GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS FOR CLIMATE CHANGE DECISION-MAKING

Peer Exchange Summary Report

Atlanta, Georgia
September 26-27, 2011

Prepared for:
Office of Planning
Federal Highway Administration
U.S. Department of Transportation

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I. Summary

On September 26-27, 2011, the Federal Highway Administration's (FHWA) Office of Planning sponsored a 1.5 day peer exchange in Atlanta, Georgia focusing on the use of geographic information systems (GIS) to support transportation related climate change decisions. The Atlanta Regional Commission hosted the peer exchange. Participants included staff from the Maine Geological Survey, Maryland State Highway Administration (MdSHA), New England Environmental Finance Center, Sacramento Area Council of Governments (SACOG), Southern Maine Regional Planning Commission, Washington Department of Transportation (WSDOT), FHWA Headquarters, and the Volpe National Transportation Systems Center (Volpe Center).[1]

The purpose of the peer exchange was to allow participants to:

- Share their knowledge and experiences with each other;
- Discuss lessons learned and challenges; and
- Identify ways to improve agencies' abilities to develop and manage GIS/climate change applications, share geospatial data, and support public outreach through GIS technologies.

This report provides overviews of the presentations given at the peer exchange and the associated questions and answers. It concludes with a summary of the roundtable discussions.

II. Background

FHWA is committed to improving transportation mobility and safety while protecting the environment, reducing greenhouse gas emissions (GHG), and preparing for climate change effects on the transportation system. FHWA is actively involved in efforts to initiate, collect, and disseminate climate-change-related research and to provide technical assistance to stakeholders.[2] For example, FHWA is conducting a two-phased study analyzing the impacts of climate change and variability on transportation systems and infrastructure along the Gulf Coast. The Phase I study[3], which was completed in 2008, examined potential climate change impacts on transportation across the Gulf Coast region. The Phase 2 study, which is currently in process, focuses on Mobile, Alabama. The Phase II study will develop transferable vulnerability assessment and risk management tools and guides to help transportation planners assess the vulnerability of transportation and adapt critical infrastructure to potential climate impacts. In addition to the Gulf Coast study, FHWA also recently published the report *Regional Climate Change Effects: Useful Information for Transportation Agencies,*[4] which provides basic information on projected future climate change effects. Finally, FHWA is funding five pilot projects for state DOTs and metropolitan planning organizations (MPOs) to implement a conceptual model to use in conducting vulnerability and risk assessments of infrastructure to the projected impacts of global climate change. The pilot projects are scheduled to be completed in the fall of 2011.[5]

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[1] FHWA identified and invited candidate agencies to participate. Appendix A provides a complete list of participants and attendees.

[2] More information on FHWA's climate change related research and activities is available at FHWA's Highways & Climate Change website http://www.fhwa.dot.gov/hep/climate/index.htm.

[3] U.S. Climate Change Science Program. March 2008. *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I.* http://www.climatescience.gov/Library/sap/sap4-7/final-report/

[4] ICF International. May 2010. Regional Climate Change Effects: Useful Information for Transportation. FHWA. http://www.fhwa.dot.gov/hep/climate/climate_effects/

[5] More information on the adaptation conceptual model pilots is available at http://www.fhwa.dot.gov/hep/climate/pilots.htm.

FHWA recognizes the effectiveness of geospatial technologies as tools to assist state DOTs and other transportation agencies in improving their decision-making processes. GIS has proven to be a useful tool in transportation agencies' efforts to analyze and address climate change as it pertains to transportation facilities and operations. The GIS for Climate Change peer exchange gave select agencies the opportunity to share information and lessons learned as they utilize GIS technologies to integrate climate change into the transportation decision-making process.

III. Presentations and Discussion

This section provides brief summaries of the presentations given by participants of the peer exchange, along with the comments, questions, and answers that followed each presentation.

Atlanta Regional Commission

David D'Onofrio, Air Quality and Climate Change Planner

Atlanta is one of the fastest growing cities in the country, both in regards to population and the built environment. In recent years, very low density development was built around the edges of the metro area, leading to an increase in vehicle miles travelled (VMT) per capita. The increase in VMT results in an increase in GHG emissions. In response to the growing trend of increased VMT and GHG emissions, the Atlanta Regional Commission (ARC) has been working to analyze GHG emissions in the region and identify solutions to reduce these emissions.

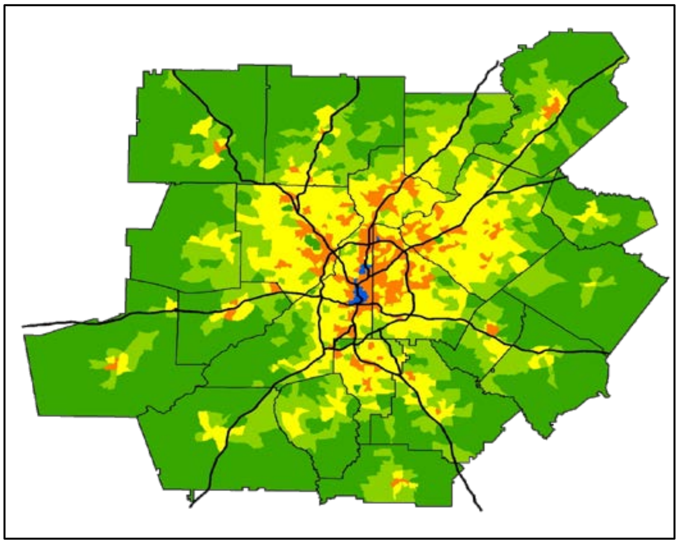
<u>Regional Sustainability Indices</u>

ARC developed regional sustainability indices, which identify areas that support alternative transit or closely link residential and employment areas, in order to guide sustainable development. ARC utilizes GIS analysis to help identify the areas within the Atlanta region where investments in sustainable development will have the greatest impact.

The sustainability indices include the following measures:

- *Potential Walking Demand Measure:* the potential walking demand measure uses the street network to identify areas that can support short walking trips. These areas have high numbers of intersections per square mile and have high proximity from residential areas to retail and services. The measure does not look at pedestrian amenities, just at the overall street network and land uses. ARC utilized GIS to identify areas where pedestrian demand is greatest. ARC communicates the results of the potential walking demand measure to local governments to help them make informed decisions on where to invest in bicycle and pedestrian projects.

Figure 1: ARC's GIS analysis for the potential walking demand measure.



The areas in orange and blue depict locations with the greatest demand for short walking trips.

- *Multimodal Accessibility Measure:* Similar to the potential walking demand measure, the multimodal accessibility measure looks at areas that are accessible to employment centers by multiple modes within designated time limits (30 minutes by car, 45 minutes by transit, and 15 minutes by foot). ARC used the multimodal accessibility measures to inform residents and decision makers about locations in the region that support travel options. Areas that have the highest measures of potential walking demands and multimodal access are mainly clustered in central Atlanta.

Measuring Emissions

In addition to evaluating the potential to increase alternative transportation use in Atlanta, ARC conducted a scenario planning study to assess GHG emissions from the on-road transportation system across future alternative scenarios. ARC ran their regional travel demand model with a range of modified land use inputs to test different growth scenarios. Outputs from the travel demand model were used as inputs into EPA's MOBILE 6 emission model to calculate the total carbon dioxide produced by the network. ARC's scenario planning analysis showed that under the trend scenario, carbon dioxide emissions would increase to 160,000 tons/day by 2030. The most aggressive land use strategies and foreseeable technologies, including increases in the Corporate Average Fuel Economy (CAFE) standard, will still result in a 56 percent increase of carbon dioxide emissions over 1990 levels in 2030.

ARC recently began using the EPA's MOVES model, which provides a better representation of emissions. ARC has been able to use this model to attribute emissions to roadways, and can begin to look at origin and destination pairs, though this analysis is still in the early stages.

Comments, Questions, and Answers

Question: Does the model look at GHG emissions reduction per capita or the regional total?

- Answer: We look at GHG emissions per capita. I would argue that for Atlanta, an area that is experiencing a large population growth due to domestic migration, it is more appropriate to evaluate emissions on a per capita basis than on a regional basis.

Sacramento Area Council of Governments

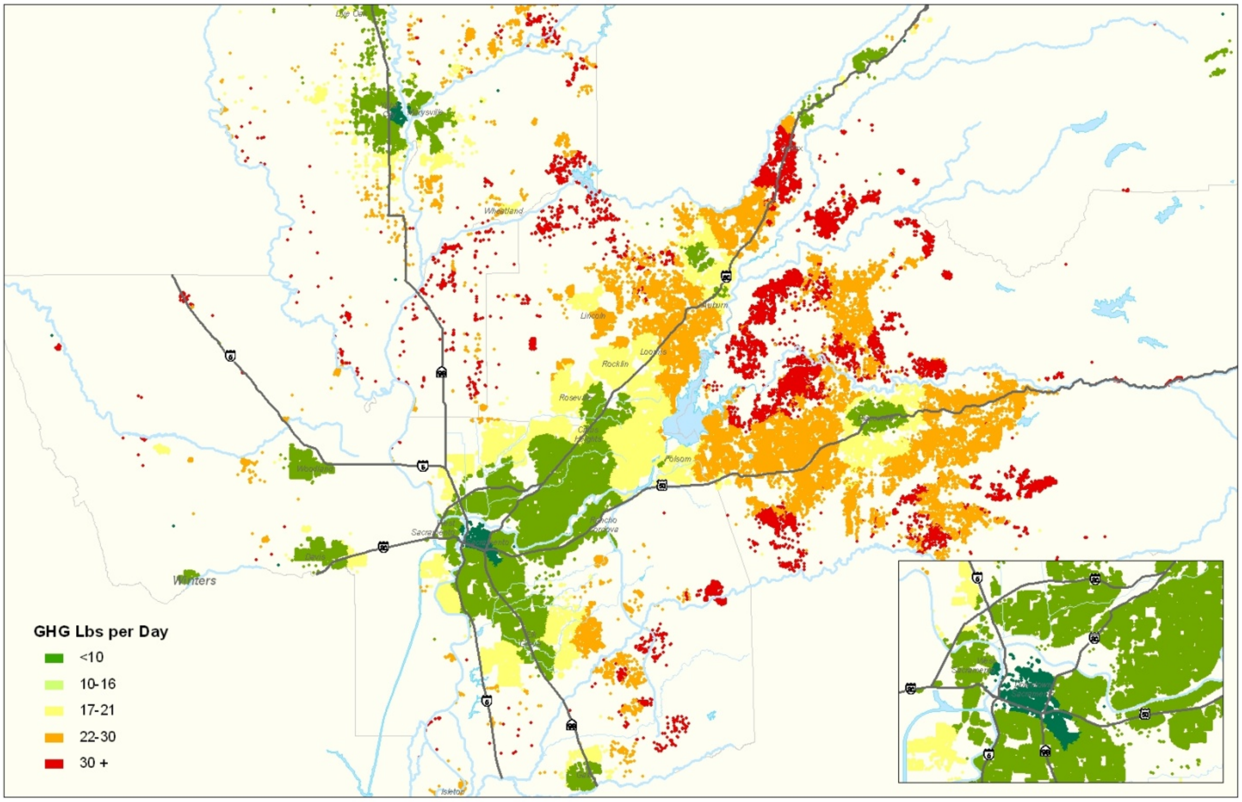
Raef Porter, Senior Research Analyst
Joe Concannon, Data Services Manager

California recently passed two important climate change related pieces of legislation. AB32, the Global Warming Solutions Act of 2006, set the goal of reducing GHG emissions to 1990 levels by 2020 and requires state agencies to adopt regulations and other initiatives to reduce GHG emissions. SB375, the Sustainable Communities and Climate Protection Act of 2008, enhances California's ability to reach the AB32 goals by promoting good planning. SB375 required California's Air Resource Board to develop regional reduction targets for GHG emissions and prompted the creation of regional plans to reduce emissions from vehicle use throughout the state. California's MPOs are required to develop a sustainable community strategy to demonstrate how the region will meet its GHG reduction target.

The Sacramento Area Council of Governments (SACOG) is the MPO for the Sacramento, California region. SACOG is currently developing its Metropolitan Transportation Plan, which will outline how the region will meet its GHG emission targets. As part of this plan, SACOG developed a custom parcel-based travel model to better analyze the relationship between land use and transportation-related GHG emissions. Land use has direct impacts on transportation. The closer individuals live to employment and commercial areas the shorter the distance they will travel. The transportation network needs to compliment an area's land uses in order to reduce the VMT in an area.

Previously, SACOG's land use and transportation model used zones as the primary unit of measurement; however, that unit of analysis did not provide enough detail to assess the land use impact on travel behavior. In place of zones SACOG developed a parcel-based travel model to better capture this relationship. The new model, the Sacramento Activity-Based Travel Simulation Model, allows planners to analyze what is happening in surrounding parcels within ¼ to ½-mile buffers. This enables SACOG to quantify the transportation-related GHG emissions associated with each buffered parcel, which provides a more accurate picture of the interaction between land use and transportation. While the parcel-based model is more data intensive, it has more realistic sensitivities to land use, costs (especially in terms of gas prices and automobile operating costs), and demographic variables.

Figure 2: 2035 GHG Emissions per Household



The map depicts the GHG emissions per household in the year 2035. Areas in green have lower emissions per day than areas in orange and red.

Using the parcel-based model, SACOG is able to calculate the VMT for each parcel. This data is joined with an estimate of emissions created per mile for a typical fleet of vehicles on the road. SACOG mapped the travel model output to visually depict where transportation emissions are highest (see Figure 2). The maps have been invaluable tools when working with decision-makers. The maps provide an easy to understand tool to illustrate the connection between land use and transportation planning, and help educate individuals on how transportation planning can help reduce transportation-related GHG emissions.

Comments, Questions, and Answers

Question: Does your analysis consider potential changes to future floodplains and how that will impact the road network?

- Answer: SACOG considers the location of floodplains when making decisions on future transportation investments. SACOG identifies floodplain locations and assesses whether the area is appropriate for future development. If not, then transportation investments will not be directed to these areas. Currently, SACOG is not considering how the existing transportation network will be affected by changes in floodplains. But, SACOG has recently begun working with the Federal Emergency Management Agency on hazard mitigation planning.

Washington Department of Transportation
Elizabeth Goss, Rideshare Programs Data and GIS Analyst
Alan Smith, GIS Branch Manager

The Washington DOT (WSDOT) owns and manages 86 million vehicle miles of roadway, over 3,600 bridges, 23 ferries, 17 airports, 296 miles of rail line, and supports passenger and freight rail and transit within Washington State. Recent State laws and executive orders have directed WSDOT and other state agencies to respond to climate change by reducing emissions, reducing VMT, and preparing adaptation plans. WSDOT has recently started using GIS to assess how climate change could affect the transportation system.

In 2011, WSDOT was chosen as one of the five Climate Change Risk Assessment pilots, which were funded in part by FHWA. WSDOT's pilot project focuses on projected impacts to State owned infrastructure. WSDOT started their risk assessment process by inventorying assets and collecting climate data for the State. The WSDOT project team conducted workshops with field maintenance staff, hydraulic engineers, bridge engineers, geotechnical staff, planners and environmental staff to determine the relative importance and climate change impact for each asset. The assets were ranked on a scale of 1 to 10, with 1 being very low importance and 10 being very critical. Evacuation routes, or roads with sole access to key industries, for example, were considered to be among the highest importance). Workshop participants also provided a qualitative assessment of the relative significance that could be caused by a climate change impact. The assets were ranked on a scale of 1 to 10, with one being reduced capacity and ten being a complete failure of the system.

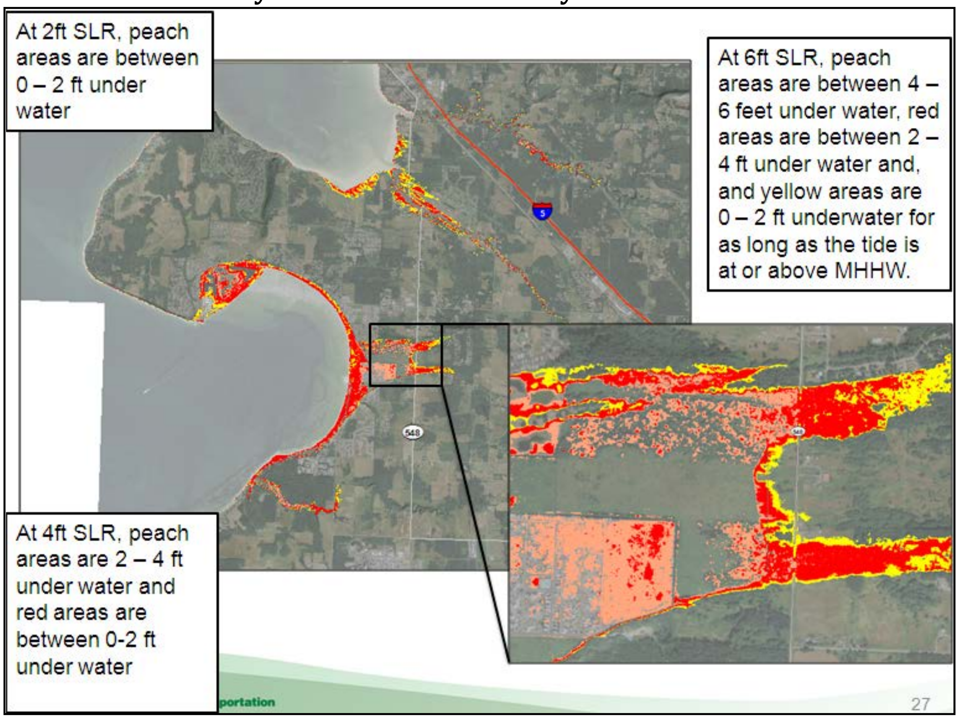
Climate Change Data

Once WSDOT developed its inventory of assets, the team identified climate impacts of concern. These impacts included sea level rise (SLR), erosion, aggradation from glacier melt, flooding, extreme heat, drought, and invasive species. WSDOT relied upon a prior analysis report, *Washington Climate Change Impacts Assessment*, for much of its climate change data. This report, developed by the University of Washington, was the first comprehensive assessment of climate change impacts on the Columbia River Basin, which included Washington State. The University of Washington's climate data was mostly raster based with a resolution of 1/16th degree (roughly 2.8X4.3miles) which is roughly acceptable at the statewide level, but would be inappropriate for analysis at a finer resolution. For the SLR analysis, WSDOT collected available Light Detection and Ranging (LIDAR) data from partner agencies and contracted with the Puget Sound Regional Council for most of the shoreline SLR layers at 22" and 50". For the remainder of the coastline, where LIDAR was available, WSDOT worked internally to develop SLR layers in GIS. The data used was from multiple sources, at different scales, which caused some challenges in the analysis. WSDOT's Photogrammetry office worked with the Computer Aided Engineering (CAE) office to try and determine a process that would allow of the LIDAR's accuracy to be harnessed to create 22", 50", and 6 foot SLR layers. Ultimately a 5ft digital elevation model (DEM), to match the contracted dataset, was developed and corrected to mean higher high water to create a SLR layer within GIS. This process will need a solution prior to project and corridor level assessments in the future.

Vulnerability Assessment

The WSDOT GIS team then conducted a vulnerability assessment process, looking at scenarios of 22", 50", and 6 foot SLR to determine which critical assets could be inundated by flooding (see Figure 3). During the workshops the 22" and 50" SLR was generally referred to as 2 and 4 foot even though the actual data was slightly different. The final product for the climate change risk assessment workshop was an ArcMap document that showed an increase in sea level of 22 inches and 6 feet, climate changes layers, and WSDOT assets. The interactive mapping method allowed the WSDOT project team to turn on/off asset data, climate change data including SLR, and add or find data on the fly to answer questions as they emerged during the workshop.

Figure 3: WSDOT Vulnerability Assessment SLR Analysis



WSDOT created an ArcMap document that showed SLR by 2, 4 and 6 feet.

In addition to the SLR vulnerability assessment, the WSDOT project team also conducted a rapid geospatial assessment using other climate change variables in order to determine if correlation between temperature, precipitation or soil moisture could be used to find the extended range of fire risk geospatially. The team found that there was no correlation between precipitation and temperature at fire locations; however, there is moderate correlation between precipitation and soil moisture, as well as with temperature and soil moisture at fire locations.

Challenges

WSDOT experienced several challenges in completing the SLR analysis for the project. The challenges included the following:

- Bathtub problem: Some areas that were shown as inundated with water due to sea level rise may not be actually inundated in reality based on elevation or other topographical differences. Additionally, the analysis does not always show damage to wetland areas.
- Coordination of resources: Working across disciplines proved challenging due to some data and software compatibility problems.
- Complexity of flooding impacts: Soil erosion and glacier melts can complicate the effects of sea level rise.
- Land use details: In some cases there may be confusion between orthophoto data and GIS data, such as identifying dikes and their functionality with changes in sea level. Additionally, assessing risk as it relates to policies about diking and physical processes that might occur is problematic.

- Road segments: WSDOT manages its road data as a Linear Referenced Dataset (LRS), which initially caused some complications with discontinuous road segments and bridges.

Comments, Questions, and Answers

Question: Was a similar analysis conducted for the port?

- Answer: King Country Metro has looked at SLR and is applying SLR analysis to many of their projects. The city of Seattle has done two large studies looking at water going into the sewers.

Maryland State Highway Administration

Elizabeth Habic, Environmental Manager
Michel Sheffer, GIS Coordinator

In 2007, Maryland's Governor signed an Executive Order establishing the Maryland Climate Change Commission. In 2009, the Commission developed a state climate action plan, which established a state-wide GHG emission target of 25 percent below 2006 levels by 2020. The plan outlined 42 GHG emission reduction strategies across all sectors and designated various state agencies as the lead agency responsible for implementing the strategy. The Maryland DOT is implementing agency for six Transportation and Land Use mitigation and policy strategies.

<u>GIS Activities</u>

MDSHA's GIS team plays a critical role in helping the agency address climate change related decisions. The GIS team is currently developing an enterprise GIS platform.

MDSHA has begun to use GIS to assess the impacts of SLR inundation and flooding on various types of infrastructure, including roadways, structures, roadway assets, and facilities. The GIS analysis will be used in project proposal evaluations. The GIS assessment relies on LIDAR data and existing SLR data produced by the state's Department of Natural Resources (the SLR inundation dataset was created to assist the Maryland Commission on Climate Change achieve its mandates). The SLR dataset represents inundation areas of Maryland coastal counties under three different SLR scenarios: 2-foot, 2-5 foot, and 5-10 foot rise. Currently the MDSHA GIS team is working with departments to inventory the agencies assets. Once the inventory is created the agency will identify which assets are vulnerable to SLR and flooding.

The GIS team is also developing an enterprise GIS platform. The enterprise system will provide a consistent presentation of climate change data as a content theme?. The system will allow users to overlay climate change related data (such as SLR rise) on top of any form of operational data.

Southern Maine Regional Planning Commission

Peter Slovinsky, Maine Geological Survey, Department of Conservation
Jonathan T. Lockman, Southern Maine Regional Planning Commission

Maine initially incorporated sea level rise in its Coastal Policies in 1985; however, implementation of sea level rise policy has had a varied history. Several studies and reports have been conducted on the topic. For example, in 1995 the state produced a report titled *Anticipatory Planning for Sea-Level Rise along the Coast of Maine.* However, this effort did not engage municipalities on the local level, and as a result, resulted in little action. In 2006, Maine adopted a policy to plan for 2 feet of

SLR over the next 100 years as part of its Coastal Sand Dune rules as part of its Natural Resources Protection Act.

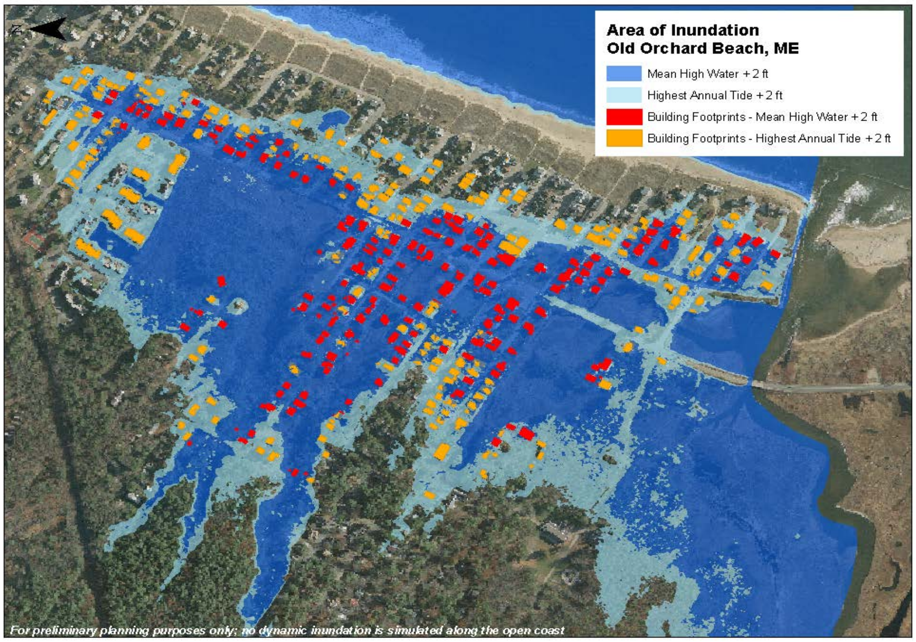
Since 2007, the Maine Geological Survey (MGS) and the Southern Maine Regional Planning Commission (SMRPC) have been involved in the Coastal Hazard and Resiliency Tools (CHRT) Project. This multi-year project, funded by NOAA, focuses on engaging communities on coastal issues, including SLR. As part of this project, MGS and SMRPC worked with four communities in Saco Bay to analyze SLR locally. In contrast to earlier efforts that focused on a top-down approach, the CHRT project emphasizes the importance of planning for SLR at the local level, gaining support for climate change adaptation strategies through a bottom-up approach.

As part of this effort, MGS and SMRPC formed a working group that included a municipal planner and an appointed citizen from each of the four partner municipalities in Saco Bay. The working group, called the Sea Level Adaptation Working Group, or SLAWG, conducted a vulnerability assessment of SLR impacts to both the natural and built environments in these communities, including impacts to marshes, buildings, and transportation networks, including the Amtrak Downeaster line, an important transportation asset.

The working group used LIDAR data from 2006, and ground-truthed the data using RTK-GPS transects. The working group then determined tidal elevations as proxies for marsh surfaces and simulated potential impacts of SLR on marsh habitat, buildings, and infrastructure. The potential future SLR scenarios were illustrated by adding two feet of water to the Highest Annual Tide (HAT) and the highest recorded water level at the Portland Tide Gauge (from the 1978 Storm) to identify buildings and transportation infrastructure that could be inundated. The working group tested the accuracy of the models by simulating existing conditions using tidal elevations as proxies for the marsh surface.

Under a future scenario of HAT + 2 feet, the analysis found over 11 miles of roads would be potentially impassable and almost 3 miles of rail line would be potentially inundated. In addition, over 1,220 building footprints and associated land, valued over $397 million, would be vulnerable to inundation under the HAT + 2 feet scenario. Under a future scenario of 100-year storm conditions + 2 feet, over 26 miles (4.5%) of roads would be potentially impassable and over 4 miles of rail line would be potentially inundated. In addition, over 2,400 building footprints and associated land, valued at over $1 billion would also be vulnerable to inundation.

Figure 4: CHRT's Vulnerability Assessment



The map depicts the areas vulnerable to inundation under various SLR scenarios for a portion of the community of Old Orchard Beach within Saco Bay, Maine.

To better communicate the effects of SLR, the working group used photos from two recent flood events in the area to illustrate the level of water damage to specific buildings and community assets. The Patriots' Day Storm of 2007, which caused widespread flooding in some areas of the partner communities, reached an inundation level roughly equivalent to the future highest tide plus 2 feet of SLR. This provided a picture of the potential future regular tidal inundation that may be faced by the communities.

<u>Potential Regional Adaptation Techniques</u>

The working group identified some possible strategies for adaptation, including:

- Identifying undeveloped upland property that the municipalities can purchase or put into a land trust to allow for the natural migration of marshes;
- Identifying critical facilities that may need to be moved in the event of major SLR.
- Identifying possible new routes for emergency access.
- Identifying areas where tidal control structures can be altered to manage flooding.
- Identifying areas where tidal connections can be improved, such as connecting rivers or river segments to reduce beach flooding.
- Elevating vulnerable infrastructure, including roads, culverts and bridges.
- Requiring buildings to include a freeboard set at 3 feet above the 100 year flood plain, an increase from the current requirement of one foot.

<u>Challenges and Lessons Learned</u>

- A major challenge to implementing strategies to reduce impacts from SLR is encouraging communities to work together. In many cases, a structure (i.e., tidal restriction) located in one community directly affects the flooding in a neighboring community. However, alleviating those affects may require one community to make changes that will not create any direct improvements for that specific community, but will benefit its neighbor and the region.

Throughout the course of the CHRT and SLAWG project the stakeholders learned a number of valuable lessons. Lessons learned included:

- Forward-looking state regulations can get lost at the local level.
- Avoid the "politics" of climate change.
- Direct municipal engagement is necessary to get communities to proactively address the issue of climate change.
- Understand local politics and engage the correct municipal players.
- Keep municipal decision-makers informed.
- Use the best science and tools available at the time.
- Do not separate discussion of natural from built environment impacts – keep environmentalists, public works staff, and emergency personnel around the same table.

Comments, Questions, and Answers

Question: How widespread is collaboration in Maine?

- Answer: We wish there was more collaboration, but we know that compared to the larger states, we probably have an easier time. We are in a small community, which can make it easier to collaborate.

Comment: This is a good technical approach and is scalable.

- Answer: We are working to expand our efforts with other communities in Maine. We've been talking to Amtrak and will likely start working with them. This approach can be taken to the state level as well. We've been fortunate to have good data to work with. NOAA has collected LIDAR data for coastal Maine. We know there is data in other sections of Maine collected by the military, though we don't have access to it.

Comment: It would be helpful to access Department of Defense data. We don't need raw LIDAR data, just the bare earth model or a five foot grid.

Question: Maryland's hazard mitigation plan will look at adaptation strategies. Are other states doing this?

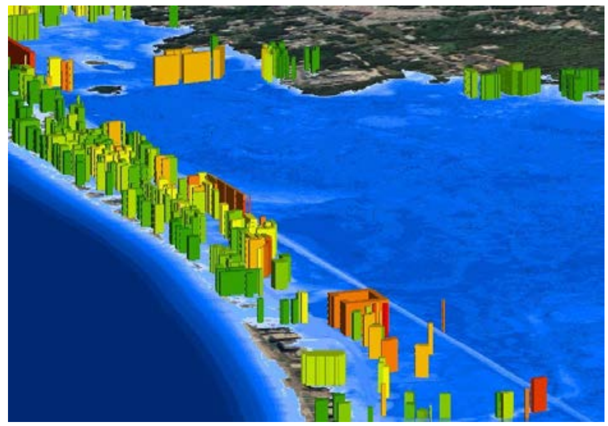
- Answer: We are working on sea level adaptation and hazard mitigation for southern Maine. The fact that FEMA floodplain management programs do not include SLR as a factor is a major challenge to our efforts. We are hoping that FEMA may begin to incorporate thinking about SLR and future floodplains, instead of limiting its analysis to the current level of risk today.

New England Environmental Finance Center
Sam Merrill, Director

The New England Environmental Finance Center developed the Coastal Adaptation to Sea Level Rise Tool (COAST) to assist entities with evaluating the potential impacts of climate change and assessing the economic costs and benefits associated with various climate change adaptive actions. COAST overlays polygons of hypothesized events on assets that have assigned economic values. The tool currently uses a bath tub model for SLR, but has the ability to utilize the results of more complex wave models or advanced climate modeling if available. The default global SLR estimates, which are derived from Vermeer and Rahmstorf 2009, are 2.56 to 5.90 feet by 2100; however, alternative SLR estimates can also be used when working with different localities.

COAST can be a powerful tool to help people understand the economic impacts associated with climate change effects. The New England Environmental Finance Center has utilized COAST on a number of different projects around the country. Examples of these projects are outlined below:

Figure 5: COAST analysis in York Maine



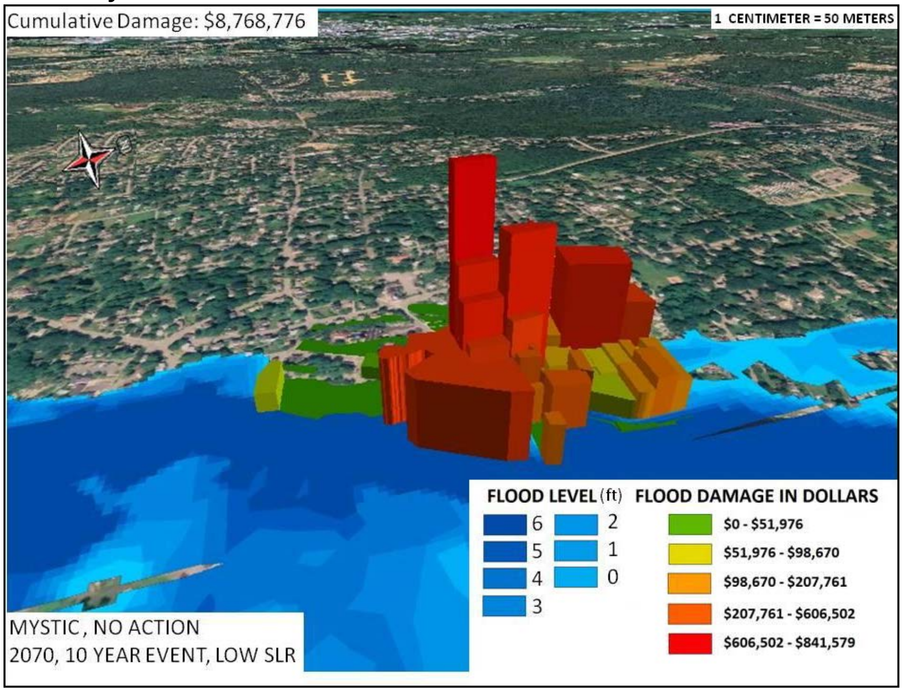
Economic impact to businesses in York, Maine from flooding.

- Portland, Maine: Portland, Maine is currently using the COAST tool to conduct an adaptation analysis for the downtown area. The analysis is evaluating the economic implications of converting the local bridge into a hurricane barrier to help alleviate flooding caused by SLR and storm surges. The tool is being used to assess the impacts of flooding on real estate using a build out scenario for the area.

- York, Maine: COAST was used to analyze the risk to employment locations in the coastal communities around York, Maine under various storm scenarios. The analysis utilized parcel maps and economic output data for businesses located in the area. The structure depth-damage to those businesses was calculated for various size storms using information provided by the Army Corps of Engineers. The economic impact for each parcel was calculated and displayed in ArcGlobe 3D. The 3D visual shows the degree of economic impact to each business location.

- Groton, Connecticut: The coastal community of Groton, Connecticut used the COAST tool to analyze various adaptation options. The town used COAST to model the economic impact, in terms of damaged real estate and building contents, from various SLR and storm surge scenarios. The town then modeled various adaptation actions, including installing a hurricane barrier, elevating a road, and building dikes. The adaptation strategies were inputted into COAST to determine how the economic impact to real estate would change as a result of those strategies.

Figure 6: COAST analysis in Groton, CT



The map depicts the economic impact on business in Groton, CT from SLR if no adaptation actions are taken.

- Maine DOT: The New England Environmental Finance Center is currently using COAST to conduct a financial impacts assessment of increasing the Maine DOT's stream crossing structure. The Center is also assisting the Maine DOT to develop a method to analyze the tradeoffs associated with different bridge design standards. The project includes identifying installation costs versus damage risk tradeoffs under different SLR, storm surge, and river flood scenarios.

IV. Roundtables and Observations

Throughout the course of the peer exchange participants engaged in several roundtable discussions focusing on various issues associated with using GIS to support transportation related climate change decisions. The topics discussed included:

- Political Climate
- Climate Change Mitigation Versus Adaptation
- Data Considerations
- Public Participation/Outreach

Political Climate

Several of the agencies participating in the peer exchange had specific agency or statewide mandates regarding climate change, such as GHG reduction targets or adaptation plans. Conversely, other agencies operate in an arena where climate change is considered a controversial issue. In order to avoid controversy, several of the participants have tailored their communication regarding climate change to focus on the effects and impacts, and not the causes of climate change. For example, in Maine, the public has experienced the rise in sea level. As a result, planners focus discussions on the existence of SLR rather than the cause of SLR. Other participants noted that activities aimed at reducing VMT and GHG emissions also have public health benefits, such as improving physical activity and air quality. As a result, agencies have started couching such activities in terms of their health impacts, and have avoided the connection to climate change.

As another solution to avoid any political debate on the effects of climate change, planners in Maine (and elsewhere) are using the term "no regrets actions," to indicate that there are many actions which will help communities adapt to or mitigate climate change, but will also benefit those communities regardless of the future effects of climate change.

Climate Change Adaptation versus Mitigation

The transportation community's response to climate change has broadly fallen into two categories: mitigation and adaptation. Mitigation involves developing measures aimed at reducing GHG emissions levels associated with transportation operations. Adaptation involves measures aimed at increasing the resiliency of the transportation network or specific infrastructure assets when confronted with expected, or actual, climate change effects. Throughout the course of the peer exchange participants highlighted the use of GIS for both mitigation and adaptation decision-making. During the round table discussions, peer exchange participants discussed the challenges associated with each.

<u>Adaptation</u>

Planners have begun to consider climate change effects when making decisions regarding transportation infrastructure. However, a number of participants noted the inherent challenges involved in working with engineers to plan for SLR and climate change. Engineers follow strict standards for construction, and currently, the data regarding climate change effects is not robust enough to have altered the construction standards. In addition, much of the existing climate data is appropriate to use on a statewide or regional scale, but it is not appropriate for analysis at a finer resolution. Many transportation agencies do not have the expertise or funding necessary to develop the data needed to make project level decisions. As a result, few agencies have incorporated potential climate change impacts into their project design decisions.

<u>Mitigation</u>

Some transportation agencies have begun to identify opportunities to mitigate the transportation sectors contribution to climate change. In many cases mitigation measures have been the result of statewide or agency emission reduction goals. However, some participants noted that in some areas, particularly areas that are experiencing high population growth, it is extremely difficult for planners to make any meaningful contributions to climate change mitigation. In such areas, even if per capita emissions are decreased, overall emissions may rise due to immigration.

The group also noted that advances in technology and national standards, such as the revised CAFE standards, are likely to have the most significant affect on climate change. Local and regional planners do not have control over these factors. Additionally, transportation planners do not have control over land use planning, which also plays an important role in climate change mitigation and adaptation. Finally, recent changes in some regional political administrations have reduced funding and emphasis for comprehensive planning, further reducing the amount of impact planners can make on climate change adaptation or mitigation.

Data Considerations
Obtaining accurate data is a critical factor in the usefulness of GIS applications for making decisions. Some common issues and challenges associated with data considerations include:

- *Lack of guidance on what estimates to use:* Participants noted that the general lack of guidance on what estimates to use for localized climate change effects (including sea level rise, precipitation, and temperature changes) presents challenges. The lack of agreement of which projections to use has resulted in agencies within the same state or region using different estimates in their analysis.
- *Appropriate scale of data:* The question that is trying to be answered with the GIS analysis dictates the appropriate scale of data to use. For example, when determining which infrastructure is potentially vulnerable to SLR, regional-scale data is probably adequate. However, project level planning and design decisions, such as the appropriate length and height to build a bridge in order to withstand future SLR, requires more localized data. Transportation planners and GIS professionals need to understand the nature of the question before determining the appropriate amount of time and money to invest in data collection.
- *Lack of accurate projection data for structures*: Several participants noted that a lack in accurate projection data for structures creates challenges in GIS analysis. Many of the agencies do not survey infrastructure once it is actually built. The data is based on the construction plans and not on what was actually built in the field.

Participants identified the following best practices in developing and using climate change projections to make decisions regarding investments in transportation infrastructure.

- Rely on source data, such as LIDAR, and stay as close to the source data as possible.
- When developing GIS outputs, always use a process or a model so that you can replicate the analysis easily, if and when there are changes in the source data.
- Coordinate with adjacent states to develop necessary data. For example, the northeast states, from Maine to New York, utilized American Recovery and Reinvestment Act (ARRA) funding to procure LIDAR data for the area. The resulting LIDAR data provides a uniform data set across all the participating states.

Participants also highlighted the following as potential data sources for climate change analysis:

- Equifax: Business and sales information
- Insurance companies: Demographic and real estate information
- Database.org: Environmental and climate change data
- NOAA's Digital Coast: A compilation of coastal datasets from numerous agencies
- Structured loss claims from FEMA
- Tele Atlas: Crowd-sourced road data
- Nokia: Crowd-sourced road data

New Trends in Data Collection

The group discussed new opportunities for data collection and analysis through social media and wireless tools. Participants noted the potential of crowdsourcing[6] as a tool for generating travel survey data. Existing mechanisms to generate travel behavior surveys are expensive, and census data is often not detailed enough to use for analysis. The group noted the potential use of smart phone-based travel behavior surveys that could utilize an application to capture behavior.

Participants also highlighted the increasing use of tracking technology, such as Bluetoad, which uses Bluetooth technology to record instances of smart phones passing by a tracking station. The technology does not capture any identifying features of the phone; however, there may be negative public reaction to it due to privacy concerns.

Public Participation/Outreach

Participants agreed that GIS output, such as maps and other visualization products, can be powerful tools to facilitate communication with the public. Agencies utilize the maps and visuals created through GIS to explain complex analysis to the public and to help them understand the interaction of land use planning and GHG emissions, as well as how climate change effects can impact them at the local level.

Visualization is an important part in conveying information about climate change to the public, as well as to other agencies. CanViz, a visualization tool, developed by the Department of Agriculture has been a helpful visualization tool to simulate flooding and inundation. The tool allows you to superimpose images of local infrastructure on the inundation model. Agencies noted that while inundation models provide useful information, showing images of a town library under water can have a much greater impact on the public.

The group also noted that it is also helpful to team up with other agencies to disseminate information to the public. Rather than holding separate meetings, transportation agencies should collaborate with other agencies, such as the state's Department of Natural Resources, when discussing issues related to climate change and SLR.

Finally, participants noted that a bottom-up approach is often critical to obtaining support from localities on climate change mitigation or adaptation actions. Agencies expressed the importance of working collaboratively with local and county officials; such officials need to be included in planning for climate change rather than such decisions being made solely at the State level.

V. Conclusions

The agencies participating in the peer exchange varied in their use of GIS analysis to support transportation-related climate change decisions; some agencies have solely focused their efforts on climate change mitigation, while others have primarily focused on adaptation. Through sharing information about GIS tools as well as knowledge regarding lessons learned, challenges encountered, and success factors, participants gained insight into how GIS tools can be developed, utilized and deployed to support climate change decisions.

[6] Crowdsourcing refers to the idea of utilizing the collective intelligence of the public at large to complete business-related tasks that a company would normally either perform itself or outsource to a third-party provider.

Peer exchange participants agreed that agencies have the right GIS tools to support transportation-related climate change decisions. However, the biggest challenge agencies face is a lack of sufficient data needed to effectively utilize the GIS tools. While GIS practitioners are able to provide meaningful analysis using the best available data, participants agreed that developing more refined data, particularly data that can assist with project level decisions, will greatly improve the ability to use GIS to make important decisions to mitigate for and adapt to climate change.

Appendix A: List of Participants

Name	Organization	Email Address
David D'Onofrio	Atlanta Regional Commission	DD'Onofrio@atlantaregional.com
Peter Slovinsky	Maine Geological Survey	Peter.A.Slovinsky@maine.gov
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Jonathan Lockman	Southern Maine Regional Planning Commission	jlockman@smrpc.org
Elizabeth Goss	Washington DOT	gosse@wsdot.wa.gov
Alan Smith	Washington DOT	SmithA@wsdot.wa.gov
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Catherine Duffy	Volpe Center	Catherine.Duffy.CTR@dot.gov

Appendix B: Peer Exchange Agenda

Monday, September 26

1:00 pm	**Welcome, Introductions, and Background**	Mark Sarmiento, FHWA
1:30	**Overview of FHWA GIS and Climate Change Activities**	FHWA
2:00	**Atlanta Regional Commission**	David D'Onofrio, ARC
2:45	**Sacramento Area Council of Government**	Raef Porter, SACOG
3:30	*Break*	
3:45	**Roundtable Discussion #1**	
4:45	**Day 1 Key Points/Wrap-up**	Mark Sarmiento, FHWA

Tuesday, September 27

8:30am	**Day I Re-cap**	Mark Sarmiento, FHWA
8:45	**Washington Department of Transportation**	Lise Goss/Alan Smith, WSDOT
9:30	**Maryland State Highway Administration**	E. Habic/M. Scheffer, MDSHA
10:15	*Break*	
10:30	**Roundtable Discussion #2**	
11:15	**Southern Maine Regional Planning Commission**	J. Lockman/P. Slovinsky, SMRPC
12:00	*Lunch (on your own)*	
1:00	**New England Environmental Finance Center**	Sam Merrill, NEEFC
1:45	*Break*	
2:00	**Roundtable Discussion #3**	
3:00	**Peer Exchange Key Points and Wrap-Up**	Mark Sarmiento, FHWA
3:30	*Adjourn*	