International Conference on Sustainable Infrastructure (ICSI 2021)

Technical Track Abstracts

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Track 1: Transportation Systems

Moderated by Theresa Harrison

Baking Resilience into Transportation Planning

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Keywords: Recoverability, Redundancy, Reliability, Resilience, Vulnerability

ABSTRACT

By its very nature, transportation infrastructure is a long-term investment, and its assets must serve the test of time. Time is not the real issue, however; it is how the system responds to and recovers from the stress and shock of natural and manmade events that determines its resilience. Resiliency allows the bridge or roadway to be efficient, reliable, and safe throughout its expected lifespan, which is important from financial and safety perspectives.

To ensure that resilience is incorporated into the transportation planning process, planners must understand four aspects:

- The definition and meaning of resilience;
- How best to raise the awareness of the need for resilience;
- An approach to incorporate resilience in transportation planning; and
- The areas where resilience best fits in the established transportation planning process.

Resilience is better understood by identifying criteria to support its essence and then using the criteria to assess the potential issue and subsequently the solution to fit the geography and situation. Today we utilize transportation infrastructure that was built by the previous generation. The phrase "we are building it for the next generation" can be the lens through which we view the long-term benefits for transportation and our mobility needs and then incorporate resilience into infrastructure and system performance. We need a resilient mindset to build a resilient transportation system.

Resilience is the Future of Transportation Networks

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Keywords: Climate Change, Emerging Technology, Equity, Nature-Based Solutions, Resilience, Transportation

ABSTRACT

The design of resilient transportation networks constitutes a paradigm shift toward systems that address natural hazards considering future climate change scenarios. This remarkable pivot from a reactive toward a proactive approach recognizes the cost of inaction and the socio-economic benefits of proactivity. Three projects present powerful models for building a resilient transportation future:

AECOM developed the SWIFT (Sustainable Ways to Integrate Future Transportation) modelling tool based on data-driven, performance-based and scenario planning that enables agencies to take proactive approaches and understand how transportation systems perform under extreme duress and unique circumstances, and to prepare them to create effective contingency plans.

The Ecuadorian National Road Network (NRN) was conceived as a system integrating the country by connecting the most important population centers and facilitating the movement of strategic goods and services. AECOM developed a strategy to design a robust NRN enabled to resist and adapt to the hazards to which it is exposed, providing continuity in the mobilization of goods and services offered to the main economic sectors and a focused a response for cities.

California State Route 37 is an important regional highway, connecting the northern California San Francisco Bay Area sub-regions. Addressing traffic congestion relief, sea level rise, flooding and ecology, AECOM led a team that broke traditional barriers in forming a technical working group of transportation planners, engineers, ecologists, regulatory agencies, environmental organizations, and others to ensure a multi-benefit cohesive resilient transportation system.

Driving the Future of Transportation Planning Through Emerging Trends

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Keywords: Freight, Planning, Resiliency, Sustainability, Technology, Transportation

ABSTRACT

Understanding emerging global and domestic trends, such as economic growth, evolving climate changes, energy resources and socio-demographics, as well as advances in technology and sustainability practices, is a critical step in preparing transportation planners and practitioners to respond to future challenges—and opportunities—facing the transportation industry. Burns & McDonnell supported the US National Cooperative High Research Program (NCHRP) in carrying out a series of research projects to identify and evaluate seven strategic long-term issues, in the coming 30-50 years, predicted to impact local government agencies, including the US State Departments of Transportation. These research projects, known as *NCHRP 20-83*, prepared transportation leaders to anticipate, and better respond to, new challenges and enabled transportation agencies in the US to shape the future by addressing emerging trends in their decision making.

To promote the integration of *NCHRP 20-83* in future transportation planning, Burns & McDonnell developed a multi-part "Foresight Series" which synthesized thousands of pages of research into a set of simple and compelling messages. The Series further prepared planning agencies for the future by outlining strategies to adapt to the uncertainty of seven strategic issues:

1. Economic Changes Driving Future Freight Transportation
2. Expediting Future Technologies for Enhancing Transportation System Performance
3. Long-Range Strategic Issues Affecting Preservation, Maintenance, and Renewal of Highway Infrastructure
4. Effects of Changing Transportation Energy Supplies and Alternative Fuel Sources in Transportation
5. Climate Change and the Highway System: Impacts and Adaptation Approaches
6. Effects on Socio-Demographics on Travel Demand
7. Sustainable Transportation Systems and Sustainability as an Organizing Principle for Transportation Agencies

Small Changes, Large Effects: Interconnected Infrastructure Networks in Food Supply Chain Disruptions and Multi-Modal Transportation Solutions

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Keywords: Energy, Food Supply Chains, Interdependent Infrastructure, Networks, Transportation

ABSTRACT

Critical infrastructures, in particular, transportation, energy and water, are key supports for supply chains generally and specifically food supply chains. A framework is developed for representative connectivity among the three infrastructures and food systems in terms of interconnected nodes and links and their properties, expanding prior research. The framework is used to illustrate how the convergence of several infrastructures often results in small connections producing large effects on interconnected infrastructures. These effects in turn can increase food system vulnerability to extreme events, often heightened by human behavior in relation to changes in vulnerability.

Methods are based on illustrative cases for food disruptions after (and not including) agricultural production encompassing processing, packaging, storage, distribution, and consumption. These cases include the COVID-19 pandemic and extreme weather events that have disrupted energy, transportation, and water through losses of transfer locations or facilities both above and below ground with impacts upon food systems. Food system examples include effects on components at the product, packaging, and equipment levels. Food supply chains are important given the extensive resources used to maintain them in emergencies and extreme events to avoid permanent and temporary food deserts and bottlenecks that often have human survival implications. Restoration time is analyzed as a critical component of the disruption and restoration phenomena and these are related to links and nodes most effective in system restoration, particularly interconnected ones.

Results focus on interconnectivity-based disruptions and ways to unbundle interconnections through more adaptive routing such as multi-modal transportation and decentralized energy systems. Such adaptive methods can prevent interconnection-related catastrophic failures by increasing system capacity to absorb shocks. Understanding these processes is an important step to support community and other stakeholder engagement in preventing or mitigating food supply chain disruptions created by supply and demand imbalances and panic reactions.

Acknowledgment: This research is supported by a U.S. Department of Transportation grant on micro-transit through NYU's C2Smart Center and National Science Foundation grants numbered 2043736, 2027884, 1444755 (cooperative agreement} and 1541164.

Track 2: Sustainability of Buildings and Other Structural Systems

Moderated by Krishna Reddy

Enhanced Investigation of Material Flood Damage to Support Multi-Scale Flood Loss Prediction

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Keywords: Benefit-Cost, Depth-Damage, Flood Loss, Hazard Mitigation, Resilience

ABSTRACT

Current practice of flood loss prediction presents limitations in accurately predicting building flood losses at multiple scales. While whole-building estimates can more accurately predict high-level losses (i.e. large groups of buildings), a significant analysis error is revealed with small-scale (i.e. individual or small groups of buildings) investigation. A more robust, data-driven, building damage model is presented based on elucidating a more fundamental understanding of flood damage to material components commonly used in construction. The model framework is based on a component-level damage database composed of data collected from experimental analysis. Structures with standard construction materials were built and incrementally flooded for short periods of time. Material component damage was defined based on material reparability, which was determined through indicators, such as moisture intrusion, corrosion, and contamination. The framework for the flood loss prediction model is designed to incorporate damage uncertainty and is capable of analysis at multiple scales. This study not only provides a fundamental understanding of material damage, but also develops a more effective modeling tool for building community resilience through flood risk analysis and hazard mitigation planning.

Mapping Standards and Rating Measures of Structural Green Roofs for Socio-Environmental Life Cycle Assessments

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ABSTRACT

Deployment of green roofs in building structures has gained popularity as a sustainable practice to partially mitigate climate change consequences through reduction of environmental footprints and to enhance the economic and social values of these built infrastructures. Various standards highlight design, construction, maintenance, and operation challenges and opportunities for green roofs. Further, building codes and regulations consider changes in loading, thermal, acoustic, and fire demands and capacities associated with green roofs. These changes are not necessarily aligned with each other. Hence, decision-making procedures for application of green roofs involve a comprehensive analysis of all structural, social, environmental and economic parameters. Sustainability rating systems provide an opportunity to simplify comparative evaluations of green roof systems, incorporating a broad range of parameters in an integrated system. This study maps sustainability credits to green roof standards for an occupied structural roof. The study incorporates the contribution of the green roof to the performance of the building envelope, like thermal performance. Provided guides complement this mapping to evaluate the effectiveness of the mapping and highlight challenges in the life cycle assessment process. Conclusions facilitate discussions on objective performance measures of green roofs for different structural systems and occupancies.

Future Projected Changes in Moisture Index over Canada

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Keywords: Building Design, Climate Change, Climate Model, Moisture Index

ABSTRACT

As a consequence of global warming, buildings in Canada and around the globe are expected to face unprecedented climate over their design lives. The Moisture Index (MI) is a climate-based indicator currently used in the National Building Code of Canada (NBCC) to guide the design of building wall assemblies for acceptable durability performance. The MI comprises of a wetting index (WI) defined as the total annual rainfall normalized by a value of 1000 mm, and a drying index (DI) defined as the drying potential of a location normalized with respect to the drying capacity at Lytton, British Columbia which is about 4.35g/kg.

This study calculates future changes in MI across Canada under 2 and 3.5ºC of global warming. Fifteen realizations of bias-corrected climate data simulated by the Canadian Regional Climate Model (CanRCM4), following RCP 8.5 is used for the calculation of MI for a historical time period (1986-2016) and future time periods commensurate with 2 (2034-2064) and 3.5ºC (2062-2092) global warming. Bias correction of the CanRCM4 large ensemble is performed with reference to a gridded observational climate dataset: WFDEI, using a multivariate bias correction method: MBCn. The value added from the bias correction step is evident as the MI values calculated from bias-corrected CanRCM4 data are closer to the MI from gridded observations than the raw (uncorrected) CanRCM4 data as seen in Figure 1.

It is highlighted in this study the importance to choose an appropriate value to normalize DI with, because when DI exceeds 1, the definition of MI fails as MI increases with increases in DI. Consequently, it is demonstrated that using the maximum drying potential value for normalization addresses this issue and ensures that the value of DI always remains less than or equal to 1 in the future. The maximum drying potential values associated with the historical and future time-periods of the 15 CanRCM4 realizations were calculated and the maximum value among them (5.4 g/kg) was used as the normalization factor for the calculation of DI. Therefore, more realistic values of DI, MI and their future projected changes were obtained by comparing future time-periods with the historical period as presented in Figure 2. The percent changes can then be imposed on the historical MI given in the NBCC, resulting in future projected MI values at the locations specified in the building code.

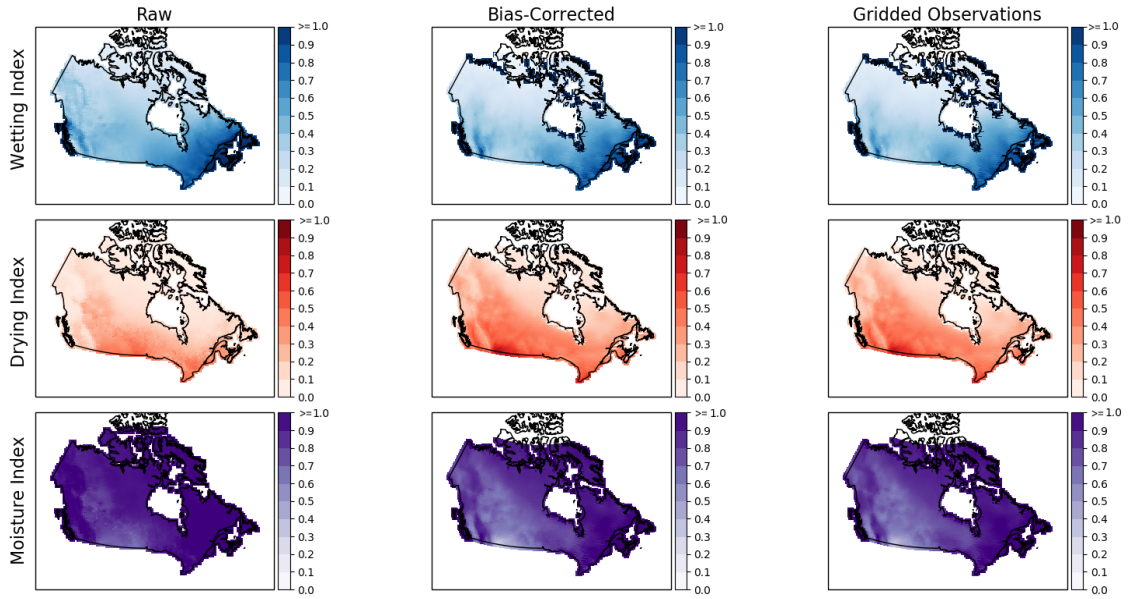

Figure 1. The historical (1986-2016) ensemble 31-year average DI, WI, and MI calculated according to the NBCC method using Raw CanRCM4, bias-corrected CanRCM4, and WFDEI.

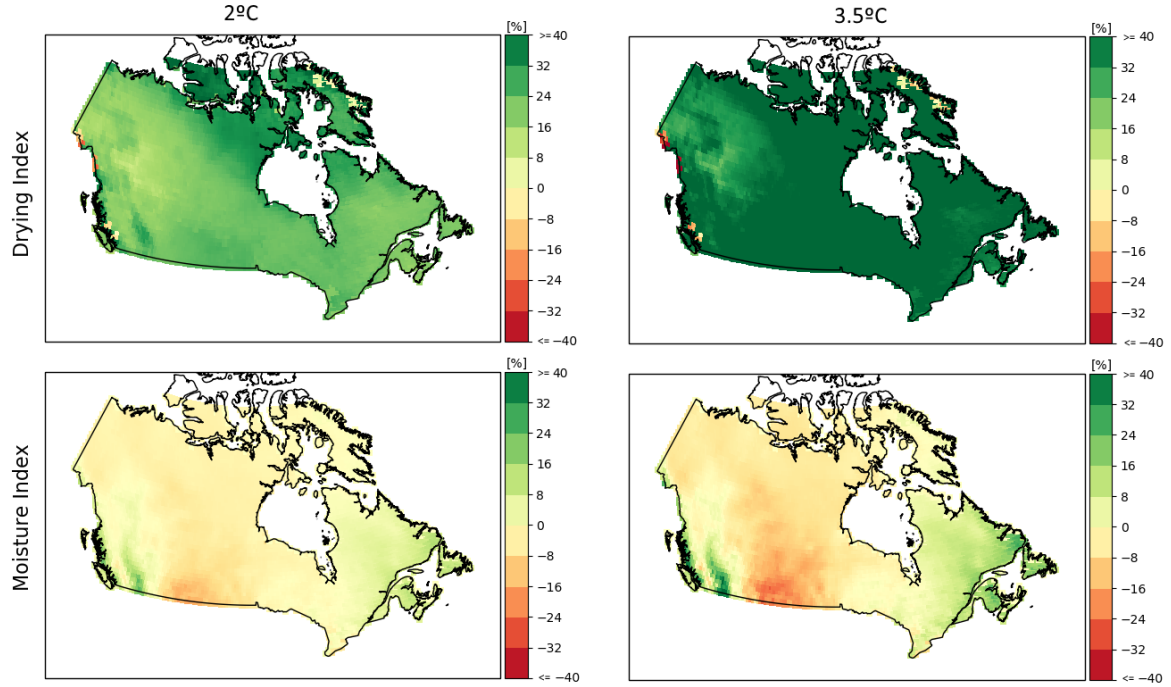

Figure 2. Projected future percent changes in DI and MI obtained when maximum drying potential value (5.4 g/kg) is used for the calculation of DI.

Results indicate that the coastal and great lakes regions of Canada will have increased MI, whereas prairies and northern regions will in the future have decreased values of MI. The current

design requirements suggest that a capillary break is required between the exterior cladding and the backing assembly of the wall for those buildings located in regions having MI > 1 and where the heating degree day (HDD) is ≥ 3400, and also when MI > 0.9 with HDD < 3400. This implies that in the future there will be a greater number of locations that satisfy these conditions and thus will require the design of the wall assembly to incorporate a capillary break.

Table 1. Province-wide distribution of NBCC locations among the two categories: a) HDD < 3400 and moisture index (MI) of > 0.90, and b) HDD ≥ 3400 and the MI is > 1, provided in NBCC (2015) and under 2 and 3.5ºC global warming.

Province (Total number of locations in Table C2)	Number of locations with HDD < 3400 and MI > 0.9			Number of locations with HDD ≥ 3400 and MI > 1		
	NBCC (2015)	2ºC	3.5ºC	NBCC (2015)	2ºC	3.5ºC
British Columbia (108)	47	62	65	12	0	0
Alberta (55)	0	0	0	0	0	0
Saskatchewan (31)	0	0	0	0	0	0
Manitoba (24)	0	0	0	0	0	0
Ontario (229)	0	67	126	2	0	2
Quebec (125)	0	2	50	24	51	41
New Brunswick (17)	0	0	8	10	17	9
Nova Scotia (25)	0	11	25	25	14	0
Prince Edward Island (4)	0	0	3	4	4	1
Newfoundland and Labrador (18)	0	0	7	12	14	7
Yukon (9)	0	0	0	0	0	0
Northwest Territories (17)	0	0	0	0	0	0
Nunavut (16)	0	0	0	0	0	0

Incorporating Holistic Sustainability and Resilience into Civil Engineering Projects

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Keywords: Civil Infrastructure, Environmental Justice, Housing, Planning, Social Equity

ABSTRACT

Investing in sustainability and resilience in the context of civil infrastructures systems delivers value by reducing disruption, speeding recovery, connecting our communities, supporting our way of life, delivering productivity gains and economic growth, reducing environmental impact, and providing enhanced protection. However, these types of investments are not codified, leaving stakeholders asking "how"? Four projects contextualize how design, planning, and operation of civil infrastructure projects can deliver social, economic, and environmental value to communities.

Measuring community capitals. Inherent to all communities are six capitals, namely, built, social, human, political, natural, and financial. Community resilience and sustainability assessments should work across all six capitals in evaluation and planning. Civil infrastructure is a major part of the built capital whereby it plays an important role in supporting the other five capitals. To date, metrics associated with standardized civil engineering procedures and guidelines relate to physical properties and the function of the finished project. For example, engineers evaluate bridges on the number and width of lanes (i.e., capacity) and the loads that they can carry. Similarly, they evaluate buildings on compliance with applicable building codes, fire ratings, and zoning regulations. While these metrics are important, it is difficult for taxpayers or developers to see the linkage to life, safety, health, and welfare outcomes, particularly at the scale of a community. This failure to create linkages undermines a popular awareness of the important role that infrastructure plays in our daily lives. It is not enough for engineers to provide a design that functions, they must also contribute to sustainable development as stewards of the natural environment while also incorporating distributional equity and procedural justice considerations of the communities they serve and support.

The application of measuring broader social and economic outcomes is gaining traction, particularly on large projects that provide both positive and negative impacts on communities. The American Society of Civil Engineers Infrastructure Resilience Division Committee on Social Science, Policy, Economics, Education, and Decision (SPEED) focuses on integrating social science and economics into the planning, design, and management

decisions surrounding physical infrastructure projects. With two representatives from the SPEED committee, this session will present one timely SPEED project that focused on identifying metrics that allow for quantification of socially driven outcomes into civil engineering projects within the discourse of resilience. The project reemphasizes that investing in resilience in the context of infrastructure systems delivers value by reducing disruption and speeding recovery; connecting communities; supporting our way of life; delivering productivity gains and economic growth; reducing environmental impact; and providing enhanced protection. Such metrics spanning the community capitals can be employed in various project phases, including planning, design, and operations, for individual projects. The metrics can also be used for a community-wide assessment across infrastructure projects to evaluate sustainability and resilience capacity, and measure how these capitals are disrupted after a disaster event.

Social equity and environmental justice. Social equity and environmental justice are getting national attention with President Biden's issuance of Executive Orders 13985 and 14008. Numerous federal agencies are gathering data and interacting with civic leaders, policy makers and the general public to support the goals articulated in each Executive Order. The information and data will provide an opportunity to examine social equity and environmental justice in a community's ability to bounce back from disasters.

In the U.S., disaster recovery is stricken with inequities. This is observed through the ever-present intersection of physical and social vulnerability that exists before disaster strikes, which leads to those with the least resources to recover being hit harder and more often by disaster, and results in exacerbated inequalities. An example of such disparities is the City of Lumberton, NC, a diverse community with median income far below the U.S. average. Lumberton suffered extensive flooding following Hurricane Matthew in 2016 and again following Hurricane Florence in 2018. On-going research by two panelists shows that household dislocation is as much of a function of flood damage as of race and ethnicity. Applying a spatial lens to explore social equity and environmental justice issues as they relate to flooding, the spatial intersection of the racial distribution within Lumberton and flood prone areas is evident. More poor, black, and American Indian residents live in the floodplains, compared to wealthier, white residents living North of the Lumber river at higher elevations.

These relationships are common in the U.S. To assist communities in being better prepared for disasters, NIST is developing tools to address social equity and environmental justice. Use of these tools with infrastructure projects requires an inclusive process that engages stakeholders that understand and represent the diverse community values, culture, and needs, and may include: representatives from the local government, such as community development, public works, and building departments; public and private developers; owners and operators of buildings and infrastructure systems; local business and industry representatives; representatives of community organizations, non-government organizations, health and educational institutions; and other stakeholders or interested community groups, such as residents of public housing.

Hurricane Sandy. The recovery process after Superstorm Sandy was unique in that the most heavily affected region (the greater New York Metro area) is rich in financial resources and political capital as compared to many other parts of the country. As such, the region

approached long-term recovery and resilience in a number of unique ways. The federal government, the states of New York and New Jersey, New York City, and even some of the smaller municipalities in the region have access to significant expertise related to resilience planning and engaged in a number of innovative programs designed to help communities recover from Sandy, while at the same time injecting future resilience into all of these efforts. This resilience mandate originated in part from the federal government, best embodied in the Hurricane Sandy Rebuilding Strategy developed by the Hurricane Sandy Rebuilding Task Force, and found its way into on-the-ground efforts ranging from HUD's Sandy Recovery Infrastructure Resilience Coordination Group as well as the agency's National Disaster Resilience Competition, the New York Rising Community Reconstruction Program, and New York City's Special Initiative for Rebuilding and Resiliency.

In all of these efforts the recovery process was in large part an opportunity to rebuild infrastructure and to radically rethink infrastructure planning and design for a new era of increased risk by prioritizing innovative design solutions, cross-jurisdictional collaboration, community participation, and holistic solutions emphasizing economic, social and environmental co-benefits. Some important drivers of this approach include planning and engineering expertise available in the region and a combination of top-down and bottom-up factors including a federal emphasis on resiliency, a long history and culture of local planning, experience with previous disasters, and a strong civil society sector intent on promoting a just and equitable recovery, among other factors. At the same time, these successes have been limited by the enormous costs inherent in some of the necessary resilience strategies, the region's complex political fragmentation, congressional restrictions, and other factors that must continue to be addressed.

Community housing project. The "We Can Make" Community Housing Project was born as a 'bottom-up' response to community demands and concerns about housing need in Knowle West, one of the most deprived areas of Bristol, UK. We Can Make uses an asset-based approach to re-imagine "how to do housing" differently in Knowle West. It starts with the know-how and resources the community already has, and uses a process of co-design to work with people to develop the tools to do housing on their terms. They call this approach "urban acupuncture" – where people with particular needs opt in to using a small piece of land to meet their housing needs.

We Can Make is about much more than just delivering housing "units". It is important that the process of building new homes contributes to the wider economic regeneration of the neighborhood, including creating new jobs and skills for local people. We Can Make uses Modern Methods of Construction (MMC) and they have developed a community fabrication space, KWMC: The Factory, as a neighborhood housing factory. They provide training for local residents and tradespeople to learn new digital construction skills. Architects and residents have worked together to create the designs for the first two We Can Make homes. Many resilience and sustainability metrics were utilized to capture individual, community and broader project benefits including social, economic, and environmental value.

Track 3: People: Social, Society, Stakeholders (Part 2)

Moderated by Anthony Kane

The Promise of Shared Electric Autonomous Mobility (SEAM) to Close Mobility Gaps for Vulnerable Populations

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Keywords: Automated, Electric, Mobility, Shared, Sustainability

ABSTRACT

As a consequence of our population living longer, society must work to accommodate the needs of older people. One of the most pressing needs for older people is mobility. Safe and convenient mobility is critical to maintaining physical and mental health, as well as avoiding social exclusion. Declining physical capabilities and mental acuity cause older drivers to cease driving, placing them at greater risk for social exclusion due to mobility gaps. Shared Electric Automated Mobility (SEAM) has the potential to provide sustainable mobility solutions for vulnerable older people populations. SEAM can help close mobility gaps that cause social exclusion, thereby improving social sustainability. In addition, SEAM has the potential to provide improved access to economic activity for the older people, improving economic sustainability. However, older drivers must be accepting of both shared and automated mobility options to fully leverage the potential advantages of these technologies. This study identifies barriers to the use of mobile and vehicle technology amongst older populations as well as a proposed framework of strategies for mitigating those barriers.

Using Integrative Design as a Lean Tool in Sustainable Infrastructure Development

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Keywords: Commercial Development, Impact Matrix, Infrastructure, Integrative Design, Lean, Sustainability

ABSTRACT

Without doubt, a high percentage of inefficiencies and poor deliveries in infrastructure development are traceable to poor planning and ineffective coordination particularly at the design stage. Aside from the cost impact that has become a worrisome debate in many projects, post construction life cycle activities can be unsustainable in the loop of these inefficiencies. At the early phase of pre-development, it is critical for project teams to understand many facets of the development including the community at large, and environmental stressors that affect their health and well-being—this is what an integrative design process can do.

This study aims to review the use of integrative design as a lean tool in infrastructure development to achieve sustainability. A commercial mixed-use development in West Africa's biggest city, Lagos, was used as a case study by critically evaluating the impact of integrative design on the project sustainability score card. A hypothesis to reflect the significance of integrative design in achieving its sustainability was tested using lean impact matrix and chi-square statistical analysis of teams' feedback from brainstorm sessions and questionnaire with results showing a near 95% significance of impacts.

Evaluating the Potential of Sustainability Rating Systems to Address Social Equity

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Keywords: Rating Systems, Social Equity, Sustainability

ABSTRACT

Awareness of equity and social justice issues has improved in recent years, but 2020 has significantly magnified these concerns. In light of the disproportionate impact of climate change on vulnerable populations and more general concerns about the unequal distribution of costs and benefits from infrastructure projects, there is a growing need to focus on social sustainability issues. Sustainability rating systems have always promoted a Triple Bottom Line approach to analyzing project costs and benefits with a goal of creating value for all community stakeholders, but the three parts of the triple bottom line may not have received equal consideration in that equation. This presentation will describe an analysis of multiple prominent sustainability rating systems, to determine how and to what extent they incorporate aspects of social equity.

The goals of the presentation will be to: describe how sustainability rating systems define social equity, illustrate how social equity as an idea is translated into rating system credits and criteria, discuss how applying rating systems to projects may help achieve social equity, even if not explicitly stated as such, and highlight gaps where additional attention to social equity might improve rating systems' triple bottom line impact.

The Inspiration of Power: Art, Culture, and Distributed Renewable Energy Infrastructure

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Keywords: Art, Education, Energy, Equity, Renewable, Social

ABSTRACT

The great energy transition is having an aesthetic impact on the visual landscapes of our cities and countryside. This trend will increase as we construct the sustainable infrastructures required to meet the climate challenge. In the early days of electrification, power plants were by necessity located in the hearts of our cities because transformers were not yet sophisticated enough to raise the voltage for efficient long-distance transmission. As a consequence, these power plants were designed by architects to be beautiful contributions to public space. Because these power plants were highly polluting of their local environments, we centralized power generation to remote areas as soon as long-distance transmission became possible. As these power houses left the city, they also left their relationship to art and to architecture. They instead became pure utility and severed their connection to human culture.

This divorce of power generation infrastructure from design and culture has continued into the present with the deployment of renewable energy landscapes that strive only to produce the cheapest kilowatt-hour. In some cases, this utilitarian approach has led to push-back within communities that find themselves in close proximity to large-scale solar and wind installations.

Recognizing the power of community-centered design, public art, and creative placemaking in this context, we can begin to take a proactive approach to the influence of renewable energy on our constructed environment. We can give city and regional planners new tools with which to integrate sustainable infrastructures into transportation corridors, waterfronts, urban farms, and other public places, providing a range of social co-benefits while improving resilience and reliability of our new low-carbon electricity grid.

The Challenge

The world faces the challenge of overseeing an energy transition to renewable sources that does not repeat some of the mistakes and unintended consequences of past infrastructure development. With trillions of dollars in near future investment and low risk returns for solar deployments, it is critically important that the opportunity for wealth generation be offered to a broad array of stakeholders. Recent energy modeling has demonstrated the value of distributed energy resources over centralized renewable energy installations. Large, centralized power infrastructures also create problems related to land use as energy

landscapes are increasingly competing with other interests such as agriculture, recreation, visual resources stewardship, land conservation, forest preservation, and biodiversity. Distributed energy assets ease the burden on long-distance transmission lines, improve resilience and reliability, and offer opportunities for energy demand services. But with the shift of energy infrastructure back into population centers comes a heightened responsibility to fit these systems into the cultural fabric of our communities in productive, inspiring, and beautiful ways.

Introduction to the Land Art Generator

Founded in 2008 with a mission to advance a just and equitable energy transition in response to the climate crisis, the Land Art Generator Initiative (LAGI) helps design places for people that share land use with distributed renewable energy generation and other sustainable infrastructures. The Land Art Generator works closely with communities to deliver sculptural installations that have the added benefit of renewable power generation. In addition to providing kilowatt-hours of electricity to the grid, Land Art Generator artworks provide a range of social benefits, including economic development and education, and are designed to address issues of energy poverty and environmental justice.

LAGI provides context-specific and culturally relevant design solutions for distributed energy that reflect the needs of the community by utilizing a variety of project delivery models. These include design competitions, direct commissions, calls for proposals, Solar Mural artworks, and participatory design processes with communities. Open design competitions for Dubai/Abu Dhabi (2010), New York City (2012), Copenhagen (2014), Santa Monica (2016), Melbourne (2018), Abu Dhabi (2019), and Fly Ranch (2020) have brought in over 1,200 designs from more than eighty countries.

LAGI Projects as Disruptive Innovations

The design brief for LAGI design competitions calls for site-specific works of art that capture energy from nature, cleanly convert it into electricity, and transform and transmit the electrical power. More recent competitions have expanded the brief beyond energy to include other sustainable infrastructures, including water, food, shelter, and waste. Consideration must be made for the safety of the viewing public and for the educational activities that will occur on site. The design should be constructible (rather than theoretical), and it must respect the natural ecosystem of the design sites.

Each year LAGI offers a unique, yet universally applicable typology that can be replicated within other similar conditions in other cities. The project has so far investigated urban gateways, landfills, brownfields, coastal sites, master plan overlay, city portals, and rural high desert.

Examples include projects such as *The Solar Hourglass* (Figure 1), a concentrated solar power plant that feeds the equivalent of a thousand homes with clean energy while inspiring the public with a positive and inspiring message about our post-carbon future. It reminds us that there is still time to avert the worst effects of climate change if we can all work together.

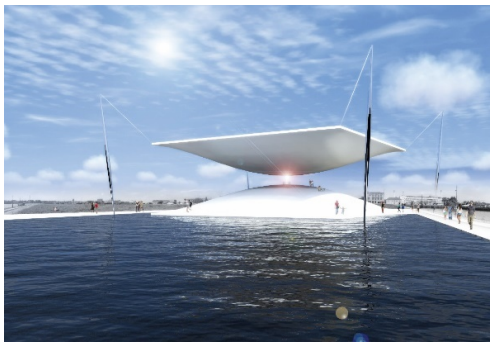

Figure 1. *The Solar Hourglass*, designed by team Santiago Muro Cortés

Equity and Social Justice

The Land Art Generator works directly with communities to assess interest, needs, and develop design ideas for integrating renewable energy or other sustainable infrastructure into neighborhoods. The workshops provide an opportunity for citizens of all ages to re-think their relationship to electricity consumption and production. The innovative and artful applications of sustainable technologies can spark the imaginations of young people and trigger curiosity in science, technology, engineering, and math. LAGI programming is a great example of STEM to STEAM and project-based learning. Through the process of designing their own land art generator, middle school and high school students show applied understanding of concepts like energy conversion efficiency and capacity factor. At the same time, they are applying knowledge of form, shape, color, and touching on aspects of urban planning and whole systems design, exactly the kind of skills needed for jobs in the twenty-first century.

How to Break Ground

With hundreds of feasible ideas in the portfolio of Land Art Generator design challenge proposals, the time is now to begin deploying these regenerative artworks at scale. Barriers to implementation, though, include funding and jurisdictional approval. What might at first seem like a challenge could become an opportunity with the right kind of hybrid development model. By merging the verticals of energy infrastructure, civic art, and human-centered mixed-use development, we can identify economies of scale and efficiencies, but it will require a redefinition of how we approach sustainable development and collaboration across disciplines that are typically siloed from one another. Burns & McDonnell brings infrastructure engineering experience while navigating public, private and environmental obstacles to bring projects from ideation to creation. This experience, combined with the disruptive vision of LAGI, will apply the innovation necessary to identify a path to implementation.

Conclusion

Cities can define themselves in the energy transition by creating new visual icons and cultural markers of what renewable energy infrastructure looks like. Vibrant and livable cities attract more business, investment, and long-term residents. Civic art that employs renewable energy technology as the media for creative expression and education will pay back its own embodied carbon footprint and cost of installation. This new way of thinking about art in public space and energy landscapes will bring forward cultural landmarks that

will be visited by future generations to remember this important time in human history when we rose to the challenge of climate change.

All the Easy Roads Have Been Built – Building Social Capital for More Resilient Communities

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Keywords: Communities, Engagement, Outreach, Planning, Public, Social

ABSTRACT

Communities are more resilient when everyone's interests are considered while making decisions that impact the public. Consistent investment in social capital and being willing to have hard conversations about controversial infrastructure projects can generate long-term value during the planning and construction process.

We explore the concept of social capital and lessons learned on how agencies and project teams can build trust and build projects that respect communities. We discuss best practices and lessons learned from large transportation infrastructure projects and touch on how to continue to build social capital and respond after a major crisis or disaster, such as the COVID-19 pandemic. We also provide insights on understanding community values, gathering meaningful input for decision-making, and overcoming issues and challenges that threaten to erode trust and halt project progress.

Track 4: Materials and Construction Components

Moderated by Imisioluseyi Akinyede

Impacts of Material Properties on the Resilience of the Built Environment

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Keywords: Hazards, Infrastructure, Materials, Resiliency

ABSTRACT

Our communities rely on their infrastructure to provide services of shelter, energy that includes electricity and fuel, water, communication, and movement of people and goods. The design and performance requirements of critical construction materials and engineered systems need to consider hazards from both: (1) acute loads due to winds, earthquakes, fires, and water intrusion, and (2) long-term exposures to environmental stressors which include ultraviolet radiation, freeze-thaw, relative humidity, deicer salts, or cyclic thermal expansion and contraction. There are many hazards to communities, and this study provides materials-related examples for roofing for wind protection, residential modifications for flood protection, and bridge strengthening. These are just three examples of many where new materials or improved materials can have a significant social and economic impact to building a community with greater resiliency, i.e. preventing the loss of life and property.

Insurance claim data and field studies have shown that older asphalt shingle roofs typically have more damage in disasters and other weather events when compared to newer roofs. Premature failure of asphalt shingles is a concern because 55% of roofing sales are for these shingles. Furthermore, the IBHS's member companies state that asphalt shingles are a primary loss driver during weather events.

Wet floodproofing can be defined as permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding by allowing floodwater to enter the structure. The basic characteristic that distinguishes wet floodproofing from dry floodproofing is that it allows internal flooding of a structure as opposed to providing essentially watertight protection. Such measures may require alteration of a structure's design and construction and the use of flood-resistant materials.

Bridges have become a weak link in the US transportation network due to deferred maintenance. As indicated by the Department of Transportation, the number of freight vehicles on the US highways is going to continue to increase in future years; that increases stresses on the US roadways and bridges, which degrades the bridges' performance. Due to the high replacement cost of bridges, strengthening existing bridges instead of bridge replacement is a lower cost alternative. New materials are being developed to increase resilience from hazards, including earthquakes, and provide durability, high strengths, and longer life to bridges. This study will review options including ultra-high-performance concrete, corrosion-resistant reinforcement, high performance steel, composites, and improved coatings.

The Significant Sustainable Benefits Afforded by Geosynthetics in Key Infrastructure Applications: A Review

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Keywords: Emissions, Environmental, Geosynthetic, Infrastructure, Resources, Sustainable

ABSTRACT

For decades geosynthetics have been utilized in infrastructure projects worldwide to improve the performance of the ground via, for example, drainage, reinforcement and stabilization. The inclusion of geosynthetics has generally been driven by reduction in construction costs and time and significantly this is typically characterized by a reduction in the volume of imported bulk construction materials like sands and gravels. This can be associated with more efficient performance of the geosynthetic systems or the ability to use marginal materials in conjunction with geosynthetics. In more recent times the considerable sustainable benefits gained from the reduction of these bulk materials have been noted and several specific studies have demonstrated large environmental savings via a range of geosynthetic applications.

The sustainable benefits include preservation of limited natural resources (e.g. gravel), emission and energy savings from the reduction in transport of bulk materials, reduction in onsite excavation and placement activity and reduction in construction programmes. Theoretical and case study examples are provided demonstrating significant sustainable benefits for a range of geosynthetic materials and infrastructure applications.

It is concluded that geosynthetic solutions offer such a clear and significant opportunity for more sustainable infrastructure development that there is a strong case to consider their inclusion in all such projects.

Addressing Embodied Carbon as a Sustainability Issue and Implementing New Technology to an Industry that Resists Change

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Keywords: Building Materials, Concrete, Greenhouse Gas Emissions, Embodied Carbon, Manufacturing

ABSTRACT

Embodied carbon is a commonly known phrase that encompasses greenhouse gas emissions due to the production, manufacturing, and use of building materials. With the construction industry's adherence to traditionalist methods, decreasing the environmental impact of standard concrete and high-carbon building materials seems like an insurmountable feat. Despite the resistance, innovative technologies are being developed to combat the carbon footprint of traditional building materials and the benefits of these technologies are irrefutable. Concrete alternative technologies such as reclaimed asphalt pavement (RAP), CO_2 injection, enhanced fly ash, and carbon nanotubes have been researched and shown to have a net positive impact economically and environmentally on smaller scaled projects. Beyond just concrete alternatives, embodied carbon solutions include using fewer finish materials, maximizing structural efficiency, using salvage materials, and minimizing waste. The biggest challenge will be widespread implementation to an industry that resists change. Embodied carbon is a sustainability issue that can be solved through these innovative solutions if they can be implemented into an industry that has not historically made sustainability or environmental resiliency a priority. However, with our increasing focus on energy conservation, green building design, and sustainability incentive programs, the importance of decreasing embodied carbon will grow as well.

Improvements in Building Energy Savings through Two-Layer Phase Change Materials (PCM) Systems Tailored for Different Indian Climate Zones

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Keywords: Buildings, Energy Efficiency, Phase Change Materials, Sustainability, Thermal Comfort, Thermal Energy Storage

ABSTRACT

The incorporation of phase change material (PCM) in the building envelopes through micro/macro encapsulated forms has been shown to reduce the energy consumption in maintaining the thermal comfort for the occupants. However, the amount of energy savings is not proportional to the thickness of the PCM layer added to the building envelopes owing to the inefficient phase conversion (melting/freezing) during the diurnal thermal cycles. In addition, incorporating a single thick PCM layer presents a challenge from the construction point of view. In this research work, a proper combination of PCMs in the form of a two-layer system is proposed to improve the overall energy savings efficiency and is compared with the single-layer system.

The primary objective of this work is to find the appropriate PCM (melting temperature, enthalpy) to be incorporated in two-layers systems in building envelopes located in different weather conditions using numerical simulations in terms of energy saving and thermal comfort. The study has been carried out for buildings (residential apartment buildings, partially air-conditioned) located in major Indian cities representing different types of climatic conditions, namely, New Delhi (composite), Jodhpur (hot and dry), and Chennai (warm and humid). The results show average 20% - 26% savings in cooling energy consumption due to incorporation of optimized combinations of PCM layers. The thermal properties of PCM determined experimentally are used as input properties. Numerical simulations for these buildings with PCM layers are performed using the EnergyPlus (V9.4.0) program through conduction finite difference (ConFD) solution algorithm with fully implicit scheme.

Track 5: Local Lessons: Learning from One Another

Moderated by Gridelda Gonzales

The Roadmap to Resilience for Small to Medium Size Communities

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Keywords: Efficiency, Energy, Resilience, Rural, Small to Medium Size Communities

ABSTRACT

Resilient communities keep families safe, provide opportunities for improved livability and promote long-term stability. Even so, smaller to medium size communities often face unique challenges compared to their larger city counterparts when implementing resilience initiatives. These challenges can exacerbate a community's lack of preparedness and increase barriers to effective resilience planning.

The "Roadmap to Resilience" was developed to support such communities on their paths towards resilience with a focus on improving access to affordable, reliant, and resilient energy services and funded through a grant from DOE. As part of the "Roadmap" development process, the Cities of Rolla, St. James, and Stockton in the state of Missouri were engaged as partner communities. Partner organizations included the Consumer Council of Missouri (CCM), Midwest Energy Efficiency Alliance (MEEA), Municipal Public Utility Alliance (MPUA), Office of Public Counsel (OPC) and Renew Missouri. The Cities of Rolla and St. James were also selected for development of case studies built off of the Roadmap. The "Roadmap" features its six guiding actions to navigate resilience efforts for small to medium size communities, funding strategies, and opportunities for collaboration to implement effective resilient solutions.

Merced Avenue Greenway Project: A Model for Future Greener Urban Streets

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Keywords: Green Infrastructure, Hydrology, Low Impact Development, Stormwater, Urban Greening, Water Quality

ABSTRACT

The Merced Avenue Greenway Project aims to improve stormwater management and water quality along a 1.1-mile stretch of Merced Avenue in the City of South El Monte, California. The project also aims to decrease flood risk, increase vegetative cover including habitat restoration, improve active transportation through enhanced pedestrian and bike mobility, and reduce urban heat island effect. The project has a significant community outreach component and encourages ongoing educational and project development participation by community members, the key benefactors of the project. The combination of these project objectives coupled with the fact that the City of South El Monte is a severely disadvantaged community will provide immense community and societal benefits that will aid in the mission of creating resilient communities.

This presentation will benefit the professional community by apprising and educating the audience on how this project serves as a pilot effort in developing design standards for future urban street retrofits in Los Angeles County to include climate change resilient stormwater Best Management Practices (BMPs) and urban greening elements. Additionally, the presentation covers the varying community outreach strategies utilized in order to keep stakeholders informed and involved during the project. The project is at the forefront of incorporating stormwater BMPs into urban street retrofits, and the proactive efforts in community outreach and education throughout the project promote a sustainable future for stormwater management.

Integrated Resilient Design for an Urban Wilderness Park

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Keywords: Drought Resilience, Flood Resilience, Parks, Rainwater Harvesting, SITES, Water Reuse

ABSTRACT

Population growth and resultant urbanization have dramatically increased in Houston over the last 30 years in parallel to increasing severity of flooding and drought. Conservation of green spaces that respond to extreme events is now more critical than ever. As development closes in on remaining undeveloped land and floodplains, these spaces must meet multiple objectives. Memorial Park is a 1,500-acre urban wilderness park in the center of Houston, TX. Recent park redevelopment focuses on conserving and maintaining the historical and ecological landmark while providing amenities that are resilient to impacts of climate change such as flooding, fire, hurricanes and drought.

Memorial Park Eastern Glades is designed for sustainability and resiliency, highlighted by the site's central feature—a 5-acre constructed lake. This multi-functional lake provides storage for the site's non-potable water reuse system as well as aquatic habitat, storm water treatment and flood control benefits to the site and community. Eastern Glades utilizes Green Stormwater Infrastructure to capture and route runoff from hardscape through a series of vegetated collection systems prior to discharging to the lake.

In addition to water resiliency, this project also includes restoration of native habitats to intercept, transpire, and infiltrate rainfall. These ecosystems include mixed pine-hardwood forests, savanna, and wetlands. In recognition of integrated sustainable design and resiliency, this project is currently pursuing certification through the Sustainable SITES Initiative. Through certification this project aligns its design and development with functions of healthy ecosystems, water quality/quantity management and public engagement.

Josey Lake: Transforming Stormwater Management into an Amenity

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Keywords: Amenitized Infrastructure, Native, Resiliency, Stormwater Management, Stormwater Quality, Sustainability

ABSTRACT

Josey Lake Park is a signature, 140-acre recreational greenspace that provides concurrent accessibility to nature and activities while also serving as a regional connector to neighboring communities and commercial developments. While its primary functions are stormwater detention and conveyance infrastructure, the design objective was to take land typically designated for infrastructure and turn it into an exceptional amenity with various ecosystem types and multiple levels of active and passive recreation. Through close collaboration between the client and consultants, a stormwater detention system was envisioned as a highly functional, aesthetic, and sustainable space. Several other items were taken into consideration including long-term maintenance costs, varying ecologies, and wildlife habitat, improving stormwater quality, and providing an area suitable to host community events.

Development in the Houston metro area requires responsible planning and engineering of stormwater detention facilities. Recent events punctuate this fact now more than ever. However, detention facilities need not be trapezoidal shapes with 3:1 slopes and channelized flowlines. By mimicking nature, these facilities can not only provide their baseline function of flood prevention and conveyance, but also provide social, environmental, and economic benefits.

Taking into consideration various inundation events, strategically placed program elements throughout the site utilize all available land down to the static water elevation. Approximately 80% of Josey Lake Park is located below the 100-year flood elevation.

Reference:
Josey Lake Case Study: https://clarkcondon.com/resources/josey-lake-case-study/

Bridgeland, A Master Planned Sustainable Community

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Keywords: Biofiltration, MPC, Rain Garden, Water Reuse

ABSTRACT

Bridgeland is an 11,500-acre master planned community (MPC) in NW Harris County, on the edge of the rapidly expanding Houston, Texas metropolitan area. Bridgeland currently ranks as the #1 selling MPC in Texas and #9 nationally. Sales volume has continued to rise over the past decade as the development grows and its identity as a sustainable live-work-learn-play nature-based community is recognized.

Early in Bridgeland's planning and development, sustainability was paramount. A series of detention lakes were envisioned to serve as rainwater capture for non-potable irrigation of public green spaces. Furthermore, the detention lakes were designed with recreational and ecological benefits in mind, which helped illustrate Bridgeland's tag line, "Be More Connected", by providing ample outdoor amenities to connect residents to nature in a meaningful way. Wastewater treatment plant effluent was further treated for non-potable uses.

Transportation planning provided sustainable and safe corridors for both pedestrians and vehicles. Hierarchical hike and bike pathways were imagined alongside streets to identify conflicts where overpasses and pedestrian tunnels could be incorporated into the drainage conveyance system. Hierarchical roadways were designed and constructed to separate neighborhood, local and regional traffic, reducing traffic loading in residential neighborhoods.

Bridgeland took a lead in the Houston region with incorporation of biofiltration, bioswales and rain gardens, some of which reside within the fabric of various neighborhoods throughout the community.

Parks and open space were further imaged to include sustainable planting pallets, reducing the need to mow turf grasses and increasing the biodiversity of habitat for birds, pollinator insects and all of nature's creatures. The grandest example of sustainable development resides in the 140-acre Josey Lake project which layers stormwater detention mitigation, environmental impact mitigation and stewardship, recreation, and irrigation water sources, while adding a layer for social connectivity with a variety of gathering spaces for community events and recreation.

Finally, the Bridgeland development led a cooperative approach with a public-private consortium of regional landowner developers and Harris County Flood Control District to develop a phase of "Frontier" regional detention incorporating a wide inline detention area, geomorphological pilot channel, stormwater treatment trains at development outfalls and

wetland planting areas to mimic a natural floodplain. The project is envisioned as a future recreation corridor as well.

Bridgeland has proven that with proper planning and an eye towards sustainability, infrastructure can be established that not only provides services, but enhances the environmental and social aspects of a community. Additionally, buyers of residential homes and commercial property have confirmed its vision of sustainability, even in the world's energy headquarters of Houston.