

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

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**“Is LA Metro Ready for Climate Change?”**

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Report No. 2019 – 0021

July 18, 2019



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**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,

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- 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.

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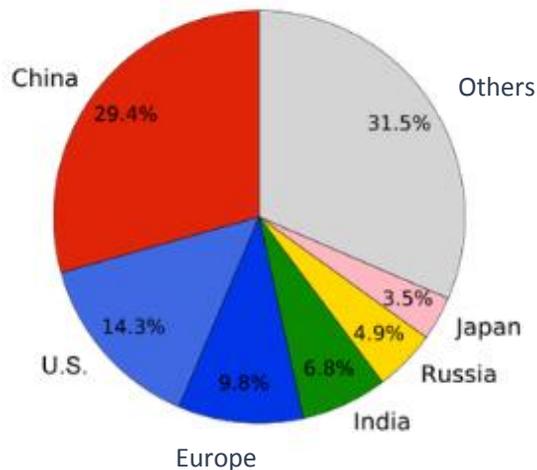
## VI. BACKGROUND

In the first two decades of the 21<sup>st</sup> 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<sub>2</sub>). CO<sub>2</sub> 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<sub>2</sub> emitter is China, but the three countries with the most at stake from climate change are the United States, India, and Saudi Arabia.<sup>1</sup> The following graph shows the major contributing countries of CO<sub>2</sub>.



**Figure 2: Global carbon dioxide emissions by country<sup>2</sup>**

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The following graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO<sub>2</sub> has significantly increased since the Industrial Revolution.



**Figure 3 : Increase in atmospheric carbon dioxide; Ice Age to present<sup>3</sup>**

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.<sup>4</sup>

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.<sup>5</sup> Ocean acidity will intensify from increasing CO<sub>2</sub> 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.<sup>6</sup> 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

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31, 2030, it is the intent of the Legislature that the commission and the Energy Commission implement the California Renewables Portfolio Standard Program.”<sup>7</sup>

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.<sup>8</sup> 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.<sup>9</sup>

Sea level rise is another symptom of climate change.<sup>10</sup> The oceans are losing the electro logical effect that breaks down hydrogen and oxygen.<sup>11</sup> 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.



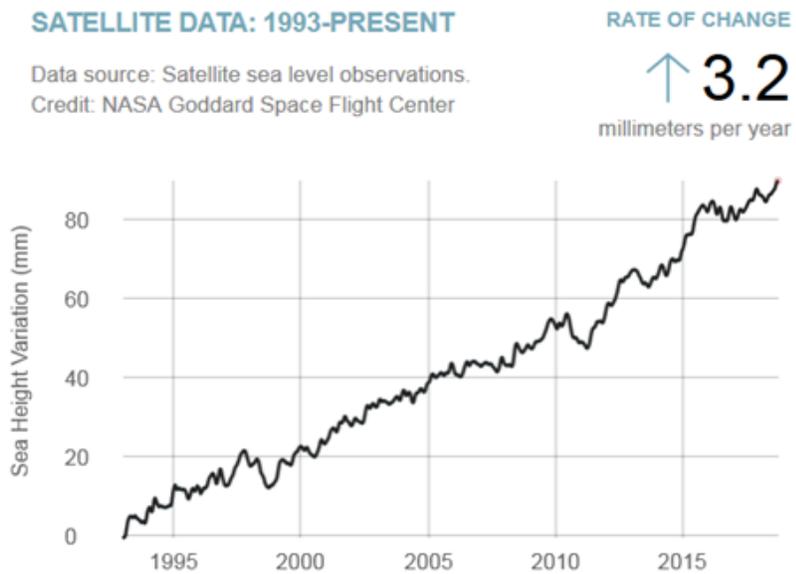
**Figure 4 : Flooding from sea level rise  
Imperial Beach, San Diego CA.**

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.

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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.<sup>12</sup>

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.<sup>10</sup>



80mm = 3.15 inches in 25 years

**Figure 5 : Change in sea level from 1993 to present<sup>10</sup>**  
**Global Ocean rise**

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 3<sup>rd</sup> hottest city in the world and Las Vegas is close behind as the 7<sup>th</sup> hottest city in the world. These cities were chosen as "baseline" comparison cities because of their extreme heat.<sup>13</sup>

#### 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

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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.<sup>14</sup>

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.<sup>15</sup> 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° 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.<sup>16</sup> 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.<sup>17</sup>

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° F.

### **Phoenix, Arizona** **Buses**

About 95% of Valley Metro buses use Compressed Natural Gas (CNG) and they also have 30 hybrid electric diesel buses.<sup>18</sup> 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

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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.<sup>19</sup>

### **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.<sup>20</sup> 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.<sup>21</sup>

## **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 4<sup>th</sup> hottest city in the world with a rail system,<sup>13</sup>
- 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.

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### 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.<sup>22</sup>

### Australia

Metro Trains Melbourne (MTM), operates a train system in the 4th hottest city in the world with 115°F summers.<sup>15</sup> 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.<sup>23</sup> When actual track temperatures reach 131°F or higher, the speed limit is restricted to 50 MPH.<sup>24</sup> Moreover, MTM installed concrete sleepers (rail ties) to prevent the rail track from buckling (because the concrete ties accommodate superior anchoring techniques).<sup>25</sup> Also, they found that extreme temperatures cause



**Figure 6: Sun kinks occur with wooden ties**



**Figure 7: Concrete sleepers prevent deformation in rail**

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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



**Figure 8: Weather station to monitor rail temperature**

speed restrictions at vulnerable locations (curves and bridges). The speed restrictions reduce 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.<sup>26</sup> 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.<sup>[27,28]</sup>

### Singapore

In 2016, Singapore’s Land Transport Authority (LTA) tested the installation of electric fans at five bus stops.<sup>29</sup> 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**

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In 2018, LTA built a trial “smart bus-stop” on a busy major road in Singapore.<sup>30</sup> “Smart” bus-stops are equipped with the Airbitat Oasis ventilation system. This system consists of several



**Figure 10: Airbitat Oasis smart bus stop in Singapore**

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.

## 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:

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- 1) Mitigation: Taking actions to reduce greenhouse gas emissions.
- 2) Adaptation: Taking actions to adjust to the effects of climate change.<sup>31</sup>

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](http://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

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

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

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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.<sup>33</sup> 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

## Is LA Metro Ready for Climate Change?

Certification Standards of the United States Green Building Council.<sup>34</sup> 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.<sup>[35,36]</sup>

## **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.

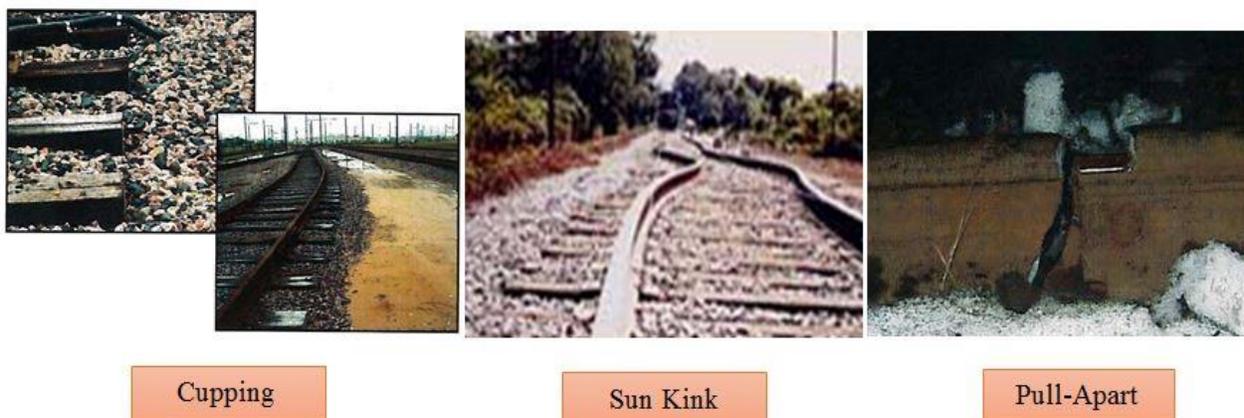
The maximum train speed is 55 mph under normal conditions (determined by California's Public Utility Commission for semi exclusive right of way). Trains are ordered to slow down to 30 mph when the temperature is 115°F. Rail temperatures typically are 20-25°F above the outside

## Is LA Metro Ready for Climate Change?

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  $\pm 5^\circ$  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"**

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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.<sup>37</sup>

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 7<sup>th</sup> Street/Metro Center Station. The trolley wire terminates where the system goes underground into the 7<sup>th</sup> 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

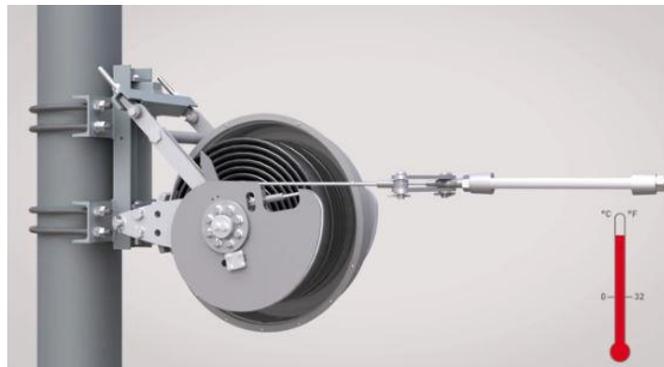
all other locations on the LA Metro system except for the yards (which use trolley wire) and underground tunnels which are heavy rails and uses 3<sup>rd</sup> rail pick-up for electrical power. The trolley wire system does not have the supporting weight tensioning system that the OCS has. The trolley 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



**Figure 13: Blue line trolley wire & cross wire**

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 14: Proposed spring stack tensioning system**

## Is LA Metro Ready for Climate Change?

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

**METRO Gold Line Balanceweight Improvements**

Replace with Spring Tensioners	51
Weight Adjustments Required	16
No Action Required	63
<b>Total</b>	<b>130</b>

**Table 1: Systems Engineering summary results of Gold Line**

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.

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

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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.

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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.

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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).<sup>38</sup>

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### **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.<sup>39</sup>

## **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<sub>2</sub>. 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.

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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 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

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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

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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.

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**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° 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.

## **Is LA Metro Ready for Climate Change?**

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### **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.

## Is LA Metro Ready for Climate Change?

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**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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