Strategy for Adapting to Extreme Weather Events and Climate Change – Implementing CEDR Research into NRA’s Protocols, Guidelines and Standards – Road Drainage Design

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Nov 2018
Introduction
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<tr>
<th>CEDR CALLS</th>
<th>TII Response</th>
<th>Ireland National</th>
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<td><strong>2008</strong></td>
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<td>RIMAROCC:</td>
<td>Research study</td>
<td>Carbon Targets.</td>
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<td>SWAMP:</td>
<td>Commissioned flooding study.</td>
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<td>ROADAPT</td>
<td>New Drainage Standards Accounting for climate change.</td>
<td>National Coordination Group on Severe Weather.</td>
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<td>CliPDaR</td>
<td>Comprehensive set of flood maps</td>
<td>EPA publications on Climate Change in Ireland.</td>
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<td>Risk assessment on road network.</td>
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<td>DeTECToR</td>
<td>Climate Change Strategy document.</td>
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<td>Developed new forecasting tool</td>
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<td>2008: Road Owners Getting To grip with Climate Change.</td>
<td>Initiated Research through Irish Universities on Drainage Design on national road network. 4 Year Post Doc Trinity. Published on TII website.</td>
<td>Carbon Targets.</td>
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<td>In house expertise in drainage design.</td>
<td>GHG’s.</td>
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<td>Commissioned research in relation to risk of flooding on national network. JBA 2 year study. Not a custom methodology in SWAMP.</td>
<td>Transport big contributor to GHGs along with Agriculture and Industry.</td>
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<td>RIMAROCC: Risk Management for Roads in a Changing Climate</td>
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<td>Legislation for industry and agriculture (management) but very little for transport.</td>
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<td>SWAMP: Storm Water prevention – Methods to Predict Damage from the Water Stream in and near Road Pavements in lowland Areas</td>
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Conclusions from research

- Work Practices, Assessment methodology for Groundwater Aquifers, volumetric calculations, Engagement with stakeholders.
- Road runoff contains SS, heavy metals and PAHs
- These pollutants represent a pressure on surface waters and groundwaters
- A lot of research conducted on impacts on surface waters and mitigation measures defined
- Little research on groundwater impacts – perceived risk – costly mitigation measures
Conclusions from research

- SUDS treat runoff very effectively
  - Wetlands and grassed channels
  - Lack of design information

- Groundwater is less susceptible to pollution by particulates, but remains at risk from soluble contaminants

- HAWRAT tool introduced as part of standards to assess pollutant load of runoff

- Biggest concentration of pollutants is in sediment bound phase.

- Climate Change – reviewed but little science. 20% approach questioned.
Wetland
Impermeable liner

Class 1a, 1b, 804. Material
Top Soil and grassed
70 l/s peak flow

10 to 15 minutes for peak flow rates (i)

70 l/s peak flow
- Unrestrained development runoff
- Development runoff: limited to same volume and peak flow rate as greenfield runoff
- Greenfield runoff
- Discharge from long term storage
- Period at which river is at risk from flooding
EVENT: 5-APR-11 19:00 to 6-APR-11 5:00 (Time in hours)

RAINFALL (mm/h) [Averaged]  
Total rain = 13.6 mm Peak = 12.0

FLOW (l/s)  
Total vol = 115.9 m³ Peak = 19.1

SITE 02: 5-APR-11 19:00 to 6-APR-11 5:00 (Time in hours)

Inlet flow  
Grassed channel  
Flow rate 20 l/s

Outlet to stream  
Channel plus wetland  
Flow rate 3.5 l/s  
Lag 2.5 to 3 hrs
How can SUDs be used to adapt for Climate Change

- More resilient and sustainable than conventional systems
- Will treat and attenuate short duration intense summer rainfall events – these carry biggest pollutant load.
- Will restore Greenfield site conditions protecting morphology of receiving waters.
- Offer a broader biodiversity.
- Can be sized to cater for increased rainfall intensity.
Groundwater Management

- Groundwater monitoring boreholes measuring metals and PAHs
- Blanket Bog, Rainwater fed
- Karst systems
- Kildare, Fen, Groundwater Dependent Ecosystem
Conclusions M7 Monitoring

- Groundwaters adjacent to M7 contain:
  - Metals Zn, Pb
  - PAHs
- Motorways with heavy traffic > 70,000 AADT – require treatment of runoff to protect both surface waters and groundwaters.
- GSWC, concrete channels
- Additional treatment (wetland) prior to discharge.
Soil Functions

- Growing food, plants, forestry.
- Filtering water.
- Controlling the rate at which rain water reaches watercourses.
- Storing carbon and exchanging greenhouse gases with the air.
- Supporting valuable habitats, plants and animals.
- Preserving cultural and archaeological heritage.
- Providing raw materials.
- Providing a platform for building on.
Soil degradation, therefore, will impact on:

- Water quality
- Human health
- Climate change
- Biodiversity
- Food supply.
Impacts on Blanket Bog – groundwater Dependent Ecosystems

- Rainwater fed (rather than fen or flush groundwater fed)
- Potential to dewater
- Introduce longitudinal drain by excavating peat
- Mitigation?
Site Investigation

Bigger groundwater component that initially thought

Mitigation

• Longitudinal Barriers
• Transverse Barriers

Climate Change Role

Trinity College
Dublin
Blanket Bogs and Climate Change

- Major reservoir for Carbon
- Dynamics of hydrology and hydrogeology is changing – more intense rainfall, more flooding, longer droughts.
- Required to understand dynamics and propose mitigation in the light of Climate Change
- Major challenges.
KARST
Priority Habitats – Habitats Directive

Turlough – seasonal lakes
Hydrograph for Turlough
Geological Survey of Ireland and Trinity College Dublin
Karst Features and Climate Change

- Turloughs
  - More frequents flooding and overspilling
- Sinkholes
  - Impacted by increases in conduit flow
  - More frequent
- Coastal rise in sea level
  - Impact discharge
  - More salinity
- Several research programmes
Whorl Snail (*Vertigo* *Sp*)
Groundwater Systems

- Groundwater dependent ecosystems
  - Dynamics are changing as a result of climate change
  - Road infrastructure interacting with these systems required to understand groundwater controls and impacts of climate change (precautionary approach)

- Difficult to predict how systems will change
  - Mitigation measures ??
  - Monitor
    - But how?
Subsidence detected with InSAR along the M18 Sentinel-1A/B PS analysis

The orange points have LOS velocities between -4.9 mm/yr and -2.9 mm/yr. They all show the same displacement behaviour, with a step-like subsidence of 6-7 mm between 18/03 and 24/03. Notice also the noisier points between 22/02 and 18/03.
TII Status 2012

- Very good understanding of water management on network
- Need to develop understanding of climate change and risk to road infrastructure from surface water and groundwater perspective.
- Transfer research into TII Policy Documents
- Disseminate information to Local Authorities and regional offices.
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<td>2012: Road Owners Adapting to Climate Change. ROADAП – Roads for Today, Adapted for Tomorrow</td>
<td>Comprehensive set of flood maps of the entire national road network and high level protocol for assessment of flood risk (RIMAROCC)</td>
<td>National Coordination Group on Severe Weather.</td>
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<td>ClПDаR - Design guideline for a transnational database of downscaled climate projection data for road impact models</td>
<td>Developed complete set of drainage design standard documents to account for research findings. Accounting for climate change in designs: both rainfall and actual design (SUDS).</td>
<td>EPA publications on Climate Change in Ireland - Sectoral inputs into climate change. (Transport very high. Agriculture highest.)</td>
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JBA has hydraulically accurate modelling of extreme flooding.

- JFLOW+ software solves the full shallow water flow equations.

- Also derived a Comprehensive Flood Map (CFM) for Ireland, covering fluvial, coastal and extreme surface water for different extreme events.

- Lidar
New NRA Drainage Standards

• Revised NRA Design Manual for Roads and Bridges (NRA DMRB) (1 amended and 13 new documents).
  • New Designs for SUDs elements.
  • New protocol for design process.
  • Update on volumetric calculations.
Climate Ireland EPA - Projections

Nested two Regional Climate Models (RCMs) into a set of Global Climate Models (GCMs).

RCMs
- COSMO-CLM
- WRF

GCM
- Max Plank In ECHAM5
- UK Met HadGEM2-ES
- CGCM 3.1
- EC – Earth

Simulated using IPCC scenarios
- SRES A1B, A2, B1
- RCP 4.5, 8.5

Projected climate data are based on:
Ensemble of regional climate model projections for Ireland
Author: Paul Nolan, Irish Centre for High-End Computing and Meteorology and Climate Centre, School of Mathematical Sciences, University College Dublin
Figure 3.5. Projected changes (%) in seasonal precipitation. (a) Medium- to low-emission scenario; (b) high-emission scenario. In each case, the future period 2041–2060 is compared with the past period 1981–2000.
Better understanding of climate change and risk to road infrastructure

New Drainage Standards
- Accounting for climate change
- Risk assessment procedure for groundwater and surface water impacts

Detailed flood maps covering entire network

Missing
- Detailed climate change – how embed into engineering designs
- Climate Change strategy
- Protocol for retrofit
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<td><strong>2015: Climate Change: From Desk to Road</strong></td>
<td>Developed Climate Change Strategy document. Published.</td>
<td>New Government Climate Change Unit.</td>
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<td>DeTECToR – Decision support tools for embedding climate change thinking on road</td>
<td>Developed Sustainability Statement.</td>
<td>National Climate Change Adaption Plan for transport sector.</td>
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<td><strong>WATCH</strong> – Water management for road authorities in the face of Climate Change</td>
<td>Developed Country Specific Carbon Tool.</td>
<td>National Climate Change Mitigation Plan.</td>
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<td><strong>MoDBeaR</strong> – Mobility Management and Driver Behaviour Research</td>
<td>Developed new forecasting tool for predicting network flooding on a detailed level (individual sections of motorway. New detailed protocol for assessment of mitigation measures.</td>
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Strategy for Adapting to Climate Change on Ireland’s Light Rail and National Road Network

Transport Infrastructure Ireland
Strategy for Adapting to Climate Change on Ireland’s Light Rail and National Road Network

- TII’S STRATEGY FOR ADAPTING TO CLIMATE CHANGE
- Road
  - Managing flood events
  - Flood assessment and Protocol
  - Creating a database of flood events
  - Implementing mitigation measures
  - Coordination with relevant authorities
  - Prevention
  - Energy and carbon assessment
- Light rail – severe weather management plan
How resilient is the network to future extreme weather events? Fluvial, Pluvial Coastal.

How will climate change influence these events?

Can we take account of these changes in future designs and how is this achievable?
Flood hazard data supplied for fluvial, coastal and pluvial extreme outlines
NRA LiDAR data merged into OSI
Depths, velocities and hazard grids generated
Linear metrics for hazard on the road
Combined with traffic volumes to generate a new ‘exposure’ measure
How will climate change influence these events

- Short duration events more intense
  - Bigger carrier pipes
- Long term
  - Seasonal changes more pronounced
  - Consider changing design approach
- More frequent storm events
  - Return periods
Can we take account of these changes in future designs and how is this achievable.

- Into Design Standards only if specific factors or ranges can be applied to rainfall intensities on a regional scale.
  - Retrofit
  - 20%
- Can adapt a more sustainable SUDS approach by constructing wetlands and using grassed channels.
- Revisit storm design return periods
- Close collaboration between climate modellers and design engineers.
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<td><strong>WATCH – Water management for road authorities in the face of Climate Change</strong></td>
<td>Methodology for accounting for climate change in rainfall data. Protocols for the implementation of SUDS into designs. Socioeconomic analysis of implementing climate change into designs – cost benefit analysis. Case study on implementation of findings.</td>
<td>New revision of drainage standards and climate change factors. New protocol for the implementation of SUDS. Protocol for cost benefit analysis.</td>
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## Future Implementation

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<td>DeTECToR – Decision support tools for embedding climate change thinking on road</td>
<td>Embedding climate change into procurement and design.</td>
<td>Use carbon tool to facilitate carbon savings on road and light rail projects.</td>
</tr>
<tr>
<td>MoDBeaR – Mobility Management and Driver Behaviour Research</td>
<td>Awareness of Mobility Management.</td>
<td>Expand on Mobility Management in conjunction with National Transport Agency.</td>
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Key to implementation

- In house knowledge of water management and NRA’s standards and protocols
- Hands on approach to managing CEDR projects – attending workshops – highlighting NRA’s requirements
- PEB board with expertise in the specific areas of research
- Translate research findings into policy – assign task to individuals.
Challenges

- SOILS
  - Compaction, erosion, sealing, organic content

- Groundwater Systems
  - Understanding hydrology and hydrogeology in light of Climate Change

- Predicting impacts in karst areas.

- Imbedding CC into designs and procurement.