City of Chula Vista

Drainage Management System

Asset Management Plan

2016

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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, Drainage Management System Asset Management Plan, will focus on the storm drain assets.

The City owns and manages approximately 43 miles of channels, 34 miles of brow ditches, 8 miles of box culverts, 207 miles of storm drain pipes, 40 detention basins, and 10,552 junctions.

An overall map of the drainage assets, excluding junctions, is shown below.

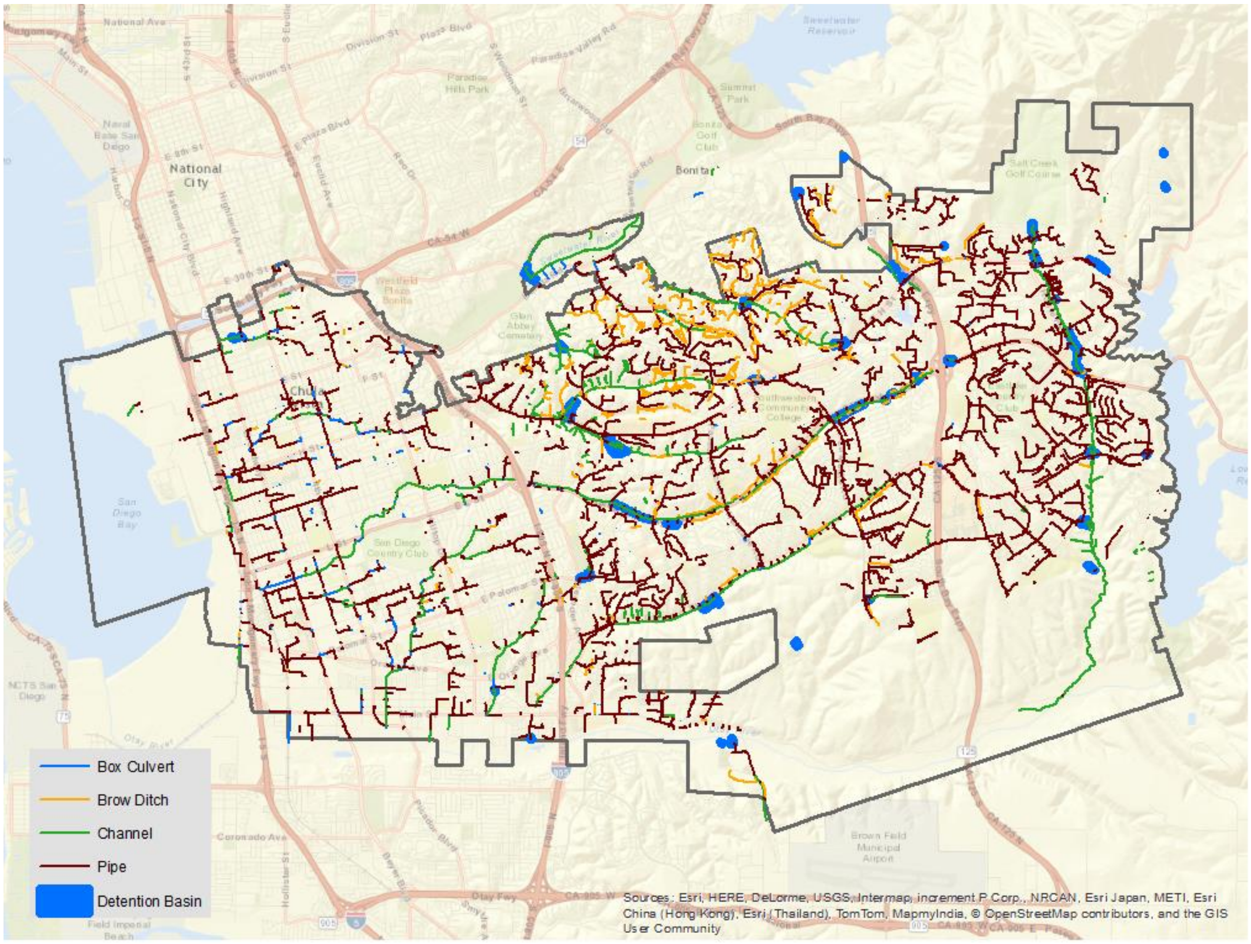


Figure 1-1 Chula Vista Drainage Map

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 replacement and rehabilitation 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 latest technological advances in infrastructure 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, at the right cost
- Be transparent by involving the Council and the Public in the development of the asset management program and the associated decisions

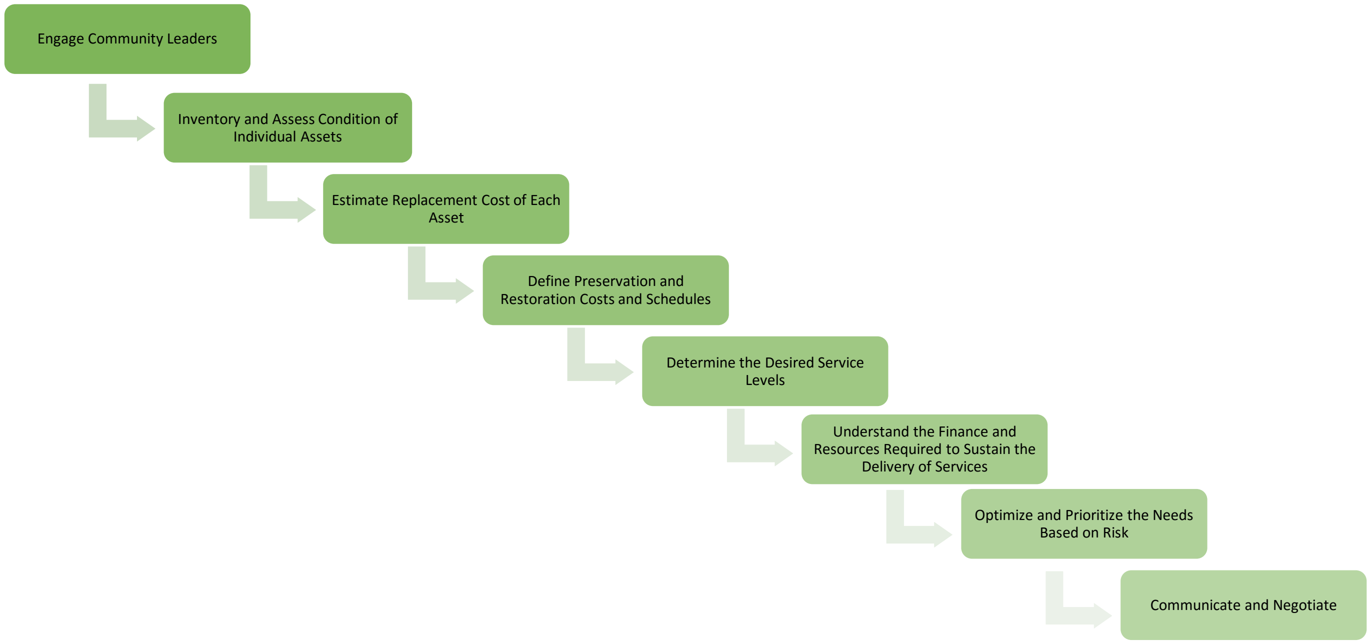
In essence, the City wanted to gain better understanding of the current and future asset needs, asset risk profile, appropriate levels of service, cost to provide services, and financial requirements to sustain the delivery of services. The City then wanted to communicate this improved understanding of the infrastructure status with the public and the decision makers. Together, the City wanted to develop management strategies that deliver the established levels of service while managing individual assets to minimize life-cycle cost with an acceptable level of risk.

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

- *Catch Up* – What levels of work, resources, and budget are required to bring the asset back 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 Advisor 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.

A technical committee was 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 with 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 is 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 the organization and 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 a key component of the 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. For the Drainage Management System, the asset register captured drainage assets that included the following:

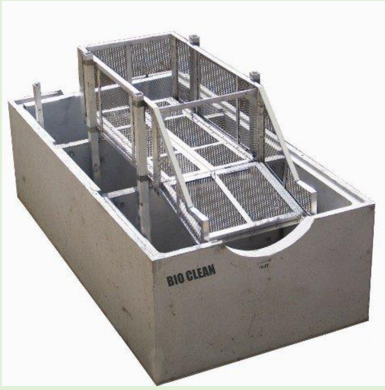
Asset Class	Description	Sample Image
Detention Basin	An area where excess storm water is stored or held temporarily and then slowly drained when water levels in the receiving channel recede	
Outfall	The point at which a channel, pipe, or other asset discharges storm water	
Catch Basin	A curbside drain that collects rainwater and transports it to local waterways through a system of underground piping, culverts, and/or drainage ditches	

Asset Class	Description	Sample Image
Continuous Deflective Separation (CDS)	A structure that is placed on large storm drain lines to capture floatable trash/debris and sediment from a large drainage area	
Cleanout Access Cover	The cap to a pipe which provides access to a sewer line	
Corrugated Metal Pipe (CMP) Riser	A structure made of corrugated metal pipe that regulates water level	
Concrete Riser	A structure made of concrete that regulates water level	

Asset Class	Description	Sample Image
Curb Outlet	A storm drain outlet in a curb	
Drop Inlet	A vertical inlet to a buried culvert or storm drain attached at the upstream end of a horizontal culvert. The drop inlet can be constructed as a filter to prevent debris from entering the culvert and causing it to fail	
Drop Structures	A structure designed to dissipate energy in channels with steep gradients to maintain control of flow.	
Energy Dissipator	A structure designed to protect downstream areas from erosion by reducing the velocity of flow to acceptable limits	

Asset Class	Description	Sample Image
Filtered Drop Inlet	A drop inlet that filters various pollutants	
Filterra	A self-contained storm water treatment system that packages soil media, plants, and drainage infrastructure into a specially designed, pre-fabricated concrete structure	
Grate	A metal structure that prevents trash and debris from entering the drain	
Headwall Inlet/Outlet	A retaining wall with storm water pipe inlets or outlets	

Asset Class	Description	Sample Image
Hi Rate Biofilter	A pollutant removal system	
Gabion	A cage filled with rocks or concrete used for erosion control.	
Inlet	A point of intake for storm water	
Junction	A formed control structure used to join sections of storm drains structures	

Asset Class	Description	Sample Image
Modular Wetland	A structural storm water treatment system that utilizes a multi-stage treatment processes to prevent coarse to fine sediment and hydrocarbons from entering the subsequent wetland chamber	
Nutrient Separating Baffle Box (NSBB)	A structure that captures a variety of pollutants, such as sediment and debris, which prevents nutrient leaching	
Outlet	A point of discharge for storm water	
Plate	A device used to control storm water flow	

Asset Class	Description	Sample Image
Plug	A device used to plug storm drain pipes	
Rip Rap	Rock or other material used to line channels to combat erosion.	
Vortechs	A hydrodynamic separator that traps trash, debris, and hydrocarbons and separates them from the runnoff	

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 a centralized database (i.e., asset register). Once the data was consolidated, a data gap analysis was performed to determine which assets and/or asset attributes were missing from the register. This data gap analysis built a foundation for the data collection part of the project.

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

- **Asset Definition** – Helps to define 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 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 thousands of assets in the register. An asset class is developed by grouping assets with similar characteristics, such as type, function, useful life, material, and size. It is used these asset classes to help model the life-cycle cost of the assets.

2.1 Asset Definition

An asset definition establishes what will be included in the asset register. It defines an asset as opposed to a component. In the case of drainage, assets were defined as those with a significant value (above $5,000) and/or are required to be managed (e.g., replacement, rehabilitation, maintenance, inspection) to meet safety, capacity, and/or regulatory levels of service.

2.2 Asset Inventory

Once the asset definition was established, the City began compiling the asset register. Data was gathered from GIS, which was developed from drawings. Only a portion of these assets have been verified in the field; further verification and assessment on the Drainage Management System assets is in progress. Further detail on field verification can be found in Section 2.7 Condition Assessment.

The table below presents a summary of the drainage asset inventory. The table shows the asset inventory of drainage assets by asset class and asset type or material. As shown in the table, there are over 33 miles of brow ditches. Approximately 90% (31 mi) of all brow ditches were concrete. For channels, there were approximately 9.2 miles of concrete, 8.7 miles of natural channel, and 4 miles of riprap.

Table 2-1 Drainage Asset Inventory

	Asset Type	Length (ft)	Length (mi)	Area (SqFt)	Count
Box Culvert		41,468	7.9		377
Brow Ditch	Concrete	161,202	30.5		553
	Natural	17,975	3.4		54
Channel	Natural	46,046	8.7		98
	Concrete	48,672	9.2		89
	Riprap	21,681	4.1		19
	Gabions				
Detention Basin				2,978,296	40
River		10,071	1.9		10
Secant Wall		700	0.13		1
Stream		98,521	18.7		273

The following table shows the asset inventory for junctions. Most of junctions were drop inlets (3,906; 37%) and cleanout access covers (3,571; 34%).

Table 2-2 Junction Asset Inventory

Asset Type	Count
Outfall	148
Catch Basin	921
Continuous Deflection System (CDS)	25
Cleanout Access Cover	3,571
Corrugated Metal Pipe Riser	18
Concrete Riser	6
Curb Outlet	90
Dissipater	147
Drop Inlet	3,906
Filtered Drop Inlet	348
Filterra	42
Grate	27
Headwall Inlet	226
Headwall Outlet	289
Hi Rate Biofilter	2
Inlet	126
Junction	494
Modular Wetland	10
NSBB	3
Outlet	93
Plate	3
Plug	46
Slotted	8
Vortechs	3

The following table shows the asset inventory for drainage pipes. Over 85% of the drainage pipes were RCP, with a total 176 miles, and 6% of the pipes were CMP, with a total 13 miles.

Table 2-3 Drainage Pipe Asset Inventory

Asset Type	Length (ft)	Length (mi)
Acrylonitrile Butadiene Styrene (ABS)	126	< 0.1
Asbestos Cement Pipe (ACP)	39,862	7.5
Corrugated Aluminum Pipe (CAP)	279	0.1
Cast in Place Concrete Pipe (CIPCP)	12,951	2.5
Cured in Place Pipe (CIPP)	6,710	1.3
Corrugated Metal Pipe (CMP)	60,296	11.4
Corrugated Metal Pipe Arch (CMPA)	271	0.1
Corrugated Metal Pipe B (CMPB)	1,512	0.3
Corrugated Metal Pipe C (CMPC)	728	0.1
Corrugated Metal Pipe L (CMPL)	4,521	0.9
Corrugated Steel Pipe (CSP)	1,658	0.3
High Density Polyethylene (HDPE)	2,121	0.4
Prestressed Concrete Cylinder (PCC)	688	0.1
Polyvinyl Chloride (PVC)	31,139	5.9
Reinforced Concrete Pipe (RCP)	931,334	176.4
Spiral Rib Pipe (SRP)	165	< 0.1
Vitrified Clay (VP)	50	< 0.1

2.3 Asset Hierarchy

An asset hierarchy helps to efficiently and effectively organize thousands of assets in the asset register. Figure 2-1 below presents an overview of the asset hierarchy established for the City's Drainage Management System.

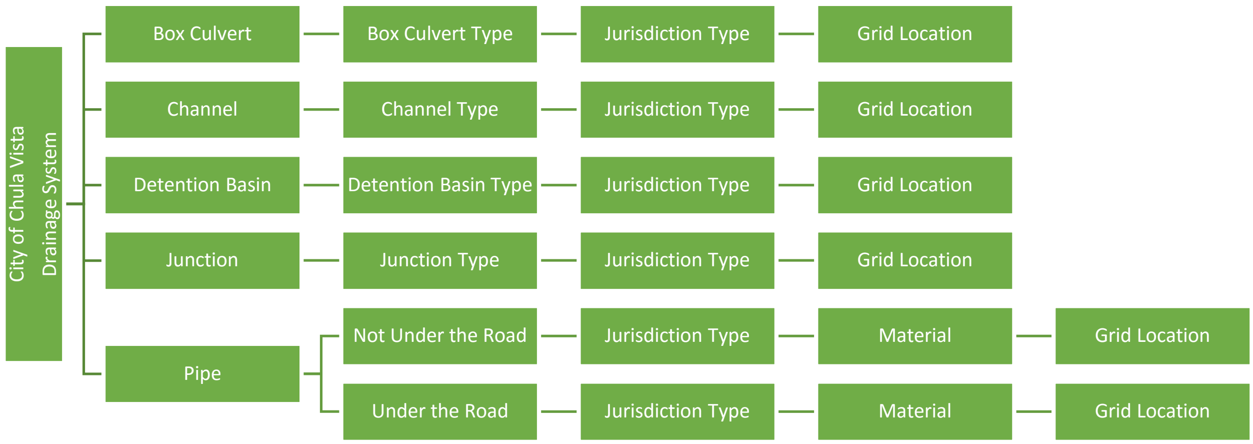


Figure 2-1 Drainage Asset Hierarchy

At the higher levels, the drainage assets are sorted into general asset categories (i.e., box culvert, channel, detention basin, junction, pipe).

For the drainage pipes, the next level in the hierarchy differentiates pipes into the ones that are located under the road and the ones that are not under the road. For the rest of the assets, the next level describes specific asset types. For example, channels are categorized into channels, brow ditch, streams, and rivers.

The next level describes the jurisdiction (e.g., public, open space, easement) of the drainage assets.

2.4 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 Drainage Management System, assets were categorized into classes such as box culvert, brow ditch, channel, detention basin, junction, and pipe. These were then further grouped into assets classes based on material or variety. For example, drainage pipes were broken down into asset classes such as corrugated metal pipes (CMP), polyvinyl chloride (PVC) pipes, and other drainage pipe materials. These asset classes help to group assets that behave similarly. For instance, corrugated metal pipes are expected to last approximately 40 years, while concrete assets, such as concrete channels, are expected to last approximately 100 years. With the asset classes, these assets can be grouped by similar life-cycle patterns. The drainage asset classes are shown in the Table 2-4 below.

Table 2-4 Drainage Asset Class

Asset Class		
Box Culvert	Curb Outlet	Nutrient Separating Baffle Box
Acrylonitrile Butadiene Styrene (ABS) Pipe	Cured in Place Pipe (CIPP)	Outfall
Asbestos Cement Pipe (ACP)	Detention Basin	Outlet
Brow Ditch – Concrete	Dissipater	Plate
Brow Ditch - Natural	Drop Inlet	Plug
Cast in Place Concrete Pipe (CIPCP)	Drop Structure	Polyvinyl Chloride (PVC) Pipe
Catch Basin	Filtered Drop Inlet	Prestressed Concrete Cylinder (PCC) Pipe
Channel - Concrete	Filterra	Reinforced Concrete Pipe (RCP)
Channel - Natural	Gabion	Rip Rap
Cleanout Access Cover	Grate	River
Concrete Riser	Headwall Inlet	Slotted
Continuous Deflection System (CDS)	Headwall Outlet	Spiral Rib Pipe (SRP)
Corrugated Aluminum Pipe (CAP)	Hi Rate Biofilter	Stream
Corrugated Metal Pipe (CMP)	High Density Polyethylene (HDPE) Pipe	Vitrified Clay (VP) Pipe
Corrugated Metal Pipe Arch (CMPA)	Inlet	Vortechs
Corrugated Metal Pipe Riser	Junction	
Corrugated Steel Pipe (CSP)	Modular Wetland	

2.5 Replacement Cost

With the asset inventory complete, each asset was assigned an estimated replacement cost. The replacement cost is an estimated budget the City will spend to replace the asset including material, labor, and other indirect costs. The estimated replacement costs were based on historical cost records, City staff estimates, or cost databases from other comparable cities.

Figure 2-2 below presents the total estimated value of drainage assets by asset class.

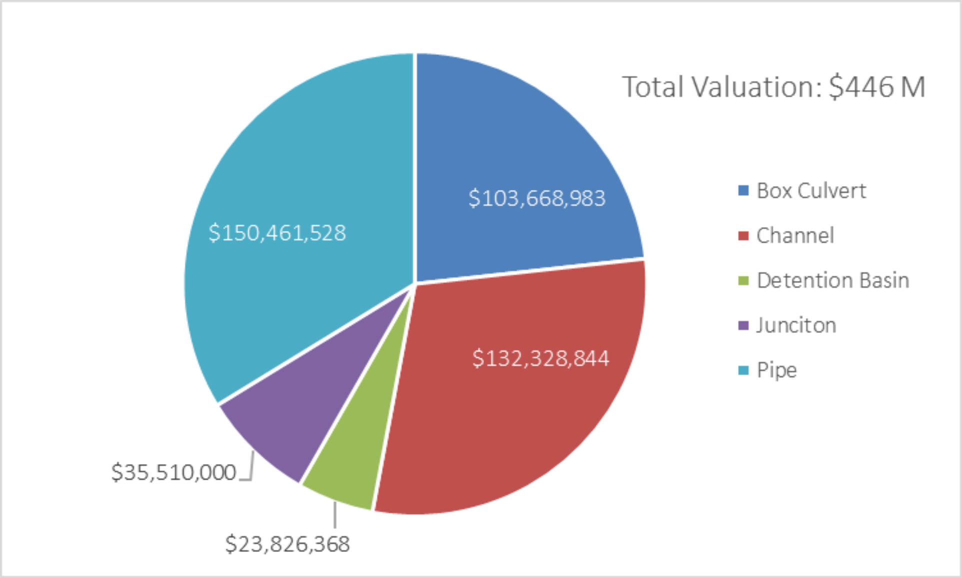


Figure 2-2 Drainage Asset Valuation

The total replacement cost for the Drainage Management System is estimated by summing up the values of the individual assets. Without taking land into consideration, the drainage system value is approximately $446 million. This estimation is based on current year dollars. The pipes have the highest total value at $150 million. Channels and box culverts make up the next highest values at $132 million and $104 million, respectively. All pipes and box culverts will need to be replaced with time; however, natural channels will only require restoration and will not be replaced.

2.6 Installation and Consumption Profile

The installation profile provides an understanding of when the assets were constructed or installed. It also helps to give an indication of the age of the assets. The installation year for each asset in the asset register was recorded based on the City's historical data or through staff knowledge. Some extrapolation was required to estimate the install year.

The historical asset installation profile for the drainage assets, except for natural assets, is presented in Figure 2-3. The graph illustrates the total replacement cost of assets installed in each year. The installation cost is represented in 2016 dollars and does not represent the actual capital investment that took place in any given year.

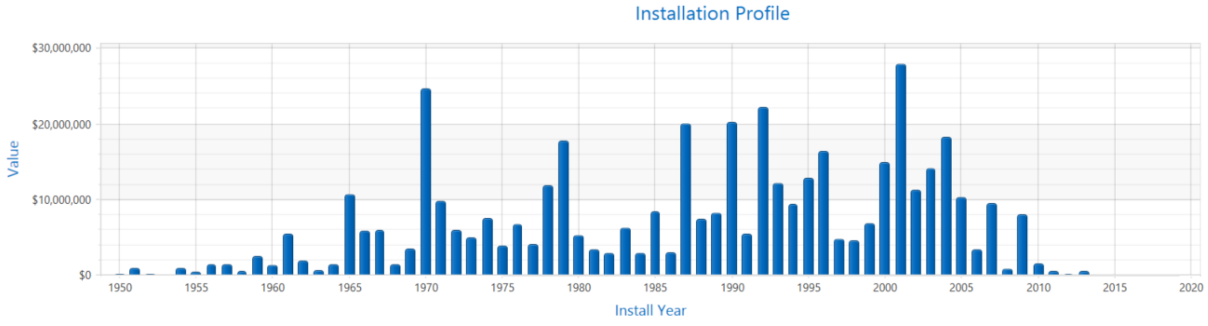


Figure 2-3 Drainage Installation Profile

As shown in the installation profile, installation of drainage assets was initiated in the early 1950s; however, no large storm drain installation activities took place until 1965. Construction peaked in 1970, and rose again in the late 1970's and early to mid-1990s. Another notable growth took place in the early 2000's. This development continued until 2005 when development of storm drain assets significantly tapered off. The trends generally coincide with events in history (e.g., economic recessions, heightened government spending, and development of communities). The sharp decrease in the mid-2000s represents the City's economic recession.

Unlike the installation profile, which focuses on the past, the consumption profile focuses on an assessment of the current state of the assets. The consumption profile provides an overview of how much of each asset's life is used up. The profile shown in Figure 2-4 provides an indication of the amount of assets reaching the end of their expected lives and when they will require replacement.

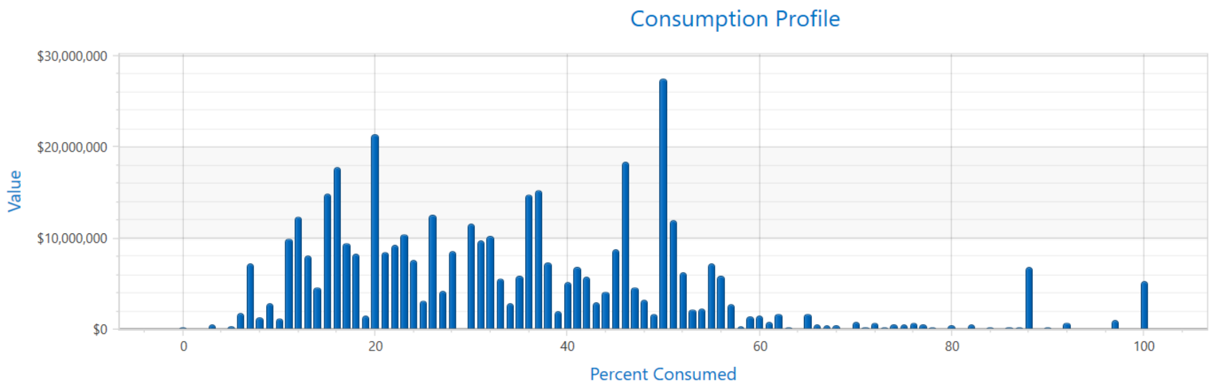


Figure 2-4 Drainage Consumption Profile

The consumption profile was developed considering estimated age and useful life of the assets in most cases. In some cases, the condition score assigned during field verification was used; more details on the sample condition assessment are provided in Section 2.7. An asset identified as 0% consumed indicates a new asset, whereas an asset identified as 100% consumed indicates the asset has reached the end of its useful life. The dollar value represented in the graph is a summation of all asset replacement cost (in 2016 dollars) for each percentage of consumption.

Drainage assets typically have long useful lives; as such, most assets fall within less than 60% consumed range. However, some assets are in the 85% to 100% consumed range. These assets are typically Corrugated Metal Pipes (CMP) installed in the 1950's and 60's. Many of these pipes are nearing the end of their estimated useful lives.

In addition, concrete and rip rap channels located at the Hilltop Park along the Telegraph Canyon Road are in need of rehabilitation due to erosion problems. The details of failing assets requiring immediate attention are discussed in Section 4.1 of this report.

2.7 Condition Assessment

Sample condition assessment was performed for channels to get a representative understanding of the channel condition. Because not every asset could be visited, sample channels were selected based on the location, criticality, and size of the channel. For example, the channels along the Telegraph Canyon Road and Olympic Parkway were assessed because these were channels along the major roads of the City. Most of the concrete channels that were indicated in GIS were visited. Condition assessment on the Drainage Management System is currently in progress. As updated data becomes available, the verified condition will be incorporated into the overall program.

These assessment values were considered in the estimation of remaining useful lives. Figure 2-5 highlights the areas of channel where the condition assessment was performed in light blue. There was a total 7 miles out of 77 miles (9%) of channels on which the sample condition assessment was performed.

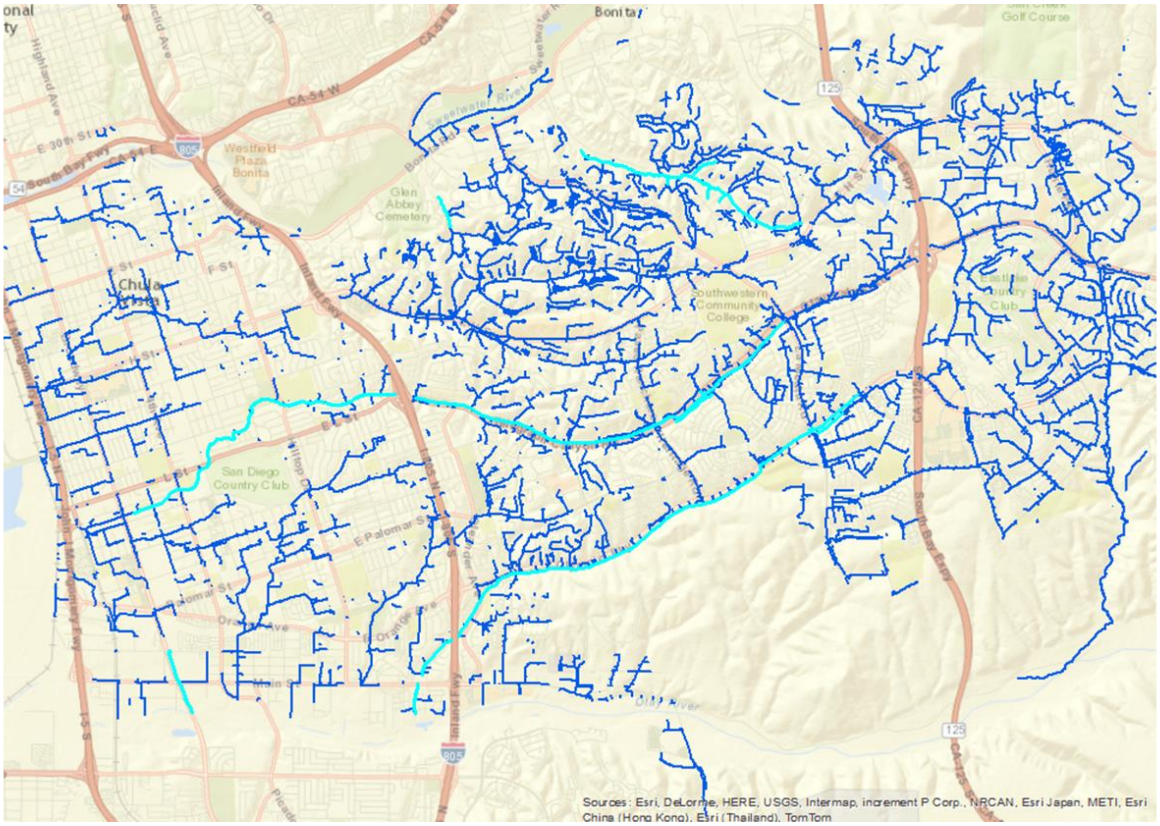


Figure 2-5 Condition Assessed Channels

In general, the structural condition of the concrete channels was sound; however, the sample channels assessed generally had vegetation and sediment problems. GPS coordinates of problematic areas in the channels have been collected in order to highlight these assets in the database and assign different management strategies to mitigate the problem.

There were some natural channels along Telegraph Canyon that had major erosion problems as shown in Figure 2-6. The details of condition assessment result are shown in Appendix A of this report.

Figure 2-6 Natural Channel along Telegraph Canyon with Erosion Problem

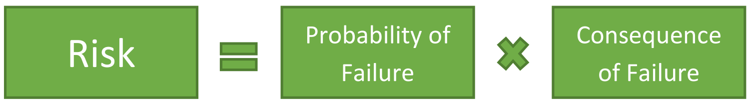
After the condition assessment took place, the City took actions to mitigate the major erosion problems along Telegraph Canyon. In 2015, the City built a 700-foot-long secant pile wall to fix the erosion problems. The erosion control structure will last about 100 years with proper maintenance.

Maintenance work resets the condition of the asset to good condition, and it also resets the the life-cycle of the asset. As an asset's condition is restored to good condition, maintenance work can then focus on other areas until the asset's condition drops once again over time.

3 Risk

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:



3.1 Probability of Failure

The PoF score indicates the projected time until the asset fails to function at the established levels of service. Some of the examples of level of service for drainage assets would be channel stability, which includes erosion and sedimentation management for flow conveyance. The PoF score for each asset was based on condition or the age of the asset.

The PoF was classified into three ratings: low, medium, and high probability (represented by green, yellow, and red, respectively). Assets considered high probability of failure were assets that had consumed 85% or more of their useful life. Assets with medium probability of failure were assets that had used up more than 50% and less than 85% of their useful lives. Assets with low probability of failure were assets that had used up 50% or less of their useful lives. These classifications provide guidance with respect to the anticipated timing of failure.

Figure 3-1 below summarizes the PoF distribution for channels, including box culverts, rivers, streams, and brow ditches. Of the total 84 miles of assets, approximately 71% (60 miles) have a low probability of failure, 27% (23 miles) have a medium probability of failure, and approximately 2% (2 miles) are estimated to have a high probability of failure. The channels with high probability of failure have been classified as such mainly due to maintenance issues, such as heavy vegetation, debris, or sediment, and not due to structural issues. Although regular maintenance is ideal, stringent regulations require permits in order to perform maintenance. Acquiring permits to enter the channel often takes several months to a year. This stringent permitting requirement and its long process significantly lessens the frequency of maintenance in these channels.

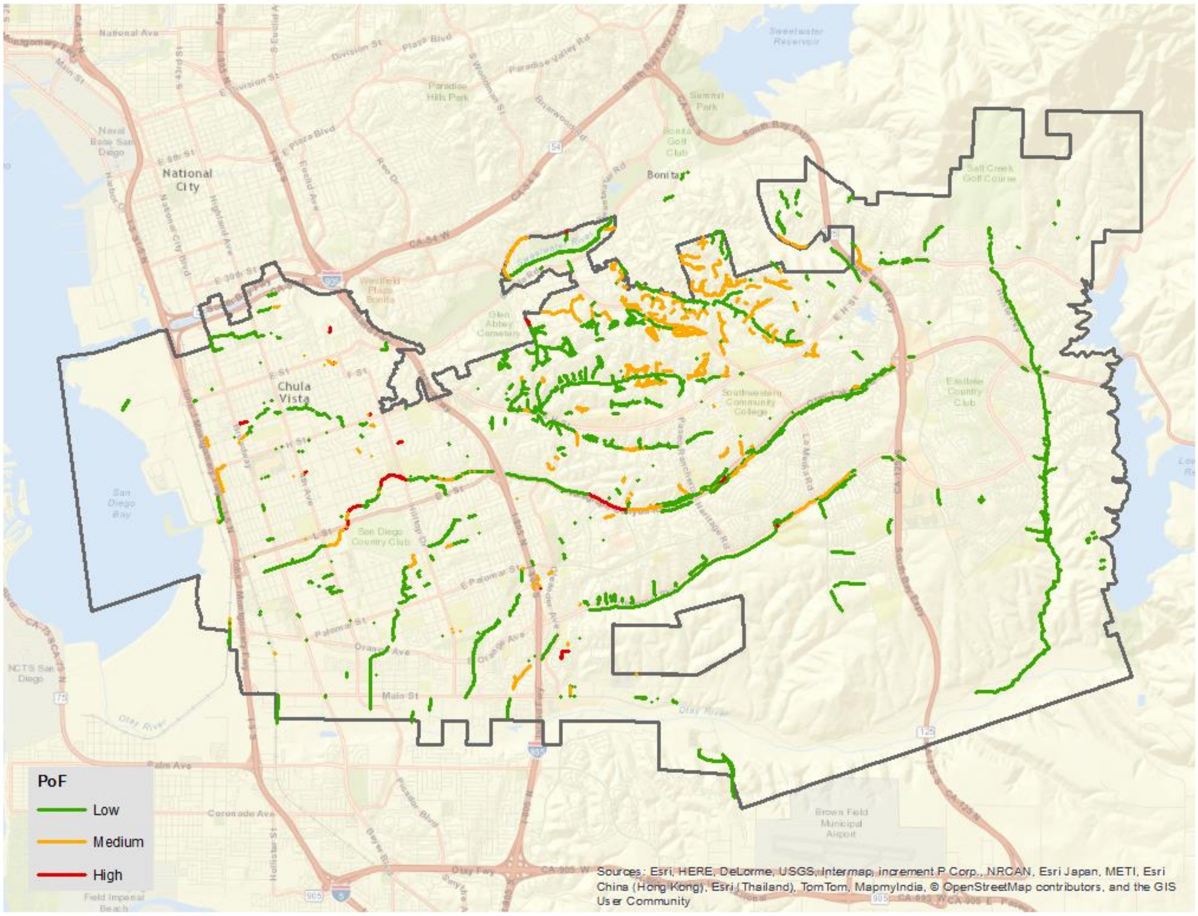


Figure 3-1 Probability of Failure of Channels

Figure 3-2 below summarizes the PoF distribution for junctions (e.g., inlet, outlet, filterra, catch basin). Of the 10,552 assets, approximately 96% (10,109) have low probability of failure, 4% (432) have medium probability of failure, and less than 1 % (11) are estimated to have high probability of failure. As expected, the junctions located on the western side of the City have more medium and high probability of failure assets due to age. Most high PoF junctions are plates and grates installed between the mid-1950s and mid-1970s. With estimated useful lives of 40 and 50 years, respectively, these plates and grates have reached the ends of their useful lives and will soon require replacement. A condition assessment of high PoF assets is warranted to verify the projected condition. If required based on the results of the condition assessment, the estimated useful life may be extended or shortened to reflect the true condition of the assets. Other high PoF assets included headwall outlets along the channels with sedimentation and vegetation problems.

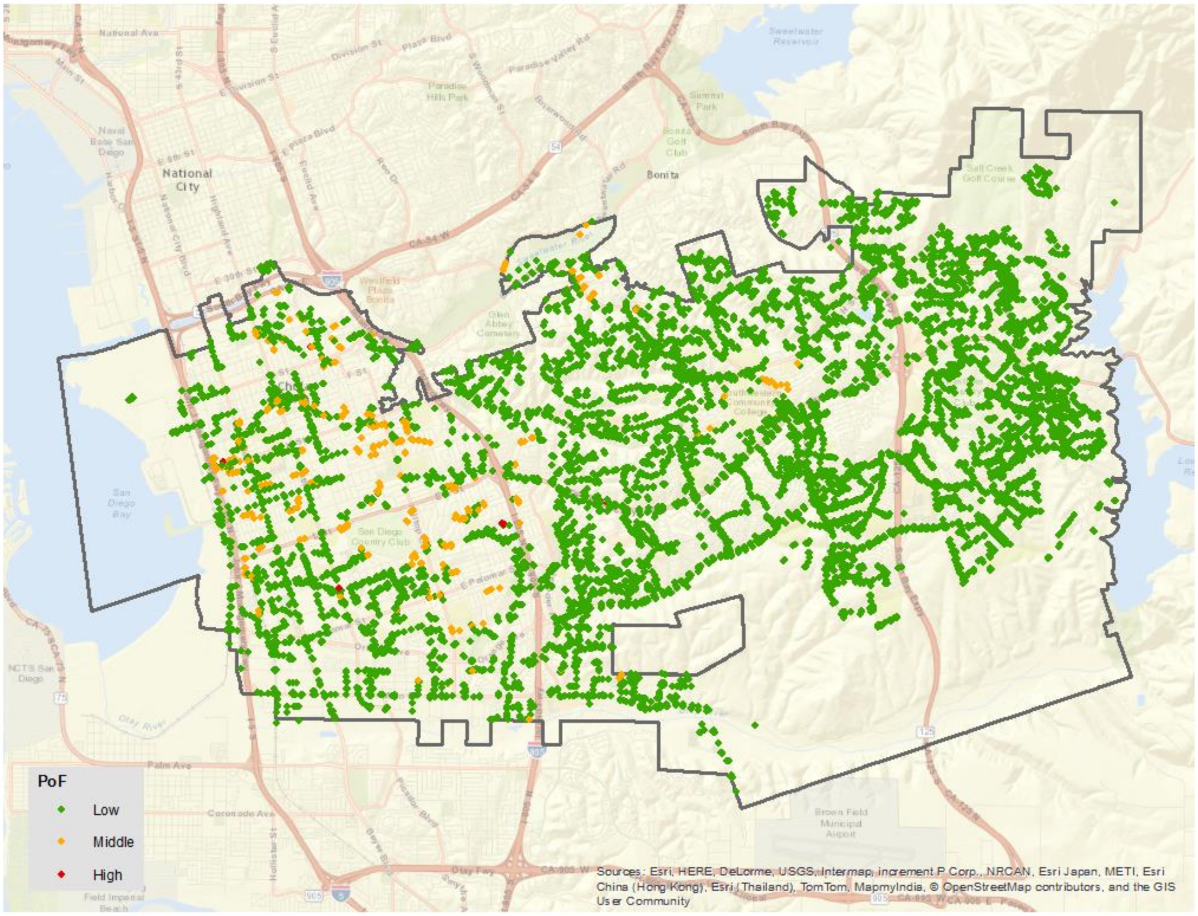


Figure 3-2 Probability of Failure of Junctions

For inlets, condition assessment meant to be done routinely (i.e., every 3 years). However, the City is currently in the process of catching up on 10 years of deferred condition assessment. The PoF scores are being used to prioritize the condition assessment and field verification process. The results of these assessments will then be incorporated into the life-cycle cost logic.

Figure 3-3 summarizes the PoF distribution for drainage pipes. Of the total 207 miles, approximately 85% (175 miles) have low probability of failure, 11% (24 miles) have medium probability of failure, and 4% (8 miles) are estimated to have high probability of failure. As expected, the CMPs located on the west side of the City are showing more medium and high probability of failure due to age and corrodible material. Out of 13 miles of CMPs, more than 65% (8 miles) were are identified as high PoF. In 2015, the City has taken initiative to perform another CCTV inspection in order to determine the current condition of the CMPs. The CCTV results are currently being reviewed in order to identify the immediate needs area.

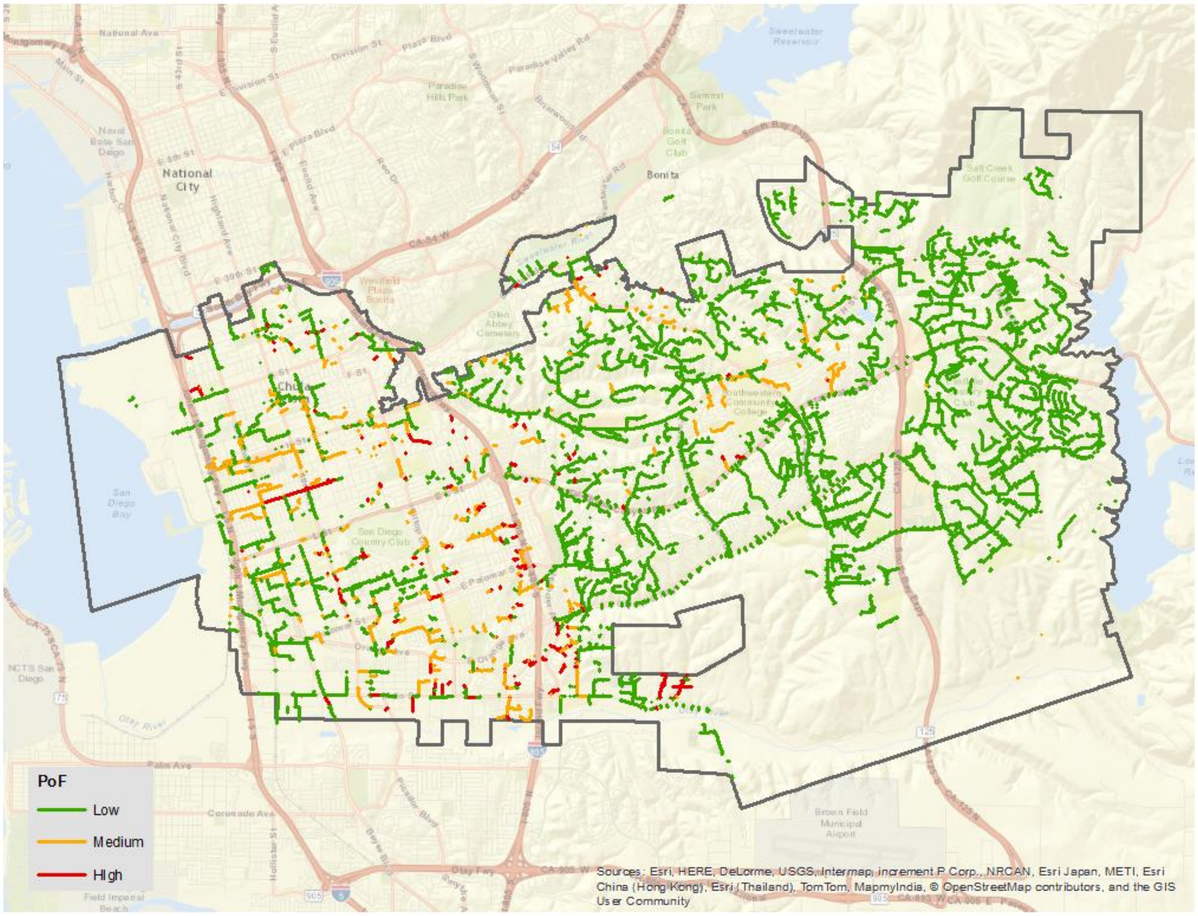


Figure 3-3 Probability of Failure of Pipes

3.2 Consequence of Failure

CoF was also assessed for each asset. CoF is a numerical measurement that represents the criticality of an asset, that is, how large an impact the asset will have when it fails. The impact of an asset failure was assessed with respect to the triple bottom line factors of sustainability: economic, social, and environmental. For example, a large diameter drainage pipe will have a higher CoF value compared to smaller diameter drainage pipe. This logic is based on the fact that larger pipe will have higher cost of failure and that flooding due to blockage of the pipe will have a higher social and environmental impact.

The logic presented in the tables below was developed to determine the CoF for each asset based on location.

The geospatial factors such as street classification, zoning type, facility type, asset class/size, proximity to river and wetland, Multiple Species Conservation Program (MSCP) preserve, and Federal Emergency Management Agent (FEMA) flood plain were used to assess the CoF for the drainage assets. As shown in Table 3-1 below, all of these factors have a relative impact on social, environmental, and economic factors.

Table 3-1 Consequence of Failure Factors

Factors	Social	Environmental	Economic
Street Classification	√		√
Zoning	√	√	√
Facility Type	√		
Asset Type	√	√	√
River/Wetland		√	√
MSCP Preserve		√	√
FEMA Flood Plain	√		√

Each of the factors is further broken down by their classification in each category. Each classification is rated based on the criticality from 1 to 5, with 5 being most critical.

The criticality rating for the street classification is shown in Table 3-2 below. The criticality ratings were assigned based on the street class in relation to the other street classes. Assets that are located near high-traffic roads, such as a freeways or arterial roads, have the highest criticality rating of 5. The assets that are located near roads that are smaller and have less traffic, such as residential streets, have a lower CoF rating. Areas such as alleys or private roads have a CoF rating of 1, which is significantly lower than residential while still having value.

Table 3-2 CoF Criticality Rating Based on Street Classification

Street Class	Criticality Rating
Freeway/Freeway Ramp	5
Trolley	5
Railroad	5
Arterial	5
Collector	4
Residential	3
Private/Un-Paved Street	1
Alley	1
Proposed/Abandoned	1
Constructed/Not Approved	1
Service/Dirt	1

Zoning data was also identified as a factor influencing the criticality of drainage assets. Drainage assets located in areas with high social impact (e.g, near hospitals, schools, shopping centers) received the highest criticality. The residential areas were further broken down by population density. Areas with higher density received higher criticality rating scores. These zoning classifications are summarized in Table 3-3 below.

Table 3-3 CoF Criticality Rating Based on Zoning

Zoning Name	Criticality Rating
Industrial	5
Commercial	5
Mixed Use (Mixed Use Commercial)	5
Residential (High)	4
Mixed Use (Mixed Use Residential)	3
Residential (Medium)	3
Residential (Low Density)	2
Park / Open Space	1

The criticality rating for the different facility types are shown in Table 3-4. The criticality rating was based on the social impact of the facility closure, including amount of traffic the facility received. Facilities such as hospitals and schools had the highest criticality, followed by the recreational facilities and then by smaller government facilities.

Table 3-4 Criticality Rating Based on Facility Type

Facility Name	Criticality Rating
Hospital	5
Trolley Station	5
Education Facility	5
Shopping/Retail Center	4
Post Office	4
Golf Course	4
Fire Station	3
Police Station	3
Government Buildings	3
Athletic Training/Sports	2
Museum	2
City Library	2
Church	2
Marina	1

Table 3-5 shows the criticality rating based on the Multiple Species Conservation Program (MSCP) preserve area. MSCP is a comprehensive habitat conservation planning program for southwestern San Diego County. The percentage of preserve refers to the percentage of a specific area that is set aside as preserve area for the program. Therefore, the higher the percentage of preserve land in the area, the higher the criticality.

Table 3-5 Criticality Rating Based on MSCP Preserve

MSCP Preserve	Criticality Rating
100% Preserve	3
75% Preserve	2

Table 3-6 shows the criticality rating based on the Federal Emergency Management Agent (FEMA). Assets that are located near the high flood risk zones have higher criticality.

Table 3-6 Criticality Rating Based on FEMA Flood Plain

FEMA Flood Plain	Criticality Rating
FP100	5
FP500	3
FW100	2

Criticality is also measured by different asset classes as shown in Table 3-7 below. Assets such as channels, dams, and detention basins had the highest criticality rating based on potential impacts of failure. Drainage pipes were further differentiated by the diameter (i.e., potential flow); pipes with a greater diameter received a higher criticality rating.

Table 3-7 Criticality Based on Asset Type within Asset Class

Asset Class	Asset Type	Criticality Rating
Channel	Channel	5
	Box Culvert	4
	Brow Ditch	2
Pipe	Diameter ≥ 72in	5
	18in ≤ Diameter < 72in	4
	8in ≤ Diameter < 18in	3
	Diameter < 8in	2
Junction	Cleanout Access Cover	5
	Junction	5
	Catch Basin	5
	Vortechs	5
	Continuous Deflection System (CDS)	5
	Inlet	4
	Riser	3
	Outlet	2
	Modular Wetland	1
	Filterra	1
	Filtered Drop Inlet	1
	Plate	1
Detention Basin	-	5
Dam	-	5

Each of the factors that affects the CoF triple bottom line factors are weighed based on the criticality as shown in Table 3-8.

Table 3-8 CoF Score Weighting Factors

CoF Factor	Weighting
Street Classification	30%
Zoning	20%
Facility Type	15%
Asset Type	20%
River/Wetland	5%
MSCP Preserve	5%
FEMA Flood Plain	5%

Figure 3-4 summarizes the consequence of failure for channels, which includes box culverts, rivers, streams, and brow ditches, as a result of the calculation logic shown in previous tables. Of the total 84 miles, approximately 77% (65 miles) are identified to have low consequence of failure, 20% (17 miles) have medium consequence of failure, and approximately 3% (3 miles) have high consequence of failure. As the map shows, large channels located close to major roads and highways were assigned medium or high consequence of failure.

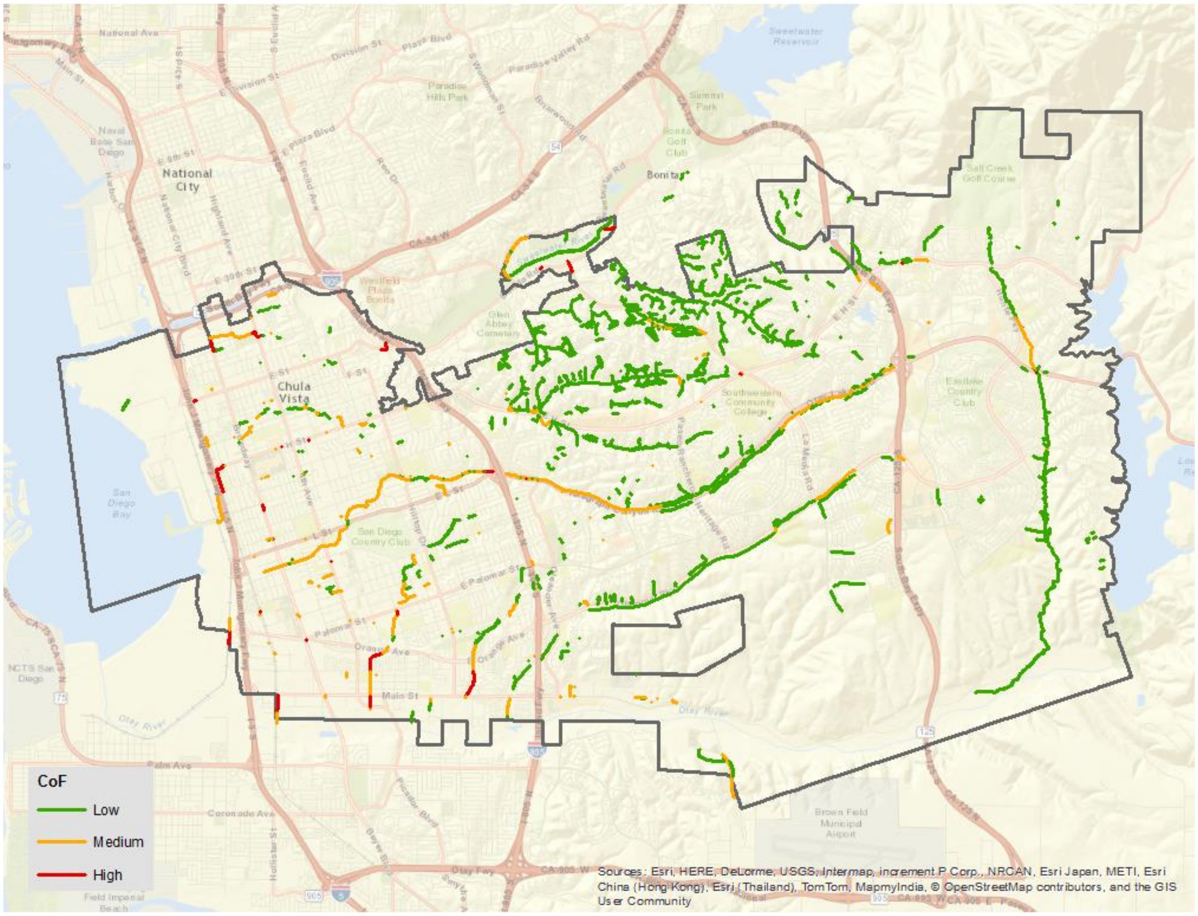


Figure 3-4 Consequence of Failure of Channels

Figure 3-5 summarizes the consequence of failure for junctions (e.g. inlet, outlet, filterra, catch basin). Of the total 10,552 assets, approximately 61% (6,467) have low consequence of failure, 37% (3,888) have medium consequence of failure, and less than 2% (197) have high consequence of failure. The junctions that were generally located near the major roads, highways, or railroads had medium to high consequence of failure due to the high traffic and large impact of a failure in these areas.

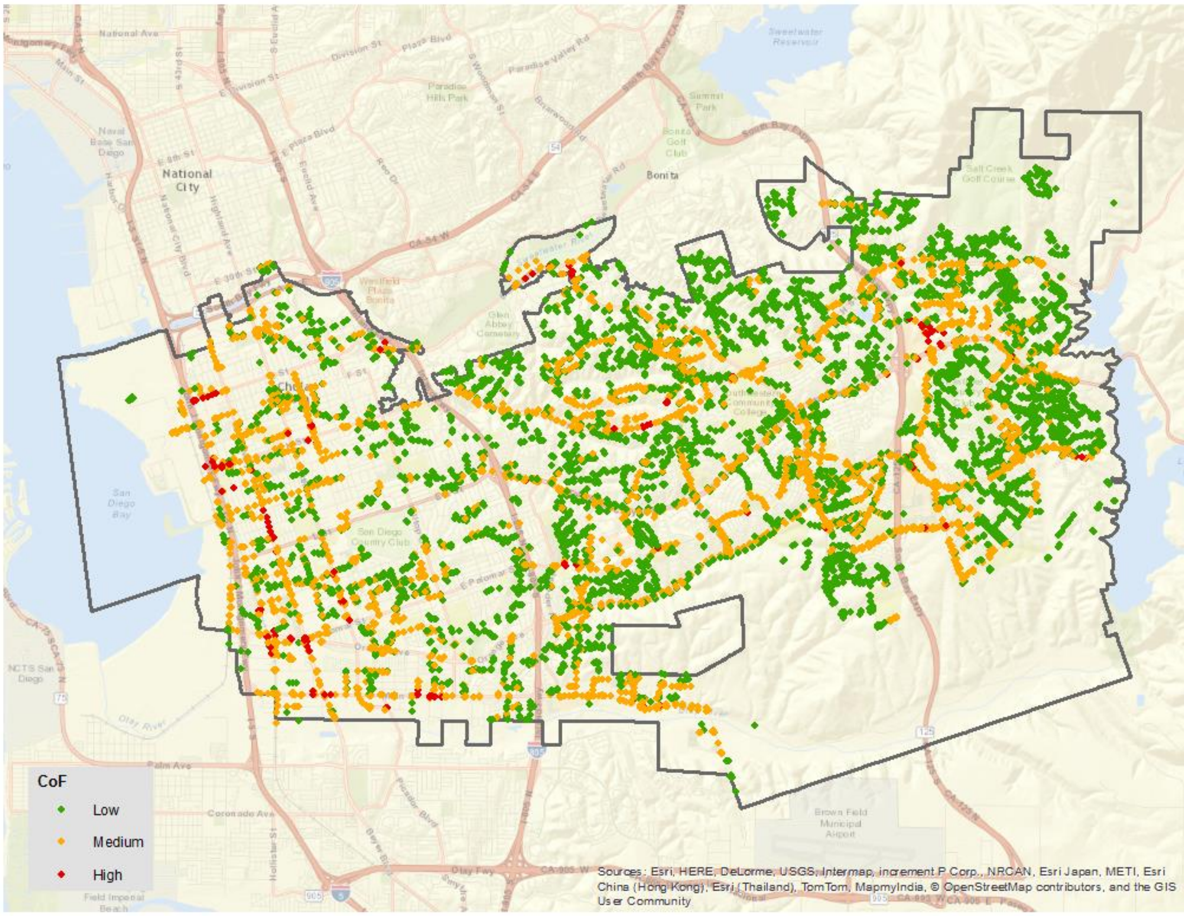


Figure 3-5 Consequence of Failure of Junctions

Figure 3-6 summarizes the consequence of failure distribution for drainage pipes. Of the total 207 miles, approximately 55% (114 miles) have low consequence of failure, 42% (84 miles) have medium consequence of failure, and less than 3% (6 miles) have high probability of failure. Drainage pipes with large diameters located along the major roads were assigned medium to high criticality; this is because large diameter pipes have a higher replacement cost and a larger impact when they fail due to the volume of water flowing through them.

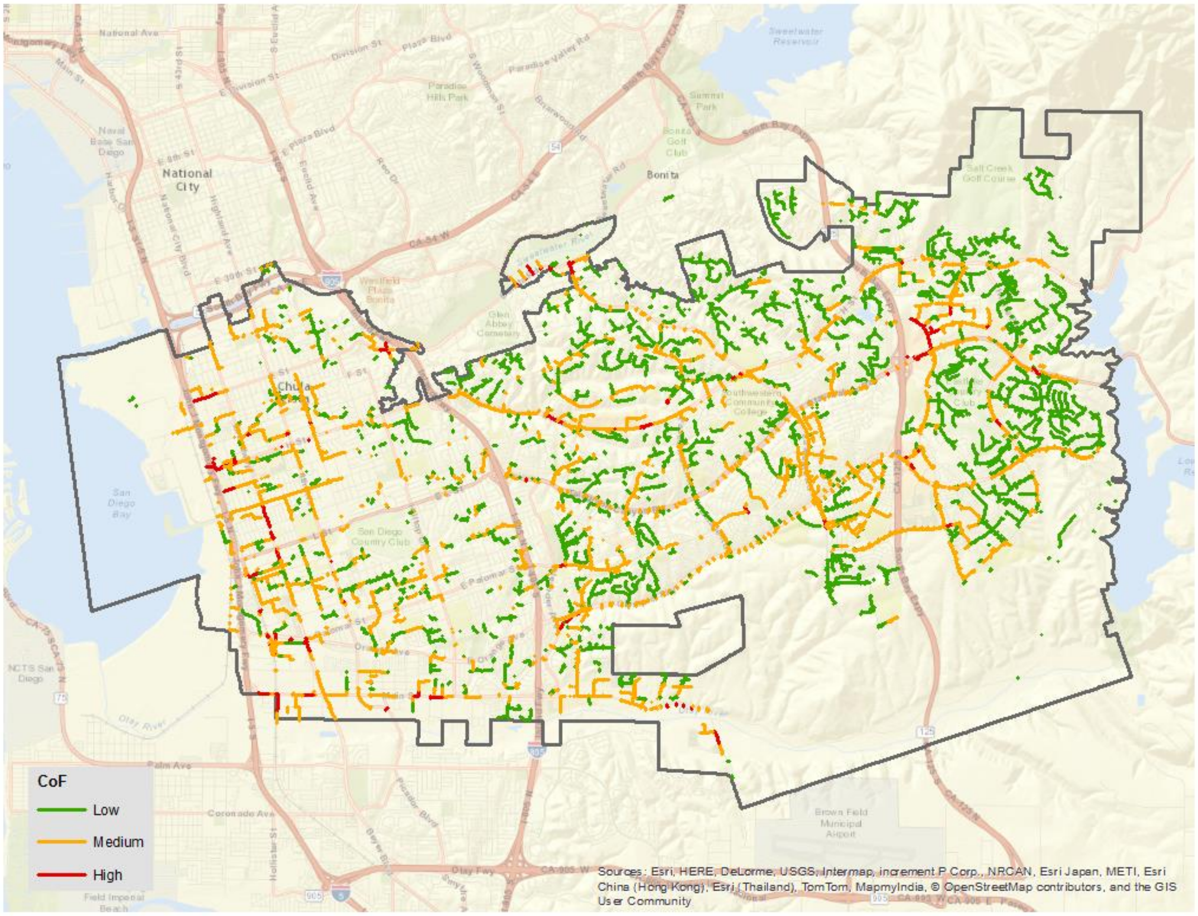


Figure 3-6 Consequence of Failure of Pipes

3.3 Risk

As defined earlier, risk is a combination of probability of failure and consequence of failure. The following figures show the resulting risk profile for the Drainage Management System.

Figure 3-7 summarizes the risk for channels, which includes box culverts, rivers, streams, and brow ditches. Of the total 84 miles, approximately 86% (73 miles) are identified as low risk, 14% (11 miles) are identified as medium risk, and approximately 1% (less than 1 mile) is estimated to be high risk.

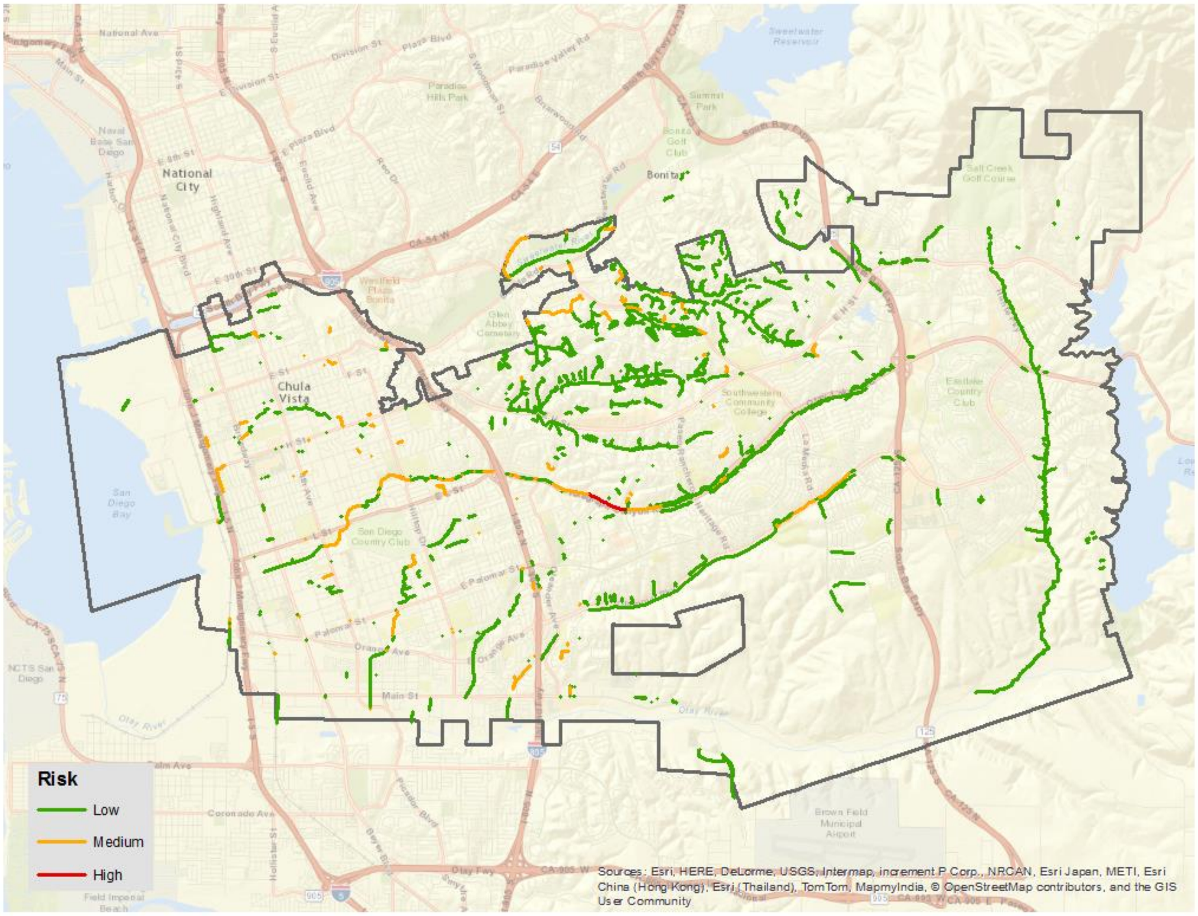


Figure 3-7 Risk of Channels

Figure 3-8 summarizes the risk for junctions (e.g. inlet, outlet, filterra, catch basin). Of the total 10,552 assets, approximately 94% (9,952) are identified as low risk and 6% (600) are identified as medium risk.

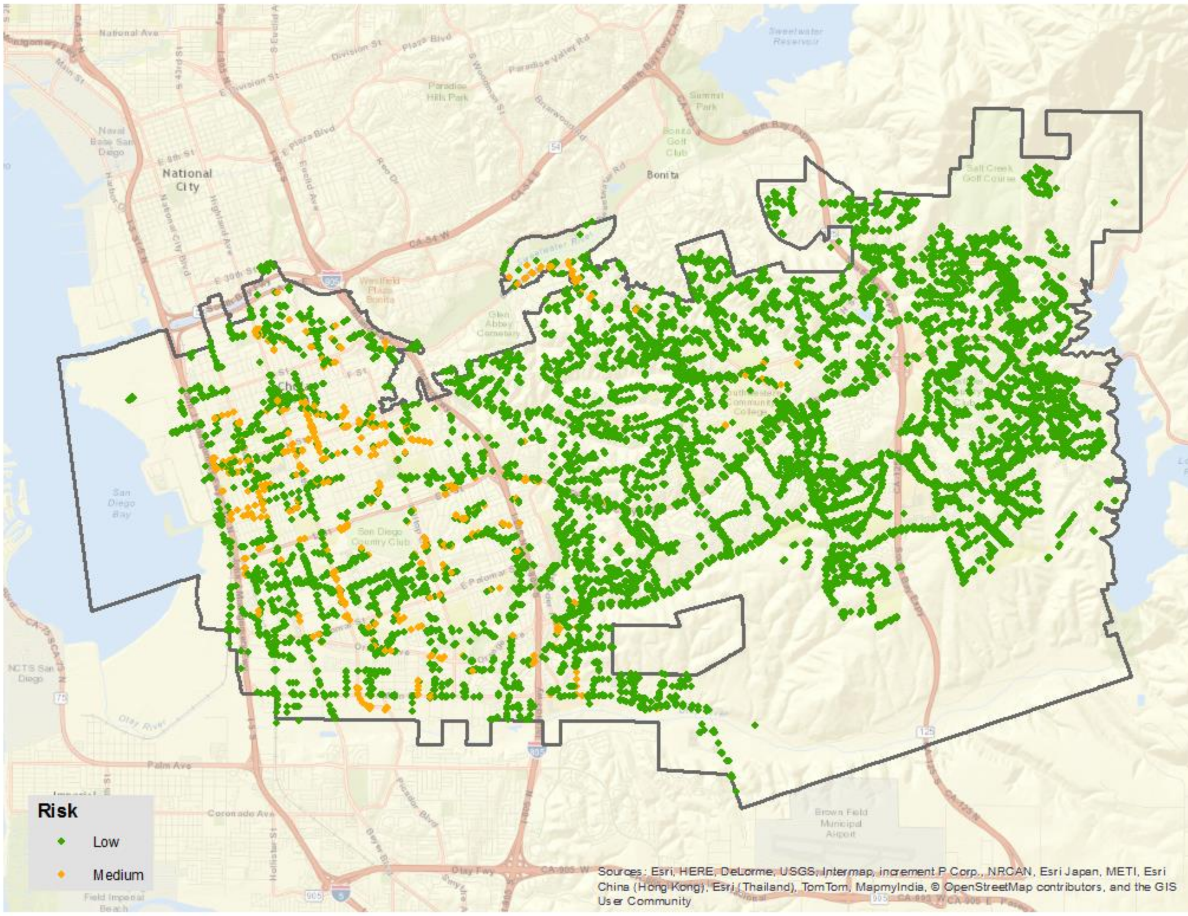


Figure 3-8 Risk of Junctions

Figure 3-9 summarizes the risk for drainage pipes. Of the total 207 miles, approximately 84% (174 miles) are identified as low risk, 15% (32 miles) are identified as medium risk, and less than 1% (2 miles) are estimated to be high risk.

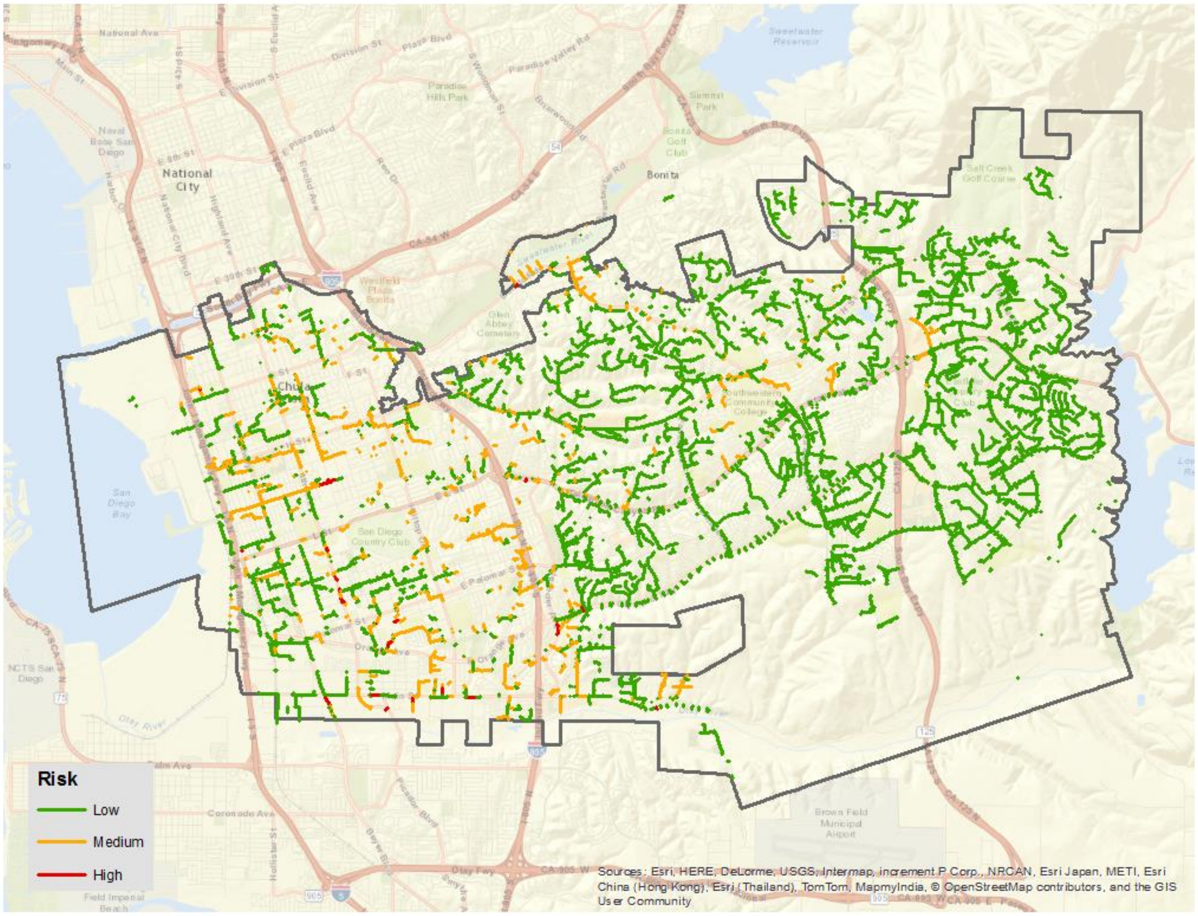


Figure 3-9 Risk of Pipes

Figure 3-10 shows the risk matrix for the Drainage Management 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.

In general, the City decided to focus on the assets in the red zone (i.e., Catch Up), which represents the assets that pose the highest risk to the City. The assets in the red zone also include the backlog work (i.e., activities from previous years that have yet to take place).

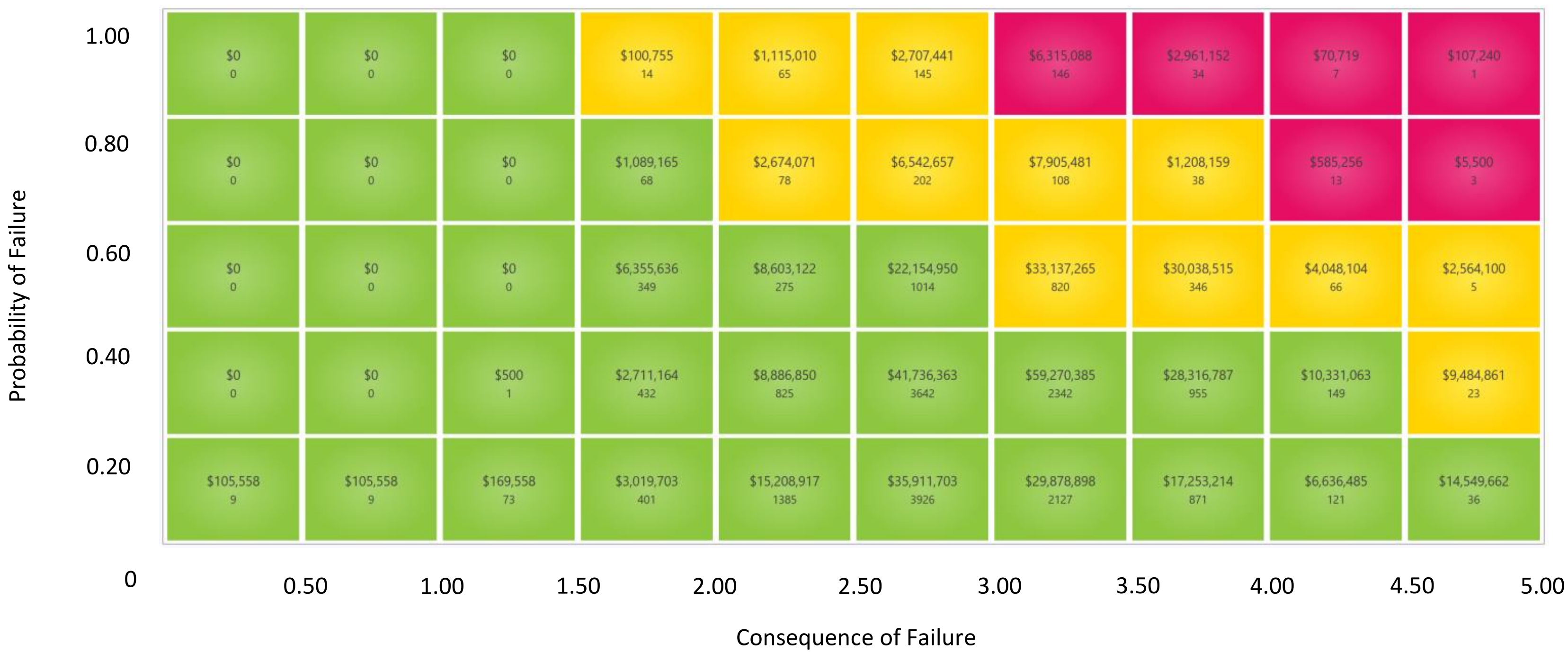


Figure 3-10 Drainage Risk Matrix

The total estimated cost for all assets in the red zone equated to approximately $10 million. For the assets in the red zone, approximately $1 million is expected to be spent on channel replacement for channels that are facing major erosion problems. Approximately $40,000 is expected to be spent on channel maintenance (e.g. vegetation removal, sediment removal) on channels that had high risk due to maintenance condition. Approximately $2 million is expected to be spent on replacing CMPs that are nearing the ends of their useful lives and are located in critical areas.

4 Future Needs

4.1 Immediate Needs

The City’s drainage assets are mostly in good shape. However, some of the corrugated metal pipes (CMP) are starting to deteriorate due to their age and the corrodible nature of the material.

In 2005, the City has performed condition assessment on all the CMP in the City using CCTV. As shown in Figure 4-1, most of the CMPs, highlighted in red, are located in the older parts of the City, especially around the downtown area.

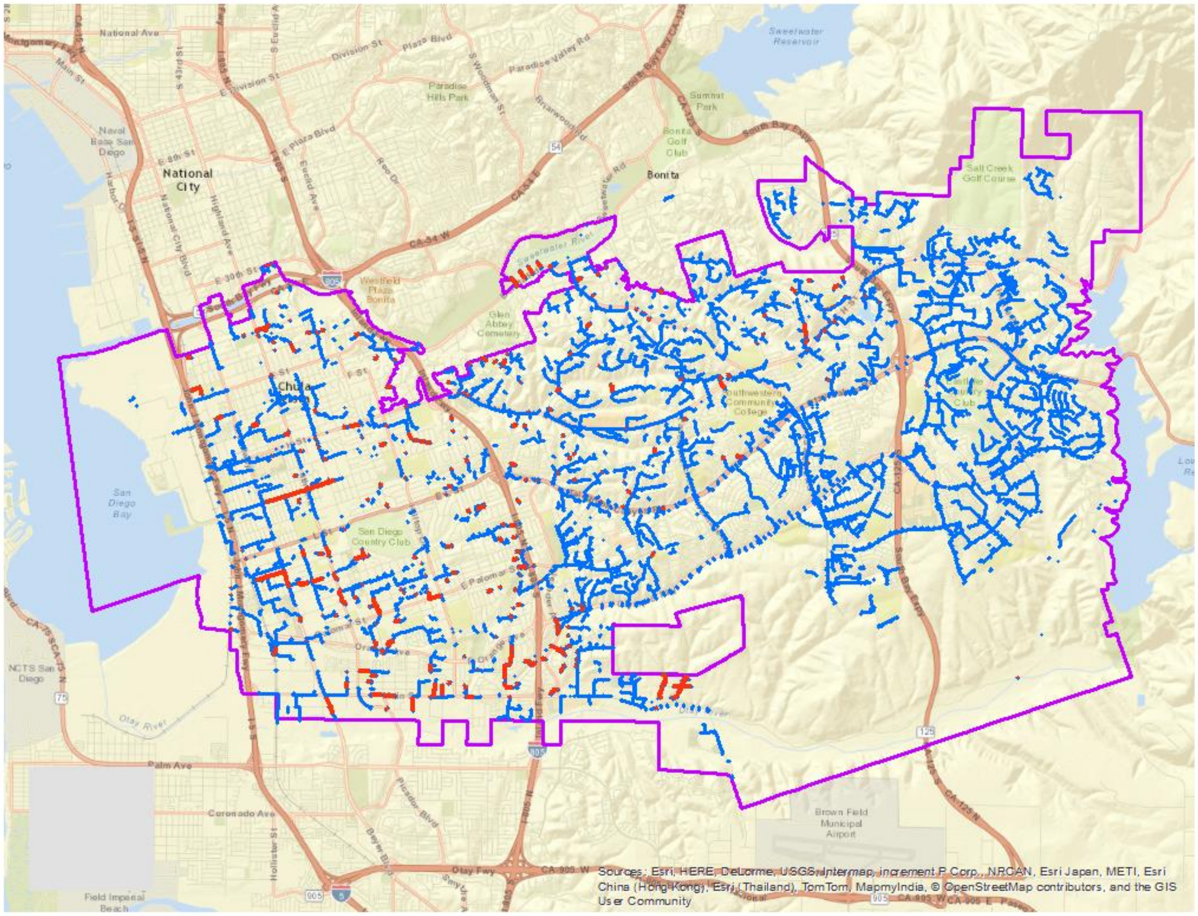


Figure 4-1 Corrugated Metal Pipes

There are approximately 13 miles of CMP located in the City. 85% (8 miles) of these pipes have consumed 85% or more of their useful lives and need immediate attention. According to 2005 condition assessment (i.e., CCTV) data, 1.8 miles of CMPs were recommended to be lined with CIPP liner and 0.4 miles of CMPs were recommended to be replaced immediately.

Despite the City’s effort to reline and replace all the problematic CMP based on the CCTV data, not all the pipe failure could be predicted. As shown in the Figure 4-2 below, a CMP located near one of the elementary schools failed and created a sinkhole in February 2015. Fortunately, no one was hurt during this failure. However, the social and economic impact was high for the City.

Figure 4-2 Sinkhole Caused by Pipe Failure on Oleander Ave near Valle Lindo Elementary School

In order to prevent future failures and to drive lower life-cycle cost, the City utilized the asset management strategies. The investigation of the failed pipe revealed that it was installed in 1967. Using this data, the City decided to investigate all pre-1975 CMPs, shown in the figure below. Through visual inspection, the City hopes to capture CMPs before failure and rehabilitate the pipes by lining them. The failure cost the City around $250,000 to fix. As a result, the City repurposed $1.2 million from streets to prevent future failures. During this ongoing process, CMPs with condition 5 will be addressed first. Proactively rehabilitating the CMP will cost the City about 1/3 less than the replacement cost while extending the life of the pipe approximately 30 years.

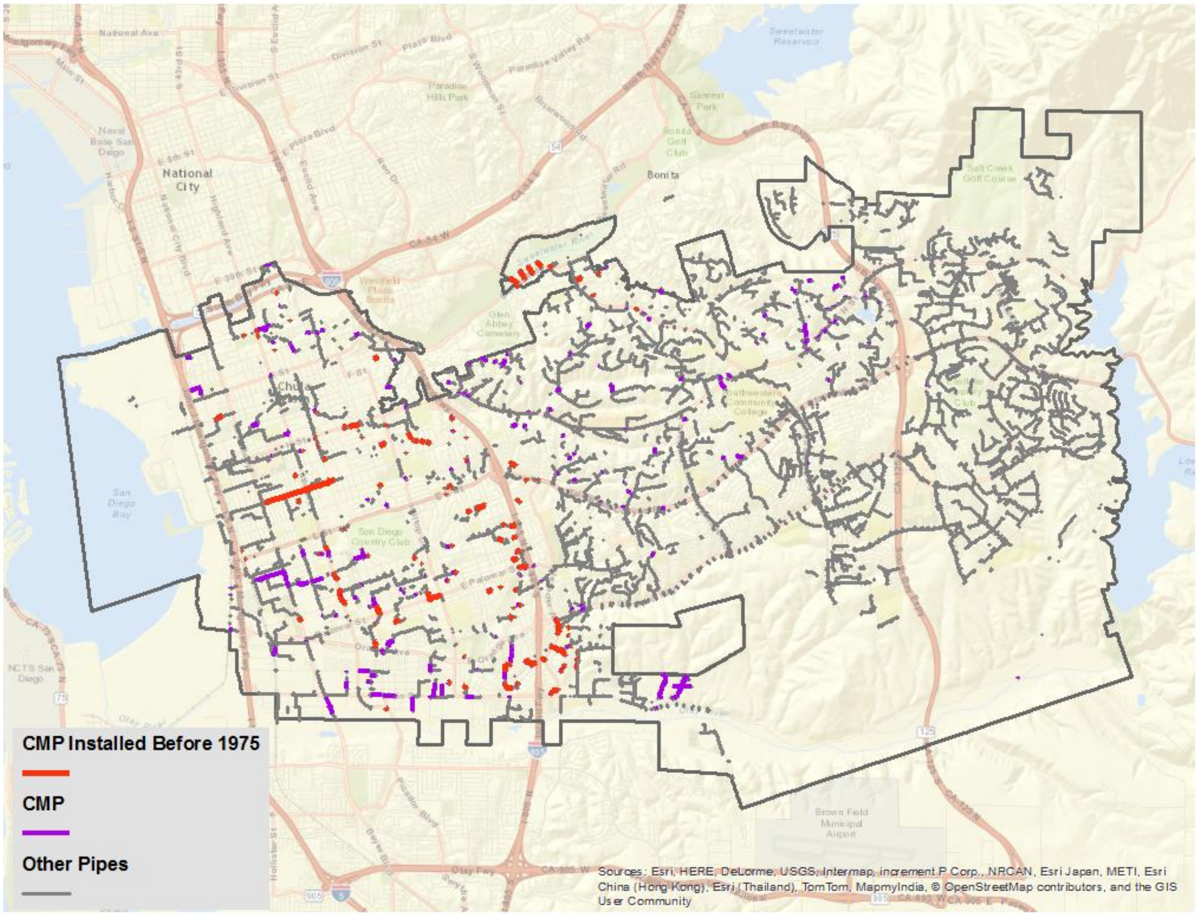


Figure 4-3 CMP Investigation

The City has already taken initiative to identify problematic CMPs by performing CCTV inspection in 2015. Incorporation of this inspection data into the Drainage Management System is recommended in the future as part of the continuous improvement process.

4.2 Life-cycle Cost Logic

Life-cycle cost analysis provides the City with an estimation of the total cost of ownership of the assets over their lifespans. It is a key element in helping to project the financial responsibility of properly managing the asset to fulfill the service requirements. Through life-cycle cost analyses, the City is able to gain understanding for each asset of what action (i.e., replacement, rehabilitation, maintenance) is required at what time and how much it will cost. By consolidating the projected asset actions year-by-year, the estimated budget and resources required to perform the work can be projected. Projecting the future needs allows the City to prepare for the financial and resource requirements.

The following sections document the logic used to calculate the life-cycle cost calculations for the drainage assets.

4.2.1 Channel

Sample channel condition assessment was performed to determine the structural and maintenance (e.g., sediment, vegetation) conditions. Depending on the verified conditions, estimated useful life was adjusted. In addition, depending on the sediment and vegetation findings, the maintenance frequency of these channels were adjusted to better reflect the actual condition.

The detailed life-cycle cost logic for channels is shown in Table 4-1. For concrete channels and brow ditches, replacement of the concrete is recommended after 100 years. Although concrete has a long useful life of 100 years, rehabilitation is necessary to fix the joints and cracks throughout the duration of the asset's life. For rip rap channels, there is no replacement; however, replenishment of the rocks is recommended every 50 years at 50% of the construction cost. Since natural assets won't be replaced, only maintenance is recommended. The maintenance activities include vegetation removal, sediment removal, debris removal, and the cost of permit which is applied for all the channel assets.

Table 4-1 Channel Life Cycle Cost Logic

Type	Maintenance Condition	Useful Life (Years)	Replacement Cost	Rehab Frequency (Years)	Rehab Cost	Maintenance Frequency (Years)	Maintenance Cost
Concrete	Standard	100	$2,000 per LF	25	$115 per LF	5	$80 per LF
	High	100	$2,000 per LF	25	$115 per LF	4	$80 per LF
	Medium	100	$2,000 per LF	25	$115 per LF	6	$80 per LF
	Low	100	$2,000 per LF	25	$115 per LF	8	$80 per LF
	Very Low	100	$2,000 per LF	25	$115 per LF	10	$80 per LF
Natural/ River/ Stream	Standard	-	-	-	-	5	$80 per LF
	Very High	-	-	-	-	2	$80 per LF
	High	-	-	-	-	4	$80 per LF
	Medium	-	-	-	-	6	$80 per LF
	Very Low	-	-	-	-	10	$80 per LF
Rip rap	Standard	-	-	50	50 % of Replacement Cost	5	$80 per LF
	Very High	-	-	50	50 % of Replacement Cost	2	$80 per LF
	High	-	-	50	50 % of Replacement Cost	4	$80 per LF
	Very Low	-	-	50	50 % of Replacement Cost	10	$80 per LF
Natural Brow Ditch	Standard	-	-	-	-	5	$20 per LF
Concrete Brow Ditch	Standard	50	$75 per LF	50	$6 per LF	5	$20 per LF
	Low	50	$75 per LF	50	$6 per LF	8	$20 per LF
	Very Low	50	$75 per LF	50	$6 per LF	10	$20 per LF

4.2.2 Pipe and Box Culvert

The detailed life-cycle cost logic for pipes and box culverts are shown in the table below. The useful lives of the pipes depend on the material. The useful lives of pipes range from 40 to 90 years. The replacement cost for these pipes vary depending on the diameter of the pipes. These costs include the material cost as well as the labor cost for pipe replacement. In addition, it is recommended that pipes be inspected every 5 to 10 years, depending on the pipe material. Box culverts have a long useful life of 100 years.

Table 4-2 Pipe and Box Culvert Life-cycle Cost Logic

Type	Material	Useful Life (Years)	Replacement Cost	Maintenance Activity	Maintenance Frequency (Years)	Maintenance Cost
Pipe	ACP	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	CAP	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	CIPCP	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	CIPP	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	CMP	40	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMPA	40	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMPB	40	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMPC	40	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMPL	70	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMP-Needs Lining[1]	60	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CMPB-Needs Lining	60	Varies; $55 - $2,000 per LF	CCTV Inspection	5	$3 per LF
	CSP	70	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	HDPE	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	PCC	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	PVC	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	RCP	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	VC	90	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
	ABS	80	Varies; $55 - $2,000 per LF	CCTV Inspection	10	$3 per LF
Box Culvert	-	100	$2,500 per LF	-	-	-

[1] These CMPs are the pipes that were identified as needing lining during 2005 CCTV inspection. It is recommended that these be relined in 2016 and then replace it completely with new material 30 years after the relining them.

4.2.3 Junction and Detention Basin

The life-cycle cost logic for junctions and detention basins is shown in the following table. Many of these assets are concrete and have long useful lives, while some of the various metal assets have shorter useful lives (e.g., 40 years). The cost includes the material cost as well as the labor cost for replacement. The inspection cost is derived from estimating approximate time the City staff needs to spend in order to perform visual inspection per asset.

Table 4-3 Junction and Detention Basin Management Strategies

Type	Useful Life (Years)	Replacement Cost	Maintenance Activity	Maintenance Frequency (Years)	Maintenance Cost
Catch Basin	100	$6,000 EA	-	-	-
CDS	100	$18,000 EA	Visual Inspection	3	$275 EA
Cleanout Access Cover	100	$1,000 EA	-	-	-
CMP Riser	60	$2,500 EA	-	-	-
Concrete Riser	100	$2,500 EA	-	-	-
Curb Outlet	100	$3,500 EA	Visual Inspection	3	$30 EA
Dissipater	80	$10,000 EA	Visual Inspection	3	$275 EA
Drop Inlet	100	$3,500 EA	Visual Inspection	3	$275 EA
Filtered Drop Inlet	100	$4,500 EA	Visual Inspection	3	$275 EA
Filterra	80	$10,000 EA	Visual Inspection	3	$275 EA
Grate	50	$500 EA	-	-	-
Headwall Inlet	100	$7,500 EA	Visual Inspection	3	$275 EA
Headwall Outlet	100	$7,500 EA	Visual Inspection	3	$275 EA
Hi Rate Biofilter	80	$60,000 EA	Visual Inspection	3	$275 EA
Inlet	100	$3,500 EA	Visual Inspection	3	$30 EA
Junction	100	$3,500 EA	Visual Inspection	3	$30 EA
Modular Wetland	80	$20,000 EA	Visual Inspection	3	$275 EA
NSBB	80	$60,000 EA	Visual Inspection	3	$275 EA
Outfall	100	$10,000 EA	Visual Inspection	3	$275 EA
Outlet	100	$3,500 EA	Visual Inspection	3	$30 EA
Plate	40	$500 EA	-	-	-
Plug	100	$1,000 EA	-	-	-
Slotted Drain	40	$1,000 EA	-	-	-
Vortechs	100	18,000 EA	-	-	-
Detention Basin	100	$8 per SF	Visual Inspection	3	$275 EA

4.3 Preservation and Restoration Profile

The preservation and restoration profile estimates the future financial needs for managing the assets. Preservation and restoration refers to the activities needed to sustain the assets, whether the activity is replacement, rehabilitation, or maintenance. Each asset in the register was assigned a life cycle cost. The life cycle cost logic was developed based on cost of the activities necessary to keep the asset at the desired level of service.

The life-cycle cost of each asset was calculated for a 100-year planning horizon. The planning horizon was set to 100 years to visualize and account for full replacement of all assets in the Drainage Management System, including those with long natural lives (e.g., pipes, channels). Every year, those assets requiring investment are identified and summed to generate the preservation and restoration profile. The life-cycle assessment allows the City to proactively management the assets. The City will be able to proactively 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 risk reduction is maximized with minimal expenditure.

A projection of the Drainage Management System's long-range financial needs for the next 100 years is presented in Figure 4-4. The average annualized need for the 100-year planning horizon is estimated to be $10.7 million per year. The large peaks of replacement and rehabilitation needs in these years past 2060 are mostly caused by concrete channels and box culverts constructed between 1960 and 1980. These assets will reach the end of their useful lives at the times of these peaks. Knowing when these rises in annual budget needs occur allows the City to prepare and manage their assets proactively.

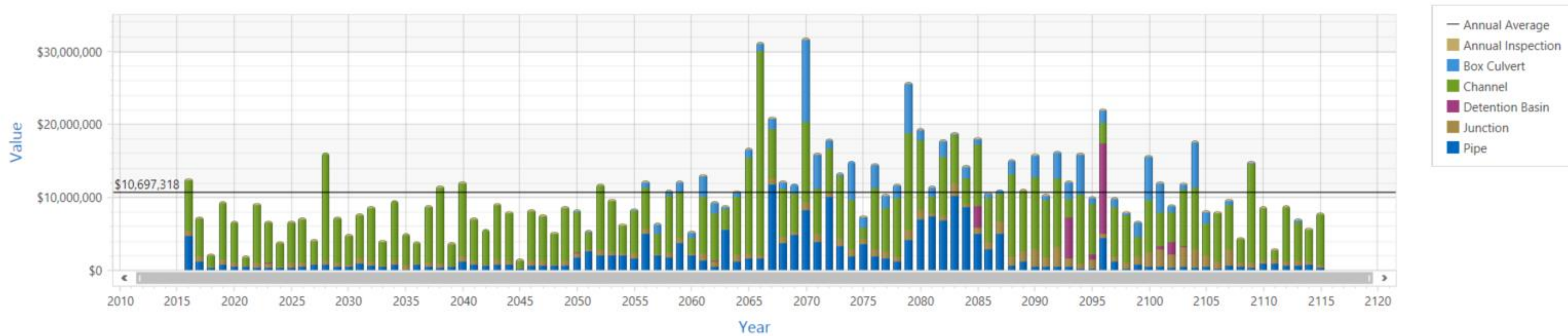


Figure 4-4 100-Year Drainage Preservation and Restoration Profile

A projection of the Drainage Management System's financial needs for the next 10 years is presented in Figure 4-5. The annual average needs over the next 10 years is approximately $6.6 million. The 10-year average is lower than the 100-year average since the projected timing of concrete structure replacements will likely to occur between 2060 to 2080.

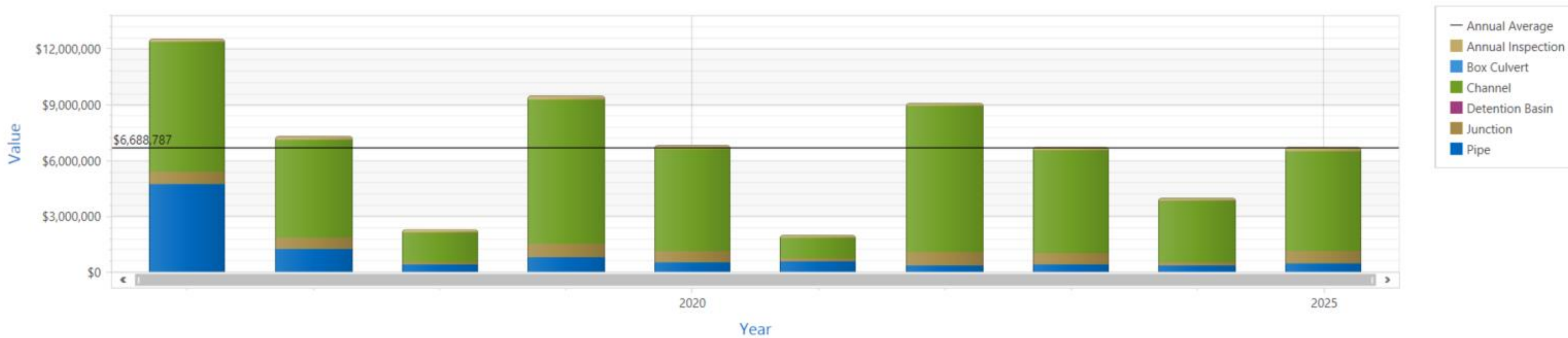


Figure 4-5 10-Year Drainage Preservation and Restoration Profile

A projection of the Drainage Management System's financial needs for the next 20 years is presented in Figure 4-7. The average annual needs over the next 20 years is approximately $7.1 million.

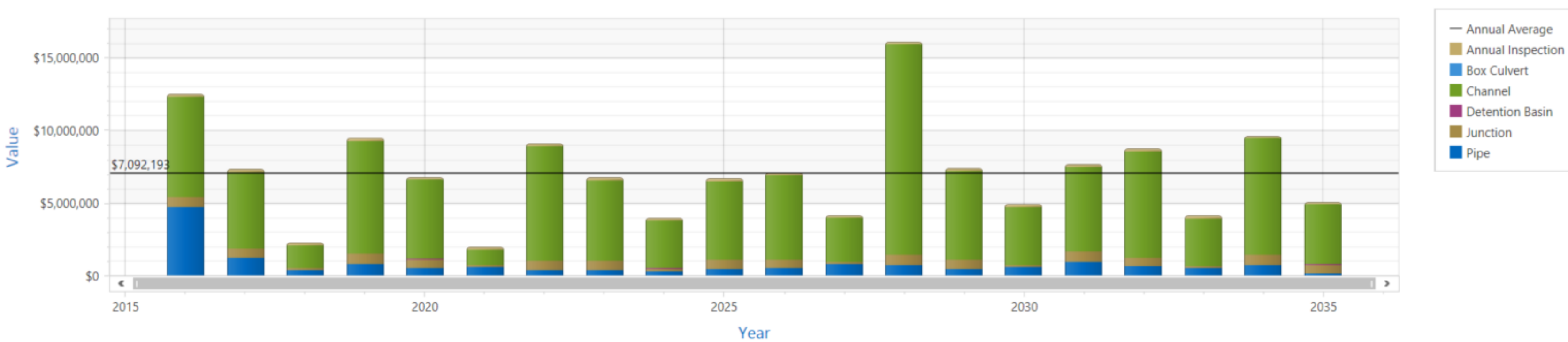


Figure 4-6 20-Year Drainage Preservation and Restoration Profile

A projection of the Drainage Management System's financial needs for the next 30 years is presented in Figure 4-7. The average annual needs over the next 30 years is approximately $7.1 million.

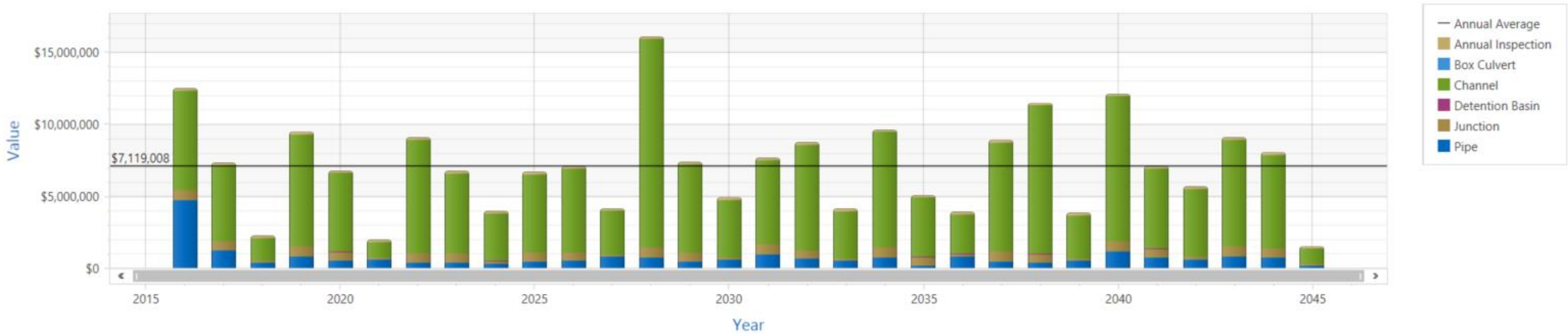


Figure 4-7 30-Year Drainage Restoration and Preservation Profile

The table below shows a summary of the annual average preservation and restoration needs for the Drainage Management System. Because many of the Drainage Management System assets that have long useful lives (e.g., concrete channels need replacement every 100 years) are in relatively good condition, the replacement of these assets is estimated to take place farther in the future. The replacement of these assets fall beyond the shorter planning horizons (e.g., 10 years, 20 years), resulting in lower average annual needs compared to the 100-year average annual needs.

Table 4-4 Average Annual Preservation and Restoration Needs

Planning Horizon	Average Annual Preservation and Restoration Needs
10 years	$ 6.7 million
20 years	$ 7.0 million
30 years	$ 7.1 million
100 years	$ 10.7 million

The following figures show the separated average annual needs for replacement versus preservation.

Figure 4-8 shows the replacement profile for the drainage assets by the first level of the asset hierarchy (i.e., box culvert, channel, detention basin, junction, pipe). The average annual needs for drainage asset replacement alone is approximately $4.5 million.

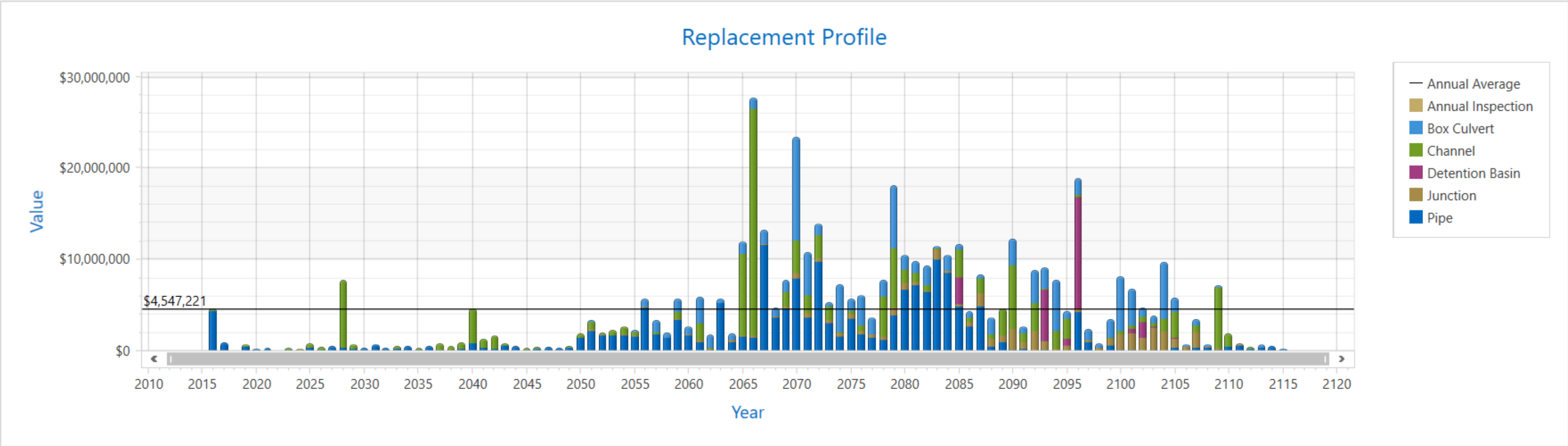


Figure 4-8 Drainage Replacement Profile

Figure 4-9 below shows the preservation profile based on the first level of the asset hierarchy (i.e., box culvert, channel, detention basin, junction, pipe). The assets that require the greatest investment are channels because channels require frequent maintenance, as shown in the life-cycle cost logic, which can have significant costs.

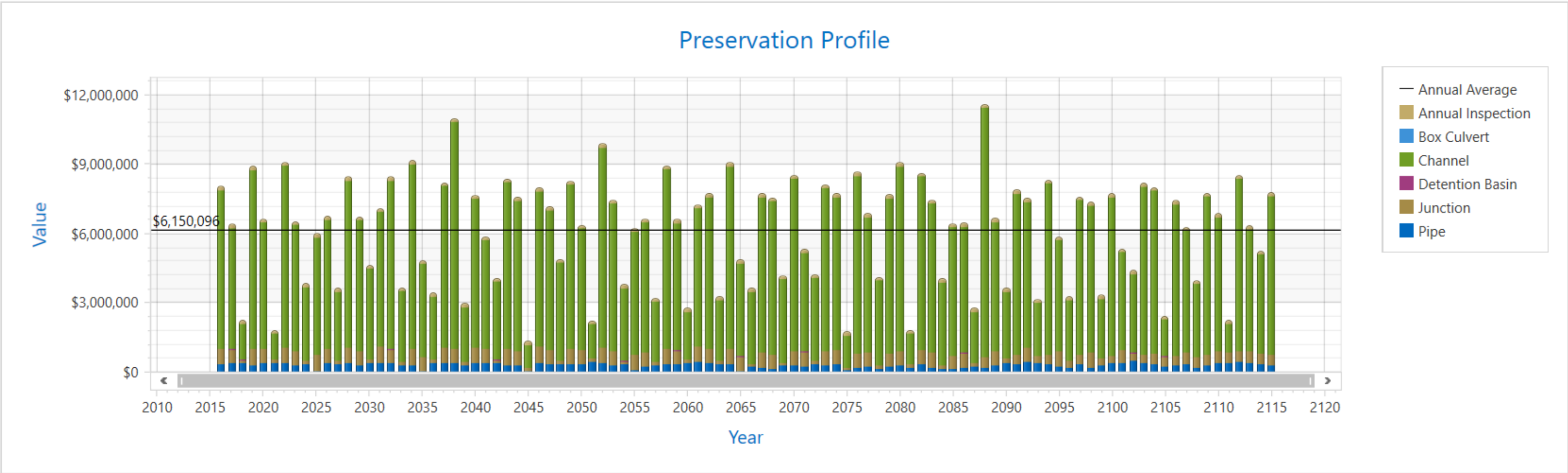


Figure 4-9 Drainage Preservation Profile by Asset Class

Figure 4-10 shows the breakdown of types of preservation. As expected, most of the investment is required for maintenance because the channel maintenance makes up most of the preservation efforts. There are other costs such as concrete rehabilitation cost, visual inspection cost for junctions, channel inspection cost, CCTV condition assessment cost for the all the pipes, and relining cost for CMPs.

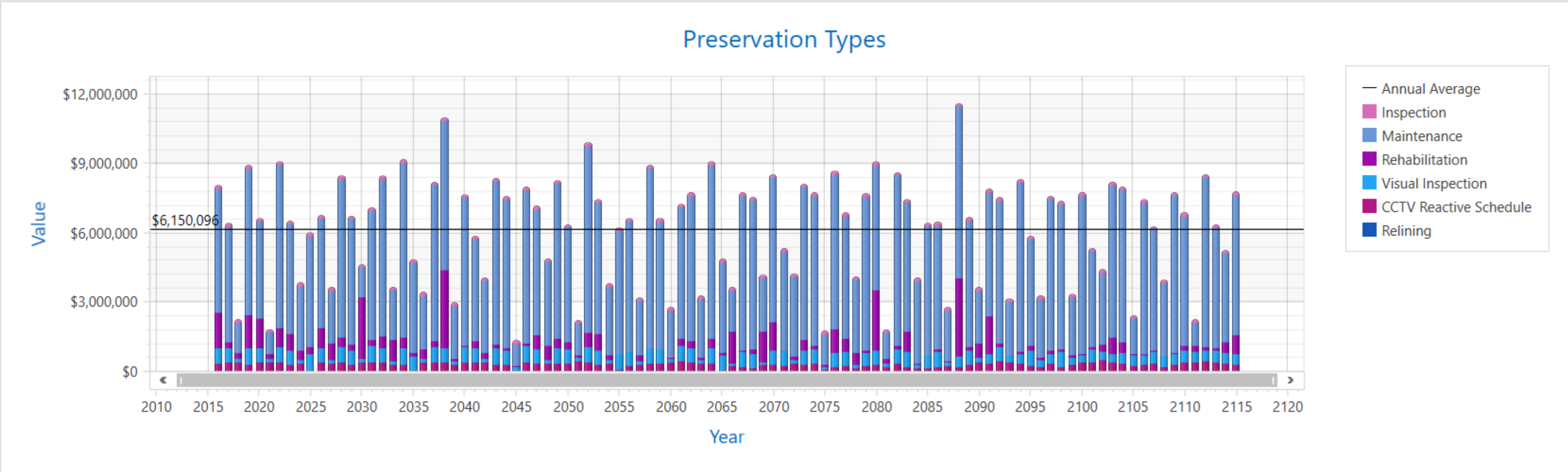


Figure 4-10 Drainage Preservation Profile by Preservation Type

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.

Table 5-2 Drainage Confidence Level

Confidence Level Factor	Confidence Level Rating Score	Weighting Factor	Weighted Confidence Level Rating Score
Asset Inventory	50%	20%	18%
Data Quality	50%	15%	7.5%
Condition Assessment	40%	20%	10%
Asset Valuation	90%	10%	9%
Life-cycle Cost Logic	60%	10%	6%
Risk	50%	10%	5%
Staff Review	90%	5%	4.5%
Technical Committee Review	0%	10%	0%
Total Score			**50%**

Asset Inventory (Unweighted Score - 50%)

While a full GIS database of all the drainage system assets exists, the accuracy and completeness of the inventory needs to be verified. As the inventory is verified, the asset inventory confidence level will rise.

Data Quality (Unweighted Score - 50%)

The data was already available in GIS. However, the data had a lot of gaps with missing information on material, drainage types, sizes, and installation years. Many assumptions were made in order to fill the data gaps. For example, missing installation years were filled by using the drawing years; if there were no drawing numbers, the recorded year map was used. The data will be improved through CCTV assessments and field work.

Condition Assessment (Unweighted Score - 50%)

Approximately 10% of the channels were visited during the condition assessment. In addition, the City has performed CCTV assessment on the CMPs in 2015, and the result of the assessment is currently being analyzed. Once the analysis is performed, the assessment data can be incorporated in the asset management program. The confidence in the condition assessment data will also rise as condition assessment is performed on other assets (e.g., other types of pipes).

Asset Valuation (Unweighted Score - 90%)

Asset replacement cost estimates were based on recent records, and confidence in the valuation estimates is high.

Life-cycle Cost Logic (Unweighted Score - 60%)

For pipes and storm drain structures, 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. The life-cycle cost logic for channels, however, required some assumptions; because the channel widths were mostly unknown, the logic was estimated based on the average width rather than the actual width of the channel.

Risk (Unweighted Score - 50%)

Condition assessment, which drives the PoF analysis, has only been performed on 10% of the channels, and the results of the recent CCTV assessment for the pipes are still in progress. A robust CoF calculation methodology was developed with input from City staff. As the data quality improves and the condition assessment has been analyzed, the risk level confidence score will rise.

Staff Review (Unweighted Score - 90%)

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

Technical Committee Review (Unweighted Score - 0%)

The technical committee will review the results of this asset management plan and its analysis.

5.1 Next Steps

The following areas are the next steps that will be taken to further improve the Drainage Asset Management Plan.

Data Quality

Some of the channel attributes are not complete. In order to close the data gap, assumptions were made. For example, in many cases, installation year was not provided. In that case, the installation year was derived from the drawing number, nearby/connected asset, or from recorded map data. It is recommended that the City gather all the information, including using field verification and inspection, in order to develop more accurate cost assumptions and life-cycle cost logic. In addition, the data needs to be continuously updated and maintained in order to keep a record of all the activities done to the asset.

Also, the GIS data had inconsistent naming convention and data schema throughout. For example, the channel data had channel type information under the material (e.g. brow ditch, channel) instead of listing the material of the channel.

Condition Assessment

As mentioned in the report, condition assessment was only performed on a sampling of the Drainage Management System assets. In the future, condition assessment should be performed on the remaining assets for the most accurate analysis and future preservation and restoration needs.

Levels 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 Drainage Management System will be to establish levels of service.

Risk

The City has agreed on scoring criteria set for determining the CoF score. Although the CoF score will not change unless there will be changes made to the scoring criteria, the PoF score will change depending on the condition of the asset. It is highly recommended that the City continues to collect and update the condition data in order to further improve the PoF scores, and maintain consistency among scoring, which will be aided by the updated maintenance guidelines. It is recommended that assets such as storm drain pipes be inspected using CCTV at least every 10 years in order to assess the condition.

Life-cycle Cost Logic

Assumptions, such as useful life, were made based on the deterioration characteristics of certain asset classes. In the future, the useful life can be further improved by keeping record of replacement and rehabilitation data. Furthermore, the life cycle cost logic is also affected by LOS. If there are changes in the LOS, then the life cycle cost logics will need to change in order to meet the new LOS.

Appendix A

The table shown below shows the detail result of the condition assessment result for channels.

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Brow Ditch	Mn16 675	1987	Concrete	102	2		2		
Brow Ditch	Mn17 198	1987	Concrete	1,122	2				
Brow Ditch	Mn14 266	1990	Concrete	681	2				
Brow Ditch	Mn14 612	1980	Concrete	404	3	Minor surface wear, minor cracks	1		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Brow Ditch	Mn16 894	1990	Concrete	767	2		1		
Brow Ditch	Mn14 550	1988	Concrete	393	2		1		
Brow Ditch	Mn15 078	1992	Concrete	42	2				

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Brow Ditch	Mn24 012	2003	Concrete	1,014	1	New			
Chan nel	Mn15 247	1976	Concrete	703	2		3		
Chan nel	Mn17 319	1988	Concrete	318	2		1		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn17541	1979	Concrete	42	4	Major spalling/cracks (exposed rebar)	2		
Channel	Mn24358	1978	Concrete	334	2				
Channel	Mn14862	0	Natural	657			4		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15093	1990	Concrete	40	2		3		
Channel	Mn16163	1977	Concrete	74	3	Minor spalling/cracks	3		
Channel	Mn14614	0	Natural	1,960			3		
Channel	Mn15769	0	Natural	318			3		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Chan nel	Mn15 784	1970	Concrete	853	2	Minor surface wear, Minor spalling/ cracks	1		
Chan nel	Mn15 781	1992	Concrete	1522	4	Major root problem	4		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15081	1992	Riprap	238	4	Major root problem	4		
Channel	Mn14425	1995	Concrete	397	2		3		
Channel	Mn15782	1970	Concrete	1,454	2	Minor surface wear, Minor spalling/ cracks	3		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15783	1970	Concrete	1,340	2	Minor surface wear, Minor spalling/ cracks	1		
Channel	Mn17667	1997	Concrete	878	4	Erosion, No stabilization			
Channel	Mn17685	1998	Concrete	1381	2		1		
Channel	Mn14863	0	Channel	137			4		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Chan nel	Mn24 354	1995	Concrete	328			4		
Chan nel	Mn15 778	1981	Concrete	480			2		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15780	1978	Concrete	225	2		2		
Channel	Mn17681	1978	Concrete	952	4	Major spalling/cracks (exposed rebar)	2		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Chan nel	Mn17 683	1978	Riprap	118	2		4		
Chan nel	Mn15 773	1995	Concrete	2,038	2	Minor spalling/cr acks	2		
Chan nel	Mn15 775	1980	Concrete	285			2		

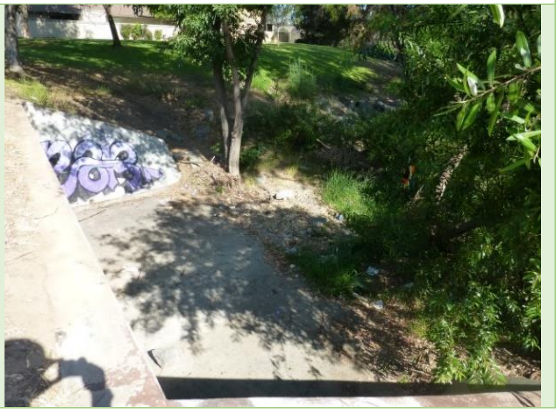
Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15777	1980	Concrete	455			2		
Channel	Mn15135	0	Natural	2,026	5	Major erosion	5		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn15377	1987	EC	933	2		1		
Channel	Mn22770	0	Connect	12			1		
Channel	Mn17287	1967	Concrete	1,599	2		1		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Chan nel	Mn17 290	1966	Concrete	1,663	2		3		
Chan nel	Mn14 613	0	Natural	157			5		
Chan nel	Mn14 615	0	Natural	40			5		
Chan nel	Mn16 165	0	Natural	111			5		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Channel	Mn16166	0	Natural	57			5		
Channel	Mn16167	0	Natural	81			5		
Channel	Mn22578	0	Natural	11			5		
Channel	Mn15619	1987	EC	892	2				

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Chan nel	Mn14 876	2001	EC	2,507	2		5		
Chan nel	Mn22 768	0	Connect	17			5		
Chan nel	Mn22 769	0	Connect	57			5		
Chan nel	Mn14 882	2001	EC	2,422	2		5		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Stream	Mn14 198	0	Stream	584			4		
Stream	Mn14 100	0	Stream	1,448			1		
Detention Basin	DB25	1996		13,405			4		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Clean out Access Cover	JC5406	1989					1		
Clean out Access Cover	JC4669	2001					1		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Dissipater	JC6292	1987					1		
Drop Inlet	JC383	1995					4		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Head wall Outle t	JC335 5	1977					2	3-Minor blockage (trash/small debris)	
Head wall Outle t	JC335 7	1980					4	Major blockage (large debris)/ Tree blocking	

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Head wall Outle t	JC335 9	1989					4	Major blockage (large debris)	
Head wall Outle t	JC505 2	1975					4	Major blockage (large debris)	

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Head wall Outle t	JC629 1	1987					1		
Outfa ll	JC164 70	1987					1		

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn23 635	2003	Concrete	47			2		
Pipe	Mn23 636	2003	Concrete	141			2		
Pipe	Mn33 49	1966	CMP	36	5	Excavate and replace existing pipe			

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn5312	1974	CMP	165	5	Excavate and replace existing pipe			
Pipe	Mn12993	1979	CMP	77	5	Excavate and replace existing pipe			
Pipe	Mn4192	1971	CMP	53	5	Excavate and replace existing pipe			
Pipe	Mn18027	1971	CMP	53	5	Excavate and replace existing pipe			
Pipe	Mn3719	1981	CMP	113	5	Excavate and replace existing pipe			

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn12989	1959	CMP	38	5	Excavate and replace existing pipe			
Pipe	Mn99999	1989	CMP	8	5	Excavate and replace existing pipe			
Pipe	Mn4590	1974	CMP	11	5	Excavate and replace existing pipe			
Pipe	Mn10037	2003	CMP	513	5	Excavate and replace existing pipe			
Pipe	Mn11380	2000	CMP	534	5	Excavate and replace existing pipe			

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn13 570	1990	CMP	132	5	Excavate and replace existing pipe			
Pipe	Mn17 38	1951	CMP	77	5	Excavate and replace existing pipe			
Pipe	Mn17 41	1951	CMP	39	5	Excavate and replace existing pipe			
Pipe	Mn35 27	1969	CMP	62	5	Excavate and repair severe deformati on; line with CIPP liner			
Pipe	Mn33 48	1966	CMP	110	5	Excavate and replace existing pipe			

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn11 229	1961	CMP	27	5	Excavate and replace existing pipe			
Pipe	Mn10 262	1970	CMP	37	5	Excavate and replace existing pipe			
Pipe	Mn35 17	1969	CMP	39	5	Excavate and replace existing pipe			
Pipe	Mn10 140	1971	CMPB	82	5	Excavate and replace existing pipe			
Pipe	Mn18 033	1971	CMPB	82	5	Excavate and replace existing pipe			

Type	Asset ID	Install Year	Material	Length (ft)	Structural Condition	Structural Condition Comment	Maintenance Condition	Maintenance Condition Comment	Image
Pipe	Mn23 039	1974	RCP	318	5	Broken (hole in the pipe)