

DRAFT
**OVERVIEW OF CLIMATE CHANGE ADAPTATION AND THE 2050 REGIONAL
TRANSPORTATION PLAN – WHITE PAPER**

INTRODUCTION

Adaptation is defined by the *California Natural Resources Agency* as: *Efforts that respond to the impacts of climate change – adjustments in natural or human systems to actual or expected climate changes to minimize harm or take advantage of beneficial opportunities.*¹

Mitigation is defined as actions to reduce greenhouse gas (GHG) emissions. Mitigation alone will not prevent climate change from having serious impacts on the San Diego region. The current concentration of GHGs in our atmosphere – without considering continued and accelerated pace of emissions – will continue to change the climate for the next 30 to 40 years.² Adaptation to the changes that have already been set in motion is essential to maintain the region’s economy, ecosystems, and public health.

The following discussion is an overview of potential impacts to transportation infrastructure due to climate change and the proposed climate change adaptation strategies to deal with these impacts for consideration in the 2050 Regional Transportation Plan (RTP). This discussion includes efforts being made by federal, state, and local governments. While some strategies may not ultimately prove viable for the San Diego region, they are presented in this White Paper to provide decision-makers with a broad range of options for consideration. Also included are draft recommendations focused on the San Diego region that if implemented would require a more detailed study and analysis prior to implementation.

Objectives for the 2050 RTP

The objectives of this white paper for the 2050 RTP are threefold. They include:

1. Assessing the 2010 California RTP Guidelines regarding best practices for addressing climate adaptation in RTPs.
2. Identifying strategies included in the 2009 California *Climate Adaptation Strategy* related to transportation Infrastructure.
3. Evaluating adaptation efforts by transportation agencies across the country.

Background

Climate change is happening now and its impacts are readily apparent, with temperatures increasing, Arctic sea ice disappearing, and sea levels rising beyond climate scientists’ worst-case estimates. Recently it was reported that January 2000 to December 2009 was the warmest decade

¹ 2009 *California Climate Adaptation Strategy*, California Natural Resources Agency, p.4

² 2009 *California Climate Adaptation Strategy*, California Natural Resources Agency, p.14

on record.³ Recent atmospheric measurements of carbon dioxide and methane (two important GHGs) exceed the natural range over the last 650,000 years.⁴ The predicted rate of temperature change by 2050 as a result of these GHG levels is 10-50 times faster than the temperature changes that occurred when the ice ages receded.⁵

Most significantly, the results of GHGs produced by the fossil fuel energy we burn to power our society are a major contributor to climate change. We are largely dependent on fossil fuels to generate electricity, drive our vehicles, transport goods, heat and cool our homes, produce and deliver food, convey and treat water, and provide power to our businesses and industries.⁶

The most significant climate impacts to California's transportation infrastructure are predicted to be from higher temperatures and extreme weather events across the state, reduced and shifting precipitation patterns throughout California, and sea-level rise. The largest projected damages will come from sea-level rise threatening large portions of California's coastal transportation, housing, and energy-related infrastructure.⁷ The San Diego region is not immune to these threats.

Temperature extremes will impact the transportation sector. It is expected less extreme cold days will reduce road damage related to frost and other cold weather conditions, but extreme hot days (including prolonged periods of very hot days), are likely to become more frequent, increasing the risk of buckling of highways and railroad tracks and premature deterioration or failure of transportation.⁸

By 2050, the San Diego region is expected to experience a rise in average annual temperatures between 1.5 and 4.5 degrees Fahrenheit. Greater increases will occur in summer, with peak temperatures consistently reaching the upper 80s and low 90s. Larger temperature increases are expected in inland areas as compared to the coastal zone (within 50 km). Though precipitation is expected to maintain the existing Mediterranean pattern with dry summers and most rainfall happening in the winter months, rainfall amounts will likely vary widely from year to year, leaving the region highly vulnerable to drought.⁹

The combination of a generally drier climate in the future, which will increase the chance of drought and wildfires, and the occasional extreme downpour, is likely to cause more mud- and landslides during winter months. Specifically, researchers and the California Department of Transportation (Caltrans) expect increased damage of transportation infrastructure such as coastal and inland highways, railways, and associated business interruptions. The related debris impacts are

³ National Aeronautics and Space Administration. 2010. *NASA Research Finds Last Decade was Warmest on Record, 2009 One of Warmest Years*. Available at: www.nasa.gov/home/hqnews/2010/jan/HQ_10-017_Warmest_temps.html.

⁴ Intergovernmental Panel on Climate Change. 2007. *IPCC Fourth Assessment Report: Climate Change 2007. Working Group I: The Physical Science Basis*. Available at: www.ipcc-wg1.unibe.ch/publications/wg1-ar4/wg1-ar4.html

⁵ The San Diego Foundation. 2008. *Summary of The San Diego Foundation Regional Focus 2050 Study: San Diego, California*. Available at: www.sdfoundation.org/communityimpact/environment/Initiative-Climate2050.html

⁶ SANDAG 2010 Climate Action Strategy – Final, p. 1

⁷ *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p.124

⁸ *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 122

⁹ SANDAG 2010 Climate Action Strategy – Final, p. 14 and The San Diego Foundation's Focus 2050 Study: San Diego's Changing Climate – A Regional Wakeup Call, p. 6

historically well known to California, but if they become more frequent, they will create greater costs for the state and require more frequent repairs.¹⁰

The largest projected damages will come from sea-level rise up to 12-18 inches higher in San Diego.¹¹ This threatens large portions of California's coastal transportation, housing, and energy-related infrastructure.¹² Sea-level rise Impacts on transportation infrastructure will include flooding of roads, railways, transit systems, and airport runways in coastal areas. A substantial amount of this ground transportation infrastructure is predicted to be at risk from sea-level rise by 2100, including 2,500 miles of roads and rails. Such infrastructure is vital to the state's economy for both the movement of commercial freight and the ability of Californians to get to work and school. In the San Francisco Bay Area, the major airports of San Francisco and Oakland are near sea level and would require additional elevation, protection, or relocation to remain functional.¹³

A report cited in the *2009 California Climate Adaptation Strategy* estimates that the cost of no action in California would be on the order of "tens of billions of dollars in direct costs" and would "expose trillions of dollars of assets to collateral risk." The San Diego region also would likely have to bear its share of the cost climate change impacts will produce.

State of the Planning Practice

In general, transportation agencies nationwide are not yet incorporating climate change adaptation measures into long-range planning. The large uncertainty in the location and magnitude of impacts makes agencies reluctant to take major action on adaptation, given the multitude of other pressing demands for Departments of Transportation (DOTs) and Metropolitan Planning Organizations (MPOs), and their funding limitations.¹⁴ As a result, agencies that are considering adaptation are typically focusing on building awareness of the issues and on research. However, there are recent examples summarized in this report where this focus is beginning to change and that more agencies are recognizing the value of taking action earlier.

Identification of Problems

The states' transportation infrastructure faces potential risk from climate change impacts stemming from changes in temperature, sea-level rise and precipitation. To summarize the changing risks that California's transportation infrastructure may be facing from climate change, the likelihood of occurrence of the projected consequences was qualitatively assessed. The economic cost associated with the required alteration, fortification, or relocation of existing infrastructure is likely to be in the tens of billions.¹⁵ The resulting risk profile for California's transportation infrastructure can be characterized as follows:

¹⁰ Navai, R. (2008). *Climate Adaptation and California's Transportation Infrastructure*. Staff White Paper, California Department of Transportation. Sacramento, CA

¹¹ The San Diego Foundation's Focus 2050 Study: San Diego's Changing Climate – A Regional Wakeup Call, p. 4

¹² *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 119

¹³ *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 68

¹⁴ Gallivan, Ang-Olson, and Turchetta (2009). *Integrating Climate Change into State and Regional Transportation Plans*, Federal Highway Administration. itre.ncsu.edu/adc10/PDFs/2009_Winter_Conference/Turchetta_Session530_paper.pdf

¹⁵ *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 128

- Temperature extremes can increase the risk of road and railroad tracks buckling, decreasing transportation safety and creating higher maintenance costs.
- Winter storms, especially if coinciding with earlier snowmelt and high runoff, can cause flooding and physical damage to culverts, canals, tunnels, coastal highways, runways, and railways, and associated business interruptions.
- More drought, fires, and intense rainfall events will produce more mud- and landslides, which can disrupt major roadways and rail lines. These impacts will likely be felt in the San Diego region.
- Sea-level rise is likely to cause the greatest impacts on California's and on the San Diego region's infrastructure, including more frequent storm-related flooding of airports, seaports, roads, and railways in floodplains due to higher sea levels.
- As sea level rises at a faster pace and coastal storm surges increase, existing fortifications will be increasingly inadequate and need to be raised, and areas previously not at-risk will become at risk.

DISCUSSION

The following section focuses on efforts being made by federal, state, and local governments. Their different approaches to climate change adaptation provide insight and background to the policy and issues section in this paper.

Potential Solutions and Alternatives

Federal

Interagency Climate Change Adaptation Task Force¹⁶

In the Fall of 2009, in response to President Obama's Executive Order 13514, the U.S. Global Change Research Program (USGCRP), the White House Council on Environmental Quality (CEQ), the White House Office of Science and Technology Policy (OSTP), and the National Oceanic and Atmospheric Administration (NOAA) convened the Interagency Climate Change Adaptation Task Force to begin the development of federal recommendations for adapting to climate change impacts both domestically and internationally. More than twenty federal agencies, departments, and offices are participating in this Task Force and contributing their operational capabilities and expertise through a series of workgroups, coordinated with USGCRP, on specific topics related to climate change adaptation.¹⁷

¹⁶ Interagency Climate Change Adaptation Task Force www.whitehouse.gov/sites/default/files/microsites/ceq/20100315-interagency-adaptation-progress-report.pdf

¹⁷ Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas c. Peterson, (eds.). Cambridge University Press, 2009.

Goals of the interagency adaptation work include:

- Forming recommendations toward a national adaptation strategy that uses a set of best practices derived from the best available science and the experience and knowledge of governments and stakeholder groups across the United States and abroad.
- Integrating climate change resilience and adaptive capacity into federal government operations, and coordinating interagency preparations for climate change impacts with domestic and international activities.
- Broadening the understanding of vulnerability to climate impacts, equipping communities with information to use in local adaptation policies, and learning from communities who have taken steps to adapt.

The Task Force has found that there already is substantial U.S. government and non-government activity towards adapting and building resilience to climate change risks. Current activities include landscape conservation cooperatives supported by the Department of the Interior, to a comprehensive risk assessment of Gulf Coast transportation infrastructure by the Department of Transportation, and the Environmental Protection Agency's efforts to support local decision-makers through Climate Ready Estuaries.

As required by Executive Order 13514, the Interagency Climate Change Adaptation Task Force will deliver a report to the President in the fall of 2010. The report will detail the development of domestic and international dimensions of a U.S. strategy for adaptation to climate change, agency actions in support of that strategy development process, and recommendations for any further measures to advance towards a national strategy. The Task Force will not, however, deliver a complete U.S. adaptation strategy to the President.

Over the next several months, the Interagency Climate Change Adaptation Task Force may refine recommendations around structural issues such as improving and integrating science results in developing policy and a framework for federal agency adaptation, as well as cross-cutting topics, including water resources management and international adaptation. The Task Force also may establish additional workgroups, in cooperation with USGCRP, including those to inform the development of a national strategy in the areas of communications and capacity-building, coordination and collaboration across government and with partners, evaluation and learning, and other priority issues. Through a series of regional outreach meetings and pilot activities, the Task Force will continue moving towards recommendations on the development of a national strategy on climate change adaptation.

In tandem with these efforts, the U.S. Department of Transportation's Federal Highway Administration (FHWA) and the U.S. Army Corps of Engineers (USACE) are in the beginning stages of engaging in climate change adaptation issues. FHWA's approaches to climate change are being looked at as a Surface Transportation Safety and Operations issue. In this context, FHWA will be engaging state and local agencies or projects that require FHWA preliminary engineering and NEPA reviews.

In the area of outreach and education, FHWA has established peer exchanges, a Transportation & Climate Change Clearinghouse, and a FHWA Adaptation Working Group. It also is providing technical assistance in the areas of modeling, adaptation, and research.¹⁸

Also at the federal level, the USACE is working towards addressing climate change adaptation. In its circular published in July 2009, guidance is provided for incorporating the direct and indirect effects of projected future sea level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects.¹⁹

State of California

2009 California Climate Adaptation Strategy (CAS)

The changes necessary to protect the state's transportation infrastructure will require collaboration between multiple state, regional, and local agencies. In an effort to begin protecting these assets, Governor Schwarzenegger signed Executive Order (EO) S-13-08. This order provides direction on developing California's first statewide adaptation effort. It requires the California Natural Resources Agency to develop the CAS as the state's first comprehensive guide on climate adaptation.

The CAS was developed with the input of numerous stakeholders including state agencies and seven climate adaptation working groups.²⁰ Although the CAS focuses on state level efforts, climate change vulnerability assessment planning tools, policies, and strategies will be integrated at the local level (MPOs, RTPAs) in conjunction with Caltrans.²¹ The CAS states that impacts of climate change on infrastructure will vary at the local level, but it is certain they will be widespread and costly in human and economic terms, and will require significant changes in the planning, design, construction, operation, and maintenance of California's infrastructure.²²

The CAS has identified the following priorities in addressing climate adaptation for California state agencies. The near-term actions referenced below are those actions that have been identified and which can be initiated or completed by November 2011. The long-term actions include those recommended actions that will require support from California and collaboration with multiple state agencies.²³

¹⁸ *Summary Report: Peer Workshop on Adaptation to Climate Change Impacts Appendix A - Adaptation of Transportation Infrastructure to Global Climate Change (GCC) Effects: Implications for Design and Implementation*, U.S. Department of Transportation, Federal Highway Administration

¹⁹ United States Army Corps of Engineers (USACE) circular: Water Resource Policies and Authorities Incorporating Sea Level Change Considerations in Civil Works Programs

²⁰ 2010 California Regional Transportation Plan Guidelines (Final Draft, February 8, 2010), p. 136

²¹ 2010 California Regional Transportation Plan Guidelines (Final Draft, February 8, 2010), p. 137

²² *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 132-134

²³ *2009 California Climate Adaptation Strategy*, California Natural Resources Agency, p. 127

Strategy 5 – TRANSPORTATION: Develop a detailed climate vulnerability assessment and adaptation plan for California’s transportation infrastructure.

Near-Term and Long-Term Actions:

- a. Vulnerability and Adaptation Planning – Business, Transportation and Housing Agency (BTH) and Caltrans will develop a climate vulnerability plan that will assess how California’s transportation infrastructure facilities are vulnerable to future climate impacts, assess climate adaptation options, prioritize for implementation, and select adaptation strategies to adopt in coordination with stakeholders. This plan will be coordinated with an updated climate mitigation plan that will act as BTH’s and Caltrans’ overall transportation climate policy.
 - i. Develop a transportation use “hot-spot” map – Caltrans will research and identify transportation “hot spots” to identify across the state where the mixture of climate change impacts, population increases, and transportation demand increases will make communities most vulnerable to climate change impacts. Caltrans will include in this analysis how the lowest-income communities in hot spot areas will be impacted.
- b. Economic Impacts Assessment – Complete an overall economic assessment for projected climate impacts on the state’s infrastructure under a “do nothing” scenario and under climate policy scenarios identified by BTH/Caltrans.
 - i. Prepare a list of transportation adaptation strategies or measures based on the “hot spot” map and prepare an economic assessment and cost-benefit analysis for these strategies vs. a do nothing scenario.

Strategy 6 – TRANSPORTATION: Incorporate climate change vulnerability assessment planning tools, policies, and strategies into existing transportation and investment decisions.

Near-Term and Long-Term Actions:

- a. Integrate Mitigation and Adaptation System-wide – Caltrans will develop and incorporate climate change mitigation and adaptation policies and strategies throughout state strategic, system and regional planning efforts. These will be included in key phases of the following planning and project development phases when appropriate:
 - i. Strategic Planning (Governor’s Strategic Growth Plan and California Transportation Plan)
 - ii. System Planning (i.e., District System Management Plan, Interregional Strategic Plan, Corridor System Management Plan, and Transportation Concept Report)
 - iii. Regional Transportation Planning (RTP Guidelines and Regional Blueprint Planning)
 - iv. Project planning (Project Development Procedures Manual, Project Initiation Document, Project Report, Environmental Guidelines)
 - v. Programming (State Transportation Improvement Program, State Highway Operations and Protection Program, California Transportation Commission State Transportation Improvement Program Guidelines)

Strategy 7 – TRANSPORTATION: Develop transportation design and engineering standards to minimize climate change risks to vulnerable transportation infrastructure.

Near-Term and Long-Term Actions:

- a. Transportation infrastructure assessment – Caltrans will assess existing transportation design standards as to their adequacy to withstand climate forces from sea-level rise and extreme weather events beyond those considered.
- b. Buffer zone guidelines – Develop guidelines to establish buffer areas and set backs to avoid risks to structures within projected “high” future sea-level rise or flooding inundation zones.
- c. Stormwater quality – Assess how climate changes could alter size and design requirements for stormwater quality best management practices.

Strategy 8 – TRANSPORTATION: Incorporate climate change impact considerations into disaster preparedness planning for all transportation modes.

Near-Term and Long-Term Actions:

- a. Emergency Preparedness – Caltrans provides significant emergency preparedness abilities for all transportation modes across the state. The transportation system is sensitive to rapid increases in precipitation, storm severity, wave run-up, and other extreme weather events. Caltrans will assess the type of climate-induced impact information necessary to respond to district emergencies. Results will be incorporated into existing operations management plans.
- b. Decision Support (Near-Term) – Caltrans will identify how climate impact information can be integrated into existing Intelligent Transportation Systems and Transportation Management Center operations.

2010 California Regional Transportation Plan Guidelines

Subsequent to the passage of California Assembly Bill (AB) 32 (California Global Warming Solutions Act of 2006), the California Transportation Commission (CTC) adopted an addendum to the 2007 RTP Guidelines in May 2008 to address a request from the California Legislature to ensure climate change issues were incorporated in the RTP process.²⁴

On April 7, 2010, the CTC approved the 2010 RTP Guidelines which incorporate new planning requirements as a result of Senate Bill (SB) 375 and also incorporate the addendum to the 2007 RTP Guidelines. SANDAG staff has been participating in this update process. SB 375 requires MPOs to identify a forecasted development pattern and transportation network that will meet GHG emission reduction targets specified by the California Air Resources Board (CARB) through their RTP planning processes.²⁵

²⁴ 2010 California Regional Transportation Plan Guidelines (Final Draft, February 8, 2010), p. 14

²⁵ 2010 California Regional Transportation Plan Guidelines (Final Draft, February 8, 2010), p. 14

In addition, the CTC references the transportation adaptation strategies contained in the 2009 CAS for guidance on addressing Climate Change Adaptation. The CTC also endorses the CAS' position on the need for significant changes in the planning, design, construction, operation, and maintenance of California's infrastructure. The changes necessary to protect the state's transportation infrastructure will require collaboration between multiple state, regional, and local agencies. Regional planning agencies should incorporate these practices in the implementation of transportation strategies in conjunction with Caltrans, to the extent that they are feasible.²⁶

Best Practices

The 2010 California RTP Guidelines states that notwithstanding a lack of reliable information on the future impacts of sea-level rise, precipitation changes, or extreme heat events, MPOs and RTPAs should begin to address climate change in their long-range transportation plans. There are numerous ways planning agencies can begin preparing for climate change adaptation on the transportation infrastructure including preliminary mapping of infrastructure that is vulnerable to changes in precipitation, heat, and sea-level rise. It is also recommended that design and planning standards be re-evaluated to accommodate potential changes. It is important to ensure that planned infrastructure is engineered and built in locations that can withstand future climate change impacts.

The California Environmental Quality Act (CEQA)

On December 30, 2009, the Resources Agency adopted an amendment to the CEQA Guidelines, Section 15126.2 Consideration and Discussion of Significant Environmental Impacts now requires an Environmental Impact Report (EIR) to evaluate the effects of climate change on the locating of a project in areas susceptible to hazardous conditions, e.g. floodplains, coastlines, wildfire risk areas as identified in authoritative hazard maps, risk assessments or in land use plans addressing such hazards areas. This Amendment became effective on March 18, 2010, and is now included in the California Code of Regulations.²⁷

Other Agencies

City of Chula Vista

In 2009, the City of Chula Vista began developing its *Climate Change Adaptation Strategy (CCAS)*.²⁸ The development of the CCAS also coincides with its participation in the International Conference on Climate Adaptation held in Seville, Spain in May 2009 and the resulting adaptation planning priorities (known as the "Seville Declaration") agreed upon by various California and Spanish government entities. This cross continent exchange was held because of the similar climates the Andalusia region of Spain and Southern California share and potentially similar adaptation strategies they would likely need to implement. Participants of this event representing cities in California and Spain will continue an information exchange on climate adaptation best practices as both regions develop their adaptation strategies.

²⁶ 2010 California Regional Transportation Plan Guidelines (Final Draft, February 8, 2010), p. 137

²⁷ California Environmental Quality Act (CEQA) Proposed Guidelines Amendments & Related Materials ceres.ca.gov/ceqa/docs/Adopted_and_Transmitted_Text_of_SB97_CEQA_Guidelines_Amendments.pdf

²⁸ City of Chula Vista: Climate Change Adaptation Strategy – Roadmap for Development, 2009.

In addition, the City of Chula Vista established a Climate Change Working Group (CCWG), which is comprised of Chula Vista residents, businesses, and community group representatives to assist in developing climate adaptation strategies suitable for Chula Vista. The Climate Change Working Group will be asked to use the following guiding principles to evaluate and prioritize possible adaptation options:

1. Seek out the best available science to understand local climate change impacts and their relative risks;
2. Give priority to policies that can build on existing work rather than policies which require new sources of funding or staffing;
3. Ensure that the legitimate interests of all City stakeholders are considered in evaluating options;
4. Develop policies flexible enough for future incorporation of new science or improved modeling, but defined well enough for staff to implement;
5. Ensure that adaptation strategies complement climate protection measures already in place in Chula Vista;
6. Consider strategies to adapt to both short- and long-term impacts from climate change, but only in areas where the group decides there is enough evidence to support the work;
7. Prioritize strategies in accordance with the degree of risk that different climate impacts pose to Chula Vista, its residents, and businesses;
8. Recommend adaptation strategies that address the most immediate risk in the most financially feasible way (i.e., require the least General Fund support);
9. The strategies chosen should not cause a significant adverse economic and/or environmental impact to the community; and
10. Reach consensus on a preferred list of final recommended adaptation strategies which best meets all City stakeholders' needs.

Following these guiding principles and through a community-based process, the development of a local CCAS would be incorporated into the City's current Climate Action Plan, for City Council review and consideration by the end of 2010. The CCAS would address the following sectors projected to be adversely affected by climate change:

- Water Management
- Energy Management
- Infrastructure & Resources
- Public Health
- Wildfires
- Ecosystems & Biodiversity
- Business & Economy

San Francisco Bay Area

The Bay Conservation and Development Commission (BCDC) is dedicated to the protection and enhancement of San Francisco Bay and to the encouragement of the Bay's responsible use.²⁹ The BCDC has taken a lead role in adaptation planning for the Bay Area. The BCDC will consider an amendment to the San Francisco Bay Plan, which regulates development within the 100-year floodplain of the Bay, to address climate change including adaptation strategies. The following are proposed amendments:³⁰

1. Proposed additions to Bay Plan findings and policies
 - a. Create a climate change policy section of the Bay Plan that addresses the following:
 - (1) Updating sea-level rise scenarios and using them in the permitting process
 - (2) Developing a long-term strategy to address sea-level rise and storm activity and other Bay-related impacts of climate change in a way that protects the shoreline and the Bay; and
 - (3) Working with the Joint Policy Committee (JPC) and other agencies to integrate regional mitigation and adaptation strategies and adaptation responses of multiple government agencies, to analyze and support environmental justice issues, and to support research that provides useful climate change information and tools.
2. Proposed changes to existing Bay Plan findings and policies
 - a. Amend findings and policies on public access to provide public access that is sited, designed and managed to avoid significant adverse impacts from sea-level rise and ensure long-term maintenance of public access areas.
 - b. Amend findings and policies on tidal marshes and tidal flats to ensure that buffer zones are incorporated into restoration projects where feasible and sediment issues related to sustaining tidal marshes are addressed.
 - c. Amend the policies on safety of fills by updating the findings and policies on sea-level rise and moving some to the new climate change section of the Bay Plan.
 - d. Amend the policies on protection of the shoreline to address protection from future flooding.

²⁹ The San Francisco Bay Area Bay Conservation and Development Commission's website: www.bcdc.ca.gov/mission.shtml

³⁰ *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*. San Francisco Bay Conservation and Development Commission, p. 7

3. The Metropolitan Transportation Commission (MTC) included the following actions to combat global warming and help clean Bay Area air in its Transportation 2035 Plan:³¹
 - Commits \$400 million to fund a multi-agency Transportation Climate Action Campaign to reduce our carbon footprint, complementing MTC's Transportation for Livable Communities Program, Regional Bicycle Program, Regional Rideshare Program, and other Transportation 2035 bicycle and pedestrian investments.

King County, Washington

King County Climate Plan proposes to protect the integrity and safe operation of regional transportation infrastructure from climate change impacts.³² King County Road Services Division will incorporate climate change impacts information into construction, operations, and maintenance of infrastructure projects.

Actions already underway by King County Road Services Division include:

- Evaluation of higher flows on bridge and culvert design as well as seawall modifications;
- Participation in King County's interdepartmental climate change adaptation team; and
- Initiation of educational efforts to facilitate the sharing of information among staff on the projected impacts of climate change.

In the near term, King County Road Services Division will incorporate climate change into its own planning and design documents, and comments on others' planning and design documents, as they come up for revision. King County Road Services Division also plans to identify and expand policies and plans that adjust transportation infrastructure improvements and maintenance to ongoing and anticipated climate and weather changes. Additionally, the division is looking at ways to incorporate climate changes predicted in the future into current transportation project designs. For example, the Road Services Division is currently rebuilding over 57 bridges and 40 culverts that will need to be designed to improve streamflows and endure the most significant impacts of climate change.

In the long-term, some strategies that are being considered by Road Services Division include:

- Replacing or rehabilitating bridges in order to improve floodwaters conveyance and to avoid scour during high flows;
- Using pervious pavement and other low impact development methodologies to manage stormwater through reduced runoff and onsite flow control; and
- Modifying existing seawalls to avoid failures in transportation facilities.

³¹ *Transportation 2035 Plan Draft Environmental Impact Report*. Metropolitan Transportation Commission, p. 14

³² 2007 King County Climate Plan (February 2007). King County Departments and Divisions on Climate Change Impacts, p. 118

Issues and Policy Implications

One of the goals identified in the SANDAG 2010 Climate Action Strategy is to protect transportation infrastructure from climate change (Goal 4). This Strategy acknowledges that in addition to being the number one source of climate change emissions in our region, the transportation sector is threatened by the impacts of climate change. Adapting transportation infrastructure to prepare for climate change is emerging as a new concern for designing future projects as well as maintaining our current system. As such, the tools and methodologies for evaluating and adapting to impacts are still in the early stages of development.

The Strategy outlines the following objectives and potential policy measures:³³

Objective 4a. Protect transportation infrastructure from damage due to extreme heat

Policy Measures

- Direct research at developing materials for transportation infrastructure that is better suited to withstand high temperatures.
- Accelerate inspections schedules and prepare for increased maintenance and costs.
- Utilize adaptive management and monitoring to determine which, if any, adaptive strategies should be incorporated in transportation planning.
- Address adaptation issues in the design of new projects and when improvements are made to existing infrastructure.

Objective 4b. Protect transportation infrastructure from sea-level rise and associated higher storm surges

Policy Measures

- Develop a climate vulnerability plan that will identify areas in San Diego at high risk of damage from sea-level rise and storm surges.
- Modify standards for project design and construction to account for increased potential storm surge elevations and frequency.
- Engage a multi-disciplinary team of climate change and coastal experts along with hydraulics and bridge design specialists during scoping process of coastal bridge projects.
- Utilize adaptive management and monitoring to determine which, if any, adaptive strategies should be incorporated in transportation planning.
- Address adaptation issues in the design of new projects and when improvements are made to existing infrastructure.

³³ SANDAG's 2010 Climate Action Strategy - Final, p. 28

Objective 4c. Protect transportation infrastructure from wildfire-associated mudslides

Policy Measures

- Improve bank stabilization and erosion control measures near important transportation lines after wildfire.
- Address adaptation issues in the design of new projects and when improvements are made to existing infrastructure.

A main issue of concern is the lack of quantitative data on vulnerability available to begin to make concrete policy decisions and conduct economic impact assessments. The 2050 RTP is likely to produce a qualitative assessment of potential risks and preliminary evaluation of climate change adaptation strategies. At the project level, environmental clearance documents would conduct further evaluation related to climate change.

Currently, DOTs and their partner agencies are evolving toward "risk management" approaches to asset management and investment programs. In a limited resource environment, a process that seeks to understand and manage the risks to the transportation system from climate change, rather

than continuing with a "worst first" approach, is key to ensuring the most critical infrastructure continues to function adequately. Facilitation of cross-disciplinary collaboration (e.g., Design and Planning) within Caltrans and between local agencies is recommended.³⁴

RECOMMENDATIONS

1. Staff will continue to monitor the implementation of strategies in the CAS and evaluate which ones should be incorporated into the 2050 RTP.
2. The 2010 California RTP Guidelines suggest several ways to begin to address climate change adaptation issues. Following these Guidelines, SANDAG will evaluate the feasibility of developing preliminary mapping of infrastructure that is vulnerable to changes in precipitation, heat, and sea level rise in preparation for climate change adaptation on the transportation infrastructure.³⁵
3. Staff will monitor the implementation of Executive Order S-13-08 which states that the California Resources Agency, in cooperation with the California Department of Water Resources (DWR), California Energy Commission (CEC), California's coastal management agencies, and the California Ocean Protection Council (OPC), shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea-level Rise Assessment Report. This report will guide state agencies that are planning construction projects in areas vulnerable to future sea-level rise shall, for the purposes of

³⁴ *Summary Report: Peer Workshop on Adaptation to Climate Change Impacts Appendix A - Adaptation of Transportation Infrastructure to Global Climate Change (GCC) Effects: Implications for Design and Implementation*, U.S. Department of Transportation, Federal Highway Administration Key Workshop Themes: December 2008.

³⁵ United States Army Corps of Engineers (USACE) circular: Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs

planning, consider a range of sea-level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea-level rise. This report would be completed by March 2011.

4. The SANDAG 2010 Climate Action Strategy acknowledges that climate changes and their associated impacts vary greatly from location to location. Although national and international action is essential, many important decisions about how best to manage systems affected by climate change are made at the local and regional levels. The Strategy recommends that regional and local planning should reinforce and complement the recommendations given at the state and federal levels.³⁶ Therefore, climate change adaptation recommendations from state and federal agencies will continue to be monitored and evaluated.

For Future Analysis

1. To develop an adaptation strategy tailored to the San Diego region, SANDAG would seek funding at the state or federal level to partner with other regional agencies to conduct a vulnerability analysis. However, before conducting this analysis, the NAS California Sea-level Rise Assessment Report and any similar research would be analyzed to assess whether additional vulnerability analysis would be necessary for the San Diego region. Understanding vulnerability to the extent feasible within the limitations of available science and resources is critical to developing adaptation strategies. This analysis would include the latest projections on sea-level rise scenarios and identify existing and planned vulnerable transportation infrastructure. Adaptation strategies could be individually tailored to each of these.

In this context, vulnerability occurs over a long timeframe and affects people differently in the near-term and the long-term. Therefore, both short-term and long-term adaptation strategies should be identified. In the long-term, a variety of adaptation strategies involving many potential partners will be needed to deal effectively with sea-level rise in San Diego.

2. As Caltrans and BTH advance on the implementation of transportation strategies identified in the 2009 California Climate Adaptation Strategy, evaluate data and findings that could be applicable to future RTP updates and infrastructure projects.
3. In order to avoid duplicating research efforts, existing and planned research will be assessed for its applicability to better understand the impact of changes in sea level in other areas of strategic and economic importance, such as San Diego Naval Air Station North Island, San Diego International Airport, and the Port of San Diego. This analysis should provide the basis for further analysis of coastline vulnerabilities and the development of risk management strategies involving the public and private sectors. This analysis should also be conducted in the context that sea-level rise is expected to accelerate in decades following 2050.³⁷

³⁶ SANDAG's 2010 Climate Action Strategy - Final, p. 14

³⁷ Climate Change-Related Impacts in the San Diego Region by 2050, p. 38

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