Modelling the Precipitation Impacts on Wastewater Influent Volumes in Ireland

S.D. Saikia[1,2,3*], E. Clifford[1,2,3], P. Ryan[4]

[1]College of Science and Engineering, National University of Ireland Galway, Ireland H91 TK33; s.saikia1@nuigalway.ie; eoghan.clifford@nuigalway.ie [2] Informatics Research Unit for Sustainable Engineering, NUI Galway, [3] Ryan Institute, NUI Galway, [4] Discipline of Civil, Structural & Environmental Engineering, School of Engineering, University College Cork, Ireland; paraic.ryan@ucc.ie

INTRODUCTION

Precipitation plays a critical role in determining the influent volumes of wastewater for many urban wastewater treatment plants (WWTPs). Urban stormwater runoff, resulting from impervious surfaces and infiltration, can significantly increase WWTP influent volumes above normal dry weather flows. In the context of climate change, projected changes in precipitation events could, in particular, cause significant challenges to existing collection networks. This research aims to assess the impacts of precipitation on influent wastewater volumes using 16 urban WWTPs networks situated all across Ireland. In Ireland, most collection networks in urban areas are combined foul and storm water systems. Thus, these networks, and their connected wastewater treatment plants, can be impacted significantly by storm water (both in terms of volume and wastewater characteristics). There are various factors that have been taken into account for this research.

For the purpose of this study, parameters of climate change have been taken into consideration **(marked in red in Figure 1)**. On a monthly basis, precipitation variables representing intensity, frequency and duration of rainfall events have been identified to have significant impacts on average daily influent volume.

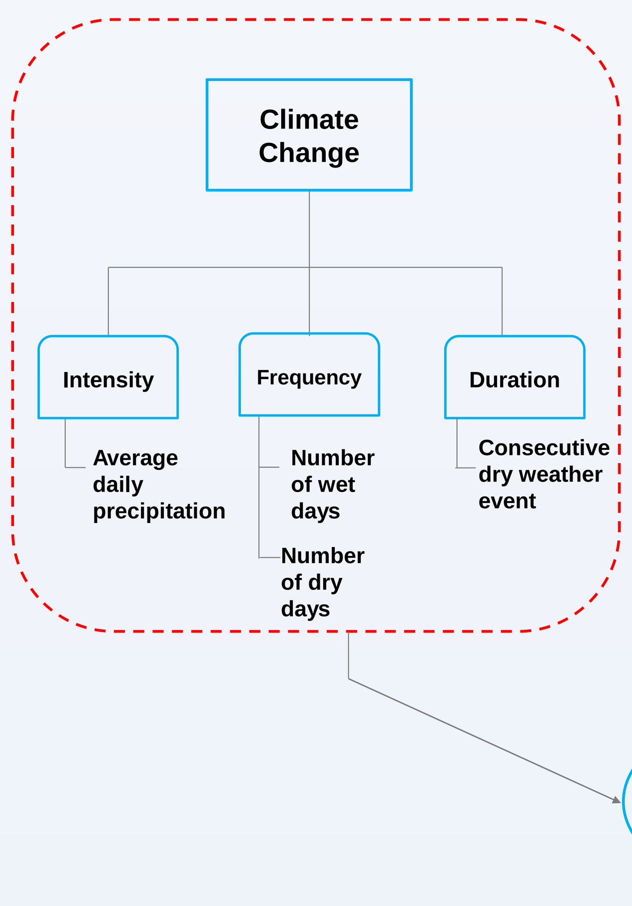

Figure 1

AIMS AND OBJECTIVES

The aim of the broader research is to help inform design and operation of climate-resilient wastewater systems through the objectives shown in **Figure 2**:

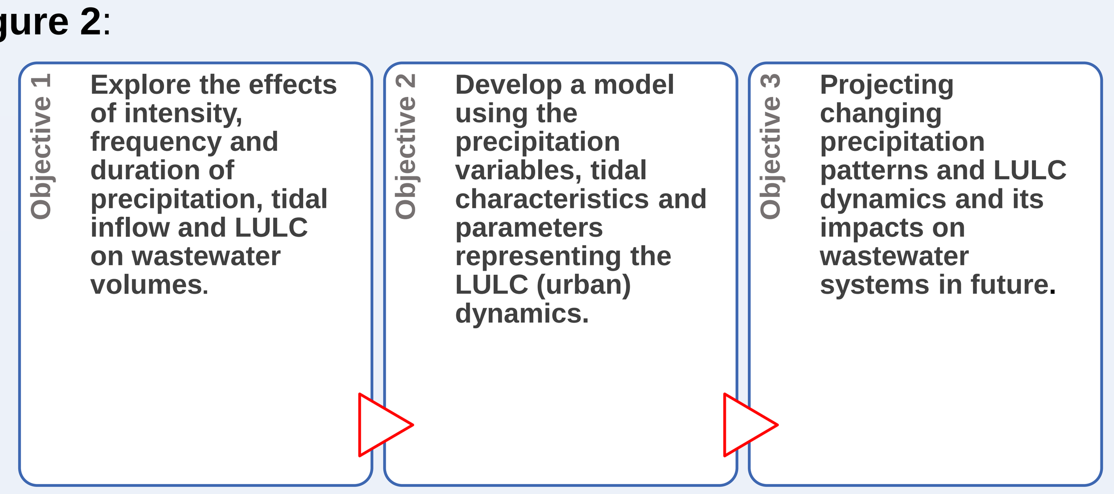

Figure 2

MATERIALS AND METHODS

DATA USED:

Daily data of influent volume and precipitation for 16 municipal wastewater treatment plants in Ireland for varying time periods were used for this study. The treatment plants have been selected based on the availability of data. The 16 WWTPs represent a range of treatment capacities that provide service to different urban agglomerations located throughout Ireland. The urban areas represent a variety of small towns to big cities. The varying treatment capacities range from 2,050 – 1,640,000 **P**opulation **E**quivalent (PE).

METHODS:

This study investigated the relationship between influent wastewater volume and precipitation, number of wet days (wet day characterised by rainfall greater than or equal to 1 mm) and the number of zero rainfall days.

REGRESSION ANALYSIS:

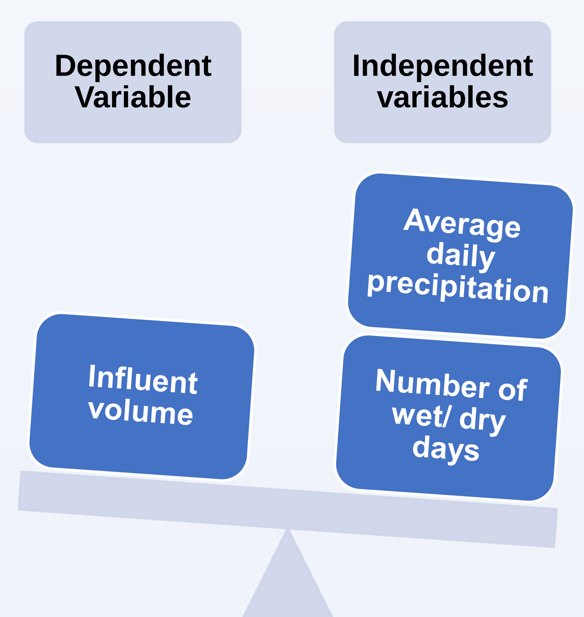

Figure 3

Simple linear and multiple linear regression methods were adopted to investigate the relationship between each of the variables with influent wastewater volume on a monthly basis.

TIME LAG:

A lag of 1, 2 and 3 days were applied to check if there is any time lag between the occurrence of a rainy day and the effect on influent volume.

PROBABILITY ANALYSIS:

The probability of exceedance of specific values of influent volume was estimated across 6 rainfall bands categorized on the basis of percentile values of rainfall data.

RESULTS

REGRESSION RESULTS:

Table 1 shows various parameters that were analyzed in relation to influent wastewater. Variables of significance are shown in green.

VARIABLES CONSIDERED
Daily precipitation (Including with lag time of 0, 1, 2 or 3 days accounted for)
Average daily precipitation over a month
Average daily precipitation over wet days in a month
Number of wet days in a month
Number of dry days in a month
Daily maximum tidal level
Daily mean river level

Figure 4 shows the results (R^2 and **R**oot **M**ean **S**quared **E**rror, RMSE) of simple linear regression (top row and bottom left) and multiple linear regression (bottom right) models for the 16 WWTPs. Between 2005 and 2018, data was available for each WWTP.

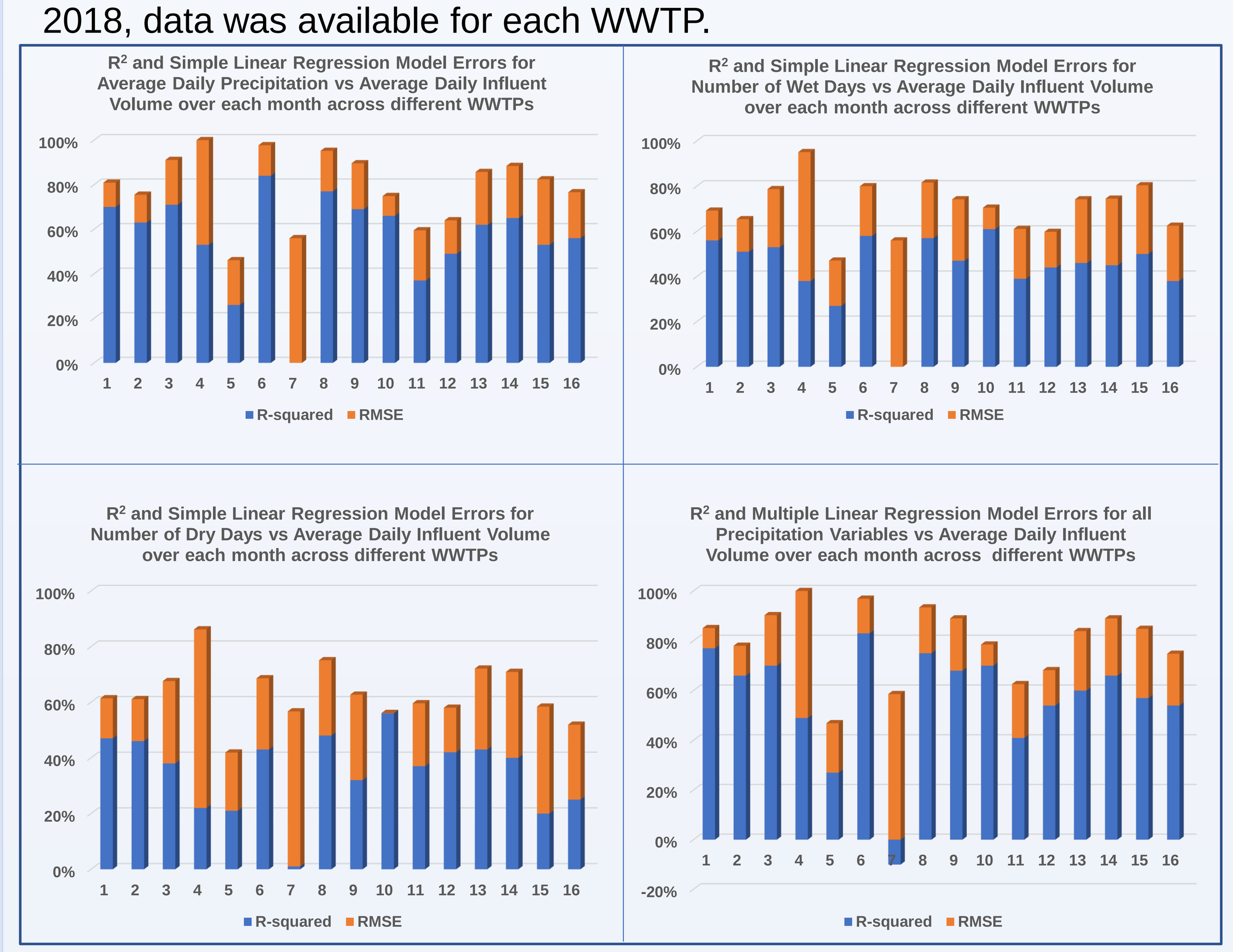

Figure 4

****All results were obtained at 95% level of confidence.**

For many WWTPs there was no significant relationship between daily rainfall and daily influent volumes (impacts of lag time were considered also). However **Figure 5** shows how the data can be represented (in a case study example) to estimate the likelihood of exceeding various influent volumes at different daily rainfall levels. This will be linked to climate scenarios in ongoing work.

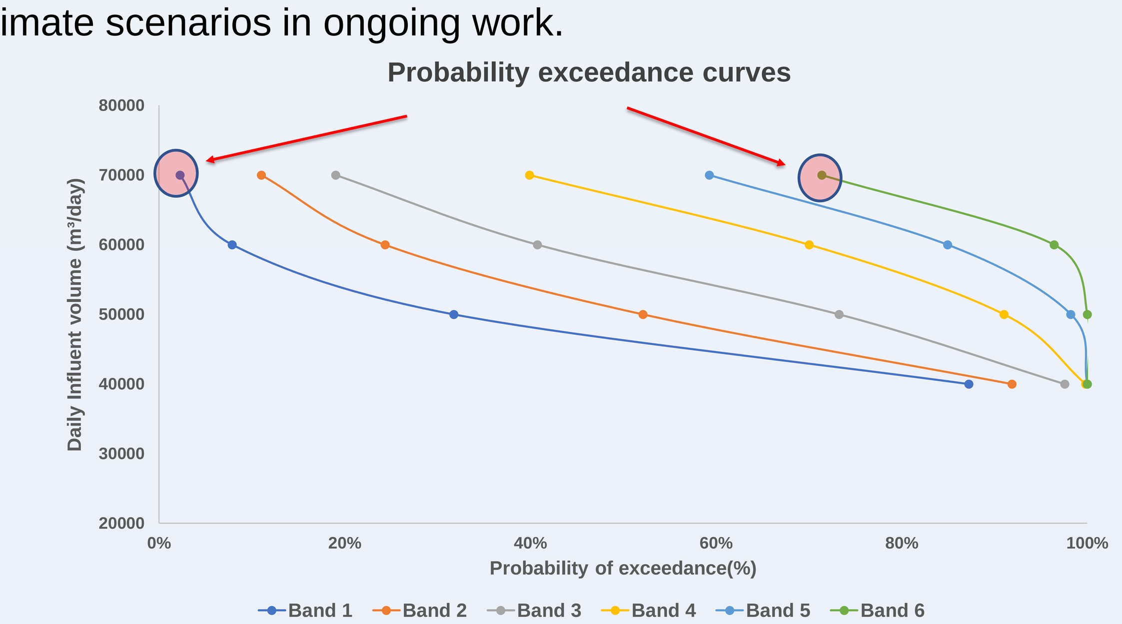

Figure 5

CONCLUSIONS AND FUTURE WORK

- This study identified the significant precipitation variables impacting influent wastewater volumes.
- The R^2 and RMSE across different WWTPs depict strong relationship between the precipitation variables and influent volume, and relatively low model errors except a few anomalies.
- Future work will analyze impacts in relation to other factors such as landuse land cover changes, river level and impacts of tides on dry weather flow for all the WWTPs.
- Next step involves a spatio-temporal analysis of all the WWTPs data of different time frames merged together. This would enable comparison of the different outcomes of the multi-WWTP vs WWTP by WWTP models.
- The ongoing analysis will be linked with climate scenarios.
- This will enable improved planning and adaptation of wastewater infrastructure to various scenarios of climate change. This would allow various stakeholders to take informed decisions for a climate-resilient urban infrastructure.

REFERENCES

R has been used for the statistical analysis for this research.

The slide template has been obtained from posterpresentations.com

ACKNOWLEDGEMENTS

This research is part of a larger project Energy Systems Integration Partnership Program (ESIPP).

This publication has emanated from research conducted with the financial support of Science Foundation Ireland under the SFI Strategic Partnership Programme Grant Number SFI/15/SPP/E3125. The opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Science Foundation Ireland.

Precipitation data has been obtained from various sources like Met Éireann, Irish Water and a calibrated weather station data of the National University of Ireland, Galway.

The influent volume data has been provided by Irish Water, Ireland's National water utility.