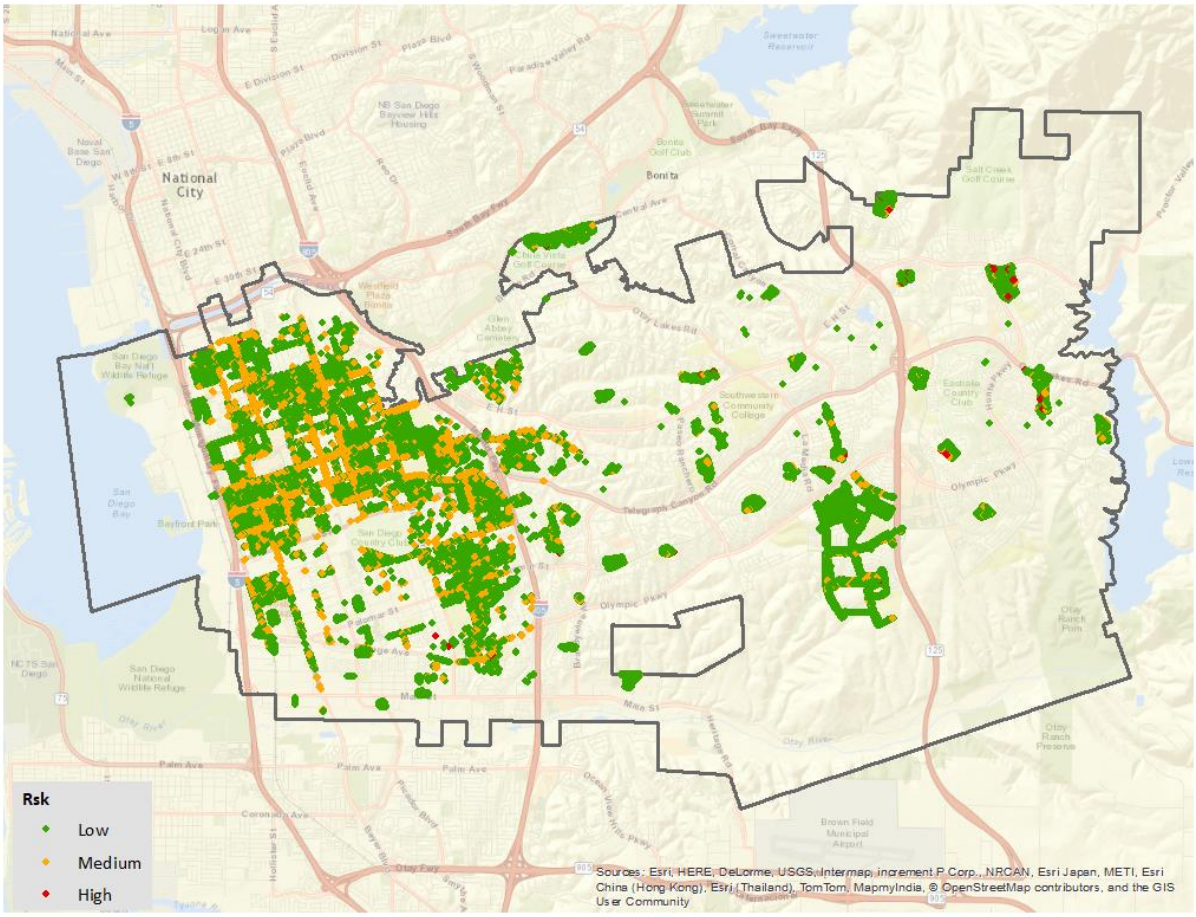


Figure 3-4 Map of Risk

Within the red zone, assets with a risk score of 4 or higher were considered high risk assets. These assets are presented in the table below. Nearly all of these assets are dead or dying trees in high CoF areas.

Table 3-2 High Risk Asset Replacement Cost

Asset Type	Replacement Cost
Broadleaf Tree	$ 1,250
Broadleaf Tree in Park	$ 123,750
Broadleaf Tree along Street	$ 6,250
Eucalyptus, Medium in Park	$ 1,250
Eucalyptus, Small in Park	$ 25,000
Stump	$ 6,825
Stump in Park	$ 48,300
Grand Total	**$ 212,625**

4 Future Needs

4.1 Immediate Needs

The City determined that the activity that needed immediate action was the removal of dead and dying trees. These assets posed a liability to the City. The removal of these assets was scheduled to take place in 2015.

There were approximately 275 dead trees inventoried during condition assessment. These represented around 1% of the total urban forestry inventory. The removal of these trees was estimated to cost around $200,000.

The map below shows the locations of the trees identified for removal. Specifically, these trees marked for removal include dead, diseased, declining, or poorly structured trees. These trees present a serious potential safety hazard.

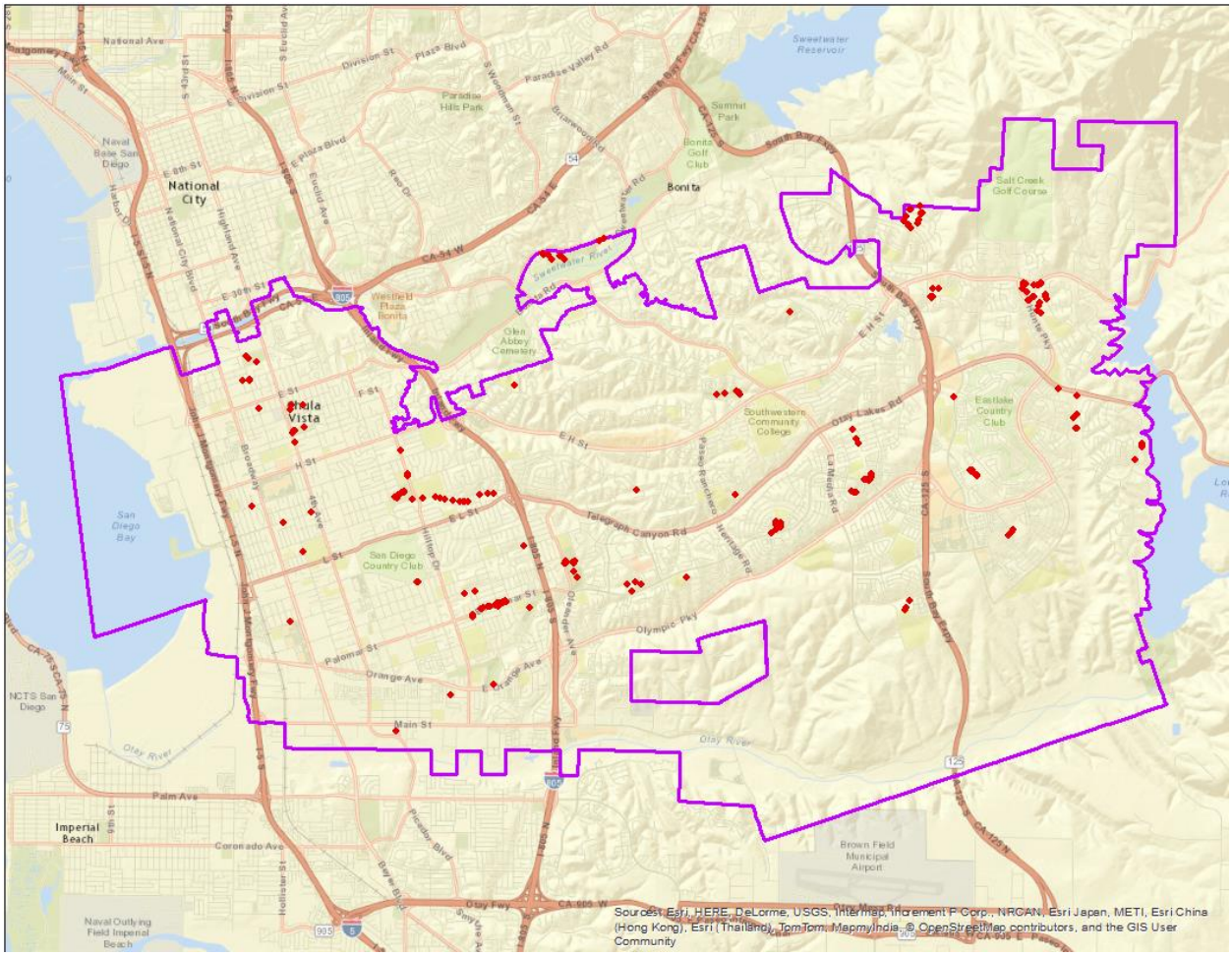


Figure 4-1 Urban Forestry Immediate Needs Map

Once the trees in the poorest condition were identified, the trees that present the highest risk were prioritized. Trees located in parks have the highest risk, so the dead and dying trees in parks were given the highest priority for removal. The following figure presents the high-risk immediate-needs assets, with the park boundaries marked in green. The total cost of removing the high-risk dead trees is approximately $88,200 at approximately $700 per tree.

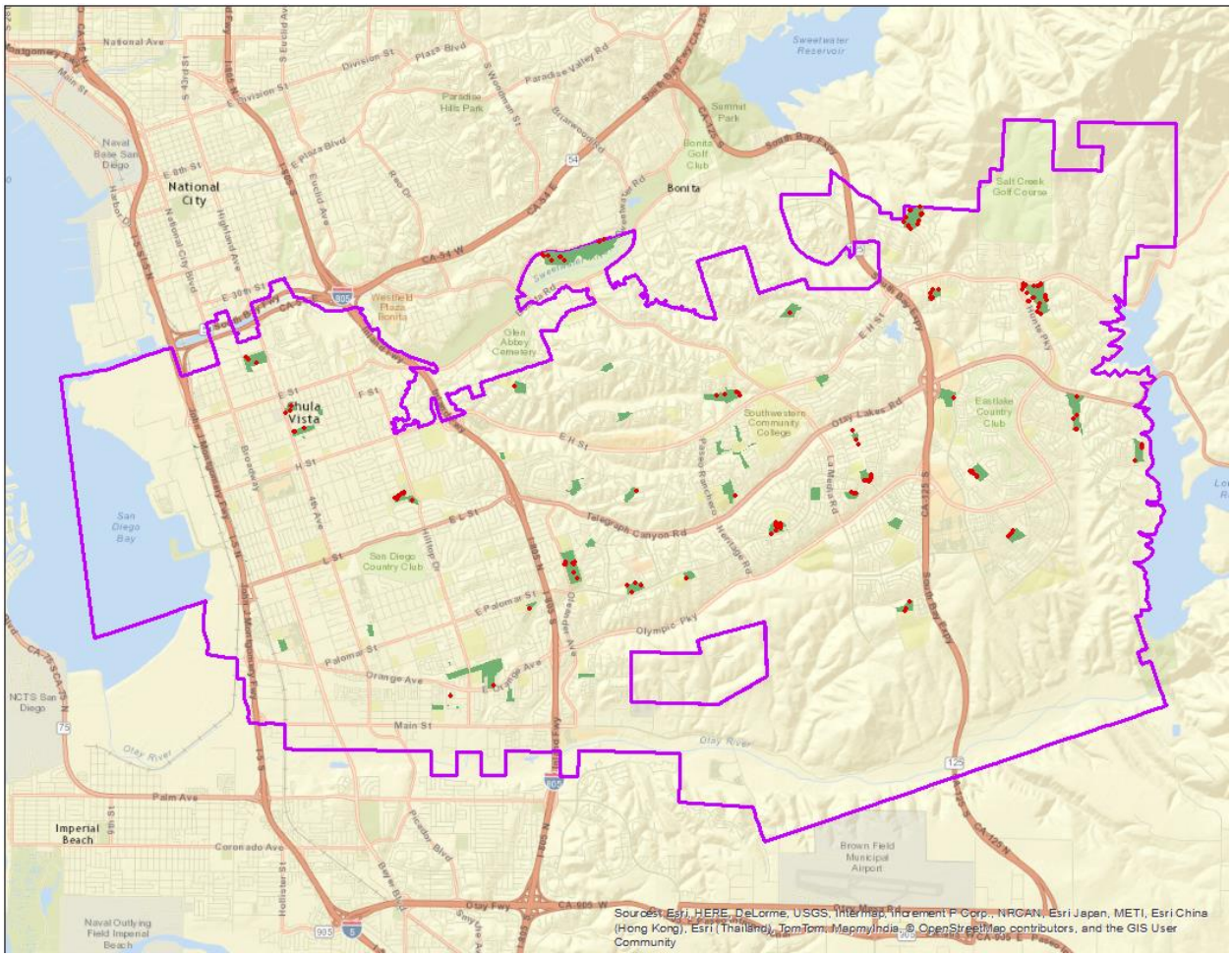


Figure 4-2 Urban Forestry System High Risk Immediate Needs

As mentioned before, the removal of dead trees is critical. The failure of an asset in the Urban Forestry System poses a large risk to the City. A liability lawsuit for an injury caused by a fallen tree could cost the City millions of dollars.

4.2 Life-cycle Cost Logic

The life-cycle cost logic is a set of activities that are needed to maintain the assets (e.g., inspection & maintenance, rehabilitation, replacement) and their associated costs. The life-cycle cost logic drives the estimation of the future financial needs of the assets.

The table below shows the replacement cost logic for the trees in the Urban Forestry Management System. Trees in parks are estimated to need replacement every 125 years at a cost of $1,250. This cost includes removal, tree purchase cost, and labor. Replacement of trees along major streets such as arterials and collectors are estimated to need replacement every 50 years at a cost of $3,125. Replacement of trees along streets cost approximately 2.5 times more than other locations due to the need for traffic control for the safe removal and replacement of a tree in this location. Trees in all other locations (e.g., buildings, residential streets, parking lots) are estimated to need replacement every 50 years at a cost of $1,250.

Table 4-1 Replacement Cost Logic

Tree Location	Activity	Frequency (Years)	Cost
Tree in Park	Replacement	125	$ 1,250
Tree along Arterial or Collector Street	Replacement	50	$ 3,125
Tree in Other Location	Replacement	50	$ 1,250

Vacant sites and stumps also have replacement activities, but unlike other asset type replacements, these assets are not replaced in kind. A vacant site “replacement” refers to the planting of a new tree. A stump “replacement” refers to the removal of a stump and the planting of a new tree. The planting activity costs are outlined in the table below. Once the new tree is planted, the replacement cost logic in Table 4-1 is applied.

Table 4-2 Vacant Site and Stump Cost Logic

Tree Location	Activity	Cost
Vacant Site in Park	Plant New Tree	$ 975
Vacant Site in Other Location	Plant New Tree	$ 700
Stump in Park	Removal & Plant New Tree	$ 875
Stump in Other Location	Removal & Plant New Tree	$ 500

The major maintenance need for the trees in the Urban Forestry Management System is trimming. The table below outlines the frequency and cost for tree trimming based on general tree types.

Table 4-3 Urban Forestry Maintenance Cost Logic

Tree Type and Location	Activity	Frequency (Years)	Cost per Tree
Broadleaf Tree	Trimming	3	$ 84
Eucalyptus, Small	Trimming	3	$ 65
Eucalyptus, Medium	Trimming	3	$ 168
Eucalyptus, Large	Trimming	3	$ 245
Eucalyptus, Mature	Trimming	3	$ 386
Palm, Dates	Trimming	2	$ 180
Palm, Fan	Trimming	1	$ 37
Palm, Queen	Trimming	1	$ 24
Pine	Trimming	3	$ 180

As is shown in the table above, the trimming costs for eucalyptus trees varies based on the size of the tree. The table below shows the estimated size ranges, which is based on the diameter of the tree. The table shows the recommended tree diameter range. The tree size used in the life-cycle cost logic, however, was based on the diameter ranges assigned during inventory.

Table 4-4 Eucalyptus Size Logic

Eucalyptus Size	Recommended Diameter	Diameter Range Used in Calculation
Small	0-12 in	0-12 in
Medium	12-24 in	12-24 in
Large	25-36 in	25-30 in
Mature	>36 in	> 30 in

As shown in the table below, future trimming cost needs for vacant sites and stumps after a tree is planted there was estimated based on the Broadleaf Tree trimming costs (i.e., $84 every 3 years).

Table 4-5 Vacant Site and Stump Maintenance Cost Logic

Asset Type	Activity After Planting	Frequency (Years)	Cost per Tree
Stump	Trimming	3	$ 84
Vacant Site	Trimming	3	$ 84

In addition to the maintenance needs, an annual inspection will take place to assess the condition of the trees. Due

to the backlog of inspection work, the annual inspection will cost approximately $75,000 per year for the first three years. The annual inspection will cost approximately $25,000 per year thereafter.

4.3 Preservation and Restoration Profile

The preservation and restoration profile estimates the future financial needs for managing the urban forestry assets by applying the life-cycle cost logic. The life-cycle cost of each asset was calculated for a 100-year planning horizon. Every year, those assets requiring investment are identified and summed to generate the preservation and restoration profile.

The life-cycle cost assessment allows the City to proactively manage the assets. The City will be able to plan for replacement of high-risk assets to prevent failure. The City will also have an understanding of the work and investment required for future years. These estimations will be used to prepare the budget and resources required to sustain the delivery of services. When budget and resource limitations exist, the City will be able to prioritize the needs by risk to ensure the budget is first spent on high-risk assets. In essence, the City will be able to ensure that minimum funds are spent to maximize risk reduction.

A projection of the Urban Forestry Management System's financial needs for the next 100 years is presented below. A long planning horizon was used in order to capture the life cycles of the assets. As trees can have very long lives, a 100-year outlook gives an indication as to when these assets may finally need to be replaced.

As shown in the 100-year outlook in Figure 4-3, there are peaks in cost in the years 2041, 2066, and 2091. These spikes in cost represent bigger planting years in which more trees need to be replaced. Knowing when these rises in annual budget needs occur allows the City to prepare and manage its urban forest assets proactively. The approximately three-year pattern of rise in cost is due to the fact that many of the trees need trimming every three years.

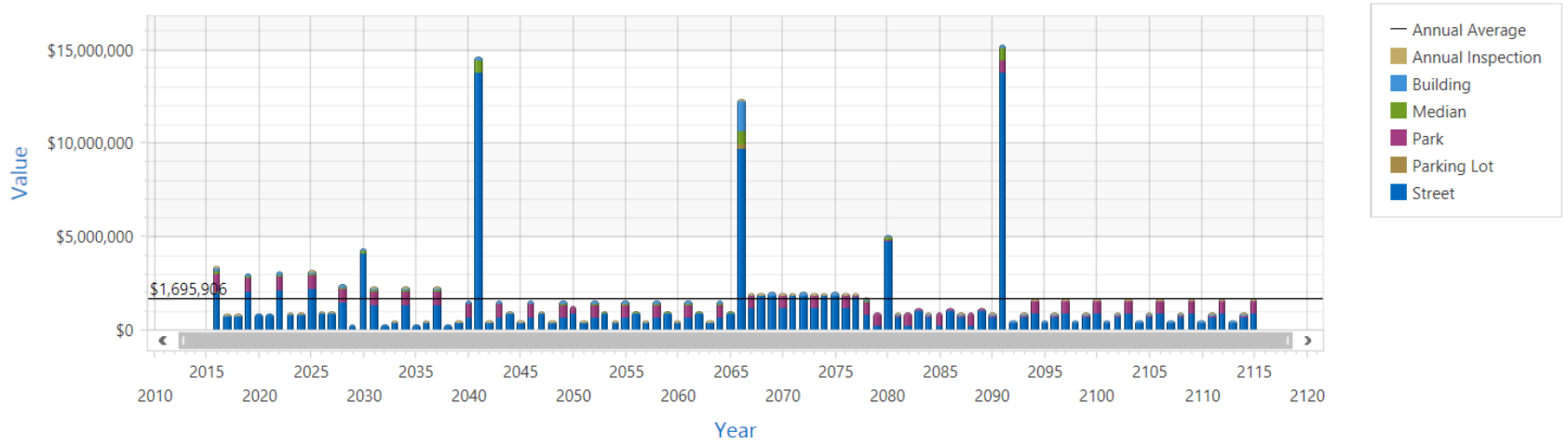


Figure 4-3 Preservation and Restoration Profile

Figure 4-4 shows the preservation profile for the Urban Forestry Management System. These costs include the annual inspection cost as well as the trimming that is required to take place each year. The average annual preservation need is approximately $1 million.

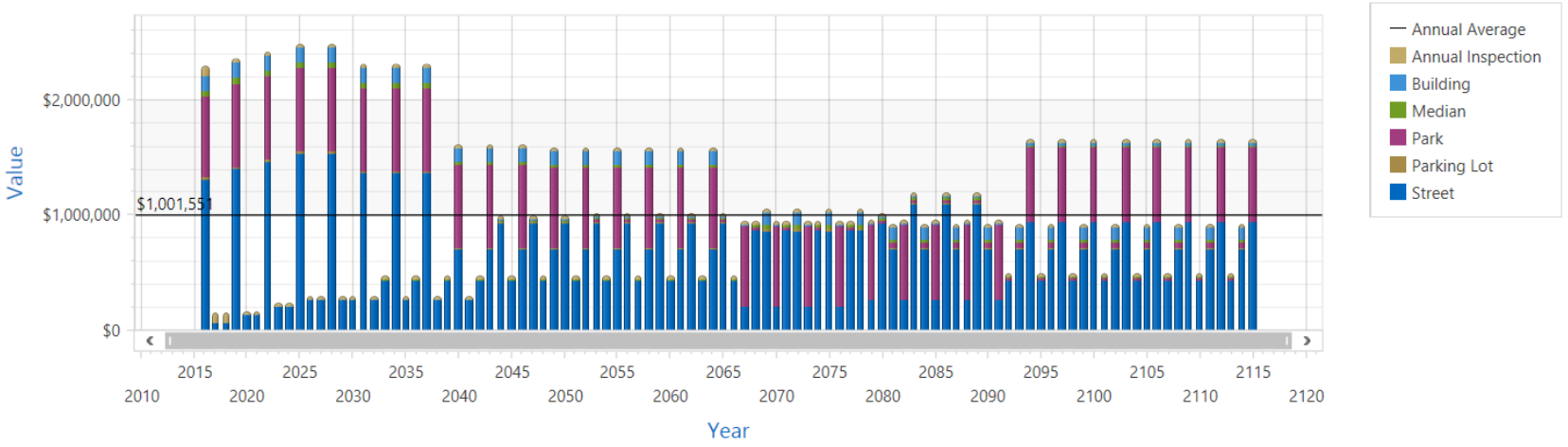


Figure 4-4 Preservation Profile

Figures 4-5, 4-6, and 4-7 show the preservation and restoration profiles over shorter planning horizons (i.e., 10 years, 20 years, 30 years). The planning horizon gives a more practical indication of the financial needs of the assets in the near future.

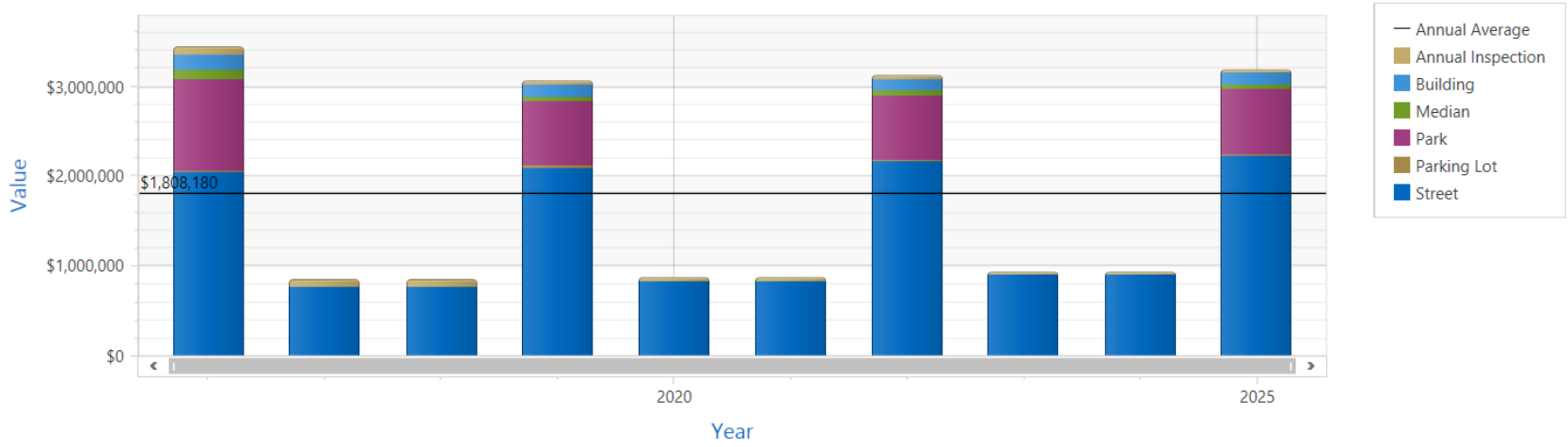


Figure 4-5 10-Year Preservation and Restoration Profile

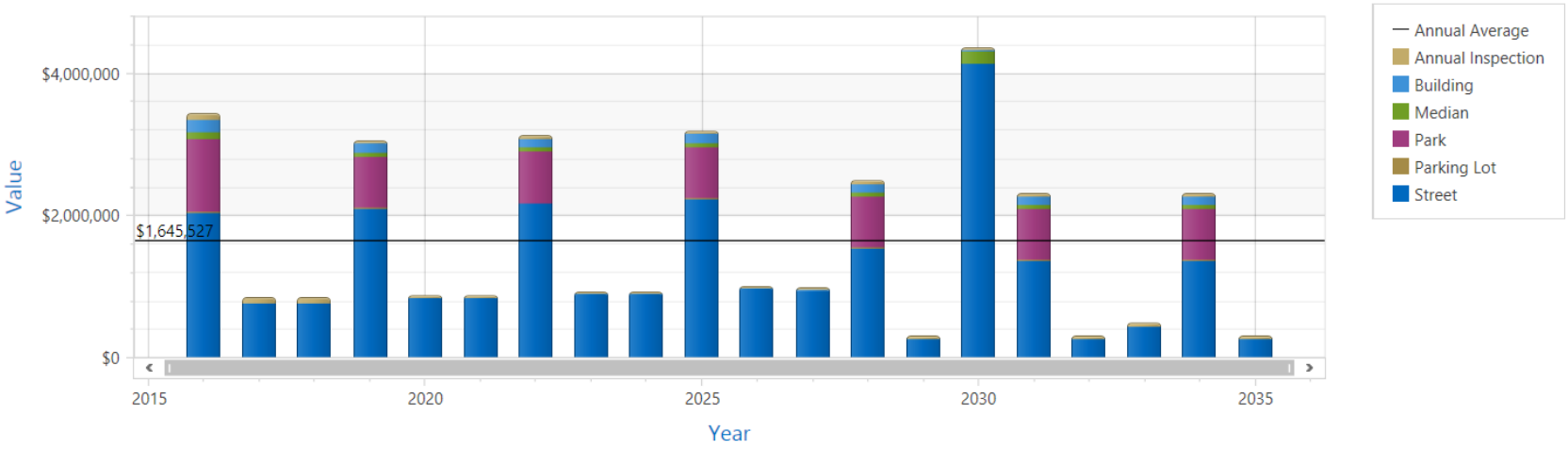


Figure 4-6 20-Year Preservation and Restoration Profile

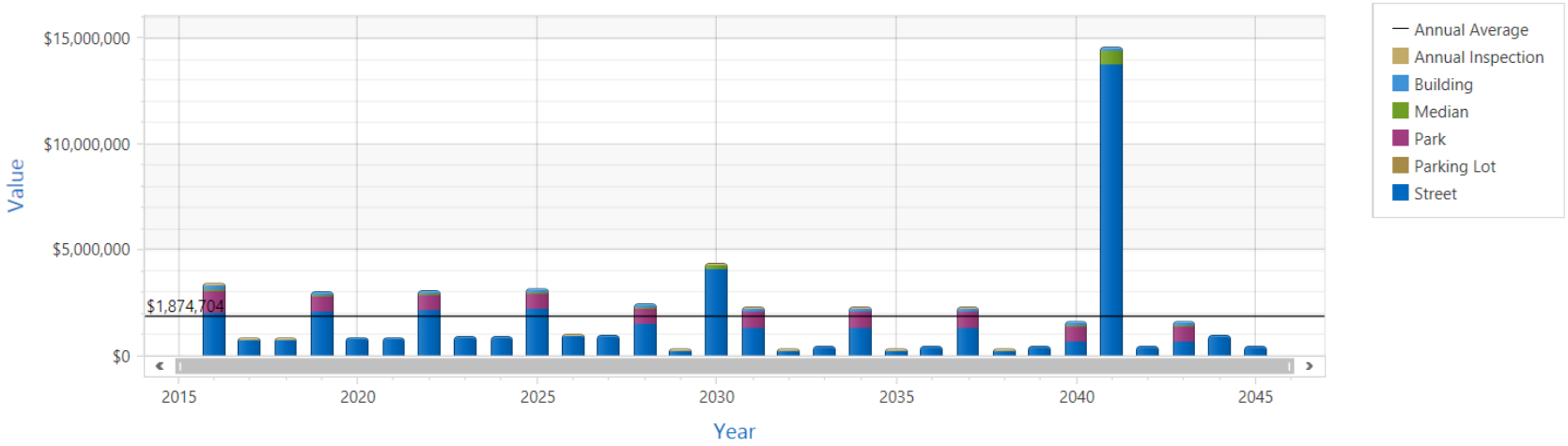


Figure 4-7 30-Year Preservation and Restoration Profile

The following table shows a summary of the average annual preservation and restoration needs of the Urban Forestry Management System.

Table 4-3 Average Annual Preservation and Restoration Needs

Planning Horizon	Average Annual Preservation and Restoration Needs
10 years	$ 1.8 million
20 years	$ 1.6 million
30 years	$ 1.9 million
100 years	$ 1.7 million

5 Confidence Level

Once the asset management plan has been established, it is important to examine the work that has been done in order to identify future improvement opportunities. In this section, the asset management system is rated on the confidence level of the data and methodology developed throughout the project.

The confidence level is rated based on the following factors:

1. Asset Inventory – examines the completeness of the asset data
2. Data Quality – examines the quality and completeness of the asset attribute data used to develop the asset management plan
3. Condition Assessment – examines the quality and completeness of the condition assessment data
4. Asset Valuation – examines the accuracy of the methodology used to calculate asset value
5. Life-cycle Cost Logic – examines the accuracy and completeness of the methodology used to calculate the life-cycle cost and the results
6. Risk – examines the accuracy of the risk assessment methodology and results
7. Staff Review – examines the staff involvement in the development and review of the asset management plan
8. Technical Committee Review – represents the review by the asset management program technical advisory committee

The following table presents the confidence level factors and their respective weights used to calculate the confidence level.

Table 5-1 Confidence Level Logic

Confidence Level Factor	Weight
Asset Inventory	20%
Data Quality	15%
Condition Assessment	20%
Asset Valuation	10%
Life-cycle Cost Logic	10%
Risk	10%
Staff Review	5%
Technical Committee Review	10%

The confidence level factor weights are based on the City's specific goals for the project. Completing the asset inventory and condition assessment were of particular interest to the City in this phase of the development of the asset management program. As such, these areas had a high weight in the overall confidence level rating. Another of the City's main goals was to encourage buy-in on the part of its and stakeholders, so the technical committee review was given a significant weight.

The confidence level ratings for the Urban Forestry Management System are shown in the table below. The City's Urban Forestry Management System has a confidence level rating of 67%. As stated before, the existing data and the developed methodologies are sound; it is the missing asset data that provides the greatest room for improvement. Explanations for the confidence level rating scores for each factor are provided below the table.

Table 5-2 Urban Forestry Confidence Level

Confidence Level Factor	Confidence Level Rating Score	Weighting Factor	Weighted Confidence Level Rating Score
Asset Inventory	50%	20%	10%
Data Quality	50%	15%	7.5%
Condition Assessment	50%	20%	10%
Asset Valuation	90%	10%	9%
Life-cycle Cost Logic	80%	10%	8%
Risk	80%	10%	8%
Staff Review	90%	5%	4.5%
Technical Committee Review	100%	10%	10%
Total Score			**67%**

Asset Inventory (Unweighted Score - 50%)

The City has only inventoried a portion of the trees that it owns and manages. The City estimates that it owns approximately 50,000 trees. The total number of trees that have been inventoried currently is 33,978. When the inventory of the trees is more complete, the confidence level in the asset inventory data will rise.

Data Quality (Unweighted Score - 50%)

The data quality for the data that has been collected has a very high confidence level. However, the City has only inventoried a portion of the trees that it owns and manages. When the inventory of the trees is more complete, the confidence level in the asset inventory data will rise.

Condition Assessment (Unweighted Score - 50%)

The condition assessment confidence level factor measures how well the overall condition assessment results reflect the condition of the entire asset management system. When the inventory of the trees is more complete, the confidence level in the overall condition assessment data will rise.

Asset Valuation (Unweighted Score - 90%)

Extensive efforts were made to ensure the asset value truly reflected the value versus the replacement cost of the urban forestry assets. A very robust methodology was developed to calculate the value of each asset. In addition, the replacement costs estimates were based on recent records, so confidence in the valuation estimates is high.

Life-cycle Cost Logic (Unweighted Score - 80%)

The life-cycle cost logic was driven by extensive knowledge from City staff as well as recent cost history from the City's maintenance contractor. Therefore, confidence in the life-cycle cost logic is high.

Risk (Unweighted Score - 80%)

Condition assessment was performed during this phase with a very high confidence in its accuracy, which translated into the PoF scores. A robust CoF calculation methodology was also developed with input from City staff. As such, the resulting risk scores have a high confidence level. As the asset inventory becomes more complete, the risk level confidence score will rise.

Staff Review (Unweighted Score - 90%)

City staff were highly involved in the development of the urban forestry asset management program, which led to a high confidence level rating.

Technical Committee Review (Unweighted Score - 100%)

The technical committee reviewed and approved the results of this asset management plan and its analysis.

5.1 Next Steps

The asset management plan is meant to be a living document. As more accurate and updated information becomes available, the City will update the asset management plan as part of the continuous improvement process. The following sections present the next steps in the journey to a more robust asset management program.

Asset Inventory, Data Quality, and Condition Assessment

Moving forward, the City will continue to inventory and assess the condition of the trees around its parks, streets, medians, parking lots, and buildings. The inventory will focus on the east side of the City where the largest data gaps in inventory exist.

It is important to note that the City will develop a separate system dedicated to the management of its open space. The trees in the City's open spaces will be included under the Open Space Management System, not its Urban Forestry Management System.

Level of Service and Resources

Levels of service are specific activities developed to meet the City's objectives, and they include specific performance metrics to allow the City to measure how well they are achieving the target performance. Defined levels of service can be used to track performance of the City's activities and identify areas where activities are not in alignment with the mission or goals of the organization. These levels also help to determine the levels of resources needed for the management of the system. Part of the next steps for the Urban Forestry Management System will be to establish levels of service.

6 Appendix A – Species Rating

Species	Species Rating	Species	Species Rating
Eucalyptus	0.8	Strelitzia	0.8
Pine	0.9	Arborvitae	0.8
Pepper	0.5	Wattle	0.7
Queen Palm	0.7	Silk-floss	0.7
Pear	0.8	Locust	0.8
Fan Palm	0.7	Tallow	0.8
Flame	0.8	Strawberry	0.8
Jacaranda	0.7	Buckeye	0.7
Bottlebrush	0.8	Maidenhair	0.8
Palm	0.8	Cherry	0.8
Box	0.9	Honeymyrtle	0.7
Sycamore	0.9	Hibiscus	0.9
Sweetgum	0.7	Melaleuca	0.7
Elm	0.8	Juniper	0.7
Myrtle	0.8	She-oak	0.9
Orchid	0.8	Dead	0
Ash	0.9	Gum	0.9
Magnolia	0.9	Bay	0.9
Pistache	0.9	Cedar	0.9
Camphor	0.8	Orange	0.7
Olive	0.9	Butterfly	0.8
Oak	1	Chinaberry	0.7
New Zealand Christmas	0.8	Frangipani	0.7
Date palm	1	Pittosporum	0.8
Silk	0.9	Purple	0.8
Plane	0.9	Guava	0.7
Carrotwood	0.7	Photinia	0.8
Bottle	0.8	Unidentified	0
Cajeput	0.5	Xylosma	0.8
Tipu	0.9	Horsetail	0.7
Palm-dates-canary	0.9	Pomegranate	1

Species	Species Rating	Species	Species Rating
Palm-pygmy dates	1	Rubber	1
Stump	0	Dragon	0.9
Sumac	0.7	Empress	0.9
Fig	0.6	Palo verde	0.9
Medallion	0.8	Paperbark	1
Cypress	0.9	Schefflera	0.9
Poplar	0.8	Toyon	1
Plum	0.7	Hackberry	0.8
Cottonwood	0.7	Kaffirboom	0.8
Peppermint	0.9	Mesquite	0.7
Flamegold	0.9	Plume	0.7
Myoporum	0.4	Sweetshade	0.8
Coral	0.7	Berry	0.5
Acacia	0.8	Bush	0.5
Weeping fig	0.6	Cherimoya	0.9
Goldenrain	0.8	Hopseed	1
Pink trumpet	0.9	Lemon	1
Willow	0.8	Other tree	0
Carob	0.8	Papaya	0.9
Redbud	0.9	Peach	0.9
Yucca	0.6	Pecan	0.9
Alder	0.8	Redwood	0.9
Chitalpa	1	Smoke	0.8
Loquat	0.8	Umbrella	0.9
African	0.7	Walnut	0.9
Mulberry	0.7	Almond	0.9
Oleander	0.6	Apple	0.9
Hawthorne	0.7	Apricot	0.9
Privet	0.7	Avocado	0.9
Dracaena	0.7	Bauhinia	1
Elderberry	0.7	Birch	0.9
Euonymus	0.7	Sapote	0.8
Fruit	0.7	Trident	1

Species	Species Rating	Species	Species Rating
Heaven	0.7	Trumpet	0.9
Laurustinus	0.7	Tulip	0.9
Markhamia	0.9	Tupidanthus	1
Pencil	0.9	Wisteria	1
Primorse	0.8	Zelkova	0.9