

Climate Change Adaptation and Mitigation: State Transportation, Regional, and International Strategies: Synthesis

Prepared for

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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WSDOT staff. Online and print sources may include newspaper and periodical articles, NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs and related academic and industry research. Internet hyperlinks in the TSRs are active at the time of publication, but host server changes can make them obsolete.

Request for Synthesis

This synthesis and literature review requested by Seth Stark, Sustainable Transportation Manager, Washington State Department of Transportation, provides information on strategies other state DOT's countries, and local agencies are using to prepare for climate change adaptation and mitigation of the impacts. This Synthesis gathered published information on how other state DOT's and countries are addressing adaptation of highway infrastructure to the future impacts of climate change. Where available, international policies and practices that support the development and implementation of climate change adaptation strategies, are included to assist State DOT's and local agencies in their planning and procedures, design for pavement and bridges, asset management approaches, and other transportation system management activities. The main focus is on transportation infrastructure; related information that may transferable to transportation facilities was included as available.

Databases Searched

- TRID - A Transportation Research Database at the Transportation Research Board (TRB)
- Research in Progress (RiP) – A Database of Current Transportation Research at TRB
- Previous Synthesis Reports on WSDOT Research Website
- Google
- Wisconsin DOT Transportation Synthesis Reports
- Federal Transit Administration (FTA) website
- Federal Highway Administration (FHWA) website
- International Transportation and other Research Websites

State and Regional Adaptation and Mitigation Strategies

Alaska

Alaska's Climate Change Strategy: Addressing Impacts in Alaska

Alaskan Adaptation Advisory Group; January 2010

This report includes the recommendations of the Alaskan Adaptation Advisory Group, which was charged with evaluating and developing options to adapt to climate change. The report also provides additional background on projected climate impacts for Alaska.

http://www.climatechange.alaska.gov/aag/docs/aag_all_rpt_27jan10.pdf

Decision-Making for At-Risk Communities in a Changing Climate

Alaska Center for Climate Assessment and Policy; March 2009

This report is intended to inform decision-makers relating to climate change and uncertainty, risk management, and relocation planning. The report is not intended as a one size fits all plan for relocating at-risk communities.

<http://ine.uaf.edu/accap/>

Estimating Future Costs for Alaska Public Infrastructure at Risk from Climate Change

Authors: Peter Larsen and Scott Goldsmith, Institute of Social and Economic Research (ISER), UAA Orson Smith, Civil Engineering Department, UAA; Meghan Wilson, ISER, UAA; Ken Strzepek, University of Colorado at Boulder; Paul Chinowsky, University of Colorado at Boulder; Ben Saylor, ISER, UAA; University of Alaska Foundation; National Commission on Energy Policy.; Alaska Conservation Foundation, Anchorage, Alaska; Rural Alaska Community Action Program; June 2007

Summary: This report discusses new model developed to estimate costs associated with climate change adaptation of public infrastructure in Alaska. The report provides information about how the researchers estimate costs and the difficulties of creating an accurate inventory of public infrastructure throughout the state. . .

<http://www.iser.uaa.alaska.edu/Publications/JuneIICLE.pdf>

California

Adapting to Rising Tides: Transportation Vulnerability and Risk Assessment Pilot Project

San Francisco Bay Area Metropolitan Transportation Commission; November 2011

Summary: The San Francisco region's MPO was one of five transportation agencies selected by FHWA in 2011 for a pilot project to test a draft [vulnerability and risk assessment conceptual model](#) for transportation infrastructure. The model is intended to serve as a framework to help transportation agencies assess the risk to infrastructure of projected climate change impacts. The Bay Area project inventoried potentially vulnerable transportation assets along a section of the Alameda County shoreline and measured their relative importance to the health of the broader transportation network.

http://www.mtc.ca.gov/news/current_topics/10-11/sea_level_rise.htm

California Governor Hosts Conference on Climate Risk to State's Future

Office of Gov. Edmund G. Brown; Dec. 15, 2011

Summary: California Gov. Jerry Brown (D) convened a conference to discuss ways in which the state can prepare for and protect itself from the risks of climate change. The *Governor's Conference on Extreme*

Climate Risks and California's Future brought together representatives from government, business, and environmental groups in response to the findings of the United Nations' Intergovernmental Panel on Climate Change's final report issued in November 2011. Additional complementary events are scheduled through the first half of 2012. Recordings and conference materials are available on the conference website.

http://www.climatechange.ca.gov/ecrcf/co_events.html

Caltrans Issues Guidance on Incorporating Sea-Level Rise in Programming and Design of Projects

California Department of Transportation; June 9, 2011

This guidance document addresses the consideration of sea-level rise in the design and programming of transportation projects in California. The guidance calls for an analysis of whether the potential exists for a project to be impacted by rising sea levels and whether to incorporate sea level rise adaptation measures into the project, with the results documented in the Project Initiation Document.

http://www.dot.ca.gov/hq/tpp/offices/orip/Updated_Climate_Change/Documents/Sea_Level_Guidance_May2011.pdf

First Progress Report on California Climate Adaptation Strategy Released

California Natural Resources Agency; Nov. 15, 2010

Summary: This report tracks the state's progress in implementing the state's multi-sector climate adaptation strategy finalized in 2009. Released at the Governors' Global Climate Summit at the University of California, Davis, the document describes the working and/or stakeholder groups that have been formed to develop plans and strategies for seven sectors: public health, biodiversity and habitat, oceans and coastal resources, water management, agriculture, forestry, and transportation and energy infrastructure.

<http://www.energy.ca.gov/2010publications/CNRA-1000-2010-010/CNRA-1000-2010-010.PDF>

California Infrastructure Adaptation Strategies

California Infrastructure Adaptation Strategies; Climate Adaptation Working Group (California Energy Commission and California Department of Transportation); 2010

Summary: The state agencies that participated in the Climate Adaptation Working Group (California Energy Commission and California Department of Transportation) developed the following strategies and are responsible for and will spearhead strategy implementation . . . and will require significant changes in the planning, design, construction, operation, and maintenance of California's infrastructure. Infrastructure adaptation strategies developed thus far pertain to two aspects of development: transportation and energy.

. . . Adaptation plans will be developed for the long-term with estimations of future growth, demand, and vulnerability issues . . . areas may be identified that will need to be returned to a natural state. . .

http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy_-_Chapter_10_-_Transportation_and_Energy_Infrastructure.pdf

Connecticut

Adapting to Connecticut's Changing Climate

Department of Environmental Protection; State of Connecticut; March 2009

Summary: These fact sheets detail current observations and provide some cursory recommendations for alternative approaches to foster adaptation at the local and regional levels.

<http://www.ct.gov/dep/lib/dep/air/climatechange/adaptation/090320facingourfuture.pdf>

Delaware

Transportation Planning in Response to Climate Change: Methods and Tools for Adaptation in Delaware

Authors: Oswald, Michelle; McNeil, Sue; Ames, David; Mao, Weifeng; Transportation Research Board Washington DC; Transportation Research Board 91st Annual Meeting; 2012

Abstract Summary: As the risk of climate change increases, pressure for adaptation within transportation agencies to promote sustainable practices and alter behavior continues to rise. While mitigation efforts are essential to slowing the threat of climate change, adaptation practices to build resilience and protection from impacts should be accelerated. Implementing designs that are responsive to climate change-induced factors to reduce impacts through transportation adaptation practice is fundamental to regional transportation planning in Delaware. . . This study explores methods for analyzing potential climate change impacts such as sea level rise on transportation infrastructure in Delaware, specifically the I-95 corridor. . . The methods implemented for adaptation planning in northern Delaware provide an example of how agencies throughout the country can begin to adapt to climate change.

<http://pubsindex.trb.org/view.aspx?id=1129294>

Florida

Development of a Methodology for the Assessment of Sea Level Rise Impacts on Florida's Transportation Modes and Infrastructure

Author: Leonard Berry; Florida Atlantic University; Florida Department of Transportation; March 2, 2012

Summary: This report addresses the assessment of impacts from sea level rise (SLR) on Florida's transportation infrastructure for planning purposes. The research included a literature review and analysis of SLR projections, studies, models, and methodologies used in the state. The report specifies a recommended methodology for forecasting SLR in Florida and identifies potentially vulnerable infrastructure, summarizes potential SLR impacts on Florida's coastal and low-lying transportation infrastructure, and lists currently available tools for infrastructure protection and adaptation of transportation networks and systems. The report also provides short-term and long-term recommended actions for incorporating SLR into the FDOT planning process.

<http://dels.nas.edu/Report/Level-Rise-Coasts/13389>

Florida Action Team Final Report

Governor's Climate Action Team; Florida Governor's Climate Action Team Website; 2012

Summary: Adaptation . . . this Phase 2 report to Governor Crist . . . contains 50 separate policy recommendations and a separate suite of recommendations as guidance to the Florida Department of Environmental Protection in its development of a regulatory, market-based cap-and-trade emissions limiting program. The report builds on the recommendations of the Phase 1 report released November 1, 2007.

<http://www.flclimatechange.us/documents.cfm>

Florida's Adaptation Response

FHWA Website; Climate Change; FHWA/AASHTO Climate Change Adaptation Peer Exchange; December 2009

Summary: . . . FDOT has also been conducting partner outreach to inform and engage them about current climate change activities and related requirements in state law and expected federal legislation . . . The key adaptation topics to discuss during the development of the 2060 FTP, currently underway, will include:

- Working cooperatively to identify infrastructure at risk and to coordinate adaptation efforts;
- Considering the feasibility and cost-benefit analysis of alternatives needed to support future adaptation investment decisions (e.g., looking at risk, recognizing limited resources and the life expectancy of structures);
- Integrating adaptation into transportation asset management efforts statewide; and
- Identifying supportive research needs.

Florida's Action Plan and information about other climate-related activities are available at www.flclimatechange.us .

Barriers to Adaptation

. . . barriers to adaptation in Florida, including a lack of standardized climate projections, lack of coordination on data that is available and the politicized nature of the issue of climate change. . . http://www.fhwa.dot.gov/hep/climate/peer_exchange/peer07.cfm

Florida Stormwater Erosion and Sedimentation Control Inspector's Manual

Florida Department of Environmental Protection Nonpoint Source Management Section; Tallahassee, Florida; July 2008

This updated version of the *Florida Stormwater, Erosion, and Sedimentation Control Inspector's Manual* is an important element of FDEP's training and certification program. It provides a "toolbox" of BMPs with instructions for their use and is designed to be a comprehensive reference source . . . <http://www.dep.state.fl.us/water/nonpoint/docs/erosion/erosion-inspectors-manual.pdf>

Hawaii

Transportation Asset Climate Change Risk Assessment Report

SSFM International, Honolulu, HA: Island of Oahu Metropolitan Planning Organization; November 2011

Summary: This report documents work conducted by the Oahu MPO as part of a pilot project to test FHWA's draft [vulnerability and risk assessment conceptual model](#) for transportation infrastructure. The model is intended to serve as a framework to help transportation agencies assess the risk to infrastructure of projected climate change impacts. The Oahu MPO project conducted a stakeholder workshop to identify the most critical areas of transportation vulnerability on the island. Additional information on the pilot projects is available on FHWA's webpage, [Adaptation Conceptual Model Pilots](#). http://www.oahumpo.org/reports/transportation_vulnerability_due_to_climate_change.html

A Framework for Climate Change Adaptation in Hawaii

Hawaii's Ocean Resources Management Plan Working Group; University of Hawaii, Center for Island Climate Adaptation and Policy; November 2009

Summary: This is a collaborative framework for adaptation planning in Hawaii, containing six elements: (a) Climate Change Adaptation Team; (b) Long-Term Vision; (c) Planning Areas and Opportunities; (d) Scoping for Climate Change Impacts to Major Sectors; (e) Vulnerability Assessment; and (f) Risk Assessment.

http://hawaii.gov/dbedt/czm/ormp/reports/climate_change_adaptation_framework_final.pdf

Iowa

Iowa Climate Change Adaptation & Resilience Report: How Should Hazard Mitigation and Other Community Planning Programs Respond to Climate Change?

Corporate Authors: Environmental Protection Agency; Federal Emergency Management Agency, WA DC; EPA; 2011

Abstract Summary: This report presents the findings of a pilot project initiated by the U.S. Environmental Protection Agency (EPA) to work with Iowa stakeholders and governments to identify barriers to and incentives for considering regional effects of climate change in hazard mitigation planning and other community planning processes. . . Iowa communities have been experiencing floods that are growing more severe and frequent, and state and local planners are working to identify local planning approaches that improve resilience to future floods and help communities recover after disasters. . .

http://www.epa.gov/smartgrowth/pdf/iowa_climate_adaptation_report.pdf

Missouri River Flood of 2011: Transportation Impacts

Iowa Department of Transportation; May 30, 2012

Summary: Iowa DOT has released a web-based “Storify” project chronicling the 2011 Missouri River flooding and its impacts on the state’s transportation system. The flood covered 150 miles of western Iowa, causing extensive damage to roadways. The webpage features links to photos, video, news articles, and a narrative describing the events of the flooding and the efforts to rebuild.

<http://www.iowadot.gov/floods/>

Kansas

New Research Focuses on Storm Water Management Systems

Researchers at Kansas State University are investigating how rainfall and weather patterns are affected by climate change with better adaptation and mitigation strategies as the end result. To ensure that storm water management systems are up to date and can handle future weather changes, the researchers are updating Kansas rainfall distribution data, maps that have not been updated since 1961.

<http://www.ruraltraining.org/resources/item/new-research-focuses-storm-water-management-systems>

Designing stormwater systems for the future

Homeland Security Newswire; More Sharing ServicesShare; 2012

Researchers study how climate change is affecting rainfall and weather patterns throughout Kansas to help with future adaptation and mitigation strategies; the researchers are updating rainfall distribution data to ensure current stormwater management systems can handle future weather changes. . .

<http://www.homelandsecuritynewswire.com/dr20120425-designing-stormwater-systems-for-the-future>

Whether the weather is cold or hot, rainy or not, research is ensuring stormwater systems are designed for the future

Source: Stacy Hutchinson; News release prepared by: Jennifer Tidball ; News and Editorial Services, K-State Today, K-State Newsmakers, News and Editorial Services, Kansas State University, Manhattan, KS; April 23, 2012

Manhattan, KS -- In a world of changing weather and rainfall patterns, engineers face challenges when designing stormwater management systems.

A Kansas State University team is researching how climate change is affecting rainfall and weather patterns throughout Kansas to help with future adaptation and mitigation strategies. The research team, led by Stacy Hutchinson, associate professor of biological and agricultural engineering, is updating rainfall distribution data to ensure current stormwater management systems can handle future weather changes.

"We are looking at how the state can minimize risk by developing a better understanding of past weather variability while looking forward at the variability expected with future climate change -- whether it is farm production systems or stormwater management," Hutchinson said.

<http://www.k-state.edu/media/newsreleases/apr12/rainfall42312.html>

Louisiana

Recommendations for Anticipating Sea-Level Rise Impacts on Louisiana Coastal Resources during Project Planning and Design (Draft)

Louisiana Coastal Protection and Restoration Authority; LCPRA Website; Feb. 6, 2012

Summary: This draft technical report includes recommendations for state coastal planners and managers to incorporate sea-level rise (SLR) into planning and engineering for future habitat restoration and storm protection projects. The report recommends that planners and designers anticipate an average SLR on Louisiana's coast of 3.3 feet by the year 2100.

<http://coastal.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=240>

Maine

Climate Change and Transportation in Maine

Judy Gates, Director Maine DOT Environmental Office; Maine Department of Transportation; Oct. 14, 2009

Summary: This report from the Maine Department of Transportation describes the projected effects of climate change on transportation infrastructure in Maine. The report also discusses appropriate strategies to address the impacts. The report was issued in response to state legislation directing state agencies, businesses, industry, and other stakeholders to convene a workgroup, under the direction of the Maine Department of Environmental Protection, to address the challenges of climate change. The report also serves as a commitment to action on climate change, thus allowing MDOT access to planning funds from the Federal Highway Administration.

www.maine.gov/.../ClimateChangeandTransportationinMaine-Final.doc

Maryland

Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase II: Building Societal, Economic, and Ecological Resilience

Report of the Maryland Commission on Climate Change Adaptation and Response and scientific and technical working groups; University of Maryland, January 2011

http://ian.umces.edu/pdfs/ian_report_299.pdf

A Sea Level Rise Response Strategy for the State of Maryland

Zoë Pfahl Johnson, NOAA Coastal Management Fellow; Maryland Department of Natural Resources October 2000.

Summary: This sea level response strategy was developed through an extensive review of related technology, data, and research, along with an assessment of Maryland's vulnerability based on the range of magnitude of impact, the physical characteristics of the coastline, and population growth patterns. This report contains specific recommendations for reducing the State's overall vulnerability to sea level rise.

http://dnrweb.dnr.state.md.us/download/bays/sea_level_strategy.pdf

Massachusetts

Massachusetts Climate Change Adaptation Report

Massachusetts Executive Office of Energy and Environmental Affairs; Submitted by the Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee; Sept. 27, 2011

Summary: This report offers a blueprint for addressing climate change impacts in Massachusetts, including effects on natural resources and habitat, infrastructure, human health and welfare, local economies and governments, and coastal zones and oceans. The report stresses the importance of protecting infrastructure and development from inundation, especially along coasts and in floodplains, and the importance of including climate change predictions in development and design practices. The report also reviews potential strategies to enhance emergency response, to protect natural habitats and watersheds, to establish redundant supply routes, and to incorporate climate change projections into municipal planning.

<http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf>

New Jersey

Climate Change Vulnerability and Risk Assessment of Transportation Infrastructure

North Jersey Transportation Planning Authority; November 2011

Summary: NJTPA was one of five transportation agencies selected by FHWA in 2011 for a pilot project to test a draft [vulnerability and risk assessment conceptual model](#) for transportation infrastructure. The model is intended to serve as a framework to help transportation agencies assess the risk to infrastructure of projected climate change impacts. The NJTPA project involved an inventory of transportation assets using available climate change/weather models and a risk assessment of the vulnerable transportation infrastructure. Additional information on the pilot projects is available on FHWA's webpage, [Adaptation Conceptual Model Pilots](#).

<http://www.njtpa.org/Plan/Element/Climate/FHWAConceptualModel.aspx>

New York State

Mainstreaming Climate Change Adaptation Strategies into New York State Department of Transportation's Operations

Authors: David C. Major, Ph. D., Rae Zimmerman, Ph.D., John Falocchio, Ph.D., Klaus Jacob, Ph.D., Megan O'Grady, Radley Horton, Ph.D., Daniel Bader, Joseph Gilbride, and Taylor Tomczyszyn; Columbia University Earth Institute Center for Climate Systems Research, Armstrong Hall, 2880 Broadway, New York NY; New York State Department of Transportation, Albany NY; October 11, 2011

Abstract Summary: This study identifies climate change adaptation strategies and recommends ways of mainstreaming them into planned actions, including legislation, policies, programs and projects in all areas and at all levels within the New York State Department of Transportation (NYSDOT). . .The results

of the project are presented (following the Introduction) in terms of: the current understanding of climate change science and climate futures for New York State; climate change impacts and vulnerabilities to transportation in NYS; adaptation strategies and best practices; potential adaptation strategies for mainstreaming climate change into the NYSDOT's operations and investment, including the detailed results of climate risk management discussions with personnel from 2 Divisions, 12 Offices, and 1 Region; and a communications and technology transfer plan.

https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-09_synthesisfinalReport1.pdf

Mainstreaming climate change adaptation strategies into NYS Department of Transportation operations: Final Report

SPR_C-08-09; Columbia University Earth Institute Center for Climate Systems Research; New York State Department of Transportation (NYSDOT); October 31, 2011.

This study, developed by Columbia University Earth Institute Center for Climate Systems Research, identifies climate change adaptation strategies and recommends ways of mainstreaming them into planned actions, including legislation, policies, programs and projects in all areas and at all levels within the New York State Department of Transportation (NYSDOT). October 31, 2011.

https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-09_synthesisfinalReport1.pdf

Oklahoma

Making Decisions: An Assessment of the Climate-Related Needs for Oklahoma Decision Makers

Southern Climate Impacts Planning Program; February 2012

Summary: This document provides a climate needs assessment for the State of Oklahoma. The assessment finds that Oklahoma will be subject to rain events that are less frequent but more intense, increasing the risk of drought and floods. The assessment also identifies the types of information that long-range planners, including transportation planners, will need to effectively address climate impacts. The SCIPP is a National Oceanic and Atmospheric Administration regional integrated sciences and assessment team. Findings resulted from interviews with state decision makers conducted by the University of Oklahoma and Louisiana State University.

http://www.southernclimate.org/publications/OK_Climate_Needs_Assessment_Report_Final.pdf

Oregon

ODOT's Climate Change Adaptation Strategy Report

Liz Hormann, ODOT; ODOT Climate Change Technical Advisory Committee; Oregon Department of Transportation; April 2012

Summary: This report from the Oregon Department of Transportation provides an assessment of potential climate change impacts to ODOT; underscores the need for an in-depth vulnerability and risk assessment of ODOT's assets and systems operations; and highlights potential adaptation strategies and existing adaptive capacity within ODOT.

http://www.oregon.gov/ODOT/TD/CLIMATECHANGE/docs/ODOT_Adaptation_Strategy_Final.pdf

Identifying Surface Transportation Vulnerabilities and Risk Assessment Opportunities Under Climate Change: Case Study in Portland, Oregon

Lindsay Walker, Miguel A. Figliozzi, Ashley R. Haire, and John MacArthur, Portland State University, Oregon Transportation Research and Education Consortium; 2011

Summary: This article discusses a method for transportation departments, using geographic information systems, to assess the vulnerability to climate change of various multimodal surface transportation systems. Using Portland, Ore., as a case study, the study outlines how climate change effects can be identified, prioritized, and their impacts assessed.

<http://trb.metapress.com/content/pv122013607m1k84/?p=703e6f75aa74408bac23cb3409252510&pi=5>

The Oregon Climate Change Adaptation Framework

The framework has been developed in parallel with the Oregon Climate Assessment Report (OCAR) by the Oregon Climate Change Research Institute (OCCRI); December 2010

Summary: This introduction to the Oregon Climate Change Adaptation Framework summarizes the key findings and recommendations of the participants in this initial effort to review the emerging science on climate change and evaluate what our priorities should be at a statewide level in terms of preparing people, communities and resources for the coming changes. . . A major determinant of what new actions to recommend is our initial assessment of costs and benefits.

http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf?ga=t

Pennsylvania

Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations

Pennsylvania Department of Environmental Protection; Jan. 27, 2011

Summary: This report represents the first statewide effort to identify practical strategies for addressing climate change impacts. The report includes the recommendations for climate change adaptation of four sector-specific working groups established by DEP and the state Climate Change Advisory Committee: Infrastructure, Public Health and Safety, Natural Resources, and Tourism and Outdoor Recreation. Recommended actions for the transport sector include reviewing research for materials that have the potential to withstand higher temperatures to prevent buckling of roadways and bridges and performing more intense inspections of transportation infrastructure after high impact events in areas subject to erosion. Cross-cutting recommendations include adopting green infrastructure, walkable communities, and integrating adaptation and mitigation strategies as part of government agency planning and operations.

<http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-82988/7000-RE-DEP4303%20combined%20report.pdf>

Pennsylvania Climate Impact Assessment: Report to the Department of Environmental Protection

Authors: James Shortle, David Abler, Seth Blumsack, Robert Crane, Zachary Kaufman, Marc McDill, Raymond Najjar, Richard Ready, Thorsten Wagener, and Denice Wardrop; Environment & Natural Resources Institute, Penn State University; June 2009

Summary: This report describes the expected impacts of climate change on Pennsylvania, including temperature and precipitation impacts, as well as implications for water resources, forests and wildlife, aquatic ecosystems and fisheries, agriculture, energy, human health, tourism and outdoor recreation, insurance and economic risk - but not infrastructure.

<http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/7000-BK-DEP4252%5B1%5D.pdf>

Rhode Island

Summary: Preliminary Assessment of Rhode Island's Vulnerability to Climate Change and its Options for Adaptation Action

Brown University; February 2010

Summary: This report describes the likely impact of climate change on Rhode Island, and the implications for adaptation in Rhode Island.

<http://envstudies.brown.edu/links/SpecialReports.html>

Vermont

Lessons from Irene: Building Resiliency as We Rebuild

Vermont Agency of Natural Resources; Feb. 13, 2012

Summary: The Vermont Agency of Natural Resources' Climate Change Team has issued a report that examines impacts from the August 2011 Tropical Storm Irene to different sectors in the state, including transportation and buildings and infrastructure. State highway impacts, for instance, included damage to 500 miles of roads and over 200 bridges at an estimated cost of up to \$250 million. The report cites Vermont's vulnerability to similar intense flooding events, with more expected in the future to due to climate change, and poses a series of questions regarding how the state and its communities can begin building flood resiliency.

<http://www.anr.state.vt.us/anr/climatechange/irenebythenumbers.html>

Virginia

Assessing Vulnerability and Risk of Climate Change Effects on Transportation Infrastructure – Hampton Roads Virginia Pilot

Virginia Department of Transportation; November 2011

Summary: VDOT was one of five transportation agencies selected by FHWA in 2011 for a pilot project to test a draft [vulnerability and risk assessment conceptual model](#) for transportation infrastructure. The model is intended to serve as a framework to help transportation agencies assess the risk to infrastructure of projected climate change impacts. The Hampton Roads area project focused on developing tools for prioritizing which transportation assets were more vulnerable to climate change or were higher priority under different scenarios. Additional information on the pilot projects is available on FHWA's webpage, [Adaptation Conceptual Model Pilots](#).

http://www.virginia.edu/crmes/fhwa_climate/

Virginia Case Study: Stemming the Tide: How Local Governments Can Manage Rising Flood Risks

Submitted by Chris Coil; Georgetown Law Climate Change Website; May 1, 2010

Summary: This case study analyzes the authority of Virginia local governments to use existing land use regulations to adapt to sea level rise impacts. Specifically, this study looks at local authority to implement policy options identified in the Virginia's Climate Action Plan. Also available: Companion presentation slides.

<http://www.georgetownclimate.org/virginia-case-study-stemming-the-tide-how-local-governments-can-manage-rising-flood-risks>

Washington State

Preparing for a Changing Climate: Washington Change Response Strategy State's Integrated Climate

Washington State Department of Ecology; April 3, 2012

Summary: This report, which was developed in collaboration with several other state agencies, is intended to provide a broad framework for decision makers to ensure that consideration of climate change impacts is given a high priority in their day-to-day work. The report calls for reducing risk of damage to infrastructure by identifying vulnerable areas and taking proactive steps to reduce risks, avoiding climate risks when siting new infrastructure and planning for growth, and enhancing capacity to prepare for impacts such as more frequent and severe flooding. The report also identifies seven high-priority adaptive strategies.

http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm

Climate Impacts Vulnerability Assessment Report

Washington State Department of Transportation; November 2011

Summary: This report documents work conducted by WSDOT as part of a pilot project to test FHWA's draft [vulnerability and risk assessment conceptual model](#) for transportation infrastructure. The model is intended to serve as a framework to help transportation agencies assess the risk to infrastructure of projected climate change impacts. The WSDOT project applied the model using scenario planning in a series of statewide workshops, using local experts, to create a qualitative assessment of climate vulnerability on its assets in each region and mode across the state. Additional information on the project is available in a [folio](#) published by WSDOT. Additional information on the pilot projects is available on FHWA's webpage, [Adaptation Conceptual Model Pilots](#).

http://www.wsdot.wa.gov/NR/rdonlyres/B290651B-24FD-40EC-BEC3-EE5097ED0618/0/WSDOTClimateImpactsVulnerabilityAssessmentforFHWA_120711.pdf

Adapting to a Changing Climate

Washington State DOT; WSDOT CC Website; 2012

Summary: This web page provides information on Washington State DOT's adaptation efforts, including WSDOT's [Statewide Vulnerability Assessment Fact Sheet](#) and WSDOT's [internal guidance document for project-level greenhouse gas and climate change evaluations](#).

<http://www.wsdot.wa.gov/SustainableTransportation/adapting.htm>

Climate Change Impacts, Preparation, Adaptation Website

Washington State Department of Ecology; ECY Website; 2012

Summary: This website provides a range of technical, scientific, and policy-related information about the impacts of climate change on Washington's communities and natural resources. It also describes actions underway by six state agencies, along with other representatives from across state government, to develop a draft climate change impacts response strategy for the state.

<http://www.ecy.wa.gov/climatechange/adaptation.htm>

Atlantic Coast

The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure - Atlantic Coast Study

ICF International, Washington, DC; U.S. DOT; October 2008

Summary: This study assesses the potential net effects of sea level rise, and associated increases in storm surges, on transportation infrastructure coastal states and low-lying regions on the Atlantic coast from New York to Florida. Using statistics from the United Nations Intergovernmental Panel on Climate Change, the report describes several scenarios for sea level rise and provides a series of statewide and county maps that visualize the potential impacts of sea level rise on transportation infrastructure.

http://climate.dot.gov/impacts-adaptations/sea_level_rise.html

Does Sea Level Rise Matter to Transportation Along the Atlantic Coast?

By Jim Titus, J.D., Director, EPA Sea Level Rise Project; EPA Sea Level Rise Workshop; 2002

Summary: . . . As of 2002, no one has assessed the extent to which today's decisions leave our transportation infrastructure vulnerable to climate change. This paper is part of a DOT process to motivate adaptation to climate change in the U.S. transportation sector. In this paper, the implications are laid out that seem important . . . both as a first step toward a comprehensive assessment of how the transportation sector can adapt to sea level rise, and hopefully, to motivate some decision makers to recognize those cases where they need not await such an assessment before beginning to take appropriate measures.

<http://climate.dot.gov/documents/workshop1002/titus.pdf>

Gulf Coast States

Impacts of Climate Variability and Change on Transportation Systems and Infrastructure – Gulf Coast Study

Savonis, M. J.; V.R. Burkett; and J.R. Potter (eds.); USDOT; March, 2008

Summary: The research, sponsored by the U.S. Department of Transportation (DOT) in partnership with the U.S. Geological Survey (USGS), was conducted under the auspices of the U.S. Climate Change Science Program (CCSP). This report . . . describes ways to incorporate climate change issues into transportation planning. The major drivers of climate change examined in the report are sea levels rise, warming temperatures, precipitation pattern changes, and increased intensity of storm activity.

<http://www.climatescience.gov/Library/sap/sap4-7/final-report/>

Mid Atlantic States

Coastal Sensitivity to Sea-level Rise: A Focus on the Mid-Atlantic Region

EPA; January 2009

Summary: This study assesses the impacts of sea-level rise on the physical characteristics of the Mid-Atlantic coast, on coastal communities, and the habitats that depend on them. The report examines multiple opportunities for governments and coastal communities to plan for and adapt to rising sea levels. [USDOT was a contributing author to Chapter 7.]

<http://www.epa.gov/climatechange/impacts-adaptation/>

Midwest States

Midwest Adaptation Peer Exchange Report: Minimizing the Impacts of Climate Change on Transportation Systems in the Midwest

Federal Highway Administration; Sept. 27, 2011

Summary: This report summarizes an April 2011 peer exchange hosted by FHWA on climate adaptation concerns for Midwest state departments of transportation and metropolitan planning organizations. Key topics addressed included criticality and vulnerability of transportation assets, hazard mitigation planning, asset management, and operational strategies. Participants discussed opportunities for climate adaptation, barriers to adaptation, challenges to defining critical assets for planning purposes, and opportunities for future collaboration.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/workshops_and_peer_exchanges/midwest_adaptation_peer_exchange/index.cfm

Western States

Adaptation Case Studies in the Western United States

Authors: Joel Smith, Jason Vogel, Karen Carney, Colleen Donovan, Stratus Consulting, Inc., Boulder, CO; Georgetown Climate Center; Nov. 1, 2011

Summary: This report includes two case studies of the potential role of state governments in adapting to climate change impacts to wildlife and water resources the western United States. The first case study examines the state of Wyoming's management of a species of ground-dwelling bird, the greater sage grouse, and the second case study considers Colorado's management of water supplies in the Colorado River basin. Both case studies provide an overview of the roles of both the state and federal government and include discussion of the adequacy of existing authorities and mechanisms to facilitate climate adaptation efforts.

http://www.georgetownclimate.org/sites/default/files/Adaptation_Case_Studies.pdf

Climate Adaptation Priorities for the Western States: Scoping Report

Western Governors' Association; June 2010

Summary: This report, which was developed by the Governors' Climate Adaptation Work Group, calls for enhanced coordination between state and federal efforts to identify key scientific needs for western states related to climate change. The report also identifies ways that western states can incorporate "smart" climate adaptation practices into resource management and decision making, addresses currently available climate science that supports adaptation planning, and identifies basic principles of importance to western states that should be considered in any federal legislation addressing climate adaptation.

http://www.westgov.org/index.php?option=com_joomdoc&task=doc_download&gid=1279&Itemid

Pacific Northwest and West

Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future

Authoring Body: Committee on Sea Level Rise in California, Oregon, and Washington; Department of Commerce; NOAA; Department of Defense: USACE; DOI/USGS; State of California; State of Oregon; State of Washington; National Research Council; June 22, 2012

Summary: . . . The NRC . . . report on research regarding the factors affecting sea level rise along the coasts of California, Oregon, and Washington. The report says that sea level is rising along much of the coastline but is falling south of California's Cape Mendocino. The report says that global mean sea level rise is modified based on regional factors such as ocean and atmospheric circulation patterns, the geological movement of continental and oceanic plates, and the effects of the loss of glacial ice.
<http://dels.nas.edu/Report/Level-Rise-Coasts/13389>

Climate Change Impact Assessment for Surface Transportation in the Pacific Northwest and Alaska

Authors: MacArthur, John, Oregon Transportation Research and Education Consortium; Mote, Philip; Ideker, Jason; Figliozi, Miguel; Lee, Ming; Corporate Authors: Oregon Transportation Research and Education Consortium, Portland State University, Portland, OR; WSDOT, ODOT, IDT; ADOT;FHWA; 2012

Abstract Summary: . . . The objective of this research project was to conduct a preliminary vulnerability assessment of the risks and vulnerabilities climate change poses to the surface transportation infrastructure system in the Pacific Northwest and Alaska region. . . The report synthesizes data to characterize the region's climate; identifies potential impacts on the regional transportation system; identifies critical infrastructure vulnerable to climate change impacts; and provides recommendations for more detailed analysis and research needs as appropriate to support managing risks and opportunities to adapt multimodal surface transportation infrastructure to climate change impacts.
<http://www.wsdot.wa.gov/research/reports/fullreports/772.1.pdf>

State of the Practice in Adaptation Planning: Alaska, Idaho, Oregon, and Washington

Authors: Walker, Lindsay, Figliozi, Miguel A, Portland State University; Haire, Ashley R, Portland State University; MacArthur, John, Oregon Transportation Research and Education Consortium; Transportation Research Board; Washington, DC; 2011

Abstract Summary: . . . This research summarizes the findings of the surface transportation climate change literature and explores the efforts under way in the transportation planning realm with respect to adaptive preparations of transportation infrastructure for the effects of climate change. This research focuses on transportation facilities and operations in the Pacific Northwest region of the United States. . . . This report builds on recent research on governmental climate change planning efforts to explore how agencies in Alaska, Idaho, Oregon, and Washington are preparing for climate change in their climate action plans, to investigate how the goals and recommendations of those plans are reflected in long-range transportation planning documents, and to identify key resources and strategies agencies may adopt to ensure that the anticipated impacts of climate change on transportation are addressed in transportation planning documents.
<http://dx.doi.org/10.3141/2252-15>

Tribal

Tribal Climate Change Adaptation Options: A Review of Scientific Literature

U.S. Environmental Protection Agency, Region 10; June 2009

Summary: This White Paper is a review of the scientific literature available and summarizes the physical changes in the climate due to climate change, the vulnerabilities of natural resources to these effects, and adaptation options that may be relevant to tribes in EPA Region 10.

Transportation Adaptation and Mitigation Strategies

Adapting Infrastructure to Extreme Weather Events: Best Practices and Key Challenges

AASHTO Workshop and Webinar; American Association of State Highway Transportation Officials; May/June 2012

Summary: AASHTO hosted a webinar June 27, 2012 to provide an overview of a workshop on adapting infrastructure to extreme weather held in conjunction with AASHTO's spring meeting in May 2012. The workshop, titled Adapting Infrastructure to Extreme Weather Events: Best Practices and Key Challenges, provided information on approaches to evaluating and mitigating the impacts of extreme weather events on transportation infrastructure. State DOT officials from across the country discussed their recent experiences with extreme weather impacts and shared perspectives on how to manage weather-related risks. The webinar featured case studies of efforts by the state DOTs in California, Iowa, and Washington to address adaptation issues and speakers described challenges and barriers state DOTs face in addressing those issues. For more information, link to the [workshop summary report](#), a [background white paper](#), and [Webinar Power Point presentations](#).

Climate Change Vulnerability Assessment Pilot: Assessing Vulnerability and Risk of Climate Change Effects on Transportation Infrastructure: Pilot of the Conceptual

Federal Highway Administration; FHWA CC Website; 2012

Summary: This document outlines a conceptual Risk Assessment Model that will be piloted by three to four State Departments of Transportation (DOTs) or Metropolitan Planning Organizations (MPOs) (hereafter, "transportation agencies") selected by the Federal Highway Administration (FHWA). Using feedback and lessons learned during this pilot phase, FHWA will refine this draft conceptual model and develop a final version for all transportation agencies.

The goal of the Risk Assessment Model is to help transportation decision makers (particularly transportation planners, asset managers, and system operators) identify which assets (a) are most exposed to the threats from climate change and/or (b) are associated with the most serious potential consequences of those climate change threats.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/conceptual_model62410.cfm

FHWA/AASHTO Climate Change Adaptation Peer Exchange

Highways and Climate Change FHWA, Highways & Climate Change, Resources, Peer Exchange Opening Presentations - FHWA/AASHTO Climate Change Adaptation Peer Exchange - Highways and Climate Change; FHWA; 2012

Summary: Includes Presentations from FHWA, AASHTO, and State DOT Executives and staff. FHWA began staff reviewed climate change adaptation activities underway at FHWA Headquarters with a description of the definitions of two key terms: mitigation and adaptation.

Mitigation – Actions taken to reduce greenhouse gas (GHG) emissions, mitigating the severity of effects of climate change.

Adaptation – Actions to avoid, withstand, or take advantage of current and projected climate changes and impacts. Adaptation decreases a system's vulnerability, or increases its resilience to impacts.

FHWA's efforts on six related, but independent, adaptation efforts were then discussed.
http://www.fhwa.dot.gov/hep/climate/peer_exchange/peer05.cfm

Climate Change Adaptation

The Fed Center, Fed Center Website; 20 12

Summary: The new Climate Change Adaptation Program Area supports Federal agency climate adaptation planning. Please check in periodically for new information.

- What is climate change adaptation & why do Federal agencies need to adapt?
- Background on the Implementing Instructions for federal agency climate change adaptation
- Federal framework for adaptation planning and guiding principles
- What is Climate Change Adaptation & Why is it Important?

. . . Background on the Implementing Instructions for Federal Agency Climate Change Adaptation

Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance, establishes an integrated strategy for sustainability within the Federal Government. . . The Implementing Instructions for Federal Agency Climate Change Adaptation Planning identify how agencies should respond to the adaptation requirements under the Executive Order.

Federal Framework for Adaptation Planning, and Guiding Principles

. . . The planning framework is not meant to be prescriptive or to provide detailed recommendations for project-level adaptation, those detailed options will be developed over time by each agency with the help of a growing set of planning tools, illustrative case studies, and lessons learned. . .

<http://www.fedcenter.gov/programs/climate/>

Climate Change Adaption for Sustainable Transportation Systems

Art Hirsch; TerraLogic Transportation Blog; Wednesday, April 25, 2012

Summary: . . . New research shows that if present trends continue, the total cost of global warming will be as high as 3.6 percent of gross domestic product (GDP). Four global warming impacts alone -- hurricane damage, real estate losses, energy costs, and water costs -- will come with a price tag of 1.8 percent of U.S. GDP, or almost \$1.9 trillion annually (in today's dollars) by 2100 (1).

. . . It is important that new transportation and other infrastructure projects are designed with flexibility and resiliency to accommodate climate change's short and long term impacts. Climate change needs to be part of the long term thinking for transportation planning, design, and operation and maintenance of transportation systems.

http://terralogicss.com/blog/Sustainable_Transportation/post/Climate_Change_Adaption_for_Sustainable_Transportation_Systems/

Transportation Impacts & Adaptation: Climate Impacts on Transportation

US EPA; USDOT; 2012

Summary: The report indicates:

- Climate change is likely to damage transportation infrastructure through higher temperatures, more severe storms, and higher storm surges.
- Coastal roads, railways and airports are vulnerable to sea level rise, which could lead to delays as well as temporary and permanent closures.
- Warmer winters can alleviate the costs of clearing ice and snow, especially in northern areas.

In the United States, transportation systems are designed to withstand local weather and climate. Transportation engineers typically refer to historical records of climate, especially extreme weather events, when designing transportation systems. For example, bridges are often designed to withstand storms that have a probability of occurring only once or twice every 100 years. [1] However, due to climate change, historical climate is no longer a reliable predictor of future impacts.

<http://www.epa.gov/climatechange/impacts-adaptation/transportation.html>

Assessing Criticality in Transportation Adaptation Planning

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; June 13, 2011

Summary: Federal, state, and local transportation planners are considering the range of impacts that climate variability and climate changes may have on assets. Federal Highway Administration (FHWA) put forth a draft conceptual model to assist transportation agencies in systematically assessing the vulnerability of transportation assets.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/assessing_criticality/index.cfm

Adapting to Climate Change: Another Challenge for the Transportation Community

Authors: Schwartz Jr., and Henry G; Serial: Transportation Research E-Circular; Issue Number: E-C152

Publisher: Transportation Research Board; 2011

Abstract Summary: . . . This paper does not address the science of climate change or the issue of mitigation to reduce the emissions of greenhouse gases (GHG). Rather it accepts the current state of knowledge on global warming and focuses on adaptation. How does the transportation community develop solutions and approaches that will minimize or eliminate the impact of climate change? . . . While most of these scenarios deal with transportation, a few others are included to demonstrate the breadth of the impacts.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Adapting Transportation to the Impacts of Climate Change: State of the Practice 2011

Authors: Wenger, Joyce; Serial: Transportation Research E-Circular, Issue Number: E-C152;

Publisher: Transportation Research Board; 2011

Abstract Summary: . . . This document focuses on transportation adaptation practices that can be implemented to yield benefits now and in the longer term. It highlights what climate change adaptation means for the transportation industry and why it is so important.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Real Solutions for Climate Change: State DOT Workshops on Climate Change

Presented by: Cindy Burbank, Parsons Brinckerhoff; Sarah Siwek, Sarah J. Siwek & Associates, Inc.; Caroline Paulsen, American Association of State Highway and Transportation Officials (AASHTO); Diane Turchetta, Federal Highway Administration (FHWA); Kevin Walsh, Massachusetts Department of Transportation; Gina Campoli, Vermont Agency of Transportation; Perry Keller, West Virginia Department of Transportation; AASHTO; July 20, 2011

Summary of Workshop: Four key workshop purposes:

1. To build awareness of climate change challenges
2. To address both GHG mitigation and climate adaptation
3. To increase capacity of state DOTs to respond to climate change
4. To foster collaboration among state DOTs and their key partners

http://climatechange.transportation.org/pdf/webinars/combined_gcc_workshop_webinars_110720.pdf

Adapting Transportation to the Impacts of Climate Change: State of the Practice 2011

Joyce Wenger, Wenger and Wenger Consulting; Special Task Force on Climate Change and Energy; Transportation Research Board, w.TRB.org; June 2011

Summary: . . . This document focuses on transportation adaptation practices that can be implemented to yield benefits now and in the longer term. It highlights what climate change adaptation means for the transportation industry and why it is so important.

This document . . . address a broad range of adaptation issues facing state departments of transportation and metropolitan planning organizations, including the issue of risk and vulnerability, which is being addressed by an assessment tool that FHWA is testing in a number of states. . . .article highlights quite a number of specific adaptation strategies that have been implemented by various states in the United States that are providing successful results and that bear consideration by agencies across the country. An article on aviation focuses on some of the unique aspects of dealing with adaptation in relation to airport operations, when many constituents are involved—the ideas on communication, cooperation, and collaboration of interest to those dealing with other transportation modes. The final feature article highlights the need for transportation planners and operators to work and plan in close cooperation with a range of agencies and across regional boundaries, and to include weather forecasters and emergency responders.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use

Submitted by Chris Coil; Georgetown Climate Center; November 1, 2011

Summary: The Adaptation Tool Kit explores 18 different land-use tools that can be used to preemptively respond to the threats posed by sea-level rise to both public and private coastal development and infrastructure, and strives to assist governments in determining which tools to employ to meet their unique socio-economic and political contexts.

To this end, the tool kit also provides policymakers with a framework for decision making. Each tool is analyzed by (1) the type of power exercised to implement it (planning, regulatory, spending, or tax and market-based tools); (2) the policy objective that it facilitates (protection, accommodation, planned retreat, or preservation); and (3) the type of existing or potential land uses that the tool can be used to adapt (critical infrastructure, existing development, developable lands, and non-developable lands).

A top level analysis of the trade-offs between tools—the economic, environmental, and social costs and benefits, and the legal and administrative feasibility of implementing each tool—is also provided.

<http://www.georgetownclimate.org/adaptation-tool-kit-sea-level-rise-and-coastal-land-use>

Educating the Public on Climate Change Issues: DOT and MPO Best Practices

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; June 15, 2010

Summary: This document summarizes outreach activities and public education initiatives used around the country by State Departments of Transportation (DOTs) and Metropolitan Planning Organizations (MPOs) to educate the public on transportation-related climate change issues. ([PDF - 129Kb.](#))

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/educating_the_public/index.cfm

Regional Climate Change Effects: Useful Information for Transportation Agencies

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; May 10, 2010

Summary: This document provides information on projected future climate change effects (changes in temperature, precipitation, storm activity and sea level rise) over the near term, mid-century and end-of-century. The report includes two appendices: maps for some of the climate change effects, and a "typology" of projected climate change information gleaned from recent reports.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/climate_effects/

Climate Change - Model Language in Transportation Plans

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; May 2010

Summary: This document provides excerpts from various MPOs and DOT's transportation plans that illustrate how climate change considerations have been integrated into the documents.

Agencies that are looking for ideas about how to incorporate climate change into their transportation plans could find the model language very useful. ([PDF 89 KB](#))

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/model_language/index.cfm

Literature Review: Climate Change Vulnerability Assessment, Risk Assessment, and Adaptation Approaches

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; July 2009

Summary: This document details how vulnerability, risk, and adaptation assessments have been or could be used to integrate climate change impacts into transportation decisions and ultimately increase the adaptive capacity of the highway system.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/vulnerability_assessment/index.cfm

Sustainability Peer Exchange – Center for Environmental Excellence by AASHTO

Prepared by CH2M HILL and Good Company for the Center for Environmental Excellence by AASHTO; Best Practices Background, Transportation and Sustainability Peer Exchange May 27-29, 2009, Gallaudet University Kellogg Center; May 27-29, 2009

Summary: Global concerns about climate change, energy use, environmental impacts, and limits to financial resources for transportation infrastructure require new and different approaches to planning, designing, constructing, operating, and maintaining transportation solutions and systems. This memorandum provides background about key leading practices and methods that transportation professionals are using to address sustainability issues relating to transportation.

<https://www.dot.ny.gov/programs/greenlites/repository/AASHTO%20Sustainability%20Briefing%20Paper.pdf>

FHWA/AASHTO Climate Change Adaptation Peer Exchange - December 2009

FHWA; Climate Change Adaptation Workshop; 2009

Summary: This report provides an overview of Six Adaptation Efforts Underway in States. The report provides an overview of responses recently provided by FHWA Division Offices in to a survey of climate change adaptation activities in their state. Several divisions had not yet responded, so . . . remarks were based on a subset of the full suite of survey responses.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/workshops_and_peer_exchanges/illinois_12_2009/peer06.cfm

Adaptation Planning – What U.S. States and Localities Are Doing: Overview

The PEW Center; PEW Climate Change Website; 2009

Summary: . . . While governments act to mitigate future climate change, they must also plan and act to address the impacts. This preparation includes risk assessments, prioritization of projects, funding and allocation of both financial and human resources, solution development and implementation, and rapid deployment of information sharing and decision-support tools.

Corresponding to the size of the challenge, impacts span entire communities and regions. As such, adaptation is dependent on numerous stakeholders from federal, state and local government, science and academia, the private sector, and the general public to develop solutions to complex problems for which prior solutions may not exist. Adaptation will require creativity, compromise, and collaboration across agencies, sectors and traditional geographic boundaries.

<http://www.flclimatechange.us/ewebeditpro/items/O12F18595.pdf>

Strategies for Reducing the Impacts of Surface Transportation on Global Climate Change: A Synthesis of Policy Research and State and Local Mitigation Strategies

Prepared by Cynthia J. Burbank, Parsons Brinckerhoff, Washington DC; Requested by: American Association of State Highway and Transportation Officials (AASHTO); February 2009

Summary: In the past five years, the science of climate change has advanced and it is now unequivocal that climate change is happening and poses significant risks to the planet. . . Climate change puts transportation infrastructure at risk due to rising sea levels, more intense storms, higher temperatures, and other climate changes that have already begun to occur. The risk of temporary or permanent disruption of key parts of the U.S. transportation network is growing over time. Several valuable studies have been conducted in the U.S. and Europe on adaptation, but significantly more work is needed, especially to estimate the localized and regional risks to infrastructure and the changes needed to meet those risks.

. . . According to the Stern Review on the Economics of Climate Change, global gross domestic product could be 20 percent lower if the world fails to invest in climate adaptation and GHG reduction.

[http://www.ruraltransportation.org/uploads/nchrp20-24\(59\).pdf](http://www.ruraltransportation.org/uploads/nchrp20-24(59).pdf)

Literature Review: Climate Change Vulnerability Assessment, Risk Assessment, and Adaptation Approaches

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; July 2009

Summary: This document details how vulnerability, risk, and adaptation assessments have been or could be used to integrate climate change impacts into transportation decisions and ultimately increase the adaptive capacity of the highway system.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/vulnerability_assessment/index.cfm

Literature Review: Transportation Adaptation in Response to Climate Change

Michelle Oswald; University of Delaware, University Transportation Center; 2009

Summary: . . . A growing concern facing the transportation sector in the United States is the potential impact of climate change on land transportation. . .

As the risk of climate change becomes imminent, pressure for adaptation within transportation agencies to promote sustainable practices and alter behavior, continues to rise. While mitigation efforts are essential to slowing the threat of climate change, adaptation practices to build resilience and protection from impacts should be accelerated (Stern, 2006).

Bridging the connection between climate change-induced design factors and reducing their impact through transportation adaptation practice is fundamental. As mitigation techniques such as alternative fuels, congestion pricing, and transportation demand management techniques are implemented, adaptation practices must support changes in infrastructure, land use, and development patterns. . . exploring the integration between mitigation and adaptation from climate change can provide a foundation for developing a decision tool for adapting to climate change through sustainable transportation planning. . .

http://www.ce.udel.edu/UTC/Presentation%2009/Literature%20Review%20Climate%20Change%20Adaptation%20Oswald_090728.pdf

Integrating Climate Change into the Transportation Planning Process

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; July 2008

Summary: This study reports on opportunities for States and MPOs to incorporate climate change considerations into long-range transportation planning (LRTP) processes that include adaptation and mitigation practices. The study also describes examples of current state and MPO practices that link climate change and the LRTP process.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/integrating_climate_change/index.cfm

On the Way to Greener Highways

By Marlys Osterhues; FHWA Public Roads Magazine, Vol. 70 · No. 3; Dec. 2006

Summary: This study describes how a new public-private partnership promotes environmental stewardship while fostering innovative streamlining and market-based approaches to meeting transportation needs.

<http://www.fhwa.dot.gov/publications/publicroads/06nov/07.cfm>

Transportation Functional Area Adaptation and Mitigation

Airport Climate Adaptation and Resilience

Author: Baglin, Chris; Transportation Research Board; Serial: ACRP Synthesis of Airport Practice, Issue Number: 33; 2012

Abstract Summary: This synthesis study provides airport heads and their technical managers with a . . . review of the range of risks to airports from projected climate change and the emerging approaches for handling them. The literature review, survey, and interviews . . . identify the ways decision makers and their stakeholders use general information on climate effects and potential adaptation measures to define, plan for, and otherwise address climate risks to their own situation, including to their assets and operations. Detailed case examples . . . capture several distinct approaches to airport climate change resilience and adaptation.

http://onlinepubs.trb.org/onlinepubs/acrp/acrp_syn_033.pdf

Climate Change Adaptation and Preparedness Planning for Airports

Authors: Stewart, Burr; Klin, Tom; Vigilante, Mary; Serial: Transportation Research E-Circular
Issue Number: E-C152; Publisher: Transportation Research Board; 2011

Abstract Summary: Airports across the United States and throughout the world are a vital part of a metropolitan area's transportation infrastructure and play a large part in linking the global economy for passengers, mail, and freight. . . adaptation thinking, planning, decision making and investment is in its infancy in the airport world. . . This article lays out the essence of how climate change is likely to affect airports in the future, the adaptation actions that airport operators can start taking to prepare and adapt to these coming changes, and some of the research needed to help the industry adapt more quickly and efficiently.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Assessing Criticality in Transportation Adaptation Planning

ICF International, Washington, DC; Federal Highway Administration, U.S. DOT; June 13, 2011

Summary: Federal, state, and local transportation planners are considering the range of impacts that climate variability and climate changes may have on assets. Federal Highway Administration (FHWA) put forth a draft conceptual model to assist transportation agencies in systematically assessing the vulnerability of transportation assets.

http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/assessing_criticality/index.cfm

The Implications of Climate Change on Pavement Performance and Design

Authors: Li, Qiang; Mills, Leslie; McNeil, Sue; Corporate Authors: Delaware Center for Transportation Newark, DE; Research and Innovative Technology Administration; Washington DC; Delaware Center for Transportation, Newark, DE; 2011

Abstract Summary: . . . This research explores the impacts of potential climate change and its uncertainty on pavement performance and therefore pavement design. Two tools are integrated to simulate pavement conditions over a variety of scenarios. . . Three test sites in the North Eastern United States are studied and the framework is applied. It demonstrates that the framework is a robust and effective way to integrate climate change into pavement design as an adaptation strategy.

http://www.ce.udel.edu/UTC/20110926_FinalReport_Pavement_ClimateChange.pdf

Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation

Authors: Hodges, Tina; Federal Transit Administration; Corporate Authors: Federal Transit Administration; Washington, DC; 2011

Abstract Summary: . . . This project provides transit professionals with information and analysis relevant to adapting U.S. public transportation assets and services to climate change impacts . . . The report gives examples of adaptation strategies and discusses how transit agencies might incorporate climate change adaptation into their organizational structures and existing activities such as asset management systems, planning, and emergency response. . .

http://www.fta.dot.gov/documents/FTA_0..._Flooded_Bus_Barns_and_Buckled_Rails.pdf

Climate Change and Transportation Engineering: Preparing for a Sustainable Future

Authors: Meyer, Michael D, Weigel, Brent; Georgia Institute of Technology, Atlanta, GA; Serial: Journal of Transportation Engineering, Volume: 137, Issue Number: 6; Publisher: American Society of Civil Engineers; 2011

Abstract Summary: . . . This paper examines the current practice of looking at transportation system adaptation to climate changes and develops a conceptual framework of the different components of transportation infrastructure that will be affected differently by a range of climate changes. An adaptive systems management approach is suggested as one approach for transportation engineers to anticipate likely climate changes, identify vulnerabilities in the transportation system, and assess different strategies for mitigating potential impacts. The result of this approach is a strategic perspective on what transportation agencies should do today and in the future to respond to changing environmental conditions. Developing an organizational strategy for dealing with the different elements of these changes is a critical component of this strategic perspective.

[http://dx.doi.org/10.1061/\(ASCE\)TE.1943-5436.0000108](http://dx.doi.org/10.1061/(ASCE)TE.1943-5436.0000108)

<http://ascelibrary.aip.org/teo>

Transportation Adaptation's Bearing on Planning, Systems Management, Operations, and Emergency Response

Authors: Radow, Laurel J, Federal Highway Administration; Neudorff, Louis; Serial: Transportation Research E-Circular, Issue Number: E-C152; Publisher: Transportation Research Board; 2011

Abstract Summary: State and local governments and private infrastructure providers should incorporate climate change into their long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans. In fact, one of the recommendations from Transportation Research Board Special Report 290 is that climate change be incorporated in these plans. This will require that transportation providers work more closely with weather forecasters and emergency planners and assume a greater role in planning and emergency response. Moreover, adaptation also may become an important criterion both for determining the form of the system and prioritization of projects.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Transportation Planning, Policy and Climate Change: Making the Long-Term Connection

Authors: Lindquist, Eric, Texas A&M University, College Station, TX; Corporate Authors: University Transportation Center for Mobility, Texas Transportation Institute, Texas A&M University System; College Station, TX; Research and Innovative Technology Administration, Washington, DC; 2011

Abstract Summary: . . . Climate Change/Variability Science and Adaptive Strategies for State and Regional Transportation Decision Making — suggest that state and regional transportation planners are not integrating climate change science into their decision and planning processes. This runs counterintuitive to the traditional long-range focus of the planning process. . . Coastal areas in particular are seen as vulnerable to climate change and variability, and thus comprise the regional focus of this study. From a temporal perspective the interest is in adaptation to abrupt climate change (discrete climate events such as hurricane or storms) as well as longer-term incremental changes traditionally associated with global warming.

http://utcm.tamu.edu/publications/final_reports/Lindquist_07-03.pdf

http://ntl.bts.gov/lib/37000/37800/37827/Lindquist_07-03.pdf

Infrastructure, Engineering and Climate Change Adaptation – Ensuring Services in an Uncertain Future

Corporate Authors: Royal Academy of Engineering, 3 Carlton House Terrace London, UK; Institution of Chemical Engineers; London, UK; Institution of Engineering and Technology; Stevenage, England; Institution of Mechanical Engineers; London, England; 2011

Abstract Summary: This report investigates sectors of infrastructure in the United Kingdom that may be vulnerable to the impacts of climate change. It explores the actions necessary to increase the flexibility and resilience of these infrastructure sectors. It also examines the ways in which the different infrastructures are interdependent, and how that impacts infrastructure vulnerability and risks. Adaptation to climate change is viewed in the light of two issues - long term impacts such as rising sea level, and extreme events, such as flash floods. . . Electric grids and smart grids are offered as examples of infrastructure interdependence.

http://www.raeng.org.uk/news/publicati.../reports/Engineering_the_future_2011.pdf

Climate Change Adaptation: What Federal Agencies Are Doing

Authors: Cruce, Terri, Holsinger, Heather; Pew Center on Global Climate Change; Pew Center; Washington, DC; 2011

Abstract Summary: This report describes the efforts of federal agencies to adapt to climate change. Agency activities listed include the following agencies and sub-agencies: (1) Executive Office of the President and Interagency Initiatives - a. Interagency Climate Change Adaptation Task Force, b. Executive Order 13514 - Federal Leadership In Environmental, Energy, and Economic Performance, c. Council on Environmental Quality, d. Office of Science and Technology Policy, e. United States Global Change Research Program, f. National Climate Adaptation Summit; . . . (8) Department of Housing and Urban Development (HUD); (9) Department of the Interior (DOI) - a. Bureau of Land Management, b. Bureau of Reclamation, c. Fish and Wildlife Service, d. U.S. Geological Survey, e. National Park Service; (10) Department of Transportation (DOT) - a. Federal Highway Administration; and (11) Environmental Protection Agency (EPA).

http://www.pewclimate.org/docUploads/F...rnmntLeadershiponAdaptation_Nov2010.pdf

State Departments of Transportation Working to Adapt to a Changing Climate

Authors: Paulsen, Caroline and Phillips, Amy; Serial: Transportation Research E-Circular, Issue Number: E-C152; Transportation Research Board; 2011

Abstract Summary: Changing weather patterns, increasing storm intensities and flooding, rising sea levels, and increasing temperatures are presenting a “new normal” under which transportation agencies across the United States are starting to weigh the potential vulnerability of their transportation infrastructure and come up with plans to adapt. Many coastal states, while experienced with severe weather and effects of storm surge, are now preparing for more permanent effects—including disinvestment and abandonment of some transportation infrastructure, and in some cases, relocation of entire communities. For some non-coastal states, increased frequency and intensity of storm events—and the associated flooding and wind damage—have become critical issues. Tools have been developed to help transportation agencies with vulnerability and risk assessments, and states are developing their own tools for adaptation planning. But the uncertainties surrounding climate change impacts remain a challenge, as transportation agencies continue to cite the need for consistent and reliable data to help predict sea level rise, temperatures, and storm events, and to protect vulnerable infrastructure.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Federal Highway Administration Activities Related to the Adaptation of Transportation Infrastructure to Climate Change Impacts

Authors: Hyman, Rob; Lupes, Rebecca; Perlman, David; Serial: Transportation Research E-Circular Issue Number: E-C152; Transportation Research Board; 2011

Abstract Summary: The projected effects of climate change could have significant implications for the nation's transportation system. . . Recognizing the need for adaptive transportation systems, FHWA's Sustainable Transport and Climate Change Team has developed several programs and initiatives to provide FHWA Division Offices, state departments of transportation (DOTs), and metropolitan planning organizations (MPOs) with the data and tools needed to identify and adapt to climate-related impacts on vulnerable transportation infrastructure. Three initiatives described here illustrate the range of activities underway at FHWA: a report on regional climate change, an in-depth study of climate impacts in the Gulf Coast region, and pilot-testing of a conceptual model for risk and vulnerability assessments. <http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Synthesis of Climate Change and Transportation Research Efforts at State DOTs, State Universities, and Federal Level

Corporate Authors: ICF International, Fairfax, VA; NCHRP, AASHTO, TRB; 2011

Abstract Summary: This white paper provides a synthesis of climate change and transportation research efforts at state departments of transportation (DOTs), state universities, and the Federal government based on a recent study requested by the National Cooperative Highway Research Program (NCHRP) and American Association of State Highway and Transportation Officials (AASHTO). The white paper . . . two sections, Climate Change Mitigation (Section 2) and Climate Change Adaptation (Section 3). Each section provides a synthesis of recent climate change and transportation research at the Federal, state DOT, and university levels. . . Research gaps and needs are summarized at the beginning of each section and described in detail at the end of the mitigation and adaptation sections. http://climatechange.transportation.or...CandTransSynthesis_NCHRP_7%2015%2011.pdf

Summary Report: Workshops on Integrating Climate Change with Transportation Planning, October & November 2010

Corporate Authors: Resource Systems Group, Incorporated, White River Junction, VT; Federal Highway Administration, Washington DC; 2011

Abstract Summary: This report provides a summary of five workshops on addressing climate change in the State and metropolitan transportation planning processes that the Federal Highway Administration (FHWA) sponsored in 2010. This report also provides an assessment of the workshop results and suggestions for further FHWA activity related to supporting consideration of climate change in transportation planning. The workshops allowed for five State departments of transportation and metropolitan planning organizations to receive expert technical assistance focused on integrating climate change considerations (both greenhouse gas mitigation and adaptation to climate change impacts) into their planning process. <http://www.fhwa.dot.gov/hep/climate/workshops/workshops.pdf>

2010 Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance - Report to Congress

Corporate Authors: Federal Highway Administration, Washington, DC; Federal Transit Administration; Washington, DC; 2010

Abstract Summary: . . . This document . . . and report to Congress. . . provides decision makers with an objective appraisal of the physical conditions, operational performances, and financing mechanisms of highways, bridges, and transit systems based both on the current state of these systems and on the projected future state of these systems under a set of alternative future investment scenarios. This report offers a comprehensive, data-driven background to support the development and evaluation of legislative, program, and budget options at all levels of government. . .

<http://www.fhwa.dot.gov/policy/2010cpr/pdfs.htm>

<http://www.fhwa.dot.gov/policy/2010cpr/pdfs/cp2010.pdf>

Climate Change/Variability Science and Adaptive Strategies for State and Regional Transportation

Authors: Lindquist, Eric, Texas A&M University, College Station, TX; Corporate Authors: Texas A&M University, College Station; Institute for Science, Technology and Public Policy, College Station, TX; Southwest Region University Transportation Center, Texas Transportation Institute, Texas A&M University, College Station, TX; 2010

Abstract Summary: . . . this study purpose was to generate a baseline understanding of current policy responses to climate change/variability at the state and regional transportation planning and decision levels. . . . the reports basic question: are state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) in the United States addressing the issue of climate change in general and, more specifically, the issue of adaptation to potential climate change and variability impacts? . . . findings reveal that acceptance and movement in state DOTs and MPOs on these complex climate-related issues and solutions, where they exist at all, are slow. Mitigating the impacts from transportation appears to still be the primary policy linkage between climate change and transportation for these agencies. Public interest, political acceptance, and lack of downscaled state- and regional-level data are all factors that require further attention in the climate change/transportation nexus.

<http://swuttc.tamu.edu/publications/technicalreports/167165-1.pdf>

FHWA/AASHTO Climate Change Adaptation Peer Exchange

Corporate Authors: ICF International, Washington, DC; Federal Highway Administration, Washington, DC; 2009

Abstract Summary: The Federal Highway Administration (FHWA), with the support of the American Association of State Highway and Transportation Officials (AASHTO), convened a peer exchange on current climate change adaptation activities and strategic needs in Schaumburg, Illinois, on December 8, 2009. This workshop included senior officials of state departments of transportation (DOTs), FHWA headquarters and division offices and AASHTO. This report summarizes the results of the exchange, and is one of series of FHWA reports documenting the results of national peer exchanges on integrating climate change considerations into the transportation planning process . . . The report summarizes participant presentations and the key issues that emerged during the event . . . this report identifies suggestions from the peer exchange participants for potential elements of guidance, research and policy at the national level.

http://www.fhwa.dot.gov/hep/climate/peer_exchange/peer00.cfm

Federal Highway Administration Integrating Climate Change into the Transportation Planning Process: Final Report

Prepared for Diane Turchetta, FHWA; Prepared by ICF International; July 2008

Summary: . . . This study's objective . . . advances the practice and application of transportation planning among state, regional, and local transportation planning agencies to successfully meet growing concerns

about the relationship between transportation and climate change. This report explores the possibilities for integrating climate change considerations into long range transportation planning at state DOTs and MPOs . . . and reviews the experience of a number of DOTs and MPOs that are already incorporating climate change into their transportation planning processes and identifies their successes as well as challenges faced by these agencies.

<http://www.fhwa.dot.gov/hep/climatechange/climatechange.pdf>

Summary Report: Peer Workshop on Adaptation to Climate Change Impacts--2008

Corporate Authors: Federal Highway Administration; FHWA, Washington, DC; 2008

Abstract Summary: Recent research suggests that relatively little has occurred across the nation to proactively develop strategies and implement actions to adapt the transportation system to the various predicted impacts of climate change . . . This report summarizes participant presentations and the key issues that emerged when officials of state departments of transportation (DOTs), FHWA headquarters and division offices and AASHTO met in peer workshop. To help support state DOT and other transportation agency efforts to adapt to climate change impacts, this report identifies suggestions from the peer exchange participants for potential elements of guidance, research and policy at the national level.

<http://www.fhwa.dot.gov/planning/statewide/pwsacci.htm>

General Climate Change Adaptation and Mitigation

Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options

David L. Peterson, Constance I. Millar, Linda A. Joyce, Michael J. Furniss, Jessica E. Halofsky, Ronald P. Neilson, and Toni Lyn Morell; USDA; November 2011

Summary: This guidebook contains science-based principles, processes, and tools necessary to assist with developing adaptation options for national forest lands. . . .Regardless of specific processes and tools, the following steps are recommended: (1) become aware of basic climate change science and integrate that understanding with knowledge of local resource conditions and issues (review), (2) evaluate sensitivity of specific natural resources to climate change (rank), (3) develop and implement strategic and tactical options for adapting resources to climate change (resolve), and (4) monitor the effectiveness of adaptation options (observe) and adjust management as needed. . .

<http://permanent.access.gpo.gov/gpo18256/pnw-gtr855.pdf>

Adaptation to Climate Change: A Review of Challenges and Tradeoffs in Six Areas

Authors: Bedsworth, Louise W., and Hanak, Ellen; Public Policy Institute of California; Serial: Journal of the American Planning Association, Volume: 76, Issue Number: 4; Publisher: American Planning Association; 2010

Abstract Summary: . . . These studies focus on institutional and regulatory challenges and tradeoffs that climate change poses in six particularly vulnerable areas: water resources, electricity, coastal resources, air quality, public health, and ecosystem resources. Obstacles to adaptation planning and successes overcoming these barriers are discussed. The findings suggest that climate change will exacerbate conflicts between goals for economic development, public safety and habitat protection. . . Forward-looking climate data that include higher water and air temperatures, sea-level rise, and increased numbers of extreme weather-related events should be used when making decisions about disaster preparedness, infrastructure investments, open-space protection, and future development.

<http://dx.doi.org/10.1080/01944363.2010.502047>

Adapting to the Impacts of Climate Change

Corporate Authors: National Research Council, Board on Atmospheric Sciences and Climate, Washington, DC Availability: National Academies Press, Washington, DC; 2010

Abstract Summary: Across the United States, impacts of climate change are already evident. . . This report, part of the congressionally requested America's Climate Choices suite of studies, calls for a new paradigm-one that considers a range of possible future climate conditions and impacts that may be well outside the realm of past experience. . . This report calls for a national adaptation strategy that provides needed technical and scientific resources, incentives to begin adaptation planning, guidance across jurisdictions, shared lessons learned, and support of scientific research to expand knowledge of impacts and adaptation.

http://www.nap.edu/catalog.php?record_id=12783

Stormwater Adaptation and Mitigation

International Stormwater Best Management Practices (BMP) Database

International Stormwater Best Management Practices Database; BMPDB Website; 2012

. . . International Stormwater Best Management Practices (BMP) Database project website. . . features a database of over 400 BMP studies, performance analysis results, tools for use in BMP performance studies, monitoring guidance, and other study-related publications. The overall purpose of the project is to provide scientifically sound information to improve the design, selection and performance of BMPs. . . The database itself is downloadable to any individual or organization that would like to conduct its own assessments.

<http://www.bmpdatabase.org/>

Welcome to the UNHSC-NEMO Innovative Stormwater Management Inventory!

UNHSC-NEMO; Searchable State Website; 2012

This searchable and amendable inventory is designed to highlight innovative BMP strategies, such as Low Impact Development (LID) designs, implemented throughout New England.

Search the inventory by state or by clicking on the map, or by stormwater management practice. This generates a page displaying information from the inventory. More detailed reports may be available for specific locations. . .

. . . The purpose of this inventory is to provide real world examples of successful and innovative BMP installations throughout the region. It does not present performance data (which can be located at the International BMP Database). The UNHSC-NEMO inventory includes the location, owner, installer, designer and a brief description of local projects.

<http://www.erg.unh.edu/stormwater/index.asp>

Watershed-Ecosystem Based Approaches for Post-Construction Stormwater Management Along Highway Corridors

Art Hirsch; TerraLogic Transportation Blog; Sunday, November 06, 2011

Summary: Many state, county and municipal departments of transportation (DOTs) are spending significant amounts of financial resources on stormwater management; especially for the Municipal

Separate Stormwater Sewer System (MS4) Permit requirements for post-construction best management practices. Is this really an environmentally and financially sound approach to protect water quality?

http://terralogicss.com/blog/Sustainable_Transportation/post/Watershed-Ecosystem_Based_Approaches_for_Post-Construction_Stormwater_Management_Along_Highway_Corridors/

US EPA Perspective on Stormwater & Climate Change Adaptation

Dr. Cindy Lin, USEPA R9; Slide presentation for Workshop on Impacts of Climate Change on Extreme Events/Severe Weather; Western States Water Council, CA DWR, Western Governors Association; March 22, 2011

Summary: EPA Climate Change Response Strategy for Water Program

- Stormwater Program
- Climate Change Adaptation for Stormwater program
- Learning from development and impacts
- What are data needs for EPA to effectively regulate flow and pollutant load with future climatic uncertainty?

<http://www.westgov.org/wswc/lin.pdf>

Green Infrastructure in Arid and Semi-Arid Climates: Adapting Innovative Stormwater Management Techniques to the Water-limited West

EPA; The American Recovery and Reinvestment Act (ARRA), Green Project Reserve of 2009, through the State Revolving Fund ,provided funding for a wide variety of qualifying projects in the categories of: green infrastructure, energy efficiency, water efficiency, and other innovative projects; 2009

Summary: “Green infrastructure” may seem incongruous with the landscapes of the arid and semi-arid West, but forward-thinking communities in these water-limited regions are increasingly recognizing green infrastructure as a cost-effective approach to stormwater management that conserves water supply.

http://www.azwater.gov/AzDWR/waterManagement/documents/10504-08AridClimatesCaseStudy_v2.pdf

Protocol for Stormwater Best Management Practice Demonstrations

The Technology Acceptance Reciprocity Partnership, Endorsed by California, Massachusetts, Maryland, New Jersey, Pennsylvania, and Virginia, Final Protocol 8/01-Updated: July 2003

Summary: The state partners in California, Massachusetts, Maryland, New Jersey, Pennsylvania, and Virginia agreed to a protocol with elements . . .

. . . This Protocol describes a set of uniform criteria acceptable to the endorsing states. However, specific state requirements must be considered when applying for certification or verification of a stormwater BMP in a particular state. Each partner reserves the right to evaluate any application and request specific information as outlined in Appendix D in order to satisfy an individual state’s requirements. . .

<http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/pdf/Tier2protocol.pdf>

Research Currently Underway

Costs and Impacts of Extreme Weather Events on State DOTs

NCHRP Synthesis 20-05/Topic 44-08 (New Research Project)

Staff, Jon M. Williams; Transportation Research Board; Fiscal Year; 2012

TRB's National Cooperative Highway Research Program (NCHRP) has issued a request for proposals to synthesize information on the fiscal implications of extreme weather events for state departments of transportation. Proposals are due August 10, 2012.

Tentative Scope of Work: . . . proposed research will compile and synthesize current DOT efforts in this area, briefly assess the effectiveness of such efforts, and recommend research toward more universal data acquisition efforts.

This information will be useful and timely to DOTs, from the front office to the front lines. The information developed by this synthesis will assist Planning and Programming, Design, Construction, and Maintenance. The information will enable DOTs to improve resilience of the transportation network to extreme weather events. This study will document the ways and extent to which DOTs are collecting this important information and delivering it internally. It will also document the state of the practice in using asset management approaches and GIS as tools for identifying and protecting critical infrastructure elements.

<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3360>

International Adaptation and Mitigation to Climate Change

Climate Change Adaptation: A Report on Climate Change Adaptation Measures for Low Volume Roads in the Northern Periphery (Sweden, Norway & Finland)

By Adriána Hudecz, Arctic Technology Centre (ARTEK) at the Technical University of Denmark (DTU);

ROADDEX; Swedish Transport Administration; The ROADDEX "Implementing Accessibility"; Lead Partner:

The Swedish Transport Administration, Northern Region; Project co-coordinator: Mr. Krister Palo; 2012

. . . The report summarizes recent published researches on climate change and its possible impact on low volume roads in the Northern Periphery. Its aim was to produce a practical guidance document for local engineers to help them to manage potential effects of climate change on their local road networks.

. . . The report concludes with an appendix of recommended of good practice and adaptation measures which are considered suitable for use in the ROADDEX partner areas. . .

[http://www.roadex.org/uploads/publications/Climate%20Change%20Adaptation%20\(2012\).pdf](http://www.roadex.org/uploads/publications/Climate%20Change%20Adaptation%20(2012).pdf)

Urban adaptation to climate change in Europe: Challenges and opportunities for cities together with supportive national and European policies

Authors: Isoard, Stephane; Kurnik, Blaz; Foltescu, Valentin Leonard; Swart, Rob; Marinova, Natasha; van Hove, Bert; Jacobs, Cor; Klostermann, Judith; Kazmierczak, Aleksandra; Peltonen, Lasse; Kopperoinen, Leena; Oinonen, Kari; Havranek, Miroslav; Cruz, Maria Joao; Gregor, Mirko; Fons-Esteve, Jaume; Keskitalo, Carina; Juhola, Sirkku; Krellenberg, Kerstin; van Bree, Leendert; Corporate Authors: European Environment Agency, Copenhagen, Denmark; 2012

Abstract Summary: This report provides a European overview of the challenges and opportunities of urban adaptation to climate change and links them with other initiatives that provide more detailed information on local climate change impacts, and good practice guidance. . .

Record URL: <http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change>

Order URL: <http://worldcat.org/isbn/9789292133085>

Types of cluster adaptation to climate change. Lessons from the port and logistics sector of Northwest Germany

Authors: Osthorst, Winfried; Mänz, Christine; Maritime Policy & Management; Publisher: Taylor & Francis; Serial: Volume: 39, Issue Number 2; 2012

Summary: This article describes how climate adaptation of ports is predominantly referred to as technical responses to extreme events (e.g. coastal protection). . . The article gives an overview of the literature on climate adaptation and how it applies to ports and provides a preliminary sector . . . adaptation to climate change.

<http://dx.doi.org/10.1080/03088839.2011.650724>

United Kingdom's Experience with Climate Change Adaptation and Transportation

Authors: Kollamthodi, Sujith; Fordham, Damon; Stephens, Mia; Serial: Transportation Research E-Circular, Issue Number: E-C152; Publisher: Transportation Research Board; 2011

Abstract Summary: . . . Adapting to the impacts of climate change is also becoming increasingly important in a policy context. The United Kingdom (U.K.) is currently leading the way when it comes to the implementation of climate change policy frameworks by being the first country to have a legally binding long-term framework to cut carbon emissions by 80%, enacted through the United Kingdom's Climate Change Act . . . sets out the requirements for the country's response to climate change adaptation and the appropriate actions to be undertaken.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

International Scan on Climate Change Adaptation

Authors: Weiner, Edward; Serial: Transportation Research E-Circular, Issue Number: E-C152
Publisher: Transportation Research Board; 2011

Abstract Summary: The Netherlands, Venice, Italy, and two coastal states in Germany have already taken action because they recognize the vulnerability of their transportation infrastructure to climate changes. . . The results of this scan will provide engineers and planners in the United States with new ideas on approaches that they can use in their own communities to adapt transportation to climate changes.

<http://onlinepubs.trb.org/onlinepubs/circulars/ec152.pdf>

Adapting to climate change: implications for transport infrastructure, transport systems and travel behaviour

Authors: Taylor, M A, and Philp, M; University of South Australia, Institute for Sustainable Systems and Technologies; Source Agency: ARRB Group Limited; 500 Victoria, AU; Serial: Road and Transport Research, Volume: 19, Issue Number: 4; Publisher: ARRB Group Limited; 2010

Abstract Summary: This paper reviews land based transport related issues from considerations of climate change adaptation in Australia. The two main issues for climate change adaptation are sea level rise and the increased frequency and intensity of extreme weather events. . .It considers the risks to existing transport infrastructure and the resulting considerations necessary . . . There is a need to

undertake research into the likely impacts of climate change on Australia's transport infrastructure, establish the categories of infrastructure most at risk, and outline opportunities for adaptation responses, and examine the current governance structures. Then the administrative, legal and other issues that may impact on climate change adaptation can be identified.

<http://worldcat.org/oclc/26087078>

Building resilience to climate change - an adaptation plan for transport 2010-2012

Department for Transport, UK; Source Agency: Transport Research Laboratory, Berkshire, UK; 2010

Abstract Summary: The UK's legislative framework sets the agenda for domestic action to adapt to the projected impacts of climate change. For the Department for Transport, this means meeting its strategic aim of 'transport that works for everyone' through planning, designing, maintaining and operating a transport system that is resilient to future change. The frequency of disruptive events caused by weather is considered likely to increase and social and economic costs will result. Incident management plans are being drawn up. A plan to embed the consideration of climate change risk into the Department's decision making processes is described. The implications for the design, construction, maintenance and operation of roads, railways, ports and airports are outlined.

<http://www.nudgeadvisory.com/assets/uploaded/docs/76.pdf>

Impact of weather on commuter cyclist behaviour and implications for climate change adaptation

Authors: Ahmed, F; Rose, G; Jacob, C, Monash University, Atmospheric Science; Source Agency: ARRB Group Limited, Victoria, AU; 33rd Australasian Transport Research Forum, 29 September to 1 October 2010, National Convention Centre, Canberra, AU; 2010

Abstract Summary: . . . This includes for example, strategies to reduce emissions from our transport system that is heavily dependent on carbon based fuels. Adaptation research is now expanding in the transport sector with most effort addressing issues such as the vulnerability of infrastructure to higher sea levels or more frequent and severe storms. An area of adaptation that has received little attention in the literature relates to how individuals will adjust their travel behaviour in the face of changes in weather and climate. This paper examines the relationship between weather and travel behaviour with an emphasis on bicycling. . . This paper assesses adaptation behaviour in face of weather and climate change and it has important implications for government strategies that seek to increase the role of active transport in urban areas.

<http://trid.trb.org/view.aspx?id=1097035>

See [WSDOT Library](#) for Availability

Tomorrow's railway and climate change adaptation: Phase 1 report

Corporate Authors: Rail Safety and Standards Board, London, UK; 2010

Abstract Summary: Extreme weather events in the last few years have indicated that the industry has insufficient understanding of weather effects on its passengers, rolling stock and infrastructure, and staff to enable informed judgments to be made concerning adaptation policy to deliver a reliable railroad for the future. The railroad industry needs to understand how the current and future climate will impact the ability to achieve and deliver: (1) A safe railroad system, (2) A very reliable railroad system, (3) Increased capacity, (4) Value for money spent, and (5) A 'predict and prevent' ethos.

http://www.rssb.co.uk/sitecollectiondo...pdf/reports/research/T925_rpt_phase1.pdf

iRESM Initiative: Understanding Decision Support Needs for Climate Change Mitigation and Adaptation

U.S. Midwest Region, J. Rice R. Moss, P. Runci, K. Anderson; Prepared for The U.S. Department of Energy under Contract DE-AC05-76RL0183; PNNL – 20104; Pacific Northwest National Laboratory, Richland, Washington; October 2010

Summary: . . . Through its integrated Regional Earth System Model (iRESM) initiative, PNNL is developing a modeling framework to address regional human-environmental system interactions in response to climate change and related uncertainties. This framework is intended as a research tool for the scientific community to explore regional mitigation and adaptation decisions, constraints, and opportunities under alternate climate policy and climate change futures. . . This paper presents the results of the initial research into decision support needs for the first iRESM pilot region: the US Midwest . . .

The primary systems of concern for adaptation are in the areas of water resources, urban infrastructure, agriculture, recreation, ecosystems, forest management, and transportation. Potential adaptations include infrastructure modifications, technological developments, institutional changes, and ecosystem protection, enhancement, and manipulation. . .

<http://www.pnnl.gov/atmospheric/iresm/pdf/iRESMidwestStakeholderResearch.pdf>

Climate change mitigation and adaptation measures for inland waterways in England and Wales

Authors: Brooke, Jan; White, I; Inland Waterways Advisory Council, www.iwac.org.uk
London, UK; 2010

Summary: . . . Adaptation measures to increase resilience and make inland waterways better prepared to deal with the effects of climate change . . . will be necessary. . . consideration may need to be given to modifying or replacing certain operations, assets, infrastructure etc. . . . In the meantime, measures to collect, retain and manage high quality, locally relevant data, to monitor change and to improve understanding are required, in order to provide vital information to inform decision-making . . . data will also be needed to enable navigation authorities and others to future-proof ongoing operations and new developments, so that they can withstand the projected changes in precipitation, temperature and sedimentation. Many of the mitigation and adaptation measures described in this report could most effectively be delivered by encouraging behavioural changes. Educating users both about the implications of their actions and how modifying their behaviour can help to save both money and the planet can be an effective way of achieving shared objectives. Such awareness raising initiatives would best be undertaken through a coordinated approach involving a number of partner organizations.

http://www.iwac.org.uk/downloads/reports/IWAC_Climate_Change_Inland_Waterways_Apr09.pdf

Local Agency Approaches to Adaptation and Mitigation

Climate Leadership Academy - Promising Practices in Adaptation & Resilience: A Resource Guide for Local Leaders

Institute for Sustainable Communities; Produced in partnership with Center for Clean Air Policy; October 2010

Summary: The case studies of local agencies in this Resource Guide of Promising Practices in Adaptation & Resilience fall into one of four thematic groups:

Models for Adaptation Planning

- Chicago Climate Action Plan

- Interviews on the Science/Policy Connection in the Chicago Climate Action Plan
- Miami-Dade County's Adaptation Planning Process
- New York City Climate Change Risk Assessment
- Toronto Climate Adaptation Planning
- Resource Snapshot: Preparing for Climate Change

Getting Commitment to Climate Adaptation

- London's Climate Change Adaptation Strategy
- Snapshot: Boulder Residents Get Help from Artist Mary Miss to Connect the Dots

Bolstering Resilience by Integrating Adaptation into Local Planning and Operations

- Seattle and Tucson Manage Risks to their Water Supplies
- Seattle Public Utilities' Flood Risk Management Strategies
- Briefing: Insurance Industry Takes Steps to Address Future Climate Impacts
- New Orleans' Community-Driven Adaptation and Planning
- Snapshot: "Dutch Dialogues" Inform New Orleans' Approach to Life on the Delta

Cross-Jurisdictional Collaboration

- Southeast Florida Regional Climate Change Initiative.

These themes emerged from ISC's consultations with city adaptation practitioners and experts, and together constitute the scope of this Resource Guide.

http://www.iscvt.org/who_we_are/publications/Adaptation_Resource_Guide.pdf

Innovation Stormwater Policy: Minneapolis

City of Minneapolis, MN; Stormwater Website; 2012

In March 2005, the City of Minneapolis began charging property owners for management of stormwater based on the degree to which their property was covered by impervious surfaces . . . implemented a program whereby property owners could qualify for fee reductions of up to 100 percent by establishing onsite water-quality and/or water-quantity treatment systems, such as rain gardens, detention ponds and green roofs.

The Minneapolis city council sought to achieve two principal policy objectives through its stormwater policy, including an equitable stormwater fee credit system, whereby property owners paid for stormwater management in proportion to the demand their properties placed on the system. The second and more ambitious objective was encouraging property owners to manage stormwater onsite.

http://www.sustainablecommunityinitiative.com/index.php?option=com_content&view=article&id=68:innovation-stormwater-policy-minneapolis&catid=40:policy-innovations&Itemid=68

A Sustainable Approach to Stormwater Management: Portland, Oregon

City of Portland, OR; Stormwater Management Website; 2012

When it rains, stormwater runoff that isn't properly managed can flow over impervious surfaces picking up pollutants along the way and washing them into rivers and streams. Stormwater runoff can also cause flooding and erosion, destroy habitat and contribute to combined sewer overflows (CSOs).

Stormwater management systems that mimic nature by integrating stormwater into building and site development can reduce the damaging effects of urbanization on rivers and streams. Disconnecting the flow from storm sewers and directing runoff to natural systems like landscaped planters, swales and rain gardens or implementing an ecoroof reduces and filters stormwater runoff.

Portland has received international attention for its projects and designs in sustainable stormwater management. To read more about our program history and development, please visit the Water Environment Research Foundation case study report for Portland.

<http://www.portlandonline.com/bes/index.cfm?c=34598>