Los Angeles County
Metropolitan Transportation
Authority
One Gateway Plaza
3rd Floor Board Room
Los Angeles, CA

Metro

Board Report

File #: 2019-0504, **File Type:** Informational Report **Agenda Number:** 38.

EXECUTIVE MANAGEMENT COMMITTEE
JULY 18, 2019

SUBJECT: OFFICE OF THE INSPECTOR GENERAL REPORT, "IS LA METRO READY FOR CLIMATE CHANGE?"

ACTION: RECEIVE AND FILE

RECOMMENDATION

RECEIVE AND FILE Office of the Inspector General Climate Change Report, "Is LA Metro Ready for Climate Change?"

ISSUE

- Determine the anticipated impact of climate change on the transportation industry,
- Determine what actions LA Metro has already initiated to prepare for climate change,
- Benchmark against other transit agencies climate resilient actions,
- Determine what future steps LA Metro might take to prepare for climate change,
- Make recommendations for LA Metro to better prepare for meeting the effects of global warming.

BACKGROUND

The Office of the Inspector General (OIG) conducted a review to determine actions taken by LA Metro to address the impact of climate change on transit and identify best practices. During a board meeting in January 2019, LA Metro's Board Chair stated: "I don't think LA Metro is ready for climate change." This report is to show how LA Metro is preparing for climate change and recommend additional steps LA Metro might take. Our review found that LA Metro has been taking positive steps since 2007 in preparation for climate change; however, we identified additional steps LA Metro can take to ensure the agency continues to deliver safe and reliable public transportation service to customers under future more extreme weather conditions.

DISCUSSION

Climate change is occurring globally with notable effects on the environment. There have been more frequent and erratic weather variations such as extreme high temperatures, strong storms, heavy rainfall, flooding of rivers and the coastline, and sustained drought. Global warming, one symptom of climate change, refers to rising temperatures caused by increased concentrations of GHG in the atmosphere. Climate scientists from 185 countries, with thousands of pages of research, recognize the adverse impact of climate change and have committed to working together to reduce atmospheric CO_2. Erratic rainfall and sea level rise are other symptoms of climate change. Sea level rise is from two factors related to global warming: the added water from melting ice glaciers and the expansion of seawater as it warms. In the last century the California coast line has risen 7 inches and is expected to rise an additional 10 to 18 inches by 2050 because of global warming.

This review was conducted to determine what actions have already been done to prepare for climate change, identify climate resilient options, and determine additional actions needed to address the impacts of anticipated future conditions. To identify industry “best practices,” the OIG researched other transit agencies in our nation, and around the world to determine what is being done to mitigate the impacts of climate change.

National Innovations

The OIG “bench-marked” transit agencies in two hot climate cities and found significant innovations to counter climatic changes for LA Metro’s consideration.

In Las Vegas, Nevada, RTC has multiple indoor chill stations for patrons to wait for the bus out of the heat, water wagons drive the bus routes to hand out complementary water bottles to patrons, and has solar powered shade shelters with LED lighting for their passengers. In the summer, buses run with balloon tires filled with pure nitrogen to improve tire wear and provide a safer transit experience.

In Phoenix, Arizona, Valley Metro has installed an additional air conditioning condenser on the roof of its buses which increases cooling capacity by 60%. They also installed special electric engine cooling fan systems to protect engines from overheating. Their Operations and Maintenance Center is powered by solar energy. They have installed of shade canopies on light rail platforms made from fabric that blocks the sun rays. Additionally they have bus shelters with solar powered cool air ventilation system that is push button controlled by passengers. Valley Metro light rail trains employ solar reflective window tint, train bodies painted with solar reflective paint, and two over-sized AC units for redundancy are placed on each light rail vehicles, all of which enhances cooling inside the passenger compartment. Also, the agency partnered with a local refrigeration school to provide custom AC and electrical training programs unique to Valley Metro’s buses and rail cars. Graduate students are then eligible for hire, thus creating community opportunities.

Global Innovations

The cities of Hong Kong, Melbourne, Singapore and London stood out as “benchmarks” for innovation.

In Hong Kong, the Mass Transit Rail (MTR) uses regenerative braking technology to convert kinetic energy produced by the breaking process into electrical energy and puts that power back into the power supply network, with use of a super-capacitor energy storage devices.

In Melbourne, Australia, Metro Trains Melbourne (MTM), monitors real-time rail track temperatures, by installing electronic monitoring sensors in its rail lines, so that control authorities know exactly when actual track temperatures reach 131°F or higher and can immediately restrict speed limits.

In London, Network Rail has installed mini weather-stations and thousands of track-side probes to monitor the local trackside conditions (on above ground tracks). When the weather is hot, Network Rail slows down the trains to mitigate the effects of extreme heat creating track displacements due to rail buckling. Network Rail uses speed restrictions at vulnerable locations.

In Singapore, Land Transport Authority (LTA) has instituted smart bus-stops. These are equipped with the Airbitat Oasis ventilation systems which have several overhead nozzles mounted on the inner roof, and draws from a reservoir of cold water which cools and purifies the air while removing harmful particles. The cool air that is pumped out through the overhead nozzles is more than 90 percent cleaner than the air that surrounds these stations.

Los Angeles County

In California, transportation accounts for nearly 40% of all greenhouse emissions. In 2018, the Governor signed an Executive Order calling for the State to slash its overall emissions to zero by 2045. He also signed Senate Bill 100 stating, “Not only is California going to slash its emission to zero but shall have 100% of total electricity retail sales in California to come from eligible renewable energy resources and zero-carbon resources by 2045.”

LA Metro’s Environmental Compliance and Sustainability Department (ECSD) has put together a series of reports, policy, training, and environmental management systems that complement these state environmental goals. ECSD is proactive in climate change mitigation and adaptation with “key” performance goals of reducing GHG emissions and making the LA Metro system more resilient to extreme weather events and effects of global warming.

The OIG interviewed multiple LA Metro bus and rail operations officials and found:

1. During the peak summer months, buses undergo significantly more maintenance.
2. The LA Metro bus department tested a few electric buses, however the existing design failed to meet the LA Metro’s service requirements.
3. The trolley wire system and the OCS have maintenance issues during very hot periods. High

heat causes the wires to sag and lead to entanglements with the train's pantograph and the contact wire. Newer spring stack technology is available to control sagging wires.

4. The rail tracks need to be continually monitored during sustained hot weather for buckling, cupping, and sun kinks. The current method of walking the track and ordering reduced speed to the train drivers, is the way the track is currently monitored for any track anomalies.
5. Pre-stressing the rail at the temperature in the geographic location prior to installation (for new rail) is the predominate method that LA Metro currently utilizes. Pre-stressing the rail at the projected temperatures for the geographic location based on the latest climate models should be implemented as temperatures are projected to increase dramatically.
6. There are no electronic monitoring track sensors to immediately measure rail temperatures over periods of sustained heat. Deploying the most modern technology of monitoring rail track sensors should be implemented as temperature increase.
7. The ROC currently has no instrumentation to monitor weather and temperature conditions in real time other than the media and one location at Division 20. The ROC could run more efficiently with the ability to have current "real time" weather information. It would be beneficial for efficient train operation to deploy mini weather-stations to monitor the local trackside conditions at strategic key locations based on variability in micro-climates.

LA Metro has initiated many actions to address climate change and work towards achieving the State mandated emission goals. While much has been done, the OIG team found there are other actions that LA Metro could implement using the benchmarks stated in the OIG climate change report, "Is LA Metro Ready for Climate Change?"

The evidence the team discovered found, the system will be impacted when Los Angeles has sustained heat temperatures approaching those of Phoenix, Las Vegas, or Melbourne. The LA Metro System should continue to innovate and update its operations if LA Metro is to achieve the systemic LA Metro goal as stated in the 2019 draft CAAP report of having zero GHG emission by 2050. While much has been done, there remains much to do if LA Metro is to be effectively positioned to meet the demands that climatic changes will put upon this system in the near-term and the future. Metro has the responsibility to conform to California State Laws established by the Governor. Therefore, Metro ECSD should be involved in purchases for new construction of LA Metro transit system and facilities when it pertains to climate change and the warming that will continue to increase.

Our report makes 32 recommendations for LA Metro to consider implementing to prepare for the impacts of climate change. These recommendations are suggested tactical strategies; not dictates or policies. We make these suggestions without regard to cost, which we have not researched and would be dependent on many factors. Metro does not possess unlimited funds. Fiscal responsibility of the public's dollars is an essential guiding principle that we would have to be mindful of in selecting the most appropriately prioritized options.

FINANCIAL IMPACT

The financial impact is undetermined at this time and is dependent on what options Metro chooses to implement to address the impacts of climate change for the agency.

IMPLEMENTATION OF STRATEGIC PLAN GOALS

Recommendations in this report support strategic plan goal #2. The strategic goal states, “Deliver outstanding trip experiences for all users of the transportation system.”

NEXT STEPS

Recommendations are provided for multiple departments within LA Metro to consider and implement as they determine. LA Metro departments are asked to provide a written response to the OIG within 90 days.

ATTACHMENTS

Attachment A - Final OIG Climate Change Report

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Reviewed by: Karen Gorman, Inspector General, (213) 244-7337

Attachment A
Legistar File No. 2019 - 0504

Los Angeles County
LA Metropolitan Transportation Authority
Office of the Inspector General

"Is LA Metro Ready for Climate Change?"

Report No. 2019 – 0021 **July 18, 2019**

Metro

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Is LA Metro Ready for Climate Change?

DATE: July 18, 2019

TO: LA Metro Chief Executive Officer
LA Metro Board of Directors

FROM: Karen Gorman, Inspector General
Office of the Inspector General

SUBJECT: "Is LA Metro Ready for Climate Change?" Report No. 2019-0021, Legistar File No. 0504, July 2019 Executive Committee

I. INTRODUCTION

The Office of the Inspector General (OIG) conducted a review to determine actions taken by LA Metro to address the impact of climate change on transit and identify best practices. During a board meeting in January 2019, LA Metro's Board Chair stated: "I don't think LA Metro is ready for climate change." This report is to show how LA Metro is preparing for climate change and recommend additional steps LA Metro might take. Our review found that LA Metro has been taking positive steps since 2007 in preparation for climate change; however, we identified additional steps LA Metro can take ensure the agency continues to deliver safe and reliable public transportation service to customers under future more extreme weather conditions.

II. PURPOSE

The objective of this review was to:

- Determine the anticipated impact of climate change on the transportation industry,
- Determine what actions LA Metro has already been initiated to prepare for climate change,
- Identify climate resilient actions other transit agencies have implemented,
- Determine what future steps LA Metro might take to prepare, and
- Make recommendations for LA Metro to better prepare for meeting the effects of global warming.

III. METHODOLOGY

To accomplish our objectives, we performed the following:

- Interviewed Environmental Specialists from LA Metro's Environmental Compliance and Sustainability Development,
- Interviewed staff from Bus Operations and Maintenance Department,
- Interviewed staff from Rail Operations Control (ROC),
- Interviewed staff from Rail Operations,
- Interviewed staff from Wayside System,

- Interviewed staff from Global ASR Consulting Inc.,
- Interviewed staff from Safety Certification and Operations Management
- Reviewed the Draft 2019 Climate Action and Adaptation Plan (CAAP), Legistar File No. 2019-0489 present in July 2019 Executive Committee meeting,
- Conducted research of other transit agencies, studies, and articles on climate change,
- Interviewed executive staff at Las Vegas Regional Transportation Commission, and
- Attended LA Metro's G-Pro training course to better understand sustainability.

IV. SCENARIO

Jane stepped off the air-conditioned LA Metro train and onto the platform, as the doors open she is blasted by the sweltering heat.

Joe was running to catch his bus, but the bus pulled away before he could cross the street. It was 20 minutes before the next scheduled pickup. Patiently he waited with no bench, no shelter, no misters to decrease the temperature, and no water bottle.

Do these scenarios seem unfamiliar to Los Angeles, California? Currently, extreme weather events are occurring everywhere including most prominently high heat days. Even though Los Angeles experiencing good rainfall in 2019, during the last year the effects of global warming have been occurring in our landscape; rivers are drying up, soil hardening from lack of rain and hot dry winds are reducing plant life. Along coastlines, high tides are mixing salt water with fresh, poisoning fish and killing what was beautiful wetlands, flora and fauna. In other areas, wildfires are scorching thousands of acres and destroying entire communities.

What do these changes have to do with the LA Metro system? This report examines what other transit properties are doing, discusses unique problems faced by LA Metro, and discusses known vulnerabilities and how the LA Metro system is attempting to strategically position itself to deal with these challenges.

V. PROLOGUE

Is LA Metro ready for climate change? What does the future look like – Let's think ahead. What is the impact, if LA Metro does not fully embrace and speed up preparation? Global warming and climate change are reality, those facts are inescapable. No one can accurately predict the dates and degree of change; but, increases in temperature aren't far away. We can "benchmark" actions by other transportation agencies where have been operating under similar warmer conditions.

VI. BACKGROUND

In the first two decades of the 21st Century, global climate change has had notable effects on the earth's environment. Glaciers have shrunk resulting in loss of sea ice, accelerated sea level rises, more drought periods, and longer intense heat waves. Climate change refers to the increasing temperature changes over a period of time including: erratic temperatures, drought, heavy precipitation, varying wind patterns, inland flash floods, sea level rises, ground water salinization, and wildfires.

Figure 1: Greenhouse gas emission by industries

Global warming is one symptom or aspect of climate change and is due to increasing concentration of greenhouse gases (GHG) in the atmosphere. Global warming refers to the earth's rising temperature. The atmosphere is warming from the rapid increase in carbon dioxide (CO_2). CO_2 is released from the burning of fossil fuels such as coal, oil, and gas (also referred to as heat trapping gases). The world's largest CO_2 emitter is China, but the three countries with the most at stake from climate change are the United States, India, and Saudi Arabia.[1] The following graph shows the major contributing countries of CO_2.

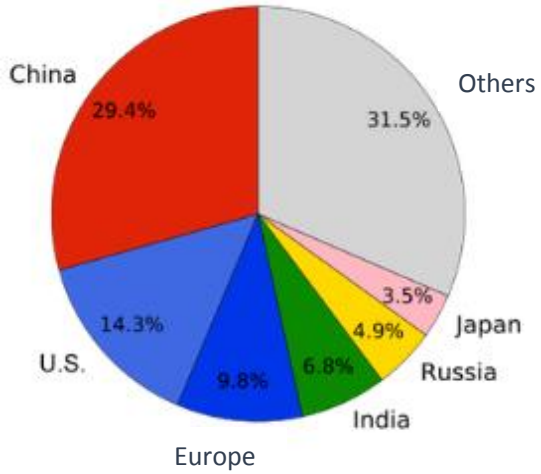


Figure 2: Global carbon dioxide emissions by country[2]

The following graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has significantly increased since the Industrial Revolution.

Figure 3 : Increase in atmospheric carbon dioxide; Ice Age to present[3]

Under the United Nations, the Paris Climate Agreement was signed in 2016 by 185 countries who agreed to reduce greenhouse gases within their countries. Each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. Although the President Trump backed out of the Paris Agreement, the U.S. Climate Alliance has been created. Through that group twelve states, Puerto Rico, 396 U.S. mayors, private industry, and nonprofit institutions joined together to work on environmental improvements in their communities.[4]

The Intergovernmental Panel on Climate Change (IPCC), is a combination of 1,300 scientists from multiple countries. They released the fifth National Climate Assessment Report in Korea in 2018. A key finding is that the earth temperature will increase between 1.8 to 5.4 degrees Fahrenheit in the next few decades and up to 10 degrees Fahrenheit in the next century.[5] Ocean acidity will intensify from increasing CO_2 as the temperature rises, which will have adverse effects on ocean life from algae to fish. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases that are emitted globally.

In 2018, Governor Brown signed Executive Order B-55-18 calling for California to slash its overall emissions to zero by 2045 and thereafter go negative in the generation of these gases.[6] He also signed Senate Bill number 100 stating:

> "100 percent of total retail sales of electricity in California to come from eligible renewable energy resources and zero-carbon resources by December 31, 2045. In order to attain a target of generating 20 percent of total retail sales of electricity in California from eligible renewable energy resources by December 31, 2013, 33 percent by December 31, 2020, 50 percent by December 31, 2026, and 60 percent by December

> 31, 2030, it is the intent of the Legislature that the commission and the Energy Commission implement the California Renewables Portfolio Standard Program."[7]

Erratic rainfall is another symptom of climate change. Extreme rainfall combined with coastal flooding and hurricanes has severe consequences. Increasing heavy rain leads to more soil erosion and nutrient loss on croplands. Decreases in rainfall cause drought. Severe reduction in rainfall affects agriculture and therefore food production and our economy.

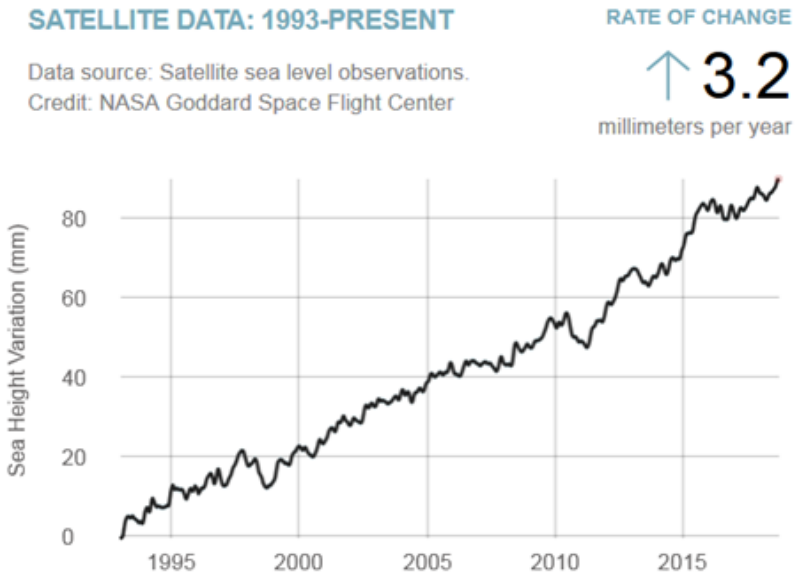
In California, flooding seems rare but periods of increased rain lead to denser vegetation growth. In summer months, higher temperatures dry out the vegetation and soil, creating conditions ripe for wildfires to develop.[8] Climate change is affecting the California rainy season, thus extending the fire season. Climate change is also shifting the Santa Ana winds that fan wildfires in Southern California. The University of California at Davis forecasts that the area burned by Southern California wildfires will increase by about 70 percent by mid-century as a result of the drier, hotter, and windier conditions caused by global warming.[9]

Figure 4 : Flooding from sea level rise
Imperial Beach, San Diego CA.

Sea level rise is another symptom of climate change.[10] The oceans are losing the electro logical effect that breaks down hydrogen and oxygen.[11] This process is now creating dead zones (areas of excessive pollution that deplete oxygen required for marine life) in places such as San Francisco bay and the Gulf of Mexico. As the ocean water table reaches the land ground water table level, subterraneously salt will leach in and destroy the trees. Trees use the carbon dioxide and give off oxygen, but trees are dying from the leaching of salt water. Louisiana, the mouth of the Mississippi river, Gulf of Mexico and Florida experience the same phenomenon where the leaching of salt water creates brackish water, consequently the vegetation is dying.

The Los Angeles river ground water table is higher than the river bottom in certain areas and concrete could not be laid on the bottom. This has created multiple problems over the past 5 decades including the mixing of salt water with the ground water table and killing trees. Additionally, since the early 1920's, firms have drilled to extract petroleum, which leaves holes and consequently lowers the water table. The ground in the Los Angeles basin is very porous because there are pockets of petroleum in Los Angeles County. These pockets of porosity allow the rising ocean water to flow-inland and mix with the land water tables. As the salt water mixes and the plants die, California becomes charred as wildfires break out in the valleys and canyons.

Sea level along the California coast has risen 7 inches in the last century. Climate changes scientists are expecting an additional 10 to 18 inches of sea level rise by 2050. Higher sea levels will compound the effects of coastal storms and increase the chances for coastal flooding.[12]



80mm = 3.15 inches in 25 years

Figure 5 : Change in sea level from 1993 to present[10]
Global Ocean rise

Sea level rise is caused primarily by two factors related to global warming: the added water from melting ice sheets and glaciers and the expansion of seawater as it warms. The above graph tracks the change in global sea level since 1993 as observed by satellites.[10]

What does this imply for the LA Metro transit system? To consider how these factors and impacts of climate change might affect our transit system and how to prepare, it is necessary to see what other transit systems, in places already affected by a warmer climate, have done to mitigate, remediate, and prepare for keeping their patrons safe and their system functioning in increased heat.

VII. OTHER TRANSPORTATION AGENCIES

A. NATIONAL

For this report, the OIG's main focus of climate change is extreme heat, therefore the OIG staff researched two transit agencies that operate in extreme heat conditions and sustained drought to better understand problems that might affect LA Metro when climatic change increases the temperature in Los Angeles County. Phoenix is rated the 3rd hottest city in the world and Las Vegas is close behind as the 7th hottest city in the world. These cities were chosen as "baseline" comparison cities because of their extreme heat.[13]

Las Vegas, Nevada

The Las Vegas Regional Transportation Commission (RTC) provides bus service (no public rail, only short privately built monorail behind the Las Vegas strip) in the Las Vegas Metropolitan area of Clark County, Nevada. During the summer, temperatures have reached 122°F, so RTC

sets up a summer heat campaign that includes "chill stations." There are twelve chill stations located at transit centers and bus stops where RTC employees provide complimentary bottled water to riders. RTC employees also remind passengers to avoid direct sun, stay hydrated, use sunscreen, wear light clothing and hats, and use umbrellas. Moreover, RTC employees use their company "access vans" as water wagons to drive along the bus route and hand out cold bottled water to the passengers who are waiting outside for the bus. They also advise passengers to download the "RideRTC" application, use the "RideTracker" or text "RideRTC" to track their bus in real-time in order to help minimize the time spent waiting outside for the bus under extreme hot conditions. They encourage passengers to wait inside until 5-7 minutes before the RideRTC application indicates when the bus will arrive at their stop.[14]

RTC installed many solar-powered bus shelters throughout the Las Vegas Valley. These shelters feature solar panels and energy saving LED lighting. They provide shade for passengers and have enough room to accommodate a passenger in a wheelchair or other mobility device.[15] There are two kinds of shelters: one has a flat top and the other has a dome top. The older flat top units provided limited shade, whereas the new dome top shelters provide considerably more shade.

When the temperature is at 105^{o} Fahrenheit or higher or when there is a power outage, the Local Emergency Center, which is run by Clark County, opens their shelter, and RTC provides shuttle transportation for people who want to utilize the shelter.[16] RTC and County authorities use television, newspaper, and social media such as Facebook, Twitter, and Instagram to warn the public about the temperature rise and to announce the opening of the emergency shelter.

RTC has found that everything made from rubber deteriorates more quickly in the sustained heat of Las Vegas. The hoses, belts, and tires on RTC buses are replaced more often during periods of sustained summer heat. This foretells for LA Metro higher inventory requirements for transportation properties to plan for as temperature increase. RTC operates with about a 20% contingency of spare vehicles but they exceed that capacity every year.[17]

RTC bus tires (balloon tires) are filled with pure nitrogen gas because nitrogen is less likely to migrate through the rubber tire than oxygen. Tires filled with nitrogen exhibit less pressure change with temperature swings. During the summer months, buses run with balloon tires which are bigger, fatter and ride softer compared to normal tires because it allows heat to dissipate more effectively (as there is more room for the tire to expand).

RTC buses are fitted with plexiglass on the top and sides of the bus and reflecting films are installed on the glass to lower the temperature of the bus. These reflecting films can reduce the temperature inside the bus by as much as 15^{o} F.

Phoenix, Arizona

Buses

About 95% of Valley Metro buses use Compressed Natural Gas (CNG) and they also have 30 hybrid electric diesel buses.[18] Unlike other transportation agencies, there is an additional air conditioning condenser on the roof of the buses. These condensers remove the heat from the inside of the vehicle and keep the air condition (AC) from shutting down during hot days. This retrofit increases the effective cooling capacity of the air conditioning by 60%. To improve performance, Valley Metro purchased new buses with a special electric engine cooling fan

system. This engine cooling system protects the engine from overheating. Valley Metro also minimizes water usage by using recycled water. They wash their buses with recycled water which saves approximately 122 gallons a month per bus, which reduces reoccurring demands for fresh water usage by 60%. Moreover, some bus shelters have louvers designed to enhance breezes, shade and reduce the temperature of the waiting area.[19]

Solar Power Facilities

Valley Metro Operations and Maintenance Center is powered by solar energy. The solar plant is comprised of 2,800 solar voltaic panels, which are mounted at ground level and on parking lot shade canopies.[20] In addition, light rail platform shade canopies are made of a fabric that effectively blocks sun rays, which reduces the heat that would result from metal canopies. There are solar powered cool air ventilation systems installed at three light rail stations. They are equipped with a button near the seating area that controls air conditioning for passengers.

Rail

The Valley Metro Rail system operates in summer temperatures of 118°F - 123°F. Light rail trains have window tint that is solar reflective. Rail cars have a special film that reduces the sun rays going through the windows. Moreover, the body of these trains is painted with solar reflective paint. Installation of these solar reflective measures reduces cooling loss inside the passenger compartment. During hot summer months, AC units run full time in the trains. Valley Metro ensures that train air condition systems are in good condition especially when temperatures are forecasted to rise. Like LA Metro, they inspect the AC and other key components during the spring. These inspections identify weak components that need repair or replacement in order to avoid failures during service periods in sustained heat. On each light rail vehicle, there are two over-sized AC units. Redundancy is required so when one of the units breaks down, the other continues to work providing cool air. Moreover, Valley Metro's director of maintenance reached out to the Refrigeration School Incorporated (RSI) in Phoenix. RSI is a private technical school that teaches custom training on Heating Venting Air Condition (HVAC), refrigeration, and electrical programs. Valley Metro partnered with RSI to develop customized training for current employees and creates a future workforce for Valley Metro.[21]

B. GLOBAL

We examined what international public transportation agencies are doing to address the challenges of climate change, with the goal of benchmarking "best practices" to better prepare for periods of sustained high heat. We researched four Metropolitan areas: Hong Kong, Melbourne, London and Singapore. The reasons for our looking at these sites are:

1) Hong Kong has created a very sustainable public transportation system,
2) Melbourne, Australia is the 4th hottest city in the world with a rail system,[13]
3) London's Underground is the oldest Metro system in the world and
4) Singapore has been rated one of the best and most affordable public transportation systems.

We found some similarity amongst these cities and their responses to climate change that parallels what LA Metro has already been doing, but there are additional innovations that LA Metro could implement.

Hong Kong

In Hong Kong, the Mass Transit Rail (MTR) is a major public transportation network consisting of light rail, heavy rail, and bus lines. According to the Sustainability Report 2017, MTR has been minimizing energy consumption, and reducing carbon emission. In order to efficiently use energy, MTR adopted regenerative braking technology for rail operations. Regenerative Braking converts kinetic energy produced during braking into electrical energy which is then put back into the overhead catenary power supply network. Other trains on the same line can then use this power as they tap into the overhead power system. MTR installed "super-capacitor" energy storage devices which store the surplus energy that is produced by regenerative braking of the trains. When energy is needed this system releases that stored energy, and that in turn, reduces the overall system demands for electrical energy.

To further minimize energy consumption, MTR replaced lighting throughout its train stations with LED lights. At some MTR stations, escalators are turned off when passenger demands are low; and cooling fans are turned off during non-operating hours. MTR has also replaced chillers, with more energy efficient ones to reduce electricity consumption. MTR cleans its trains, railway infrastructures, and stations with "recycled" water, and after rail cars are washed, this water is again recycled for toilet flushing in depots or for another evolution of train washing.

To further reduce greenhouse gas (GHG) emissions, MTR has been replacing its aged bus fleet with new Euro standard buses. Euro standard buses have LED lights and energy efficient engines installed to reduce GHG emissions. These buses also meet the latest and most stringent GHS emissions standards currently implemented in Hong Kong.[22]

Australia

Metro Trains Melbourne (MTM), operates a train system in the 4th hottest city in the world with 115°F summers.[15] Extreme heat, followed by rapid evening cooling, increases incidents of "buckled rails" (rapid expansion and cooling of the steel rail). According to MTM, trains slow down during periods of extremely high temperatures to ensure customer safety because a "heat buckled rail" can result in a derailment. To monitor real-time rail track temperature, MTM installed multiple electronic monitoring sensors on its rail lines. In 2015, MTM installed 32 new track sensors which allow them to monitor real-time rail track temperature.[23] When actual track temperatures reach 131°F or higher, the speed limit is restricted to 50 MPH.[24] Moreover, MTM installed concrete sleepers (rail ties) to prevent the rail track from buckling (because the concrete ties accommodate superior anchoring techniques).[25] Also, they found that extreme temperatures cause

Figure 6: Sun kinks occur with wooden ties

Figure 7: Concrete sleepers prevent deformation in rail

wooden sleepers to "bend" while the concrete sleepers do not distort under the changing temperatures.

London

Network Rail in London installed mini weather-stations and thousands of track-side probes to monitor track conditions. When the weather is hot, Network Rail slows down trains to mitigate the effects of extreme heat creating track displacements due to rail buckling. Network Rail uses speed restrictions at vulnerable locations (curves and bridges). The speed restrictions reduces the dynamic stresses on the rail so that the rail is less likely to buckle during the hottest part of the day. Moreover, they paint part of the rail white to lessen heat absorption, which decreases incidents of buckling.[26] Maintenance teams check the stability of the track in winter and strengthen any weak parts before summer. Outdated electrical cables are replaced to prevent sagging in extreme temperature. Auto-tensioning devices are used to ensure the tension in the cable is kept constant. Moreover, Network Rail encourages passengers to bring water bottles and provides bottled water on-board trains during periods of hot weather.[27,28]

Figure 8: Weather station to monitor rail temperature

Singapore

In 2016, Singapore's Land Transport Authority (LTA) tested the installation of electric fans at five bus stops.[29] The purpose of the fans is to cool passengers while they are waiting for their bus in periods of sustained hot weather. The electric fans are mounted on the columns of the bus shelter to provide better airflow coverage. To activate the electric fans, patrons can press the button, and the fans turn-on for 15 minutes at a time. Since the testing results proved promising, LTA now has several high volume stops in Singapore equipped with these fans to provide heat-relief for waiting passengers.

Figure 9: Electric fans installed at the bus stop in Singapore

In 2018, LTA built a trial "smart bus-stop" on a busy major road in Singapore.[30] "Smart" bus-stops are equipped with the Airbitat Oasis ventilation system. This system consists of several overhead nozzles mounted on the inner roof, which draw from a reservoir of cold water. The system filters the air of harmful particles; thus, the cool air pumped out by the overhead nozzles is more than 90% cleaner than the surrounding air. Normal air-conditioners use ozone-depleting refrigerants that generate another source of heat, however, the Airbitat Oasis system creates an eco-friendly evaporative cooling of the ambient air. Additionally, the system's sensors can measure air temperatures and transmit data to supervisor screens that display temperature and air purity levels. Also, the built in computer vision and advanced analytics allows the system to detect suspicious activities, loitering, and unattended bags. Therefore, it has a safety and security benefit too.

Figure 10: Airbitat Oasis smart bus stop in Singapore

VIII. ENVIRONMENTAL COMPLIANCE AND SUSTAINABILITY DEPARTMENT

In 2016, the State of California passed Senate Bill 32 which sets a mandate to reduce GHG emissions to 40% below 1990 levels by 2030. That goal applies to the transportation industry, including LA Metro. Transportation emissions account for nearly 40% of all GHG gas emissions in California. LA Metro has already taken steps to meet the challenge of this state law.

LA Metro is proactive in energy management and the curtailment of GHG emissions. LA Metro's 10 year Strategic Plan (LA Metro Vision 2028), addresses Metro's role and goals for achieving California's GHG reduction mandate and providing a resilient transportation system better prepared to adapt to a warming climate. The plan calls for LA Metro accomplishing the goal by expanding and improving the transportation network, as well as partnering with regional partners and stakeholders to manage and build "a resilient mobility system" that effectively reduces GHG emissions and helps to address public health issues while moving people throughout the county.

The LA Metro Environmental Compliance and Sustainability Department (ECSD) has a climate change "Program" that identifies two key avenues to address LA Metro's contribution and vulnerability to climate change and create a more resilient agency:

1) Mitigation: Taking actions to reduce greenhouse gas emissions.
2) Adaptation: Taking actions to adjust to the effects of climate change.[31]

ECSD has 150 projects under the Program taking place to promote environmental stewardship and sustainability. The LA Metro ECSD Program is guided by a Climate Action Adaptation Plan (CAAP), a Resiliency Indicator Framework, an Energy and Resources reporting mechanism, and operates under an Environmental Management System (EMS). The Program further recommends updates to the LA Metro Rail Design Criteria (MRDC) and the Bus Rapid Transit Design Criteria and other technical documents, and among others. Each element of the Program has senior environmental staff assigned to continually refine, implement, and monitor the projects under the Program (for a full list of the projects refers to Appendix A or www.metro.net/sustainability). ECSD also have put in place classes to educate both LA Metro employees and contractors on heat, resiliency, and sustainability. A few classes available are: Environmental Resilience in the Workplace, Envision Training Workshop, Heat Illness Prevention for Managers and Supervisors, and G-PRO Operations and Maintenance.

The OIG found that the draft 2019 CAAP report identifies the following five key principles of implementation to meet the challenges of climate change:

1) embrace climate leadership,
2) secure funding and prioritize resources,
3) integrate climate knowledge into existing decision-making processes,
4) monitor and evaluate progress, and
5) engage with community stakeholders.

In addition to these five key program principles, there are also two broad strategies that LA Metro is currently taking to implement climate change protection. These two strategies are:

1) reducing LA Metro's greenhouse gas (GHG) emissions, and
2) making the LA Metro system more resilient to extreme weather events and long-term climate changes.

The draft 2019 CAAP appendix section entitled "Methodology for Greenhouse Gas Analyses" identifies significant emissions sources, such as electricity usage, natural gas usage, water consumption, refrigerants used for items such as buses, wayside energy substations, photovoltaic solar panels, heating systems, water heating, water conservation, and other energy consuming systems as targets for improved efficiency and emissions reduction. The draft 2019 CAAP identifies strategies that directly target those sources of emissions and reduce them over the next several decades.

The draft 2019 CAAP report also identifies systemic risks of LA Metro facilities, equipment, and other assets based on vulnerability and criticality. A "risk" number is assigned to each factor and these factors are tallied to obtain an overall risk score. This process reveals that increased incidents of extreme heat are the worst case climate hazard for LA Metro. Of secondary importance (in declining order of impact) are landslides**,** wildfires, riverine flooding, electrical outages, and sea level rise (which can inundate low areas). The draft 2019 CAAP report identifies a process to evaluate and resolve these climate risks and provides a menu of adaptation actions as options for ways to resolve these risks. The draft 2019 CAAP should be used to assist

LA Metro in decision making processes to implement sustainable options when replacing parts of the existing system, purchasing products, or installing new systems.[32]

The 2019 CAAP report will be presented to the Board by ECSD for adoption in the July 2019 Board meeting. The next section of this report focuses upon LA Metro bus and rail operations and maintenance to determine the steps initiated to reduce GHG emissions. The OIG interviewed various directors and supervisors of Rail, the ROC and Bus departments to obtain information on the risks these departments face, and what is being planned as well as what is being done now to meet climate change challenges. The OIG asked what innovations the departments might implement to deal with each particular risk, and whether the desired changes are funded.

IX. BUS OPERATIONS AND MAINTENANCE

LA Metro Bus Vulnerabilities and Adaptation

There are many ways climate change can directly impact LA Metro bus operations and maintenance. During periods of extreme heat, buses tend to break down more frequently than is experienced during normal conditions. Currently, LA Metro bus operations has a 10% decrease in available buses during the summer due to un-scheduled and unplanned repairs related to excessive heat. Bus engines, air conditioning and venting, and electric systems along with other subcomponent equipment fail more frequently during extreme heat because of the added stress placed on these systems. When extreme heat extends for months, the demand for summer materials increases. Coolant wear components, surge tanks, radiators, water pumps, thermostats, and coolant hoses all have increased failure rates generating abnormal demand. Evaluating the summer versus winter bus parts consumption over a 5-year average, the costs show $1.6 million was spent on parts in the summer versus $404,000 for the winter. [Appendix B] This is almost a 4 to 1 difference in part consumption because of the current high heat of Los Angeles summers. As identified in the draft 2019 CAAP report, certain parts of the County could experience an additional 6-7 weeks of summer heat which could substantially increase the current 3 months of summer. This implies pushing the part spending in closer to $3 million. Greater maintenance demands will require an increase bus maintenance division annual budget if bus service is to continue at current levels.

ECSD has developed a program called the Environmental Management System (EMS) which is an FTA-endorsed program for managing environmental compliance. This program addresses risk and vulnerability through the EMS framework. LA Metro's bus maintenance facilities have aided maintenance personnel during periods of high heat. They now implement an early spring inspection and maintenance program and perform additional inspections on high heat days to proactively address severe weather impacts. During the summer, maintenance staff performs inspections and evaluates major system operations more frequently to reduce failures while in service. They are also replacing old-style hoses with new hoses (made with different materials) which can last five times longer than the previously specified hose model. If the average temperatures stayed hot for months instead of weeks, could existing maintenance staff keep up

with increased demands for inspections and proactive repairs? To prepare for climate change impacts, additional maintenance training, procedures, and budget for spare parts will be needed.

Heavy precipitation causes rust to form in the steel frames of buses at an accelerated rate. This results in buses having leaks, cracks and rust that affects the structural integrity of the bus. The normal rotation cycle of buses calls for replacement at 12-years. Some LA Metro buses have been in service for over 18 years. These older buses required fuel tank replacements as the fuel tanks certification expired which rendered buses inoperable. Fuel tanks were adapted to switch from diesel to compressed natural gas (CNG). The required bus upgrades coupled with a lesser availability of spare parts compounds the task of maintaining the fleet in a sustained "surge" operation.

Sustained periods of "bad" weather conditions (high heat or increased rainfall) create additional demands on bus braking systems, engine coolant systems, HVAC systems and other components such as windshield wipers and headlights require proactive inspection and replacement as needed. Sustained periods of heavy rains or high heat could put increased numbers of LA Metro buses out of service, resulting in service delays. During the "normal" rainy season, rain alerts and notifications are sent out by division managers to enable bus operators to prepare and be ready for storm conditions. During a rain alert, the maintenance staff check wipers at night and make sure buses are in good mechanical condition to operate in service the next day.

Regarding GHG emissions, LA Metro is developing a comprehensive master plan to convert LA Metro's entire bus fleet to be zero emission vehicles by 2030. The current bus fleet is powered by CNG which burns cleaner than diesel fuel.[33] LA Metro has ordered electric buses to "service test" the new electric bus technology. However, first generation test buses had to be returned because they did not meet LA Metro's service requirements. Fully loaded, the electric buses could not effectively transit some of the Los Angeles hills, without temporarily shutting down some of the onboard systems. LA Metro's return of these "service trial" electric buses leaves LA Metro in a conundrum as to effectively accomplish the "zero emissions" 2030 goal, based on the current state of the technology.

EMS has provided Bus Operations and Maintenance "targeted" training regarding safety, emergency response, and preparedness for natural disasters. Because of these education programs, employees are aware of the importance of the environment and the impact environmental change can have on operations. For example, before this training, some bus operators and maintenance employees did not know that oil and grease is harmful for the environment. Now, they have been trained on how to properly handle and dispose of these harmful chemicals. Currently, tailgate meetings are held daily to discuss safety and any improvements to keep bus operations safer for our customers and for employees.

X. FACILITIES

LA Metro's Program Management and ECSD has made some significant milestones in meeting the challenges of climate change. LA Metro's Division 13 Bus Maintenance and Operations Facility is an example of a high performance building which is designed to meet LEED Gold

Certification Standards of the United States Green Building Council.[34] It was designed and built with sustainable construction methods and has sustainable design features. Part of the building façade is covered with solar panels and photovoltaic panels (PV). Solar panels are installed at the top and sides of the building.

Figure 11: Division 13 - Bus operations and maintenance facility

The building is designed to allow daylight to major work areas and open spaces are naturally ventilated which makes the building efficiently cool down. Additionally, the rooftop of Division 13 has a green garden with native California plants to reduce contributions to the City's heat island effect. This green roof garden is accessible to LA Metro employees so that they may enjoy their breaks at the roof garden (studies have shown that this helps to maintain employee attentiveness, morale, and sense of well-being). There is an underground storm water retention tank (with a capacity of 275,000 gallons) that collects rainwater (purple water) for bus washing, landscaping, and other uses. In addition to the rain water, Division 13 receives 10,000 gallons of water per week from the prison next door. This water is also added to the underground storage tank. LA Metro also has a 15,000 gallon tank near the Central Maintenance Facility to gather storm water that drains into the larger tank when it gets full. At Division 10, buses are washed with purple water (rainwater or recycled water used for non-potable purposes) which lessens dependence on imported water sources.[35,36]

XI. RAIL OPERATIONS AND MAINTENANCE

LA Metro Rail Vulnerabilities and Adaptation

Climate change can directly impact LA Metro rail operations and maintenance. Metro's Rail Operations and Engineering teams identified that the Rail and the Overhead Catenary Systems (OCS) as LA Metro's assets most vulnerable to sustained conditions of high temperatures.

The maximum train speed is 55 mph under normal conditions (determined by California's Public Utility Commission for semi exclusive right of way). Trains are ordered to slow down to 30 mph when the temperature is 115°F. Rail temperatures typically are 20-25^{o}F above the outside

ambient air temperature. As the rail heats, it expands. LA Metro rails are manually checked. The track department sends staff out to walk the track, check the track temperature, and visually check for anomalies in the rail and ballast that would indicate rail displacement. They look for rail that is pulled apart (failed and separated at bolted or welded joints), or with "sun kinks" (longitudinal displacement in the track alignment resulting from the heating of the rail), or a lack of ballast around the sides of the ties (cupping) and the roadbed shoulder. These occurrences are primary causal factors in train derailments. Personnel also perform inspections at night; a person rides on a High-Rail vehicle at slow speeds and visually scan the rail to ascertain if there has been any movement from the original track alignment.

The OIG inquired as to whether there were sensors on the track to monitor the real-time rail track temperature when ambient air temperatures approach the 115°F degree threshold. The response was that those monitors are too expensive and there are too many miles of track. One of the OIG's primary concerns is safety and management of cost versus risk. Track heat sensors would only need to be added to sections of rail exposed to temperature variation in the historically and projected future hottest locations. LA Metro should consider acquiring track heat sensors for rail that is exposed to high ambient temperature variations. It may also be possible to install laser temperature technology to rail cars and transmit temperatures to the ROC or provide mobile temperature lasers to train inspectors for rail monitoring.

To avoid sun kinks, pull-apart, and/or buckling (both hot and cold weather issues), the rail is pre-stressed before new installation and whenever repaired. This is the Federal Railroad Administration-49CFAR part 213 (FRA) solution to welded rail installed in chronic warmer climates or those subject to extreme temperature variations. If during installation, the laying temperature is incorrect and the rail shrinks due to a drop in temperature more than the design allows, stresses within the rail can cause the rail to break or crack. All LA Metro lines are pre-stressed to 110°F degrees at ±5°degrees tolerance. Pre-stressing mechanically / thermally alters the rail by heating it until it expands and then anchoring it in alignment at its expanded state so that the rail is in a constant state of tension. The length of rail needed equals the same length it would be at a hot air temperature; the rail is then anchored in place with thermal forces minimized. The degree to which rail is pre-stressed is dependent on the geographical location

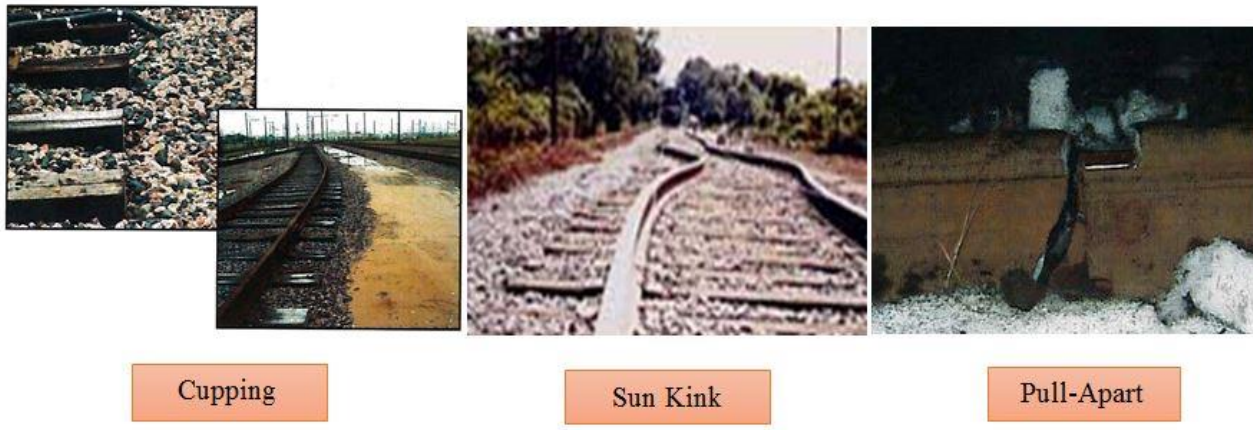


Figure 12: Photos of rail "cupping," "sun kink," and "pull-apart"

where it is going to be laid; with curves and elevation changes (such as bridges or tunnel entrances) requiring a greater degree of pre-stressing.[37]
All LA Metro rail lines are designed with Train Control Systems that use electronic circuits through the running rails of the tracks. As such when a "Rail Pull-Apart" incident occurs generally the Train Control System will be disabled or fail and the ROC is alerted that the Train Control System has a problem and ROC will Dispatch Rail Operation Staff to check the area to determine the cause of Train Control Signal Loss.

LA Metro Overhead Catenary System and Trolley Wires Vulnerabilities and Adaptation

Trolley wire, also called copper wire is on the Blue Line at sections Long Beach to Willow and Washington Blvd. to 7th Street/Metro Center Station. The trolley wire terminates where the system goes underground into the 7th Street/Metro Center Station. This trolley wire utilizes the same type of copper wire as the Overhead Catenary System (OCS). The OCS is "standard" for all other locations on the LA Metro system except for the yards (which use trolley wire) and underground tunnels which are heavy rails and uses 3rd rail pick-up for electrical power. The trolley wire system does not have the supporting weight tensioning system that the OCS has. The trolley wire system does not have a center bar support; but instead, has a cross-wire to support and lift the wire which spans multiple lanes of street traffic and ties into poles at the sidewalk or right of way. As air temperatures rise, the cross-wire heats, expands and slacks, creating a sagging in both the cross-wire and the trolley wire. Adjustments occur in the spring and fall, and typically takes a considerable amount of staff, effort, and time to tighten. As necessary, measurements of the contact wire are taken and adjusted. At the location of Flower Street and Washington Blvd. the cross wires are tied to the support poles. These poles lean when the crosswire is tightened with a winch and pull in toward each other, bow, and create a potential hazard. The OIG was told the Blue Line project originally wanted to replace this area to a spring stack tensioning system, but the upgrade would take over a year and half to obtain City Right of Way permits. We understand replacement of the poles with the spring stack heat sensitive tensioning system would take several years to accomplish as well as a significant increase in cost. With the "New Blue" project, all of the wires are being replaced but not the poles.

Figure 13: Blue line trolley wire & cross wire

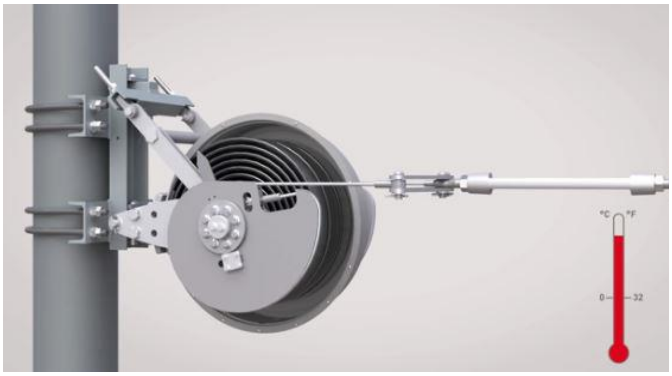


Figure 14: Proposed spring stack tensioning system

All wires are impacted by the heat. The spring stack tensioning system is most durable and effective to remove the sag from the wire in the extreme heat.

LA Metro has experienced problems with the OCS during high heat conditions on the Gold Line. To reduce and eliminate the sagging of the catenary lines, there is an automatic tension system with weight stack that is self-adjusting which exerts force on the wire to create tension. These weights pull the wire taut and remove the sag when the sun heats and expands the wire. On the Gold Line the pole heights were designed lower than the rest of the system. Additionally, on the Gold Line the original design of the pulley wheel, that the wire runs over, has frayed the wire in the past which caused the wire to snap and the weights fell to the ground. Currently the pulleys are being replaced with the correct size pulley wheel to eliminate the problem of wires fraying. The weight stack auto tensioning is operating correctly on the Blue, Green, and Exposition Lines. The OIG was also informed that birds have occasionally made nests in the weight stacks which caused the tensioning system to fail.

Figure 15: Existing weight stack tensioning system

The locations on the Gold Line in the track region of Pasadena to the end of the line along the foothills are a concern because temperatures tend to be hotter in this area. Because of the low heights of the poles with the weight stack system and the excessive heat, this area is watched very closely in the hot summer days for sagging wires, weights on the ground, and overheated rail. LA Metro's System Engineering group has evaluated the Gold Line OCS to determine and recommend where the newer technology of a spring stack tension system is more appropriate for the area. Refer to Table 1 for the summary of results balance weight improvements and Appendix C for Systems Engineering complete analysis on the balance weights. The weight stacks are bottoming out and sitting on the ground on hot days. There are 51 locations where the new spring stack tension system should be implemented, 16 locations for further adjustments to the weight system and 63 locations on the Gold Line where no action is required. The spring stack tension system can eliminate the problem of sagging catenary lines, manual inspections and works with the shorter poles. The Gold Line could benefit from the installation of the spring stack system as mentioned by Systems Engineering noted in Appendix C in order to mitigate high temperatures. LA Metro should consider retrofitting its system to include this improvement.

METRO Gold Line Balanceweight Improvements	
Replace with Spring Tensioners	51
Weight Adjustments Required	16
No Action Required	63
Total	130

Table 1: Systems Engineering summary results of Gold Line

A proactive solution developed by Wayside Systems Engineering is to have an on-board roof mounted OCS / trolley wire inspection system. This system will run as part of revenue rail service and document the condition of the Overhead Contact Power System with actual real time

analysis to alert the wayside traction power system of potential and pro-active issues associated with the power system inspection for light rail systems. This new system is currently running as a test on the LA Metro Expo and Blue Lines to validate the accuracy and performance of the equipment.

Plans are also in progress by Wayside Systems Engineering to have a wayside placed Pantograph Inspection System that would examine the pantograph on all light rail vehicles to determine if the pantograph may be showing signs of premature wear or cracked carbon strips that could contribute to an entanglement with loss of rail service. Entanglement is caused by hot temperatures heating the wires, wires then sagging and oscillating as the pantograph pushes forward on the line. Metro needs to rectify this vulnerability.

Figure 16: Pantograph entanglement with OCS wires

LA Metro, like Hong Kong MTR, has regenerative braking in all the rail lines and rail vehicles. MTR utilizes a super capacitor to put the energy back into the system by way of OCS where LA Metro utilizes the flywheel technology. The energy created by movement of the flywheel is transferred back into the system. LA Metro has two projects currently testing the system. One is on the Red Line at Westlake/Mac Arthur Station and the other is at the Gold Line at Pasadena Station. Metro is also looking into installation of a reversible traction power substation which would send regenerated energy back into the utility. By utilizing the system of regenerative braking, LA Metro is moving forward in reaching the State of California's goals of zero emissions and creating a renewable energy resource.

Other System Components

Other vulnerabilities that were identified are the Heating, Ventilation, and Air Conditioning (HVAC) systems in trackside equipment rooms and electronic component cabinets. These cabinets provide power (traction power sub-station) to the OCS, trolley wires, and communication system. These electric component cabinets often heat resulting in equipment failure and critical shutdowns. HVAC systems have been installed in the cabinets to keep the circuit boards from overheating and melting. However, the Gold Line is still vulnerable to overheating because that area is hotter than any other parts of the LA Metro system. A second exhaust fan has been added in various locations on the Gold Line. When the HVAC fails and the supervisory control and data acquisition (SCADA) equipment gets too hot, the system shuts down and goes offline. Communication cabinets are critical because it controls the radio system from the ROC to the trains. When it shuts down, there is no communication except by cell phones. When the HVAC fails in the control room and system failure occurs there are backup generators; however the generators can burn out if operated too long. Trains operating on the tracks can run independently of the ROC in the event that the ROC has a shut down or system failure due to power failure. LA Metro has a monitoring system to alert and control a system failure due to heat, however it is comprised of "standard" overheat alarms that come up on the SCADA network. The FRA standards for Positive Train Control mandates such sensors.

Proactively the Rail department has taken measures to protect equipment by installing insulated bungalows to provide protection for signaling and sensor components. Additionally, to make the train control and communication cabinets cooler LA Metro has painted the outside of the cabinets with ¾ inch thick, one time only, Marine paint. They have stated that this paint has helped in cooling the cabinet but still more AC, vents, and fans or other mitigation steps are needed as temperatures continue to get hotter, for more days per year. Exhaust fans are installed throughout the system.

In the event of severe heat has caused the system to shut down, the escalation procedure is the Emergency Notification system. The protocol is to send out an emergency alert by telephone, email, or text message. Staff will be dispatched to repair the problem.

A positive action that the train operators are doing in the hot summer is keeping the train doors shut at each terminus. Patrons push a green lighted circle on the outside the train door to open the doors. This helps to preserve cooled air inside the train.

For protection from the sun at the stations 2/3 of each station walkway is covered. As the climate becomes warmer and lasts for greater number of days, more complete coverage of the station walkways, misters, air cooling systems like Singapore's Airbitat Oasis system, and water fountains to enable people to refill water containers is desirable.

Older rail cars in the P865 series that operate on the Blue Line have issues with the HVAC system that are less dependable. Additionally, the Red Line cars have cooling deficiencies that may need to be considered for state of good repair prioritization.

Below the LA Metro light rail there are underground storage areas called vaults. When there is a heavy down pour, the underground vaults flood. Maintenance of way (MOW) personnel must pump out the vaults immediately when they flood. Spliced wires in the vaults corrodes and cause shortage failures. A drainage/flood solution is needed for the underground vaults.

The Rail Operations Center (ROC)

The ROC cannot precisely monitor real-time weather and temperature conditions at key locations on the system. We were told that they do not have this capability. They do obtain weather information from the media. The ROC could run more efficiently with the ability to have current 'real time' temperature informational feeds at multiple critical locations of the LA Metro system in order to dispatch employees when weather conditions cause a system failure or at higher risk. Currently, only one weather station, located at division 20, has been installed, but there are none on the entire rail system where it is most crucial.

When asked if there is anything that would help the ROC combating sustained periods of extremely hot days, ROC staff cited the following areas:

1. Conducting monthly pre-summer "Summit" meetings regarding anticipated hot weather, the heat impact, updating employees on the procedures for mitigation, and response plans when the temperature rises above a certain limit for a span of time.

2. Establishing "baseline" preventative maintenance for servicing and testing emergency generators.
3. Establishing a coordinated Severe Weather Plan. Beginnings of an Inclement Weather Plan was started in 2015, but never finalized.
4. Conducting monthly meetings, at the Superintendents level or lower, to allow information to flow down from the department heads to the field level supervisors, especially in regards to weather responsiveness.
5. Updating the communication equipment which employs speakers located at top of the rail platform canopies. The sound communications with patrons should be checked to ensure it is not garbled and is especially a problem on the Green Line, where patrons may have more trouble adequately hear system announcements because of traffic noise.

XII. SAFETY

LA Metro is firmly committed to the principle that safety comes first for its customers, employees, business partners and the public. To that end, LA Metro follows the California Occupational Safety and Health Administration (Cal OSHA) guidelines for authorizing the enforcement of standards which require employees and employers to maintain safe working conditions.

Policy for Employee Safety

To ensure the safety of employees who work outside during periods of extremely hot weather, LA Metro Corporate Safety has developed a "Heat Illness Prevention Program" in compliance with the California Code of Regulations. The program steps and procedures that should be followed by Metro supervisors and employees include:

1. Managers and supervisors should be trained on their responsibility to provide employees water, shade, and access to first aid, cool-down rests, and exercise.
2. Train on the responsibility to make sure water containers and shelters are available at the work site and are accessible by workers. Supervisors should ensure water containers are kept in sanitary condition and check the water level frequently when the temperature rises (above certain prescribed levels).
3. Before starting work, "tailgate" meetings should be held to brief employees about the importance of drinking water, rest breaks and the signs and symptoms of heat illnesses if the temperature exceeds or is expected to exceed 80 degrees Fahrenheit.
4. Supervisors should ensure that sufficient shade structures are available for employees and give employees a five-minute cool-down rest (every hour) in the shade.
5. If the weather is expected to have high temperatures or a sustained high heat, it is the supervisor's responsibility to modify the work schedule, as necessary.
6. During heat waves or when temperatures exceed 95 degrees Fahrenheit, each employee should be assigned a "buddy" to watch for signs and symptoms of heat illness. If new employees are assigned to work under conditions of high heat, supervisors should closely observe them for the first 14 days (until the employee becomes acclimated to the new environs).[38]

Customer Safety and Services

LA Metro cares about customer safety and gives excellent service to customers. During the hottest periods of the summer LA Metro trains run with speed restrictions to not damage the tracks or overhead power lines, and to ensure customer safety. This is prudent and necessary, because as the temperature gets high, the overhead wire tends to expand, stretch, and sag. During hot weather, trains run at slower speeds and sometimes trains are delayed or cancelled because of repairs to the overhead wires. LA Metro sends out LA Metro Rider Alerts regarding service delays or cancellations. Historically, LA Metro has announced the most delays on Expo Line, Gold Line, Blue Line and Green Line where power is strained or under high heat conditions because those lines are open air track. Customers are provided service updates via Twitter. During the summer, LA Metro reminds customers to wear loose-fitting and lightweight clothing, to use sun screen and to drink sufficient amounts of water. Train doors keep train interiors cool. Customers can press the buttons near the train doors to enter.[39]

XIII. CONCLUSION

Climate change is occurring globally with notable effects on the environment. There have been more frequent and erratic weather variations such as extremely high temperatures, strong storms, heavy rainfall, flooding of rivers and the coastline, and sustained drought. Global warming, one symptom of climate change, refers to rising temperatures caused by increased concentrations of GHG in the atmosphere. Climate scientists from 185 countries, with thousands of pages of research, recognize the adverse impact of climate change and have committed to working together to reduce atmospheric CO_2. Erratic rainfall and sea level rise are other symptoms of climate change. Sea level rise is from two factors related to global warming: the added water from melting ice glaciers and the expansion of seawater as it warms. In the last century the California coast line has risen 7 inches and is expected to rise an additional 10 to 18 inches by 2050 because of global warming.

This review was conducted to determine what actions have already been done to prepare for climate change, identify climate resilient options, and determine additional actions needed to address the impacts of anticipated future conditions. To identify industry "best practices," the OIG researched other transit agencies in our nation, and around the world to determine what is being done to mitigate the impacts of climate change.

National Innovations

The OIG "bench-marked" transit agencies in two hot climate cities and found significant innovations to counter climatic changes for our consideration.

In Las Vegas, the RTC has multiple chill stations for patrons to wait for the bus out of the heat, water wagons drive the bus routes to hand out complementary water bottles to patrons, and has solar powered shelters with LED lighting that provide shade for passengers. In the summer, buses run with balloon tires filled with pure nitrogen to improve tire wear and provide a safer transit experience.

In Phoenix, the Valley Metro has installed an additional air conditioning condenser on the roof of its buses. This increases cooling capacity by 60%. They also purchased new buses with special electric engine cooling fan systems to protect engines from overheating. The Operations and Maintenance Center is powered by solar energy. They have installed of shade canopies on light rail platforms made from fabric that blocks the sun rays. There are solar powered cool air ventilation systems installed at three light rail stations that are equipped with a button near the seating area. Valley Metro light rail trains employ solar reflective window tint, train bodies painted with solar reflective paint, and two over-sized AC units for redundancy are placed on each light rail vehicles, all of which enhances cooling inside the passenger compartment. Also, the agency partnered with a local refrigeration school to provide custom AC and electrical training programs unique to Valley Metro's buses and rail cars. Graduate students are then eligible for hire, thus creating community opportunities.

Global Innovations

The cities of Hong Kong, Melbourne, Singapore and London stood out as "benchmarks" for innovation.

In Hong Kong, the Mass Transit Rail (MTR) uses Regenerative Braking Technology to convert kinetic energy produced by the braking process into electrical energy and puts that power back into the power supply network, with use of super-capacitor energy storage devices.

In Melbourne, the Metro Trains Melbourne (MTM), monitors real-time rail track temperatures, by installing electronic monitoring sensors in its rail lines, so that control authorities know exactly when actual track temperatures reach 131°F or higher and can immediately restrict speed limits.

In London, Network Rail has installed mini weather-stations and thousands of track-side probes to monitor the local trackside conditions (on above ground tracks). When the weather is hot, Network Rail slows down the trains to mitigate the effects of extreme heat creating track displacements due to rail buckling. Network Rail uses speed restrictions at vulnerable locations.
In Singapore, Land Transport Authority (LTA) has instituted smart bus-stops. These are equipped with the Airbitat Oasis ventilation systems which have several overhead nozzles mounted on the inner roof, and draws from a reservoir of cold water which cools and purifies the air while removing harmful particles. The cool air that is pumped out through the overhead nozzles is more than 90 percent cleaner than the air that surrounds these stations.

Los Angeles County

In California, transportation accounts for nearly 40% of all greenhouse emissions. In 2018, the Governor signed an Executive Order calling for the State to slash its overall emissions to zero by 2045. He also signed Senate Bill 100 stating, "Not only is California going to slash its emission to zero but shall have 100% of total electricity retail sales in California to come from eligible renewable energy resources and zero-carbon resources by 2045."

LA Metro's ECSD has put together a series of reports, policy, training, and environmental management systems that complement these state environmental goals. ECSD is proactive in climate change mitigation and adaptation with "key" performance goals of reducing GHG

emissions and making the LA Metro system more resilient to extreme weather events and effects of global warming.

The OIG interviewed multiple bus and rail operations officials and found:

1. During the peak summer months, buses undergo significantly more maintenance as shown in Appendix B.
2. The LA Metro bus department tested a few electric buses, however the existing design failed to meet the LA Metro's service requirements.
3. The Trolley and the OCS wire systems have maintenance issues during very hot periods. High heat causes the wires to sag and lead to entanglements with the train's pantograph and the contact wire. Newer spring stack technology is available to control sagging wires.
4. The rail tracks need to be continually monitored during sustained hot weather for buckling, cupping, and sun kinks. The current method of walking the track and ordering reduced speed to the train drivers, is the way the track is currently monitored for any track anomalies. Pre-stressing the rail at the temperature in the geographic location prior to installation (for new rail) is the predominate method that LA Metro currently utilizes. Pre-stressing the rail at the projected temperatures for the geographic location based on the latest climate models should be implemented as temperatures are projected to increase dramatically.
5. There are no electronic monitoring track sensors to immediately measure rail temperatures over periods of sustained heat. Deploying the most modern technology of monitoring rail track sensors should be implemented as temperature increase.
6. The ROC currently has no instrumentation to monitor weather and temperature conditions in real time other than the media and one location at Division 20. The ROC could run more efficiently with the ability to have current "real time" weather information. We recommend that procurement and deployment of mini weather-stations to monitor the local trackside conditions at strategic key locations based on variability in micro-climates.

LA Metro has initiated many actions to address climate change and work towards achieving the State mandated emission goals. While much has been done, the OIG team found there are other actions that LA Metro could implement using the benchmarks stated in this report. The evidence the team discovered found that the LA Metro system will be impacted when Los Angeles reaches sustained heat temperatures like those of Phoenix, Las Vegas, or Melbourne. The LA Metro System should continue to innovate and update its operations if LA Metro is to achieve the systemic LA Metro goal as stated in the 2019 draft CAAP report of having zero GHG emission by 2050. While much has been done, there remains much to do if LA Metro is to be effectively positioned to meet the demands that climatic changes will put upon this system in the near-term (7-10 years) and the future. Metro has the responsibility to conform to California State Laws established by the Governor. Therefore, Metro ECSD should be involved in purchases for new construction of transit system and facilities when it pertains to climate change and the warming that will continue to increase. June 2019, LA Metro's Procurement Department also committed to a program to seek more environmental conscious purchases.

Our report makes 32 recommendations for LA Metro to consider implementing to prepare for the impacts of climate change. These recommendations are suggested tactical strategies; not dictates or policies. We make these suggestions without regard to cost, which we have not

researched and would be dependent on many factors. Metro does not possess unlimited funds. Fiscal responsibility of the public's dollars is an essential guiding principle that we would have to be mindful of in selecting the most appropriately prioritized options.

XIV. RECOMMENDATIONS

The Office of the Inspector General recommends that LA Metro management considers the following:

FACILITY

Recommendation 1: Strengthen the system-wide effort to put more solar panels, green roof gardens, cisterns for collecting rain water, and other climate resilient solutions in place to reduce the effects of climate change.

WAYSIDE ENGINEERING

Recommendation 2: A drainage/flood solution for the underground vaults along the wayside right-of-way.

Recommendation 3: A solution to address the severely leaning crosswire poles at Washington Blvd. and Flower Street which support the trolley wires lines that are prone to sagging in extreme temperatures. When the cross wires are tightened to remove the sag caused by the heat the existing poles are pulled toward each other and should be replaced in a more stringent concrete foundation.

FACILITIES/BUS

Recommendation 4: Develop a plan to improve and add bus shelters with the cities.

Recommendation 5: Offer Incentives to cities to improve their bus shelters as a part of the NextGen review. Cities that partner with Metro to increase ridership, such as by written commitments for improving bus stop accommodations, warrant consideration for continuing or increased bus service coordination over those who do not.

Recommendation 6: Identify and prioritize bus stops that have high vulnerability to high heat and that could benefit from the addition or improved of bus shelters.

Recommendation 7a: Install dome top bus shelters that feature solar panels and energy saving LED lighting. Shelters should provide shade for passengers and should have enough room to accommodate a passenger in a wheelchair.

Recommendation 7b: Install shade canopies at bus stops that are made of a non-metallic material to block the sun's rays without the excess heat that typical metal canopies generate. Paint bus shelters in heat reflecting paint.

Recommendation 8: Install bus shelters with side louvers, which allow for breezes, thick screens made of grates to prevent the inside surface of the shelter from being too hot to touch and top shade to help reduce the radiant temperatures.

BUS OPERATIONS

Recommendation 9: For the upcoming electric buses, consider ordering a special electric engine cooling fan system. This engine cooling system protects the engine from overheating.

Recommendation 10: Consider installing plexiglass on the top and sides of the bus and reflecting films on the glass that can reduce the temperature inside the bus by as much as 15^{o} F.

Recommendation 11: Plan for anticipated increases in rubber materials such as belts and hoses for bus and rail due to hot weather for operations and procurement inventory management and budget purposes.

VEHICLE ACQUISITION TEAM

Recommendation 12: Install for both buses and trains window tint (sacrifice film or glass) that is solar reflective and has a special film that significantly reduces the amount of the sun's rays.

Recommendation 13: Paint the body of the buses with solar reflective paint. Installation of these solar reflective measures reduces cooling loss inside the passenger compartment.

OPERATION MAINTENANCE

Recommendation 14: Expand partnerships with local schools to develop custom training programs such as HVAC, refrigeration and electrical programs to be ready for increased maintenance on bus and rail, like Valley Metro in Phoenix created a partnership with RSI, and thus created opportunities for Valley Metro maintenance employees (and future employees) to get customized training. Proactively, LA Metro is already working on a transit focused school in Los Angeles County.

RAIL & BUS OPERATIONS

Recommendation 15: Improving communication in Operations about temperature sensitive matters by having a Spring Heat Summit to prepare for summer as operations staff report.

RAIL ENGINEERING

Recommendation 16: Replace weight stack tension systems with newer technology of a spring stack tension system. The spring stack is appropriate for high heat climates, prevents sagging catenary lines, and eliminate manual inspections.

Recommendation 17: Paint the wayside cabinets (that are not covered in marine paint) with solar reflective paint. Painting with solar reflective paint reduces the heat to the inside of the cabinet and the risk of the components melting.

Recommendation 18: Provide mobile temperature lasers to train inspectors for rail monitoring.

Recommendation 19: Procure electronic monitoring track sensors to immediately measure rail temperatures in periods of sustained heat utilizing the most modern technology.

FACILITIES/RAIL

Recommendation 20: For outside rail platforms, consider installing a solar-powered ventilation system that consists of several overhead nozzles mounted on the inner roof of the canopy, which draw from a reservoir of cold water which cools and purifies the ambient air while removing harmful particulates and features push buttons near each seating area that provide blasts of cool air on demand.

Recommendation 21: Review the platform communication equipment which employs speakers located at top of the buildings for clarity. In the event of an emergency or weather announcement, people on the platform must be able to hear and understand the announcement.

RAIL OPERATIONS

Recommendation 22: Procure mini weather-stations and track-side probes to monitor the local trackside conditions.

Recommendation 23: Install an evaporative air cooling system that rapidly transforms hot air to cooler temperatures and has sensors that can transmit temperatures and other data to the ROC and BOC.

ROC

Recommendation 24: Provide funding and equipment for the ROC to receive "real time" information of weather conditions at different locations in LA County in order to address track conditions that might cause a system failure.

Recommendation 25: Complete and finalize the Severe/Inclement Weather Plan that was started in 2015.

Recommendation 26: Establish "baseline" Preventative Maintenance for servicing and testing emergency generators.

PROGRAM MANAGEMENT AND CONTROL

Recommendation 27: Elevate the sustainable comments/suggestions made by the ECSD staff in order to make the LA Metro system more resilient towards climate change.

Recommendation 28: Future transit construction, facility construction, and vehicle (bus and rail) purchases should consider impacts of climate change and ECSD should have input to procurement specifications.

EMERGENCY MANAGEMENT

Recommendation 29: Finalize the Emergency Management plan as it relates to system heat impacts.

CEO/EXECUTIVE DEPARTMENT

Recommendation 30: Continue to explore options for creating a manufacturing a rail/bus company in Southern California. Competition pushes the current technology and develops a fully functional transportation equipment that meets LA Metro's design standards and the goal of fully electric by 2030 and could promote a higher environmental consciousness.

Recommendation 31: Let the CAAP report assist the leadership of LA Metro in its decision processes to reduce agency-wide operational greenhouse gas emissions and implement resilient investment choices when replacing parts of the existing system or installing new operations.

Recommendation 32: Consider positioning LA Metro to successfully address climatic challenges by:

a. Establishing goals to effectively position LA Metro to meet climate change challenges into the state of good repair schedule.
b. Including necessary improvements in projects directed at climate change resiliency a part of the agencies performance goals.
c. Adopting strategies to limit exposure to the impacts of climate change and develop an All Hazard Mitigation Plan for the agency.
d. Establishing environmental and sustainability considerations as an element of every major project and procurement.

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ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

In Development
Completed
Continuous Improvement
Board Motion 57 Related Items

Reference #		Year Initiated	Current Status	Completion Date	Comments	SC(1)	Motion 57 Reference (2)(3)(4)(5)(6)(7)(8)	Reference Back to FY19 Initiatives
	CLIMATE CHANGE & RESILIENCY							
	ISO 14001:2015 Certification and Implementation			2017	Basis for the implementation of Metro Environmental Policy and other environmental and sustainability efforts for continual improvement.	*	E	
1	Design and Implement an Enterprise-Wide EMS solution for all facilities	2009		2018	EMS successfully implemented on 19 operating Divisions and three major capital projects. Evaluating the addition of three new support facilities over the next three years.	*	E	
2	Develop guiding document and integrate Climate Change into EMS	2017		2019	Climate change has been added to the Context of the Organization; guidance document for integrating climate change efforts into the EMS is not complete.	*	E	
3	Integrate EMS into construction activities	2016		2018	The Crenshaw LAX project was certified to ISO standards in 2017. Began implementation of EMS on PLE1 and Regional Connector late 2017. Ongoing evaluation of candidate construction projects to add to the EMS.	*	E	
4	Incorporate EMS into Risk Assessment/Management	2017		2019	Had been in discussions with Project Management Risk Management staff and QA staff on incorporating the ISO 14001 Environmental Management System principles as a risk reduction strategy.		E	
	Resiliency Framework							
5	Resiliency Indicator Framework Report	2014		2018	Being updated per Cris' request. Due by end of 2018.		A4	Resiliency
6	Develop a Water Conservation Program	2015		2019	Program is being managed with specific projects aimed at conserving water at Divisions and in ROWs	*	B4	
7	Develop a NOx Emissions Reduction Program	2008		2017	89% reduction in NOx emissions from bus fleet	*	A1	Climate Action Plan Update
8	Develop a CO2e Emissions Reduction Program			2017	25% reduction in CO2e emissions		A3	Climate Action Plan Update
9	Complete an updated study on flooding, rising seas levels, and high heat	2017		2019	Update to initial flood, sea level and high heat maps initiated as part of CAAP update.	*	A4	Climate Action Plan Update, Resiliency
10	Review Asset Management Framework/Tool	2017		2019	Being conducted as part of CAAP update.		A4	Climate Action Plan Update
	Climate Action & Adaptation Plan (CAAP)							
11	Create a CAAP working group	2017		2019	Working group updating CAAP	*	A2	Climate Action Plan Update
12	Develop an Energy and Sustainability Policy	2007		Jun-07	Board approved on June 28, 2007	*	A4	
13	Develop a CAAP	2017		2019	Initial CAAP was completed in 2012. The update will be completed in 2019	*	A2	Climate Action Plan Update
14	Develop Greenhouse Gas Emissions Cost Effectiveness Study			2012	While completed, study is underway to include new cost and environmental benefits monetization framework. This effort is separate from the CAAP.	*	A2	
15	Develop a Biomethane Implementation Study	2012		Jun-13	Board approved in June 2013. Metro executed first biomethane supply contract in August 2017. This effort is separate from the CAAP.	*	A1	
16	Develop a LCFS Market Analysis and Revenue Optimization Plan	2014		May-14	Board approved in May 2014. This effort is separate from the CAAP.	*	A1	
17	Implement Environmental Liability Assessment and Reporting				METRO Policy Gen 49 covers this and is an ongoing annual activity. This is separate from the CAAP update.		A3	Climate Action Plan Update
	Metro Board Motion (2016-0157)							
18	Increase agency infrastructure resiliency	2017		2019	Assessment of agency-wide resiliency plans are in development. Framework will be presented to the Board in late Fall 2018/Winter 2019.		A3, E	Resiliency

ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

	In Development Completed Continuous Improvement Board Motion 57 Related Items	Year Initiated	Current Status	Completion Date	Comments	SC(1)	Motion 57 Reference (2)(3)(4)(5)(6)(7)(8)	Reference Back to FY19 Initiatives
	Metro's Urban Greening Implementation Action Plan							
19	Project-specific Sustainability Coordinator	2016		2028	Each capital project is assigned a sustainability coordinator. Efforts are being made to include ECSD in the planning process to ensure that sustainability is integrated into the project scope, schedule and budget.	*	B3	
20	Increase the number of Urban Greening projects	2016		2019	Assessments and white paper being created to determine breadth and scope of urban greening opportunities; Initial rough order magnitude to implement completed	*	B4	
	Regional Advance Mitigation Planning (RAMP) Document							
21	Metro Regional Advance Mitigation Needs and Feasibility Assessment	2017		2018	Assessment document provided to the Metro Board in July 2018.	*	E	
22	Develop White Paper: Integrating Mitigation, Carbon Sequestration and Ecosystem Services at Community Relevant Scales	2017		2018	Being updated to reflect urban greening opportunities.		E	
23	Develop opportunities for zero/near zero emission technologies	2016		2025	Investigating and Implementing clean fuel technologies. Working with the Vehicle Engineering & Acquisition group to review technologies, negotiate rates and assess power infrastructure requirements.	*	D3	
	Green Procurement Policy, Framework and Implementation	2018		2019	Developing draft framework and policy. To be completed by Spring 2019	*	B2	
24	Sustainable Purchasing Guidelines for Gateway	2018		2019	Task order in process and initial stages of this project in beginning phases of research		B2	Green Procurement
	Metro Sustainability Implementation Plan (MCIP)	2018		2019	Draft MSIP outline discuss with Cris on 8/15/2018. As discussed, the MSIP update will proceed in conjunction with the development of the CAAP.		A, C	
25	Revise and update plan from 2008	2018		2019	Draft MSIP outline discuss with Cris on 8/15/2018. As discussed, the MSIP update will proceed in conjunction with the development of the CAAP.		A, C	Climate Action Plan Update
	LACMTA Green Construction Policy specification							
26	Revise the LACMTA Green Construction Policy specification	2016		2019	Coordinating efforts with V/CM and Project Management		B, D	Green Procurement
27	Decarbonization/Reduce onsite fuel use by 25%	2017		2020	Ongoing requirements to reduce onsite fuel during construction		B, D	Green Procurement
	Metro Climate Vulnerability and Risk Assessment	2016				*	A	
28	Update document to meet current standards	2017		2019	In development. Covered in the 2012 CAAP and being updated for ~2019 CAAP	*	A	Climate Action Plan Update, Green Procurement, Resiliency
	Update and Rebaseline the Metro Rail Design Criteria (MRDC)	2017		2018	Project was completed in 2017. To be rebaselined in 2018		A, B, C, D	Climate Action Plan Update, Green Procurement, Resiliency
29	Update baseline to cover new requirements, regulations and standards	2016		2018	Reviewing/incorporating new requirements, e.g., ASCE PS 556: Owners' Commitment to Sustainability, into MRDC.		A, B, C, D	Climate Action Plan Update, Green Procurement, Resiliency
	Update and Rebaseline the Bus Rapid Transit (BRT)	2017		2018	BRT MRDC has been updated and is being reviewed by Metro Planning		A, B, C, D	Climate Action Plan Update, Green Procurement, Resiliency

ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

	In Development Completed Continuous Improvement Board Motion 57 Related Items	Year Initiated	Current Status	Completion Date	Comments	SC(1)	Motion 57 Reference (2)(3)(4)(5)(6)(7)(8)	Reference Back to FY19 Initiatives
30	Update baseline to cover new requirements, regulations and standards	2017		2018	Futher revision might be required after Metro Planning review		A, B, C, D	Climate Action Plan Update, Green Procurement, Resiliency
	Create relationships with external stakeholders regarding climate change							
31	Engage external stakeholder regarding industry standard best practices	2016		2020	Through the Sustainability Council, technology partners, consultants, vendors and the development of the CAAP, engaging with external engagement has been a focus for sustainability at ECSD	*	E	
	Establish a program for compiling new technologies and engineering solutions	2016		2020	Ongoing evaluation of technologies for integration into the metro system. We have not developed a system for cataloging and evaluating. In partnership with other Metro departments and organizaitons incuding outside organizaitons like LA Cleantech Incubator, currently ad hoc.		D1	
32	Develop a process for to catalog and evaluate new technologies	2016		2019	Currently ad hoc through a number of lists in various departments including ECSD, OEI, and across Metro.		D1	
	Develop an Annual Sustainability Report (Energy and Resources Report)							
33	Compile a report that illustrates all the data pertaining to Metro's sustainability achievements	2016		2018	Published 2018 Energy & Resource Report in July 2018	*	A, B, C, D	Climate Action Plan Update, Green Procurement, Resiliency
	Maintain Metro's Environmental Training Institute (ETI)	2013			In place as part of Metro Environmental Management System	*	D1	
34	On-going program management and support will be provided for the ETI	2016		2018	Continually updating modules and working on new modules for internal awareness and training of regulatory issues; trained more than 700 and certified more than 400 Metro employees and stakeholders since 2017.	*	D1	
	Incorporate Sustainability plans into metro's Project Development Plans							
35	Sustainability Plans will be incorporated into project development for ALL construction projects	2016		2018	ECSD is continually working with Project Management and Construction staff to enforce the development and implementation of sustainability plan.	*	B, C	
	Strengthen and Expand Metro's Green Construction Policy (GCP)							
36	Review GCP to identify opportunities to expand and strengthen Specifications Section 01 35 66	2016			Continually being improved and updated.	*	B, C	Climate Action Plan Update, Green Procurement, Resiliency
	Update and Implement Metro's Sustainability Program and Project Plan	2016						
37	Ongoing management and support for the sustainability program and projects	2016			ECSD management and staff are dedicated to supports Metro's sustainability programs and projects, both on Capital projects and O&M	*	B, C, E	

References:

(1) Presented to the Sustainability Council either as a stand alone item or part of an overall related report.
(2) Refer to Board Motion Item #57 by Garcetti, Kuehl, Ridley-Thomas, Solis, and Bonin Dated February 18, 2016.
(3) Each of the codes below refer to the items in Motion Item #57.
(4) Item "A" referrs to climate change and resiliency
(5) Item "B" refers to sustainable infrastructure strategies
(6) Item "C" refers to transit connectivity activities
(7) Item "D" refers to green technology and partnerships
(8) Item "E" refers to Metro Environmental Compliance and Sustainability activities

ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

	In Development Completed Continuous Improvement Board Motion 57 Related Items	Year Initiated	Current Status	Completion Date	Comments	SC(1)	Motion 57 Reference (2)(3)(4)(5)(6)(7)(8)	Reference Back to FY19 Initiatives
	ENERGY							
38	**Energy Management Action Plan (EMAP)**	2016			Working through this process within the EMS. Completing an Energy Resiliency White Paper to feed into a Metro Resiliency Policy.		D	
	Metro Board Motion (2016-0157)							
39	Reduce facility energy use/cost by 2020	2017		2020	Developing baseline for energy-use intensity to account for facility growth	*	D	
40	Increase fuel efficiency	2015		2020	ZEV transitions will increase fuel efficiency	*	A4, D	Resiliency
41	Increase energy efficient lighting	2010		2020	Various lighting upgrades in progress	*	A4, D	Resiliency
42	Increase Propulsion and Auxiliary Systems	2013			Developed a Sustainable Rail Plan in 2013 that identifies opportunities for address these issues. Several pilots have been completed at the Red/Purple Line and Gold Lines with others underway.		A4, D	Resiliency
43	Implement alternative energy generation technology	2014			Developing PPA project and supporting other Metro renewable energy installation projects	*	A4, D	Resiliency
	Electric Vehicle (EV) Charging Program							
44	Conduct feasibility study focusing on conversion of non-revenue vehicles to EV	2016		Dec-16	Project was completed	*	A3, A4, A5, D	Climate Action Plan Update
45	Conduct feasibility study of zero emission vehicles to grid (V2G)	2018		Sep-18	Metro consultant is finalizing report. December 2018.		A3, A4, A5, D	Climate Action Plan Update
46	Develop EV Charger Implementation Plan	2018		Oct-18	Metro consultant is continuing to conduct interviews and develop report		A3, A4, A5, C, D	
	Bus Electrification Program							
47	Provide ongoing and as-needed support	2017		2020	Participating in regular coordination meetings with Vehicle Technology and Acquisition	*	A1, A2, A3	
48	Develop Rate analysis and structure - Resiliency	2015			Participating in regular coordination meetings with utility partners to identify opportunities.		A4, D, E	Resiliency
49	Develop Bus Division Energy Resiliency Site Analysis and Planning	2016		2017	White Paper completed by Metro consultants. Initiating next phase for implementation		A4, D, E	Resiliency
	Gateway LED Lighting and advanced lighting controls							
50	Retrofit Building LED Lighting and advanced lighting controls	2013		2019	Completed audits in 2016. Developed specifications in 2017. A building survey to develop As Built drawings was conducted in July/August 2018; final As Built drawing to be completed by September 2018. RFP package is being finalized.		A4, D, E	
51	Retrofit Garage LED Lighting Retrofit	2017		2018	Project is underway to be completed by December 2018		A4, D, E	
52	Parking Structure Lighting Upgrades	2017		2018	Project is over 50% complete (four parking structures - not gateway)		A4, D, E	
53	**Central Maintenance Facility Building 5 Air Scrubber**	2016		2018	Finalizing solicitation package. Pre-Bid Conference and Job Walk scheduled for August 29, 2018.		A4, D, E	
	Comprehensive Energy Efficiency Project Portfolio (BUS)							
54	Energy Conservation measures at Bus Div. 3,7,9 and 15	2015		2019	Lighting measures have been completed at Division 7 Maintenance Bay and Division 9 Fuel Island. Additional measures being considered.		A4, D, E	
55	Perform Energy Audits to plan ECMs	2015		2020	Energy audits were completed in 2015. Measures identified included $1.4M in lighting and mechanical measures, annual kWh savings of 1,986MW.		A4, D, E	
	Division 18 Energy Retrofit Project Portfolio							
56	Conduct energy audit to develop ECMs	2017		2020	Audits identified measures that would reduce overall energy cost by 13.5%. Measures are currently being discussed with facility stakeholders.		A4, D, E	

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	103rd Watts Outdoor Area Lighting	2017		2018	Pilot project was completed on February 11, 2018. Ten-year cost savings = $41,118.		A4, D, E	
57	Design and Install energy efficient Outdoor Area Lighting (OAL) service	2016			Project is in next phase of implementation		A4, D, E	
	Gateway Parking Garage Variable Frequency Drive (VDRs)							
58	Install VDRs on exhaust fans and supply fans	2016			Project was identified in April 2016 Gateway Building Energy Audit but was not immediately pursued. General Services is considering this project		A4, D, E	
	Division 30 Energy Efficiency Project Package Portfolio							
59	Install a portfolio of ECMs at the Central Maintenance Facility (CMF)	2015			Energy audits were conducted which identified $2.5M in lighting and mechanical measures. Projects have not been developed or funded.		A4, D, E	
	Comprehensive Energy Efficiency Project Portfolio (RAIL)							
60	Install a portfolio of ECMs at Divisions 11 & 22	2014		2016	Lighting retrofits and controls were completed at Division 11 and 22. Division 22 project verified 976,070 kWh and $59,450 in annual savings.		A4, D, E	
	Community Solar and Clean Powers Authority							
61	Work with US Department of Energy and the LA County Clean Power Authority (CPA) in increasing renewable energy mix for propulsion and facilities, specifically within the Southern California Edison (SCE) territory	2015		2019	In negotiations with community solar provider, received US DOE grant to develop comprehensive community solar program. Transition all electric meters within SCE territory to CPA for increased renewable mix and discounted energy rates.	*	A4, D, E	Resiliency
	Conjunctive Billing and Direct Access							
62	Work with utility partners to achieve favorable structures for power	2015		2019	Participating in regular coordination meetings with utility partners to identify opportunities.		A4, D, E	Resiliency
	Power Purchase Agreement (PPA) 1							
63	PPA to install PV/Roof Repairs at Division 9, 11, 14 and 22	2016		2019	Roof replacement IFB to be released shortly; targeting Notice to Proceed by the end of 2018. *The roof IFB has been released.* Electrical surveys conducted at Divisions 9, 11, 14, and 22 to identify spare conduit for connecting PV systems to the electrical service and determine capacity of the electrical systems. PV PPA SOW under going revision based on information collected during the electrical surveys. Meeting with ATU representative to be scheduled once the SOW is updated. PPA contract documents being finalized.	*	A4, D, E	Resiliency
	Bus Yard Canopy Conceptual Design							
64	Design concepts for solar canopies at three bus divisions	2016		2018	Design concepts were completed. Results being considered for additional projects.	*	A4, D, E	Resiliency
	Biomethane Procurement							
65	Manage and procure biomethane fuel	2015			Board approved in June 2013. Metro executed first biomethane supply contract in August 2017. Bench solicitation being developed for RFP release in Fall 2018.	*	A4, D, E	
	Photovoltaic Preventative Maintenance							
66	Implement a PV Preventative Maintenance system	2017		2018	Program was first implemented in 2015 and has been successful. 2018 Q1 system performance improved 18.8% over Q1 2017 and 40.5% over Q1 2016	*	A4, D, E	
	Measurement and verification (M&V) of Wayside Energy Storage System (WESS)							
67	M&V data on the effectiveness of the flywheel storage system in storing energy				Data is currently generated		D, E	
	Pathways to Zero Net Energy (PZNE)							
68	PZNE seeks to eliminate energy-related greenhouse gas emissions	2017		Jul-17	Draft report was completed and then project was shelved due to intellectual property conflicts.		D, E	

ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

	In Development Completed Continuous Improvement Board Motion 57 Related Items	Year Initiated	Current Status	Completion Date	Comments	SC(1)	Motion 57 Reference (2)(3)(4)(5)(6)(7)(8)	Reference Back to FY19 Initiatives
	Sustainability Plan - Energy Security Operations Center (ESOC)							
69	Provide ongoing and as-needed support	2017			Supporting project on an as needed basis		B, C, E	
	LOC64 Sustainability Plan							
70	Provide ongoing and as-needed support	2017			Supporting project on an as needed basis		B, C, E	
	Sustainability Plan - Westside Purple Line Extension (PLE) Section 1							
71	Provide ongoing and as-needed support	2017			Coordinating with the contractor for the May and June submittals.		B, C, E	
	Sustainability Plan - Westside Purple Line Extension (PLE) Section 2							
72	Provide ongoing and as-needed support	2017			Reviewing contractor's response to the January submittal; reviewing April and May submittals.		B, C, E	
	Sustainability Plan - Rail 2 River							
73	Provide ongoing and as-needed support	2017			Energy team gave technical advice on possibility of using DWP OAL program	*	B, C, E	
	Westwood Greenway							
74	Provided ongoing support and first mile, last mile strategies	2015			Development sustainability strategies for helping communities connect to transit		B1, B4, C3	
	Environmental Attribute (Carbon Credit) Reporting and Sales							
75	Manage the Low Carbon Fuel Standard and Renewable Fuel Standard program	2016		2028	Metro sales are 9.5% above market average. In 2018 Metro sold 150,000 credits generating $25M.		E	
	LEED-EBOM for Gateway							
76	Pursue a LEED-EBOM Re-Certification based on new lighting and other measures	2015		2019	LEED recertification is pending completion of ongoing energy measures at gateway including building lighting and controls and garage.		A, B, C, D, E	
	Division 13 LEED Audit							
77	Conduct a LEED Audit at Division 13 to identify and address ongoing operational activities	2017			Report is being finalized. Findings have resulted in additional retro-Cx activities at Division 13		A, B, C, D, E	
	Develop Enhanced Process for Commissioning and Retro-Commissioning of Facilities							
78	Implement process to reduce energy consumption through proper O&M of equipment/systems	2017		2018	Project is in development		A, B, C, D, E	
	Evaluate an Energy Management System (EMS/BMS) for Building to Reduce Energy Consumption							
79	Evaluate existing BMS systems to determine requirements for a enterprise-wide EMS system	2017		2018	Project is in development		A4, D1, D2, E	
	Conduct a Microgrid Study to determine the resiliency requirements for the Metro Power System							
80	Evaluate the system to determine if microgrids could keep critical infrastructure functioning	2016		2018	Project is in development. Working with city of Santa Monica on Bergamot Station Pilot		A4, D	Resiliency

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ECSD PROGRAM AND INITIATIVE STATUS UPDATE (Since September 2016 Response to Board Motion 57)

In Development
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Continuous Improvement
Board Motion 57 Related Items

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	SOLID WASTE & RECYCLING							
	Metro Board Motion (2016-0157)							
81	Reduce environmental liabilities related to hazardous waste	2016		2020	A review of 15 of Metro's waste related construction policies was completed in 2016 and recommendations for policy updates were identified. Recommendations to be implemented. On-going improvement related to the management of hazardous waste are being implemented quarterly.		A4, E	
	Minimize Amount of Paper Waste and Related Consumables							
82	Evaluate paper saving initiatives	2016		2018	Paper saving initiatives have been identified through Division waste characterization studies, facility walk-throughs, and staff interviews. Opportunities need to be reviewed and prioritized for implementation.	*	E	
	Reduce Stretch Wrap and Related Operations Waste							
83	Assess alternates to stretch wraps	2016		2018	A tech memo on the alternatives to stretch and sustainable shipping methods is in development and expected to be delivered in September 2018.		E	
	Revise Metro's Environmentally Preferred Purchasing Policy							
84	Develop a "Green Team" to review product and develop consensus	2016		2018	This task is being removed from the solid waste program and addressed as part of the green purchasing program		D2, E	
85	Develop a Metro-wide environmentally Preferred Purchasing Program	2016		2018	Being integrated into the Green Procurement program		D2, E	
	Increase Material Refurbishing and Re-Use							
86	A re-use program to include coffee cups, cleaning supplies, durable goods, electronics, etc.	2016		2018	Existing material reuse programs were identified through the Metro solid waste baseline assessment process. New programs for implementation are being proposed as part of the Waste Characterization Study for Gateway		E	
	Evaluate Processes and Methods to Maximize Waste Diversion							
87	Evaluate Metro's Waste service levels to determine if service can be reduced	2016		2019	Service level evaluation is being conducted as part of the new solitation for waste collecting and disposal		B2, E	
	Identify Key Recyclable Items in Waste Stream							
88	Develop a enterprise-wide recycling system	2016		2020	Waste characterization studies have been completed at Gateway, Division 7, and Division 11. Recyclable items to capture through program improvements have been identified. A recycling program is being implemented in fall 2018 at Gateway as a test case for the rest of the agency.		B2, E	
	Improve Recycling Rates Through Operational Awareness and Signage							
89	Develop a enterprise-wide recycling system	2016		2020	Metro Communications was engaged in August 2018 to design new waste and recycling signage for the agency. Signage will be rolled out at Gateway first as part of the new recycling program.		B2, E	
	Reduce Paint Waste and Recycle Usable Paint							
90	Evaluate improvements to the paint use and recycling process	2016		2020	Being reviewed as part of the wast mangement process		B2, E	
	Prevent Contamination of Recyclable Through Training and Education							
91	Develop and provide training sessions to Metro Staff	2016		2019	A custodial and general staff training program will be developed in fall 2018 to support the roll out of the Gateway recycling program.		D1, E	
	Develop and Implement an Organic Waste Management System							
92	Conduct a pilot program for Organic Waste Collection	2016		2019	Organic recycling requirements were integrated into the new tree trimming contract in spring 2018. Similar requirements need to be added to the landscaping contract. An organics collection program will be developed with the Metro cafeteria in fall 2018.		B4, E	

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	Ensure Waste Management Policy is Compliant at State/Federal and Local Levels							
93	Evaluate and confirm Metro's Policies	2016		2019	Recycling SOP and Gateway Waste Management Guidelines need to be updated to reflect BMPs and state statutory requirements. Work to be completed in FY19, as budget allows.		B, E	
	Establish Metrics and Revise Policies for Demo/Construction/Renovation Projects for Compliance							
94	Expand requirements to ensure compliance during construction activities	2016		2028	ECSD incorporated as a pilot the Crenshaw Project into the Environmental Management System to capture best practices and gaps in environmental construction compliance. Director Solis, during the August 2018 Board meeting requested documentation and report back in a future meeting (no timing provided).		B, D, E	
	Establish Baseline Metrics for Each Facility/Operation							
95	Collect and set baseline metrics for all facilities and existing programs	2016		2018	An agency wide solid waste baseline was finalized in Summer 2018 using the 2016 calendar year. The baseline will be updated in Fall 2018 to reflect additional information gathered through the Division waste characterization studies.	*	E	
	Develop a Comprehensive Solid Waste Performance Metrics System							
96	Develop a performance metrics system that ensure compliance with state/Federal and Local laws	2016		2018	Metrics tied to state and local laws were developed as part of the Metro baseline development process.	*	E	
	Standardize Solid Waste/Recycling Reporting Protocols into EMS							
97	Update EMS to include evaluation and monitoring protocols	2016		2019	Taking on the ongoing EMS efforts, ECSD staff is exploring opportunities of incoporation into the existing management system		B, D, E	
	Create Project Evaluation Tool to Rank/Prioritize Waste Management Initiatives							
98	Develop a policy, tool, and SOP	2016		2020	An Excel based tool was created to assist with ranking and prioritizing solid waste initiatives for implementation. The tool is being evaluatied for implementation into projects.		B, D, E	
	Integrate Water and Energy Sectors to Find Program Collaboration Opportunities							
99	Collaborate within the Energy and Water Sector to identify outreach and education efforts	2016			Working directly with LADWP and SCE to identify collaboration opportunities for energy development, integration and rate structures.		B, D, E	
	Develop and Integrated Waste Management Hierarchy for Highest/best Use of Materials							
100	Develop and adopt an integrated waste management hierarchy (IWMH)	2016		2019	A proposed IWMH has been developed and presented to Metro. Metro to determine how the IWMH policy will be formally adopted.		E	
	Maximize Disposal Reduction using the IWMH							
101	Expand the IWMH with a focus on Material Recovery Facility (MRF)	2016		2019	Disposal reduction and diversion opportunities following the IWMH were identified through the waste characterization studies. Recommendations need to be prioritized for implementation based on the remaining program budget.		E	
	Report Annually on Waste Sector Initiatives and Successes							
102	Report the success of the program in the E&R Report	2016		7/1/2018	Reporting for the 2017 year is complete. This is an annual initiative and requires ongoing data monitoring and validation throughout the year.	*	B3, D1, E	

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	WATER							
	Metro Board Motion (2016-0157)							
103	Conserve and reduce water usage	2016			Surveys and pilots to identify and test water conservation measures are underway.	*	B1, E	
104	Future construction projects to use methods to capture and treat stormwater/reclaimed water	2012			Incorporated into Metro Rail Design Criteria and Technical Requirements. *Developing equivalent requirements for BRT infrastructure.*	*	B, E	
105	Construction project (>$5M) shall use sustainable building material	2012			Incorporated into Metro Design Criteria and Technical Requirements	*	B, E	
	Draft 2015 Urban Water Management Plan							
106	By 2017 reduce per capita potable water use by 20% (2025 - 2035)	2015			20% reduction in water use (from 2015 levels) was achieved in 2016, but consumption increased in 2017.	*	B, E	
	Apply Diamond Seal System (DSS) to ALL Bus to Reduce Bus Washing							
107	Apply DSS to reduce dirt and residue build-up	2015		2017	Program implemented in 2016. Results showed no significant change in water use. Pilot discontinued		E	
	Retrofit BUS/CAR Wash Nozzles with Higher Efficiency Options							
108	Modify existing nozzles to reduce the amount of water needed to complete vehicle cleaning	2015			A pilot project is currently underway at Division 15 to test the water savings and cleanliness of buses using low-flow nozzle alternatives. 2.0 GPM is the baseline. A combination of 1.0 GPM and 0.5 GPM nozzles will be tested.		E	
	Adjust Sensors in Car Wash Areas to Limit Water Usage							
109	Modify the cycles to limit the amount of water used Before, During and After the Wash	2015			Timing adjustment pilots are being conducted at Division 7 and Division 9. Adjustments were made the week of 8/13/18.		E	
	Re-evaluate and Implement All 15 Water Conservation Strategies Outline in 2010 Action Plan							
110	Update all strategies to identify additional water conservation opportunities	2015		6/25/2018	A tech memo assessing the 2010 Water Action Plan strategies and recommending updates based on current opportunities was submitted to Metro on 6.25.18. Strategies are being prioritized for implementation.	*	D, E	
	Restrict Irrigation with Potable Water							
111	Research/evaluate options to reduce potable water use for irrigation	2015			Irrigation study conducted in 2015. Initial review and study completed. A tech memo on an evaluation of irrigation along the Orange Line was submitted to Metro on 1.29.18. The next step is to develop a SOW for irrigation controller replacement and determine a funding mechanism for the annual network subscription. An irrigation plan for Division 15 has also been developed. Field work requires capital funding.	*	D, E	
	Adjust BUS/CAR Wash Blowers to Capture and Recover Wash Water							
112	Pilot studies to evaluate effectiveness of modifying blowers to conserve water				Project still under development.		D, E	
	Reduce Water Consumption							
113	Remove Ornamental Turf and Install Drought Tolerant Plants	2015		2018	A tech memo on the results of a Division survey and turf removal opportunities was submitted to Metro on 6/4/18. A work plan is being developed for implementing a turf removal project at Division 15. Implementation of drought tolerant and native landscaping for ***new*** construction has been in place since 2003.	*	B2	
114	Conduct a survey with a focus on upcoming renovations	2016		2017	Survey Completed.		B2	
	Retrofit Cooling Towers							
115	Complete study to improve water recycling and reduce cost of operations	2017		8/15/2018	Cooling towers, boilers, and chillers at Gateway are already being replaced by General Services. This project is no longer necessary.		D, E	
	Replace Sanitary and Kitchen Fixtures							
116	Identify existing fixtures to be replaced with high efficiency plumbing fixtures	2017		2019	Sanitary and kitchen fixtures have been audited at the Divisions. A SOW is being developed for a pilot at Division 15 identifying the recommended make/model of the fixtures and project cost.		D, E	

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	Track Water Consumption for Individual Operations							
117	Prioritize water conservation efforts based on survey of Metro facilities	2015		Ongoing	Water use is currently being tracked for all facilities, but data validation and improvements to the tracking system are ongoing efforts. Sub-meters have been installed on the Division 7, 9, 15, and 24 bus washes to improve water tracking capabilities.		B, D, E	
	Identify Opportunities for Graywater Use							
118	Conduct study to determine if graywater retrofits are suitable for Metro Facilities	2017		3/30/2018	A tech memo on opportunities for Metro to retrofit existing properties for graywater was submitted to Metro on 3/30/18. Exploring how to fund implementation.		B2, B4, E	
	Increase Capture of Storm Water Runoff for Use in Landscaped Areas							
119	Increase bio-retention tech., permeable pavement, vegetated swales and infiltration trenches	2017			A tech memo evaluating strategies to capture and store stormwater was submitted to Metro on 5/3/18. Recommendations to be reviewed by ECSD and prioritized for implementation.		B1, B2, E	
	Require Existing Facilities to use Technologies to Capture, Reuse and Treat Storm Water Onsite							
120	Implement best management practices regarding storm water recapture and reclamation	2016		2019	Has been a best practice since 2003 in major capital projects. Current state and local requirements are being implemented on projects within Metro rights of way but has been in discussion with City and County of LA in other jurisdictions. LA Metro is inclined to install but not maintain these Low Impact Development strategies at locations other than Metro rights-of-way.	*	B1, B2, E	
	Educate Public on Water Conservation and Water Database							
121	Information shall be shared with the public via website and other outlets	2017			Metro ECSD website has information including annual reports that serve as information. We also have an opportunity to increase awareness through Green Workforce training and on-site program information panels at stations and projects like Division 4 permeable pavement.	*	D1, E	
	Educate Staff on Water Usage and Conservation Through Training							
122	Develop and integrate content for training staff on water usage and conservation strategies	2017			We also have an opportunity to increase awareness through Green Workforce training and quarterly Metro ENV SP and G-Pro certified Metro staff.		D1, E	
	Identify Funding Opportunities and Collaborate With Local and State Agencies Water Projects							
123	Identify external funding sources for water-related projects	2017			In current conversation with P3, city, and other entities on possible funding opportunities for these types of projects.		E	
	Maximize Use of Recycled Water							
124	Develop a Recycled Water Plan	2015		2019	A work plan for the cross connection test at Division 3 has been prepared and submitted for review. Metro to determine who will complete this test. Opportunity to connect Orange Line irrigation at Chandler and Colfax has been identified and is being scoped out.		B2, B3, D1, E	
125	Evaluate the feasibility and cost effectiveness of using recycled water (Purple Pipe)	2015			Purple pipe installed in capital projects such as Metro Orange Line MOL and MOL Extension. Metro has participated in the LADWP Integrated Water Resource Planning Process, City-wide One Water LA initiative, and the LA Sanitations Bluebelt research projects to develop opportunities for recycled water in multiple LA Meto facilties. Infrastructure has been built in MOL and MOL extension, but recycled water in limited use due to limited supply. Opportunities have been identified and need to be followed-up.		B2, B3, D1, E	

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	Upgrade Metro Resiliency in Terms of Water Supplies for Catastrophic Events							
126	Increase emergency water supply at Divisions and Locations	2018			Working with Emergency Management Department on a path forward.		A4, B, D1, E	
	Implement Green Construction Policies Governing New/Future Metro Divisions							
127	Leverage existing policies, ordinance, and regulations requiring the technologies that capture, treat and infiltrate storm water	2017			Expand implementation into existing facilities. Currently a requirement in new facilities.		A4, B, D1, E	
	Increase Existing underground Storage Capacity for Storm Water							
128	Assess the usage of storm water capture cisterns to reduce the use of potable water	2017		2019	Implemented in several facilities. A tech memo evaluating underground storage of stormwater system-wide was submitted to Metro on 5/3/18. Recommendations currently being reviewed by ECSD staff		A4, B, D1, E	

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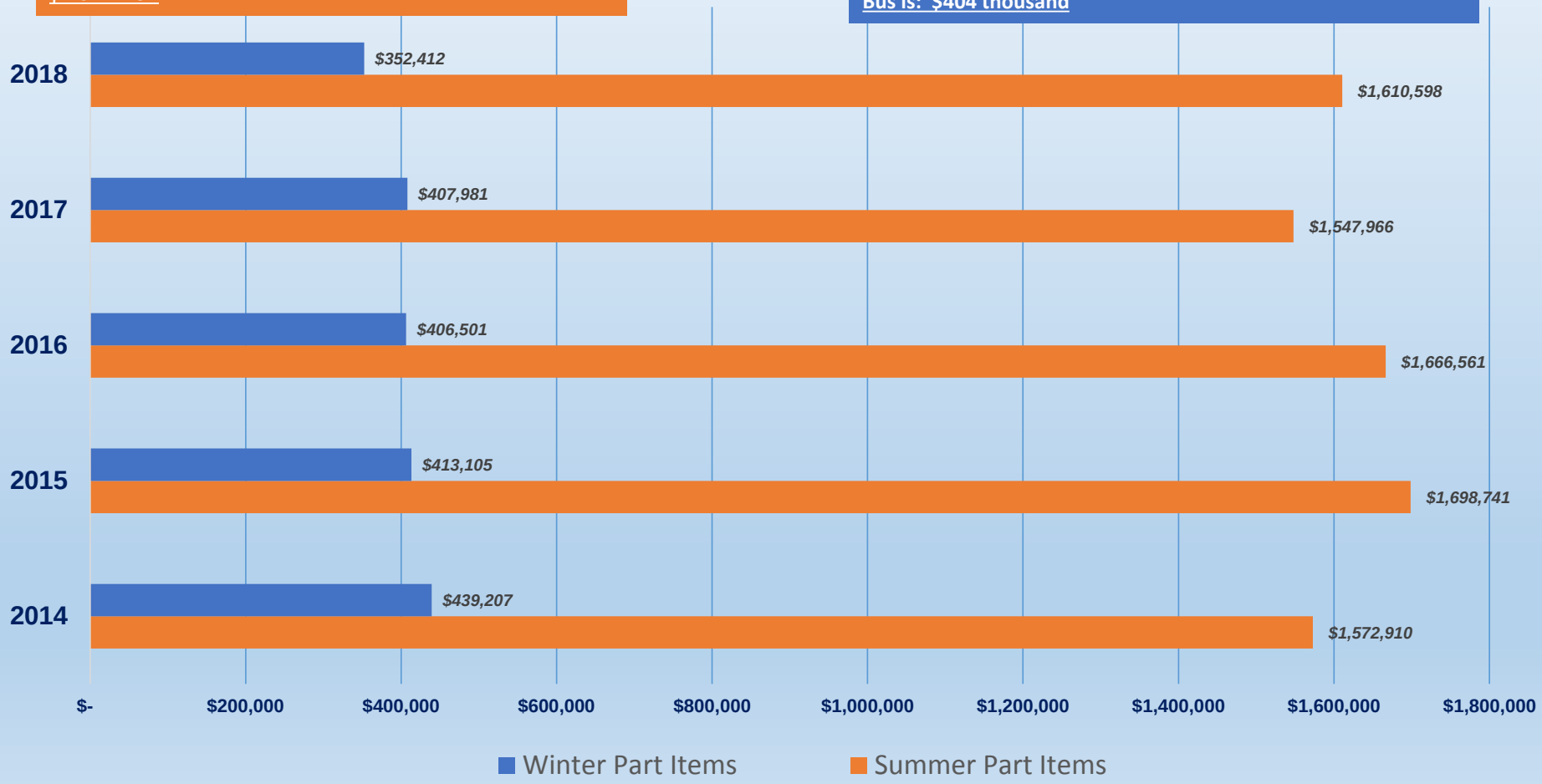
BUS PART CONSUMPTION - SUMMER and WINTER
2014 -2018

Summer Part Items consists of cooling parts such as A/C belts, A/C compressors, Alternators, Coolant - Thermostat, Inverter -Control Box and many other A/C type components. The 5-year average of Summer Part Consumption for Bus is: $1.6 million

Winter Part Items consists of Wiper Blades, Windshield Wiper Arms, Heater/Defroster Blower ASM's, Air intake Filters, Wiper Control Motor ASM, and many other wet weather type components. The 5-year average of Winter Part Consumption for Bus is: $404 thousand



Metro Gold Line Balanceweight Analysis

Wire Run	Tension Length	Station	Midpoint/FT Sta	Hot Temp	Neutral Temp	Cold Temp	BW Rise	BW Fall	Total Movement	Available Travel	Recommended Fix
881	1951	390+37	409+88	130	75	20	3.026	-3.026	6.052	6.86	OK
882	2086	388+97	409+83	130	75	20	3.235	-3.235	6.471	7.03	OK
883	1952	374+85	394+37	130	75	20	3.028	-3.028	6.055	5.53	OK
884	1847	376+40	394+87	130	75	20	2.865	-2.865	5.729	6.60	OK
885 S	2415	329+05	353+20	130	75	20	3.746	-3.746	7.491	3.59	OK
885 N	2645	379+65	353+20	130	75	20	4.102	-4.102	8.205	4.80	OK
886 S	2265	330+55	353+20	130	75	20	3.513	-3.513	7.026	4.81	OK
886 N	2792	381+12	353+20	130	75	20	4.330	-4.330	8.661	4.76	OK
887	2589	333+65	307+76	130	75	20	4.016	-4.016	8.031	3.80	OK
888	2584	335+15	309+31	130	75	20	4.008	-4.008	8.016	3.07	OK
889	1826	312+41	294+15	130	75	20	2.832	-2.832	5.664	6.17	OK
890	1796	313+41	295+45	130	75	20	2.786	-2.786	5.571	5.51	OK
891	2283	296+85	274+02	130	75	20	3.541	-3.541	7.082	4.75	OK
892	2600	298+10	272+10	130	75	20	4.033	-4.033	8.065	3.02	OK
897 S	2395	135+16	159+11	130	75	20	3.715	-3.715	7.429	4.90	OK
897 N	1320	172+31	159+11	130	75	20	2.047	-2.047	4.095	8.59	OK
898 S	2250	136+61	159+11	130	75	20	3.490	-3.490	6.980	4.60	OK
898 N	1320	172+31	159+11	130	75	20	2.047	-2.047	4.095	8.59	OK
899 S	1711	102+70	119+81	130	75	20	2.654	-2.654	5.308	2.44	OK
899 N	1818	137+99	119+81	130	75	20	2.820	-2.820	5.639	6.69	OK
900 S	1711	102+70	119+81	130	75	20	2.654	-2.654	5.308	2.44	OK
900 N	2158	141+39	119+81	130	75	20	3.347	-3.347	6.694	4.89	OK
901 S	3101	100+49	131+50	130	75	20	4.810	-4.810	9.619	-3.54	SPRING TENSIONER
901 N	3150	163+00	131+50	130	75	20	4.886	-4.886	9.771	-2.19	SPRING TENSIONER
902 S	3101	100+49	131+50	130	75	20	4.810	-4.810	9.619	-3.54	SPRING TENSIONER
902 N	2975	161+25	131+50	130	75	20	4.614	-4.614	9.228	-1.65	SPRING TENSIONER
903	2075	159+80	180+55	130	75	20	3.218	-3.218	6.437	1.15	OK
904	2135	179+55	158+20	130	75	20	3.311	-3.311	6.623	-1.04	SPRING TENSIONER
905	2450	177+80	202+30	130	75	20	3.800	-3.800	7.600	-2.02	SPRING TENSIONER
906	2760	176+55	204+15	130	75	20	4.281	-4.281	8.562	-1.98	SPRING TENSIONER
907 S	3045	198+75	229+20	130	75	20	4.723	-4.723	9.446	-2.86	SPRING TENSIONER
907 N	3208	261+28	229+20	130	75	20	4.976	-4.976	9.951	-2.87	SPRING TENSIONER
908 S	2855	200+65	229+20	130	75	20	4.428	-4.428	8.856	-2.27	SPRING TENSIONER
908 N	3070	259+90	229+20	130	75	20	4.762	-4.762	9.523	-0.94	SPRING TENSIONER
909 S	1730	257+40	274+70	130	75	20	2.683	-2.683	5.366	3.22	OK
909 N	2930	304+00	274+70	130	75	20	4.544	-4.544	9.089	-0.51	SPRING TENSIONER
910 S	1865	256+05	274+70	130	75	20	2.893	-2.893	5.785	2.80	OK
910 N	3065	305+35	274+70	130	75	20	4.754	-4.754	9.508	-0.92	SPRING TENSIONER
911	2929	330+50	301+21	130	75	20	4.543	-4.543	9.086	-0.84	SPRING TENSIONER
912	2620	329+00	302+80	130	75	20	4.064	-4.064	8.127	-0.21	ADJUST WEIGHT HEIGHT

Metro Gold Line Balanceweight Analysis

Wire Run	Tension Length	Station	Midpoint/FT Sta	Hot Temp	Neutral Temp	Cold Temp	BW Rise	BW Fall	Total Movement	Available Travel	Recommended Fix
917 S	3158	380+75	412+33	130	75	20	4.898	-4.898	9.796	-1.96	SPRING TENSIONER
917 N	3292	445+25	412+33	130	75	20	5.106	-5.106	10.212	-2.63	SPRING TENSIONER
918 S	3168	380+65	412+33	130	75	20	4.914	-4.914	9.827	-1.99	SPRING TENSIONER
918 N	3119	443+52	412+33	130	75	20	4.838	-4.838	9.675	-1.09	SPRING TENSIONER
919 S	2380	440+00	463+80	130	75	20	3.691	-3.691	7.383	1.20	OK
919 N	3055	494+35	463+80	130	75	20	4.738	-4.738	9.477	-0.89	SPRING TENSIONER
920 S	2700	436+80	463+80	130	75	20	4.188	-4.188	8.375	-0.29	ADJUST WEIGHT HEIGHT
920 N	2816	491+96	463+80	130	75	20	4.368	-4.368	8.735	-0.15	ADJUST WEIGHT HEIGHT
921 S	2900	486+80	515+80	130	75	20	4.498	-4.498	8.996	-0.41	ADJUST WEIGHT HEIGHT
921 N	2910	544+90	515+80	130	75	20	4.513	-4.513	9.027	-0.94	SPRING TENSIONER
922 S	2860	487+20	515+80	130	75	20	4.436	-4.436	8.872	-0.29	ADJUST WEIGHT HEIGHT
922 N	2685	542+65	515+80	130	75	20	4.164	-4.164	8.329	-0.25	ADJUST WEIGHT HEIGHT
923 S	2325	538+85	562+10	130	75	20	3.606	-3.606	7.212	0.87	OK
923 N	1981	581+91	562+10	130	75	20	3.073	-3.073	6.145	2.44	OK
924 S	2500	537+10	562+10	130	75	20	3.878	-3.878	7.755	0.83	OK
924 N	2113	583+23	562+10	130	75	20	3.277	-3.277	6.555	2.03	OK
925 S	2404	579+48	603+52	130	75	20	3.729	-3.729	7.457	1.13	OK
925 N	1833	621+85	603+52	130	75	20	2.843	-2.843	5.686	1.40	OK
926 S	2271	580+81	603+52	130	75	20	3.522	-3.522	7.045	1.54	OK
926 N	1833	621+85	603+52	130	75	20	2.843	-2.843	5.686	1.40	OK
927	2885	617+60	646+45	130	75	20	4.475	-4.475	8.949	-2.87	SPRING TENSIONER
928	3054	617+66	648+20	130	75	20	4.737	-4.737	9.474	-3.39	SPRING TENSIONER
929 S	3095	643+25	674+20	130	75	20	4.800	-4.800	9.601	-3.52	SPRING TENSIONER
929 N	2970	703+90	674+20	130	75	20	4.606	-4.606	9.213	-3.13	SPRING TENSIONER
930 S	2920	645+00	674+20	130	75	20	4.529	-4.529	9.058	-2.97	SPRING TENSIONER
930 N	3140	705+60	674+20	130	75	20	4.870	-4.870	9.740	-3.66	SPRING TENSIONER
931 S	2630	700+70	727+00	130	75	20	4.079	-4.079	8.158	-2.07	SPRING TENSIONER
931 N	2615	753+15	727+00	130	75	20	4.056	-4.056	8.112	-2.03	SPRING TENSIONER
932 S	2460	702+40	727+00	130	75	20	3.815	-3.815	7.631	-1.55	SPRING TENSIONER
932 N	2430	751+30	727+00	130	75	20	3.769	-3.769	7.538	-1.45	SPRING TENSIONER
933	2695	748+10	775+05	130	75	20	4.180	-4.180	8.360	-2.28	SPRING TENSIONER
934	3070	746+40	777+10	130	75	20	4.762	-4.762	9.523	-3.44	SPRING TENSIONER
935 S	2124	771+70	792+94	130	75	20	3.294	-3.294	6.589	-0.51	SPRING TENSIONER
935 N	2156	814+50	792+94	130	75	20	3.344	-3.344	6.688	-0.60	SPRING TENSIONER
936 S	1949	773+45	792+94	130	75	20	3.023	-3.023	6.046	0.04	OK
936 N	2316	816+10	792+94	130	75	20	3.592	-3.592	7.184	-1.10	SPRING TENSIONER
937	2585	835+80	809+95	130	75	20	4.009	-4.009	8.019	-1.44	SPRING TENSIONER
938	2459	836+09	811+50	130	75	20	3.814	-3.814	7.628	-1.04	SPRING TENSIONER
4 S	1860	833+80	852+40	130	75	20	2.885	-2.885	5.770	2.31	OK
4 N	1993	872+33	852+40	130	75	20	3.091	-3.091	6.182	1.90	OK

Metro Gold Line Balanceweight Analysis

Wire Run	Tension Length	Station	Midpoint/FT Sta	Hot Temp	Neutral Temp	Cold Temp	BW Rise	BW Fall	Total Movement	Available Travel	Recommended Fix
3 S	1860	833+80	852+40	130	75	20	2.885	-2.885	5.770	2.31	OK
3 N	1810	870+50	852+40	130	75	20	2.807	-2.807	5.615	2.47	OK
6 S	2610	867+40	893+50	130	75	20	4.048	-4.048	8.096	-0.01	ADJUST WEIGHT HEIGHT
6 N	2920	922+70	893+50	130	75	20	4.529	-4.529	9.058	-0.97	SPRING TENSIONER
5 S	2770	865+80	893+50	130	75	20	4.296	-4.296	8.593	-0.51	SPRING TENSIONER
5 N	2695	920+45	893+50	130	75	20	4.180	-4.180	8.360	-0.28	ADJUST WEIGHT HEIGHT
8 S	3015	917+25	947+40	130	75	20	4.676	-4.676	9.353	-1.27	SPRING TENSIONER
7 S	3040	915+35	945+75	130	75	20	4.715	-4.715	9.430	-1.35	SPRING TENSIONER
10 S	2145	944+25	965+70	130	75	20	3.327	-3.327	6.654	1.43	OK
10 N	2215	987+85	965+70	130	75	20	3.435	-3.435	6.871	3.21	OK
9 S	2311	942+59	965+70	130	75	20	3.584	-3.584	7.169	0.91	OK
9 N	2015	985+85	965+70	130	75	20	3.125	-3.125	6.251	2.33	OK
12 S	2785	982+45	1010+30	130	75	20	4.320	-4.320	8.639	-0.06	ADJUST WEIGHT HEIGHT
12 N	2995	1040+25	1010+30	130	75	20	4.645	-4.645	9.290	-1.21	SPRING TENSIONER
11 S	3005	980+25	1010+30	130	75	20	4.661	-4.661	9.322	-0.74	SPRING TENSIONER
11 N	2815	1038+45	1010+30	130	75	20	4.366	-4.366	8.732	-0.65	SPRING TENSIONER
14	2845	1035+25	1063+70	130	75	20	4.413	-4.413	8.825	-0.74	SPRING TENSIONER
13	2895	1033+15	1062+10	130	75	20	4.490	-4.490	8.980	-0.90	SPRING TENSIONER
16 S	2650	1060+60	1087+10	130	75	20	4.110	-4.110	8.220	0.86	OK
16 N	2690	1114+00	1087+10	130	75	20	4.172	-4.172	8.344	0.74	OK
15 S	2840	1058+70	1087+10	130	75	20	4.405	-4.405	8.810	0.77	OK
15 N	2520	1112+30	1087+10	130	75	20	3.909	-3.909	7.817	1.27	OK
18 S	2715	1109+20	1136+35	130	75	20	4.211	-4.211	8.422	0.66	OK
18 N	2900	1165+35	1136+35	130	75	20	4.498	-4.498	8.996	-0.91	SPRING TENSIONER
17 S	2885	1107+50	1136+35	130	75	20	4.475	-4.475	8.949	0.13	OK
17 N	2730	1163+65	1136+35	130	75	20	4.234	-4.234	8.468	-0.39	ADJUST WEIGHT HEIGHT
20 S	2720	1162+15	1189+35	130	75	20	4.219	-4.219	8.437	-0.35	ADJUST WEIGHT HEIGHT
20 N	2495	1214+30	1189+35	130	75	20	3.870	-3.870	7.739	0.34	OK
19 S	2890	1160+45	1189+35	130	75	20	4.482	-4.482	8.965	-0.88	SPRING TENSIONER
19 N	2285	1212+20	1189+35	130	75	20	3.544	-3.544	7.088	1.00	OK
22	2720	1208+90	1236+10	130	75	20	4.219	-4.219	8.437	-0.35	ADJUST WEIGHT HEIGHT
21	2740	1207+10	1234+50	130	75	20	4.250	-4.250	8.499	-0.42	ADJUST WEIGHT HEIGHT
24 S	3100	1232+80	1263+80	130	75	20	4.808	-4.808	9.616	-1.53	SPRING TENSIONER
24 N	2800	1291+80	1263+80	130	75	20	4.343	-4.343	8.686	-0.60	SPRING TENSIONER
23 S	3270	1231+10	1263+80	130	75	20	5.072	-5.072	10.144	-2.06	SPRING TENSIONER
23 N	2625	1290+05	1263+80	130	75	20	4.071	-4.071	8.143	-0.06	ADJUST WEIGHT HEIGHT
26 S	3080	1286+90	1317+70	130	75	20	4.777	-4.777	9.554	-0.47	ADJUST WEIGHT HEIGHT
26 N	2935	1347+05	1317+70	130	75	20	4.552	-4.552	9.104	0.98	OK
25 S	3005	1285+25	1315+30	130	75	20	4.661	-4.661	9.322	-0.24	ADJUST WEIGHT HEIGHT
25 N	2985	1345+15	1315+30	130	75	20	4.630	-4.630	9.259	0.82	OK

Metro Gold Line Balanceweight Analysis

Wire Run	Tension Length	Station	Midpoint/FT Sta	Hot Temp	Neutral Temp	Cold Temp	BW Rise	BW Fall	Total Movement	Available Travel	Recommended Fix
28 S	2235	1341+95	1364+30	130	75	20	3.466	-3.466	6.933	3.15	OK
28 N	2430	1388+60	1364+30	130	75	20	3.769	-3.769	7.538	2.55	OK
27 S	2425	1340+05	1364+30	130	75	20	3.761	-3.761	7.522	2.56	OK
27 N	2270	1387+00	1364+30	130	75	20	3.521	-3.521	7.042	3.04	OK
30 S	2720	1383+90	1411+10	130	75	20	4.219	-4.219	8.437	1.65	OK
30 N	1773	1428+83	1411+10	130	75	20	2.750	-2.750	5.500	3.58	OK
29 S	2907	1382+03	1411+10	130	75	20	4.509	-4.509	9.018	1.07	OK
29 N	1773	1428+83	1411+10	130	75	20	2.750	-2.750	5.500	3.58	OK
31	1150	1423+80	1435+30	130	75	20	1.784	-1.784	3.567	5.52	OK
32	1150	1423+80	1435+30	130	75	20	1.784	-1.784	3.567	5.52	OK

Legistar File
2019-0504

Office Of Inspector General
“Is LA Metro Ready for Climate Change?”

Presented By

Karen Gorman

Inspector General

July 2019

Executive Management Committee

Los Angeles County Metropolitan Transportation Authority

Metro

Rail Vulnerabilities and Adaptations

Rail expands with high heat temperatures

(1) Sun Kink

(2) Cupping

(3) Pull-Apart

A. Impacts

Trained staff walk the track, ride on high-rail vehicle and manually/visually check for anomalies in the rail

1. Sun Kink (longitudinal displacement in the track alignment)
2. Cupping (a lack of ballast rock support around the sides of the ties)
3. Pull-Apart (failed and separated at bolted or welded joints)

B. Mitigations

1. Track Sensor or Temperature Lasers
2. Track Weather Stations

Overhead Catenary System (OCS) Heat Impacts

A. Impacts

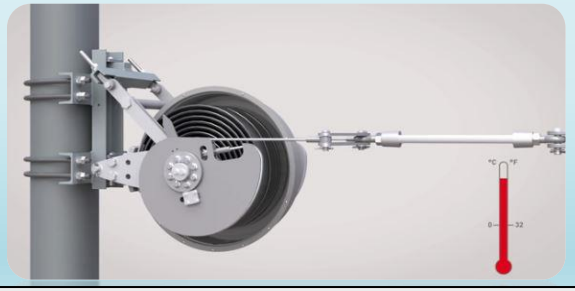
1. **Existing Weight Stack** (4) is used to reduce and eliminate sagging of catenary lines
   A. Wires fraying & broke due to incorrect pulley design. Result weights fell to the ground.
   B. Manual inspections on hot summer days, looking for sagging catenary lines
   C. Sagging catenary lines oscillate, as pantograph hook (5) passes causing entanglement with the wires

(4) Existing Weight Stack Tensioning System

B. Mitigations

1. **Spring Stack Tension System** (6) prevents sagging & eliminates inspections
2. **Pantograph Inspection System** trackside & determines signs of wear or cracks
3. **On-board roof mounted OCS/trolley wire inspection system**, performs real time analysis of the OCS to alert ROC of power system **conditions before failure.**

(5) Pantograph Entanglement with OCS Wires

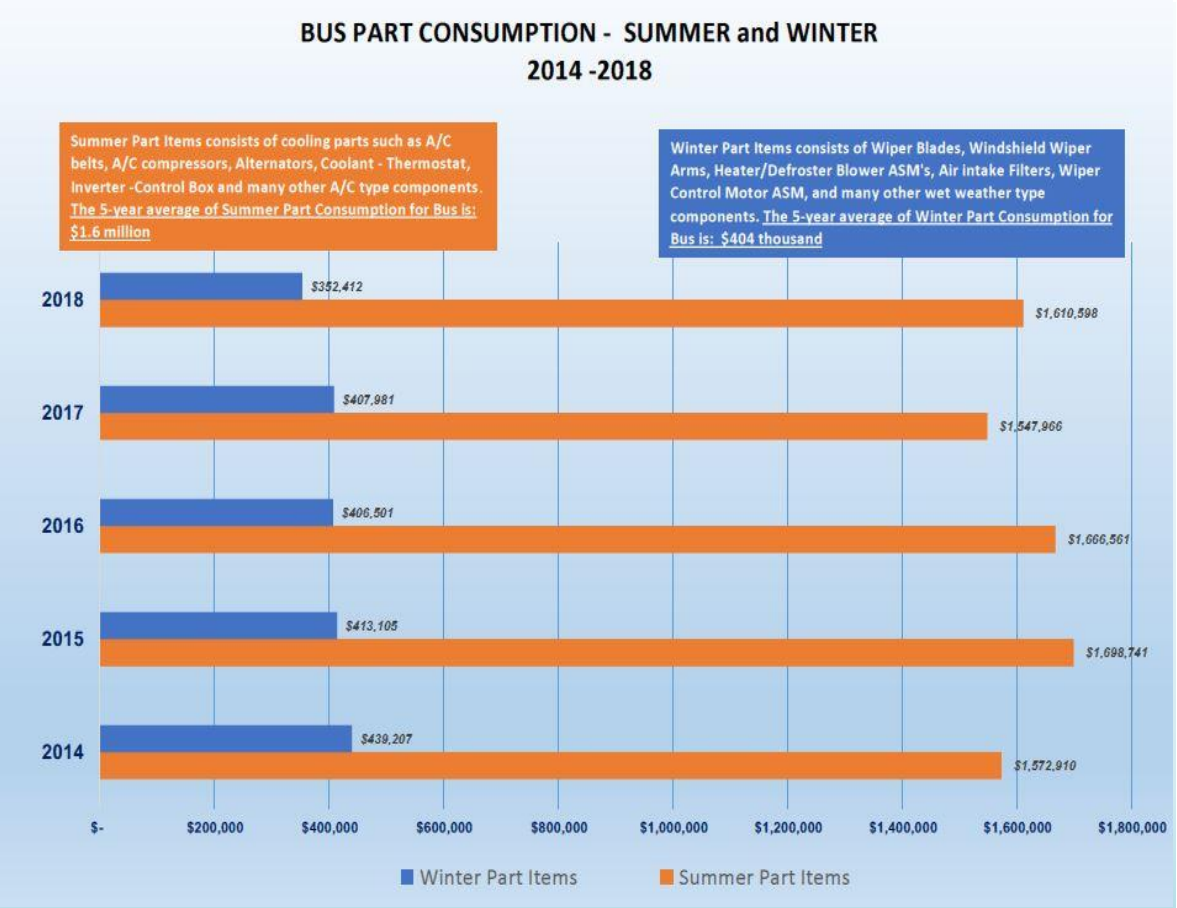


(6) Proposed Spring Stack Tensioning System

Bus Vulnerabilities To Heat

A. Impacts

1. Buses break down more summer, 10% decrease in available buses
2. Bus equipment has a higher failure in summer resulting in unscheduled repairs
3. Current Bus Part Consumption $1.6 Million in summer vs. $404 thousand for winter
4. Maintenance costs could significantly increase over extended summer, greater temperatures



B. Mitigations

1. Plan for increased maintenance
2. Pre-Summer Operations Summits
3. Parts and spares inventory readiness

C. Electric Bus

1. LA Metro Comprehensive Plan states zero emission vehicles by 2030
2. Service test failed for first generation electric buses
3. Metro is waiting for next generation to be developed

Benchmarks of Other Transit Agencies

Other Mitigations:
Nationally

A. Las Vegas, Nevada

1. Multiple Chill Stations for patrons waiting for bus
2. Hand out complementary water bottles
3. Solar powered bus shelters with LED lighting
4. Bus tires filled with pure nitrogen (exhibit less pressure change)

B. Phoenix, Arizona

1. Additional second AC on the bus roof
2. Electric engine cooling fan system on buses
3. Non-metalic shade canopies on light rail platforms
4. Solar powered cool air ventilation system at platform, button controlled by passengers
5. Solar reflective window tint and solar reflective paint on the train bodies
6. Two over-sized AC units on each light rail vehicle
7. Partner with local refrigeration school and provide custom training programs

Benchmarks of Other Transit Agencies

Other Mitigations:
Globally

A. Hong Kong
Regenerative braking technology that pushes energy back into the overhead catenary system to be used by other trains

B. Melbourne, Australia
Installed electronic monitoring sensors in rail tracks to monitor real-time rail track temperature (7)

C. London
Installed remote automated weather-stations (8) and thousands of track-side probes to monitor the local trackside temperatures and conditions

(7) Rail Track Temperature Monitoring Sensor

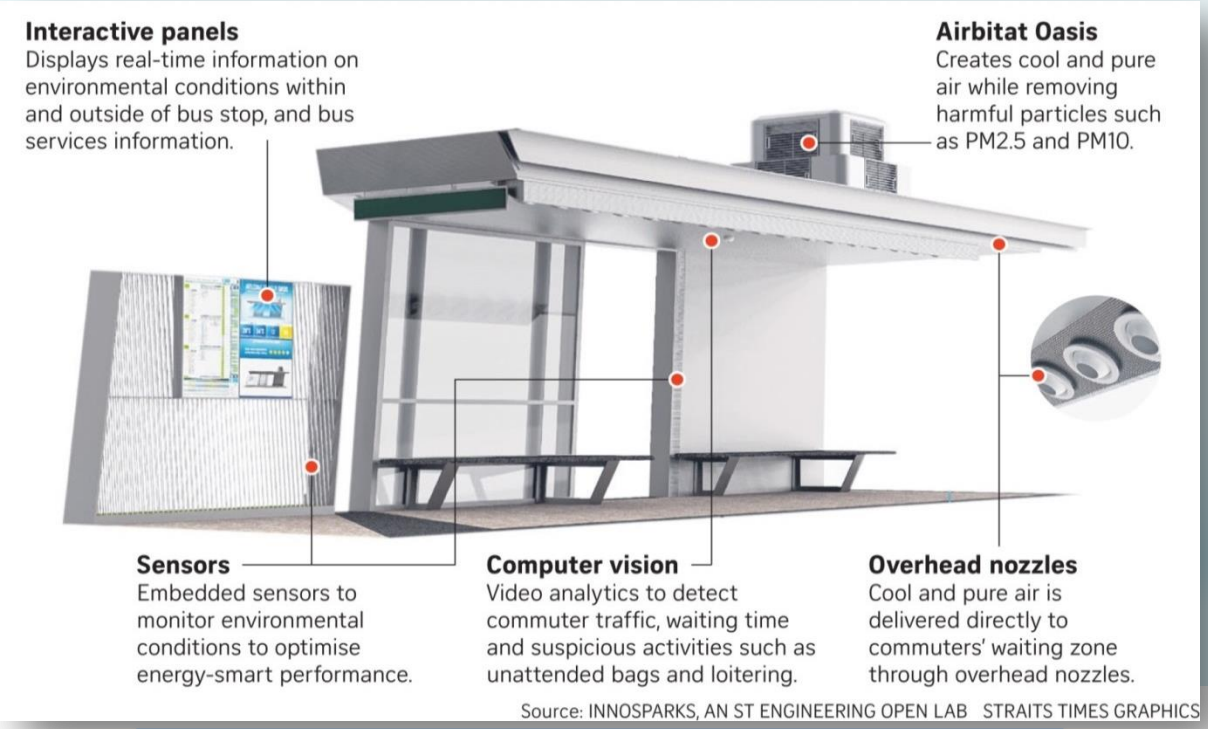
(8) Remote Automated Weather Station

Benchmark of Other Transit Agencies

Other Mitigations:
<u>Globally</u>

D. Singapore

1. Smart bus-stop equipped with the Airbitat Oasis ventilation system
2. Electric fans installed at bus stops



(9) Bus stop with Airbitat Oasis Ventilation System

(10) Electric fans at bus stop

Summary of Recommendations for LA Metro

Recommendations for Rail

1. Spring stack tension system
2. Solar reflective paint
3. Track sensors to immediately measure rail temperatures
4. Remote automated weather-stations and track-side probes to monitor trackside temperatures & conditions

Recommendations for Rail Operation Control

1. ROC to receive “real time” weather information from automated weather-station
2. Establish a coordinated Severe Weather plan
3. Establish “baseline” Preventive Maintenance for servicing and testing emergency generators

Recommendations for Bus

1. Add bus shelters with shade canopy and side ventilation louvers
2. Add dome top bus shelters featuring solar panels and LED lighting
3. Solar-powered ventilation system with overhead nozzles for cooling
4. Solar reflective paint, window tint and special films on buses
5. Purchase buses with electric engine cooling fan system

Summary of Recommendations for LA Metro

Other Key Recommendations

1. Utilize CAAP report to further analyze L A Metro's adaptation to climate change
2. Elevate the sustainable and pro-green comments and suggestions made by the environmental ECSD engineers. Environmental sustainability features should not be dismissed and eliminated as luxury items
3. ECSD should advise on climate impacts to the L A Metro system and coordinate a unified response to climate change
4. Factor climate change impacts into the State of Good Repair schedule
5. Finalize the Emergency Management Plan as it relates to system heat impacts
6. Make improvements in projects directed at climate change resiliency part of the agency performance goals
7. Consider environmental and sustainability considerations for every major project and procurement