Department of Agriculture, Environment and Rural Affairs

# SFI Covid-19 Rapid Response Call – Phase 2

# Project Completion Report

| Award Details | | | | |
|---|---|---|---|---|
| **DAERA Project Code** | **Project title** | **Start Date (as per Letter of Offer)** | **Project Duration (months)** | **Report Submission Date** |
| 20/COV/8460 | An integrated system for all-island SARS-CoV-2 wastewater surveillance and reporting | 01/11/2020 | 5 | 18/05/2021 |

| Lead Principal Investigator (Northern Ireland) | | | |
|---|---|---|---|
| **First Name** | **Surname** | **Title** | **Host Institute** |
| John | McGrath | Prof | Queen's University Belfast |
| **Co-Principal Investigator (Northern Ireland, if applicable)** | | | |
| **First Name** | **Surname** | **Title** | **Host Institute** |
| Deirdre | Gilpin | Dr | Queen's University Belfast |
| Bamford | Connor | Dr | Queen's University Belfast |
| Jennifer | McKinley | Prof | Queen's University Belfast |

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|---|---|---|---|
| Michael | Tunney | Prof | Queen's University Belfast |
| Fairley | Derek | Dr | Queen's University Belfast and Belfast Health and Social Care Trust |
| Elborn | Stuart | Prof | Queen's University Belfast |

| Lead Principal Investigator (Republic of Ireland) | | | |
|---|---|---|---|
| **First Name** | **Surname** | **Title** | **Host Institute** |
| Wim | Meijer | Prof | University College Dublin |

| Team members associated with project during project (Northern Ireland) | | |
|---|---|---|
| **Type*** | **First Name** | **Surname** |
| Postdoctoral | Gaurav | Tandel |
| Research Fellow | Jonathan | Lock |
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* Please select 'Type' from the following categories: Postdoctoral / Postgraduate (PhD) / Postgraduate (MS) / Undergraduate / Visiting Researcher / Technician / Administrative / Other

| Students Graduated during Project (Northern Ireland) | | | | |
|---|---|---|---|---|
| **First Name** | **Surname** | **Degree Awarded** | **Current Occupation*** | **Details** |
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* Please select 'Current Occupation' from the following categories: Postdoc (N. Ireland) / Postdoc (Abroad) / Further Education (e.g. PhD, MBA) / Employed in Industry / Not currently employed / Other (please specify).

| Please provide details of career progression for postdoctoral researchers and students. |
| --- |
| Dr. Tandel took up his postdoctoral position within the project team on 4th December 2020. During his tenure within the laboratory he received training in viral isolation from wastewater, nucleic acid extraction and RT-qPCR. Dr. Tandel left the group on 30th March 2021 upon completion of the research project. |

| Scientific Information |
| --- |
| **Outline of research work carried out during the project including final achievements against "Outcomes and Targets" cited in the original proposal (bullet point format appreciated)** |

As SARS-CoV-2 is shed in high levels in faeces, wastewater testing has become a complementary, early-warning strategy for outbreaks of Covid-19, aiding governmental decision making around future infection prevention/control policies. Wastewater monitoring of SARS-CoV-2 has four main objectives:

1. To complement clinical surveillance by providing information on the prevalence and spread of disease in a population. Importantly wastewater surveillance captures both symptomatic and asymptomatic cases.
2. To inform the assessment of infection risk from wastewater and from the receiving environment.
3. To act as a sentinel system as to whether virus levels are increasing or decreasing in a community. This will become especially important post-vaccination to inform if vaccine escaping mutants are beginning to circulate.
4. To monitor for new viral variants.

Across Great Britain (GB), the Republic of Ireland (RoI) and globally wastewater surveillance has become a keystone strategy for tracking outbreaks of Covid-19. Prior to this project wastewater surveillance had not yet been implemented across Northern Ireland. This project sought to (in WPs 1, 2 and 5 of the application):

a) Transfer protocols and expertise related to SARS-CoV-2 monitoring in wastewater from our project partners in University College Dublin, who were leading the RoI surveillance programme, to Northern Ireland (WP1).
b) Establish SARS-CoV-2 monitoring at 2 wastewater treatment sites in Northern Ireland (WP2).
c) Develop a GIS based reporting system for the monitoring programme (WP5).

**WP1: Technology transfer from the Republic of Ireland to Northern Ireland**

Through active collaboration with our colleagues in University College Dublin we have developed a suite of Standard Operating Procedures (SOPs) for wastewater pre-processing, nucleic acid extraction, and target detection and quantification in wastewater. This SOP development has been further augmented through our collaboration with the cognate surveillance laboratories in England, Scotland and Wales. Ultimately this work will seek to develop a standardized set of protocols for the analysis of SARS-CoV-2 in wastewater across the UK. Our primary SOP, developed within this project involves viral concentration followed by nucleic acid extraction using a Roche MagNA Pure platform. For RT-PCR, we have detected virus using the Altona Real Star SARS- CoV-2 (E and S gene targets) and also Ag Path-ID One-Step RT-PCR reagents using Qiagen primer/probes N1/N2. Within the project we have shown that superior viral detection in wastewater occurs when using N1/N2 detection

**WP2: Wastewater surveillance in Northern Ireland**

Using the protocol developed in WP1 we initiated a monitoring programme at Dunmurry Wastewater Treatment Works (Belfast) and at Ballynacor Wastewater Treatment Works (Craigavon): Ballynacor is characterized by 2 inlet steams, designated Craigavon and Seagoe. Grab samples were taken from the inlet streams of these works from 4th December 2020 – 11th January 2021. Subsequently autosamplers were installed at both sites week of 11th January 2021. Figures 1 A - C are the flow normalised levels of SARS-CoV-2 detected at each site over the monitoring period. Subsequent to this the project has been expanded, under seperate funding, to monitor an additional 12 sites across Northern Ireland. This will be further extended to 40 sites during 2021.

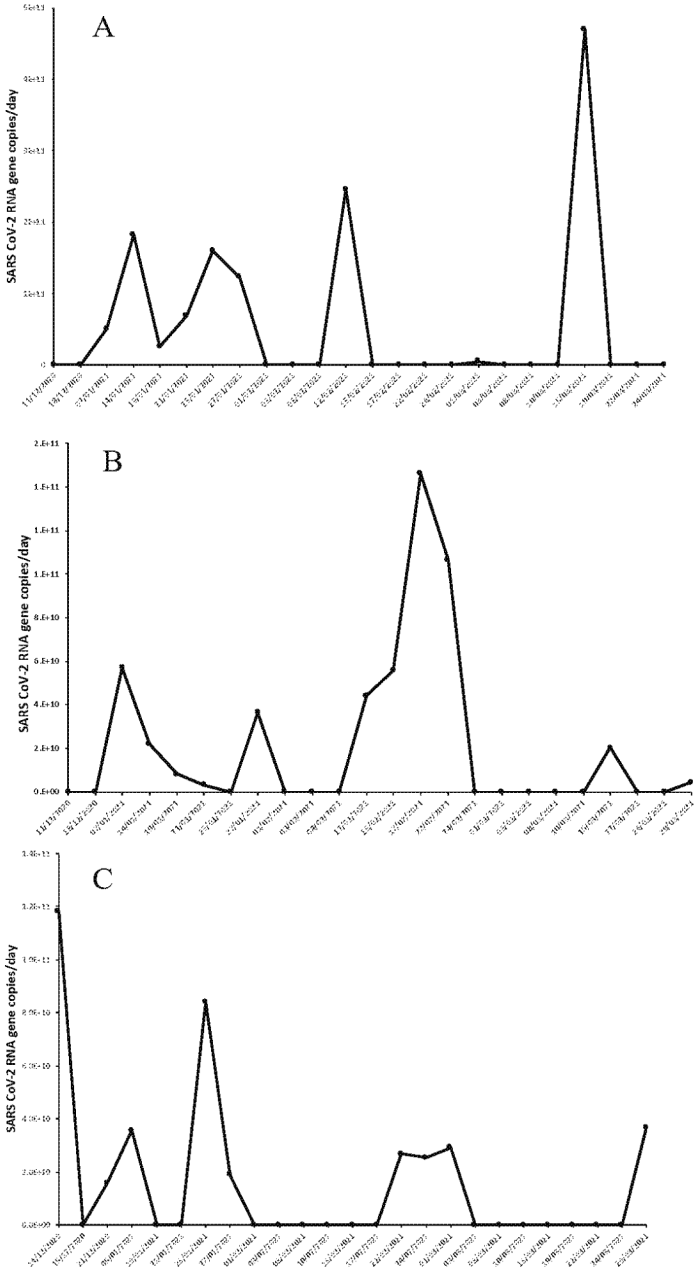


Figure 1: Monitoring of SARS-CoV-2 levels in Ballynacor Wastewater Treatment works (Seagoe inlet – A; Craigavon inlet – B) and Dunmurry Wastewater Treatment Works (C). SARS-CoV-2 levels are expressed as the number of N1 gene copies per day in the influent normalized against wastewater flow data

**WP5: GIS based reporting tool kit for monitoring SARS-CoV-2 in sewerage systems**

The aim of this WP was to develop a suitable reporting framework approach for monitoring SARS-CoV-2 in sewerage systems. Specifically the WP sought to:

1. Collate geographic data related to relevant public health data and environmental surveillance in collaboration with ordnance survey agencies (OSI and LPSNI), public health and environmental agencies/water utilities.

This has been achieved through the development of a GIS approach to the selection of wastewater treatment plant (WWTP) testing sites. This has involved:

- Interfacing with NI Waters (NIW), understanding the NIW wastewater network, sewer types, pumping stations, Wastewater Treatment Plants (WWTP), and their associated Drainage Areas (the catchments of individual WWTPs).
- Modeling population across NI- using GIS to estimate populations covered by the NIW wastewater network, the population within individual Drainage Areas, and how to balance capturing the maximum percentage of the population from a relatively limited number of sample sites, while ensuring an adequate geographic spread across NI.
- Evaluation of different techniques for modelling population and relating it to the wastewater network.
- Provision of a series of scenarios for sample selection with the percentage of population covered and its geographic spread.
- Assisting DAERA with the modelling of scenarios they propose for sampling.
- Focus on Critical locations upstream of WWTP, use of NIW supplied tracing tools allowing identification of small branches of sewage systems to select potential locations for localized samples.

2. Develop and test GIS based spatial toolkit for monitoring for SARS-CoV-2 detected in wastewater, which includes a risk threshold assessment in sewerage systems.

Deliverables: GIS-based toolkit approach for an all-island wastewater monitoring and reporting system integrating existing public health data with environmental surveillance.

This has been achieved through the development of an interactive wastewater SARS-CoV-2 Surveillance Dashboard. The Dashboard provides a display of the analysis results of sampling at various locations in NI and enables users to see and understand population distribution modelling across NI wastewater network. The GIS-based reporting tool kit (including dashboard) and the collation of geographic data have included transferred knowledge transfer working with ESRI Ireland to QUB. The approach has the potential to be created for an all-Ireland approach. The GIS team have collaborated with data analysis surveillance teams operating in England, Scotland and Wales.

**Details of deviation from approved work plan (if any) (bullet point format appreciated)**

No deviation from the workplan was required

**Research accomplishments (bullet point format appreciated)**
**Include contributions by academic or industrial collaborations**

- Protocols for the detection of SARS-CoV-2 within wastewater have been successfully developed.
- These have been shown to be effective for the routine monitoring of SARS-CoV-2 within two Northern Irish sewage treatment work, with surveillance continuing for 3 months
- Implementation of a GIS-based toolkit approach for an all-island wastewater monitoring and reporting system - which integrates existing public health data with environmental surveillance - has been achieved through the development of an interactive wastewater SARS-CoV-2 Surveillance Dashboard

**Lay person's summary of research accomplished (approx 300 words)**

As SARS-CoV-2 is shed in high levels in faeces, wastewater testing has the potential to become a complementary, early-warning strategy for future 'hot-spot' outbreaks of Covid 19, aiding governmental decision making around future infection prevention and control policies. Wastewater monitoring has distinct benefits over clinical testing as it a cheap, non-invasive method which is able to determine the level of infection in a large community using a single sample. Importantly, as faecal shedding occurs in the pre-symptomatic phase, evidence also suggests that it can be used as an early warning system to indicate when levels of SARS-CoV-2 are rising (or falling) in the community and before individuals require hospitalisation. Surveillance of wastewater for the presence of SARS-CoV-2 RNA has thus commenced in many countries around the globe. Within this project we successfully initiated wastewater surveillance at two sewage treatment sites in Northern Ireland, at Ballynacor Wastewater Treatment Works and Dunmurry Wastewater Treatment Works. SARS-CoV-2 RNA was routinely detected within the waste treatment system and allowed for the longitudinal surveillance of SARS-CoV-2 levels. Following on from this project the surveillance programme has been extended to a number of other sites across Northern Ireland.

## Strategic Information

**Outline the Economic and Societal value from the project on business and the wider community in Northern Ireland (bullet point format appreciated)**

SARS-CoV-2 surveillance within wastewater treatment systems represents a complementary approach to study its epidemiology and distribution within a population. Importantly as the virus is shed in high levels in faeces, both pre-symptomatically and from asymptomatic carriers, wastewater surveillance can improve our understanding of SARS-CoV-2 prevalence in specific communities. Development of such a monitoring approach however requires collaboration between researchers, water utilities, environment agencies, and public health departments. This joint project between research teams in the Republic of Ireland (University College Dublin) and Northern Ireland (Queen's University Belfast) has led to the establishment of wastewater surveillance programmes for SARS-CoV-2 across both jurisdictions. A major benefit of the proposal was technology transfer from the Republic of Ireland, where wastewater surveillance was already operational at project on-set, to Northern Ireland. This has significantly reduced the time required to set up a surveillance programme in Northern Ireland. By demonstrating the effectiveness of wastewater surveillance as a tool to monitor SARS-CoV-2 the project has enabled a larger roll-out of the programme. The establishment of close links with the PHA through the project has further strengthened the usefulness of wastewater surveillance for SARS-CoV-2 monitoring. Furthermore development of a robust GIS based reporting structure that combines wastewater surveillance, epidemiological and population data now provides public health officials with an invaluable source of additional information to develop and to evaluate the effectiveness of public health mandated measures to reduce the rate of infection in Northern Ireland.

## Academic Outputs

**Refereed Journal Publications Directly Supported by DAERA award**

| Author List (as published) | Publication Title | Year | Journal | Volume | Issue |
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| Refereed Conference Publications Directly Supported by DAERA award | | | | |
|---|---|---|---|---|
| **Author List (as published)** | **Publication Title** | **Year** | **Conference** | **Proceedings** |
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| Other Publications (e.g. books, technical reports) Directly Supported by DAERA award | | | |
|---|---|---|---|
| **Author List (as published)** | **Publication Title** | **Year** | **Details of Publication** |
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| International Presentations Directly Supported by DAERA award | | | | |
|---|---|---|---|---|
| **Title of the Event** | **Event Type*** | **Presentation Type**** | **Title of Presentation** | **Date of Presentation** |
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* Please select 'Event type' from the following categories: Conference / Workshop / Invited Seminar / Seminar

** Please select 'Presentation type' from the following categories: Keynote talk / Plenary talk / Invited speaker / Paper / Poster

| Scientific Awards Received | | | | |
|---|---|---|---|---|
| **First Name of Award Winner** | **Surname of Award Winner** | **Honour / Prize Bestowed** | **Awarding Body** | **Date** |
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| Details of any Conferences / Workshops / Seminars hosted during the reporting period (Northern Ireland) |
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| Details of any Education or Outreach initiatives undertaken during the reporting period (Northern Ireland) |
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## Academic Collaboration

**(Please detail all academic engagement by the Northern Ireland partners relevant to the award)**

| Name of Collaborator | Name of Institution | Location (Country) | Date joined Programme | Detail Nature of Collaboration |
|---|---|---|---|---|
| Wim Meijer | University College Dublin | Republic of Ireland | 1/11/2021 | Co-applicant |
| Nicola Fletcher | University College Dublin | Republic of Ireland | 1/11/2021 | Co-applicant |
| John O'Sullivan | University College Dublin | Republic of Ireland | 1/11/2021 | Co-applicant |
| Thomas Murphy | University College Dublin | Republic of Ireland | 1/11/2021 | Co-applicant |
| Laurence Gill | Trinity College Dublin | Republic of Ireland | 1/11/2021 | Co-applicant |

## Details of Exchange Visits between Northern Ireland and Republic of Ireland during the Project

Due to travel restriction no face-to-face meetings were possible. However a number of online meetings were held, alongside email communications.

## Industry Engagement [1] (please detail all relevant industry discussions and engagement)

| Organisation Type* | Name of Organisation | Location (Country) | Date joined Programme | Date departed Programme (if applicable) | Additional details on engagement |
|---|---|---|---|---|---|
| Government | DAERA | NI | 1/11/2021 | | Provision of samples |
| Multinational company (NI based) | NI Water Ltd | NI | 1/11/2021 | | Provision of samples |
| Multinational company (Foreign based) | Esri | Ireland | 1/11/2021 | | Development of GIS Dashboard |
| | | | | | |

* Please select 'Organisation type' from the following categories: Multinational company (NI based) / Multinational company (Foreign based) / SME (NI based) / SME (Foreign based) / Start-Up Company / Hospital / Other (please specify).

## Please describe the key contributions of each industry engagement listed above to the research programme during the project, including new activities, if any, that have evolved (bullet point format)[1]

[1] Please ensure that all necessary documentation (such as Confidentiality Disclosure Agreements and Research Collaborative Agreements etc) is in place, in accordance with your Technology Transfer Office procedures.

Both DAERA and NI Water Ltd were instrumental in providing samples for the project.

## Knowledge Transfer and Commercialisation Activities

| Please provide details of any commercialisation activities, such as invention disclosure, patent applications, patents granted, licensing agreements signed, or spin out companies created during the project. If there are no commercialisation activities yet, please indicate where there is potential for commercialisation. |
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| **Please provide details of any other activities with commercial or industrial impact (e.g. consultancy work, contract work), undertaken during the reporting period** |
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## Future collaboration

### Outline the strategy for the next phase of the existing partnership (if any)

The Northern Ireland Programme has undergone significant expansion based on the methodologies developed during the project. Currently this is funded via a Service Level Agreement with DAERA sampling 14 sites across Northern Ireland. We continue to work with our Republic of Ireland partners to develop an all-island surveillance system.

## Signature

**Lead Principal Investigator**

Name: **Name Redacted**

Signature: **Personal Data**

Date: 26th May 2021

| Final Cumulative Reporting For Duration Of Award (Northern Ireland only) | | | |
|---|---|---|---|
| **Category** | **Metric** | **Final Report** | **Additional Comments** |
| **Team Numbers** | Lead Principal Investigator | | |
| | Co-Principal Investigator | | |
| | Post-doctoral Researchers | | |
| | Postgraduates PhD | | |
| | Postgraduates Masters (e.g. MSc) | | |
| | Undergraduate | | |
| | Visiting Researcher | | |
| | Support Staff (e.g. technician, admin) | | |
| | Other | | |
| **Education** | No. of MSc degrees awarded | | |
| | No. of PhD degrees awarded | | |
| **Academic Outputs** | No. of Journal Refereed Research Papers published | | |
| | No. of Journal Refereed Review Papers published | | |
| | No. of Refereed Conference Proceedings | | |
| | No. of other publications | | |
| | No. of International Presentations | | |
| | National Presentations | | |
| | Scientific Awards Won | | |
| | Conference workshops hosted | | |
| **Commercialisation/ Tech Transfer/ Industry Engagement** | Invention Disclosures | | |
| | Patent Applications (incl. patent application numbers in comments) | | |
| | Patents Awarded (incl. patent numbers in comments) | | |
| | Licensing Agreements signed | | |
| | Provide any additional information on commercialization activities/ industry engagement | | |
| **Final Comments on Programme** | | | |