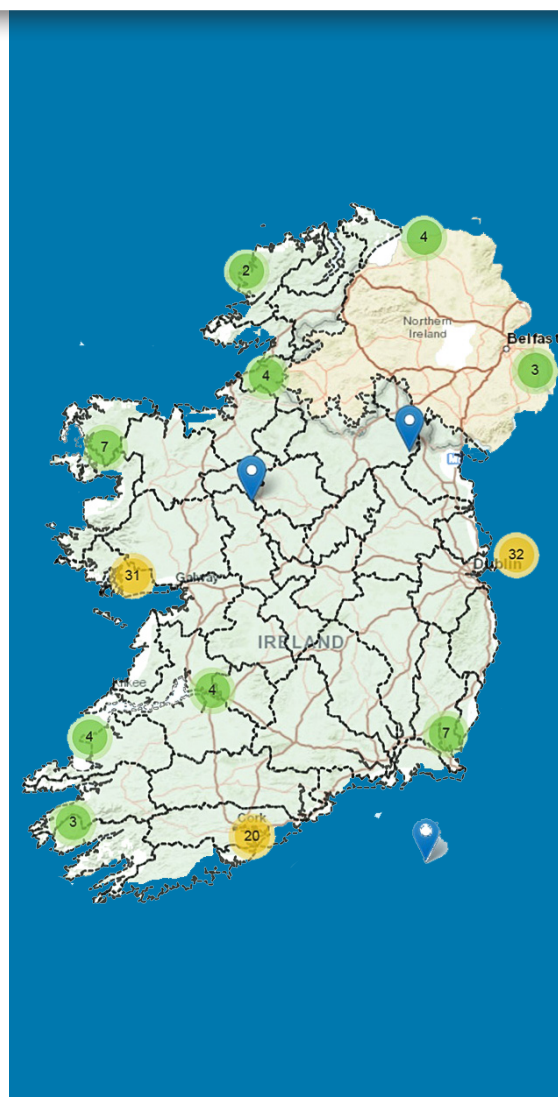
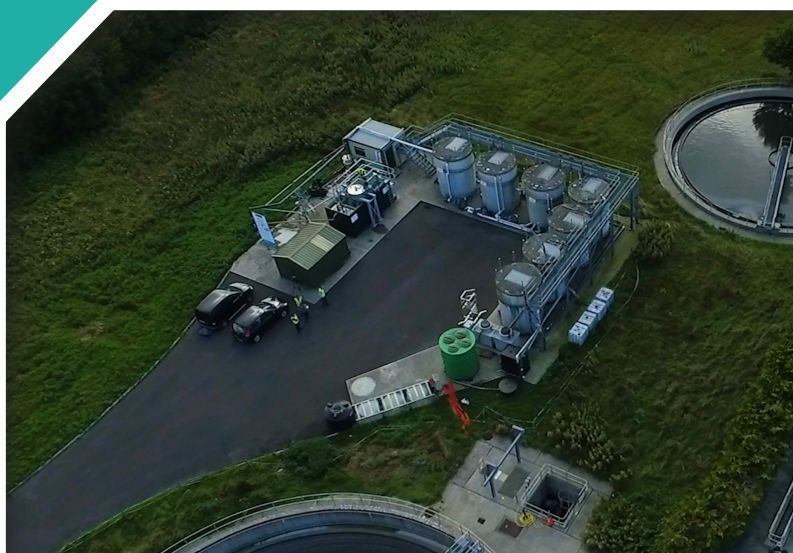


Identification and Mapping of Water-related Research Infrastructure in Ireland

Authors: Eoin Byrne, Kevin Fitzgibbon and Anca Minescu



ENVIRONMENTAL PROTECTION AGENCY

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The work of the EPA can be divided into three main areas:

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The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2014–2020

Identification and Mapping of Water-related Research Infrastructure in Ireland

(2016-W-DS-27)

EPA Research Report

Prepared for the Environmental Protection Agency

by

Cork Institute of Technology

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Research infrastructure is an integral input in facilitating excellence in water research. This water research infrastructure (WRI) needs to be easily accessible to the research community, including within the private sector, to enable engagement in applied research and innovation activities. Innovative water technologies require trialling and process-proving in pilot/demonstration sites for benchmarking against conventional technologies and to support further technology development and commercialisation. Water research is a broad research area and consists of a number of sub-areas, ranging from freshwater (rivers, lakes and groundwater) to the marine environment (coasts, oceans and ice caps), catchments and the biodiversity of these ecosystems. This has resulted in numerous and diverse organisations being involved in setting the strategy and providing funding for water research and, in turn, WRI in Ireland. Much of the water-related research and monitoring facilities in Ireland are operated on a stand-alone model, neither connected to other pieces of infrastructure nor easily accessible to other research activities because of lack of knowledge of them, unclear access procedures or financial constraints for staff or maintenance costs.

Gaps Addressed

At the outset of this project, there was no national database of Ireland's WRI available to the public or to researchers, which limited the ability to find out what facilities are available and prevented an overall view of the national WRI landscape from being formed. In addition, although Ireland's National Research Infrastructure Roadmap addresses research infrastructure needs in overall terms, the water sector is not identified in that plan as a specific area and WRI per se is not specifically identified. This project was tasked with identifying and mapping the location of all relevant WRI in Ireland and then to develop a database of this key information on WRI and make it available online to the water research community, in an easy-to-use format. It also aimed to develop a forward-looking WRI roadmap including recommendations on how best to advance WRI in Ireland. The widest possible access to research infrastructure is considered to increase the value for money for the

state and for the research community and the private sector in general.

Project Output

Through this project, a new online national WRI database has been created, by collaborating with the water research community in Ireland, using an interactive consultation and design process. It is a central database of information on all WRI in Ireland, including the types of WRI available for various research areas and applications, from the freshwater sector to the marine, climate and agriculture sectors. The WRI database raises the profile of individual infrastructures and helps connect the water research community by giving access to information on WRI, facilities, services and areas of research. This will help researchers pursue new opportunities and collaborate with colleagues, particularly those in interdisciplinary teams. The database is envisaged as a community-maintained resource, administered by the Environmental Protection Agency (EPA). Data for the database are provided by the individual RI managers who are responsible for the WRI. The data contained in the WRI database have been made available online, by extending the EPA's existing DROPLET (Database of Research Outputs: Projects Literature and Environmental Technologies) website (<http://erc.epa.ie/droplet/>). Data can be viewed in the form of a map or in tables and can be searched using keywords. At the time of writing, almost 80 WRIs have been uploaded to the new database by over 20 organisations in Ireland, across 120 locations. The integration achieved through this project for WRI points to perhaps expanding the remit of DROPLET to additional thematic/research areas (e.g. soils, waste, air, biodiversity, health and well-being).

Water Research Infrastructure Policy Input

As part of this project, recommendations on how to develop Ireland's WRI in the future have been developed, informed by the findings of the mapping study, a literature review of research infrastructure strategies and policies and interviews with research infrastructure managers. The WRI database will

help ensure effective planning for future WRI, by helping to identify gaps in existing infrastructure and opportunities for new infrastructure. Key topics were identified that are important in the planning, development and management of WRI in Ireland, including building on current strengths, taking account of various research infrastructure scales, accessibility issues, sustainability, funding and WRI gaps and opportunities. Water research funding organisations are currently co-ordinated through the Water Research Coordination Group (WRCG); consideration should be given to enhancing its role so that it more comprehensively adopts the role of managing WRI strategies and funding.

Regarding WRI, the outcomes and data from this project can aid policymakers regarding:

- Ireland's future science technology and innovation strategies, building on Innovation 2020;
- the preparation of future national research infrastructure roadmaps;
- the planning and funding of future WRI by water research funding organisations via the WRCG;

- the next funding cycle for the Programme for Research in Third Level Institutions (PRTLII) to support investment in new and existing research infrastructure;
- Science Foundation Ireland's (SFI) research infrastructure programme;
- the design of future funding calls in the EPA's Research Programme 2014–2020 on specific WRI or further development of the DROPLET platform to include other research areas;
- the current and future EPA Research Programme;
- the current and future National Marine Research and Innovation Strategy.

The development of the WRI database and expanded DROPLET platform has been funded by the EPA as part of this project. However, in order to ensure that the data are kept up to date, and to deliver sustained impact, the portal needs to be managed and maintained on an ongoing basis, which will require additional resources.

1 Introduction

1.1 Background

Ireland's waters (surface, ground, catchments, transitional, coastal and oceans) are one of our major natural resources. Water plays not only a part in sustaining life but also a fundamental role in ecosystem support, economic development and social well-being. Plentiful availability of good-quality water offers a significant competitive advantage to sectors such as agriculture, industry and tourism. Water research in Ireland supports the understanding, management and conservation of our water resources, as well as their sustainable use and development.

To conduct excellent water research, appropriate research infrastructure (RI) is required, with ease of access for researchers, support services (e.g. assisting with use of the RI) and openness to assisting public and private sector innovation (e.g. through trialling new technologies). Smart and connected water-related research infrastructure is critical to help meet this need across the water sector (e.g. in areas such as freshwater, water and wastewater treatment, the marine environment). However, many of the water-related research and monitoring facilities in Ireland are operated on a stand-alone model, neither connected to other pieces of infrastructure nor easily accessible to other research activities because of a lack of knowledge of them, unclear access procedures or financial constraints in terms of staff or maintenance costs. This is a major challenge that needs to be addressed to enable more effective water research. Additionally, this water research infrastructure (WRI) needs to be easily accessible to the research community, including within the private sector, to enable engagement in applied research and innovation activities. Innovative water technologies require trialling and process-proving in pilot/demonstration sites for benchmarking against conventional technologies and to support further technology development and commercialisation.

Large RIs are among the most expensive scientific expenditures; frequently, large capital investments are required, as well as there being associated ongoing operational costs. Therefore, there is a need to bring resources together and for collaboration

on a national, European and even global scale. At the European level, the European Strategy Forum on Research Infrastructures (ESFRI) roadmap and the RI support schemes under the European Union (EU) Framework Programmes address this challenge. Through international collaborations and participation in EU-funded projects, researchers are able to increase access to existing infrastructure and secure funding for new infrastructure. At the national level, many countries have developed an RI roadmap; Ireland developed such a roadmap in 2007, called "Research Infrastructure in Ireland – Building for Tomorrow" (Forfás, 2007). In 2015, an update of Ireland's RI strategy was published, called "Ireland's Future Research Infrastructure Needs" (Technopolis, 2015), which focused on investments of greater than €700,000.

The RIs reviewed in this document are large RIs. The main characteristic of large RIs is their (potential) national and international relevance, that is, they are used by several research groups inside and outside Ireland. Typical examples are national biobanks, high-performance computing facilities, national repositories and international databases. The rule of thumb applied in this study is that large RIs require an initial investment of at least €700,000. Substantial investment in RIs in Ireland has taken place through programmes such as the Programme of Research in Third Level Institutions (PRTL), run by the Higher Education Authority (HEA) and Science Foundation Ireland (SFI). Other investments in RI have been made by the European Commission (EC), mainly as part of Framework Programme 7 (FP7), by universities and institutes of technology (IOTs) (e.g. from core funding), by research institutes such as Tyndall, Teagasc and the Marine Institute (e.g. from block grants) and as part of research calls by domain-specific departments and public agencies [e.g. Enterprise Ireland, Health Research Board, Environment Protection Agency (EPA)]. The SFI supports investment in RI through dedicated funding calls and other programmes, including the Research Infrastructure Programme. The importance of access models for RI is addressed by the SFI in its *Guidelines for Preparing a Research Infrastructure Access Charge Plan* (SFI, 2016), as well

as by the HEA in its *National Guidelines for Access by Researchers to Research Infrastructure hosted by Higher Education Institutions or other Research Bodies in Ireland* (HEA, 2017). The widest possible access to RIs is considered to increase the value for money for the state and for the research community and the private sector in general.

Ownership of and responsibility for infrastructure for water research is dispersed across Ireland in various higher education institutes (HEIs), research organisations and state bodies. The Water Research Coordination Group (WRCG) is a research funders forum in Ireland at which research priorities for inclusion in calls for water research proposals, including infrastructure, and longer-term objectives are presented and discussed, with the aim of enhancing synergies and collaboration with other national funders. However, water research is a broad research area and consists of a number of sub-areas, ranging from freshwater (rivers, lakes and groundwater) to the marine environment (coasts, oceans and ice caps), catchments and the biodiversity of these ecosystems. This has resulted in numerous and diverse organisations being involved in setting the strategy and providing funding for water research and, in turn, WRI in Ireland, including research institutes and centres [Marine Institute, Centre for Marine and Renewable Energy (MaREI), Irish Centre for Research in Applied Geosciences (iCRAG)], state bodies (Geological Survey Ireland, Office of Public Works), universities and IOTs.

The origins of the present project lie in perceived gaps in the overall planning, management and communication of information about the wide range of WRI in Ireland. At the outset of this project, there was no national database of Ireland's WRI available to the public or to researchers. Knowledge of the range of WRI and the available equipment, facilities and applications could be described as somewhat compartmentalised, that is, to some extent knowledge has been confined to the specific researchers actively engaging with particular items of WRI. Finally, whereas the National Research Infrastructure Roadmap addresses RI needs in overall terms, the water sector is not identified in that plan as a specific area, and WRI per se is not specifically identified.

1.2 Project Objectives and Methodology

Arising from the above, the main aim of this project was to comprehensively research, identify and map the location of all relevant WRI in Ireland. The objectives for this project were to:

- identify and map the location of all relevant WRI in Ireland and Northern Ireland;
- develop a database listing key information about the WRI;
- produce an online, easy-to-use database detailing relevant infrastructure details;
- investigate solutions for the sustainable maintenance, and outline a plan for post-project management, of the online database;
- based on study findings, develop a roadmap that includes recommendations on how best to develop WRI in Ireland.

To achieve the objectives set out above, the project was divided into three main work packages as follows:

1. identification and mapping of WRI in Ireland and building a comprehensive database incorporating all data and results from the research;
2. transformation of the database into an online website to allow the water research community to easily search the database, in map and tabular format, and find information on WRI; and
3. "looking forward" – development of a WRI roadmap including recommendations on how best to advance WRI in Ireland.

In the first work package, first, a definition was formulated as to what constitutes WRI for the database. Second, the key parameters of WRI data to be collected were developed with key stakeholders. Third, a spreadsheet-based data collection form was created to allow RI managers to record their WRI data. These steps allowed the project researchers to carry out the WRI data collection. A list of all organisations known to be involved in water research in Ireland was produced. Stakeholder engagement with WRI managers and identified organisations took place between January and July 2018, when WRI managers and organisations were invited to include their WRI data in the database.

The results of the stakeholder surveys were collated in a database. The second work package of the project aimed to translate the WRI data into an online platform to be made available to the public. Three options to develop and host the WRI database were evaluated. The most feasible option was to develop a new WRI database and integrate it with the EPA's existing DROPLET (Database of Research Outputs: Projects Literature and Environmental Technologies) website (<http://erc.epa.ie/droplet/>), as it allowed for a bespoke WRI database to be developed while using DROPLET's established functions and brand, with which many water researchers would already be familiar. A Design Thinking Workshop with key stakeholders and end-users was conducted to establish and define user requirements and allow for a user-centred design process for the platform. The outcome was a software requirements specification document that described how the WRI platform was to be developed, consisting of the WRI database (back-end) and integration with DROPLET (front-end). Piloting of the WRI database on the DROPLET website was undertaken, together with full user testing, including registering an RI manager and RI upload. User guides were created for the EPA administrator, WRI managers and website users. A sustainability plan was developed, for managing the database post project and ensuring that it is kept up to date.

In the third work package a WRI roadmap report was developed, based on the outcomes of the mapping study. The report reviews RI documents, strategies, funding and policy in Europe and Ireland, with a particular focus on WRI. In addition, WRI managers were interviewed to probe the current strengths of, and challenges facing, water-related research with regard to infrastructure aspects and to identify gaps and needs to inform recommendations and roadmap development. It is hoped that this report's findings will help define future RI priorities and inform national policy on water-related infrastructure development. It is envisaged that this study will form the foundational research and knowledge content required to provide a baseline account of the current status of water-related infrastructure in Ireland, to enable policy development around future capacity building of smarter and connected water-related research infrastructure. The findings from this study will enable further development, targeted funding and advancement of WRI in Ireland in the coming years.

1.3 WRI Definition

A definition of RI for this project takes account of the current definitions utilised in Ireland and internationally. At a European level RIs are defined by the EC, and utilised in the ESFRI, as follows:

RI are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. They include: major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, e-infrastructures, such as data and computing systems and communication networks and any other tools that are essential to achieve excellence in research and innovation. (EU, 2013)

Figure 1.1 provides a narrow and broad interpretation of RI, based on the EU definition. RI consists of core facilities, equipment, instruments, databases and test beds. However, to effectively run and manage RI, associated resources are required, such as financing, research staff, management staff, operations staff, research and development (R&D) programmes, buildings, training programmes and access and support services. Without these associated resources the RI cannot be utilised effectively, and thus these resources are important elements of the broader RI scope.

As this project is focused on water-related RI in Ireland, a specific definition was developed:

The facilities, resources and related services currently used and/or potentially available for use by the scientific and engineering community, including the private sector, to conduct water-related research in Ireland.

This can include but is not limited to:

- singular, large-scale research installations or equipment;
- knowledge-based resources such as libraries and databases;
- integrated arrays of small research installations;
- enabling information and communications technology (ICT) infrastructures such as networks of sensors or big data-processing applications; and

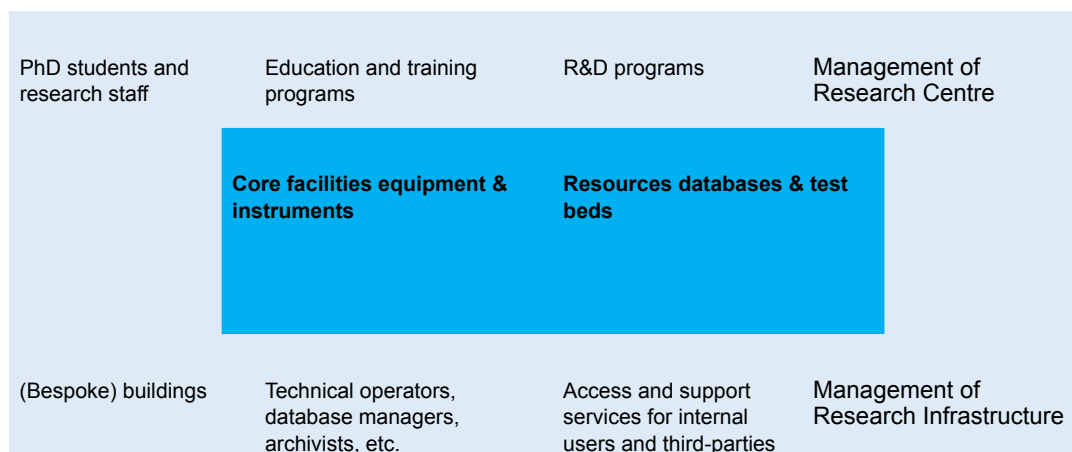


Figure 1.1. Research infrastructure definition. Reproduced from Technopolis (2015).

- laboratory and analytical research services, field trial sites, testbed sites, remote observation systems, special habitats, research vessels, satellite observation facilities and coastal observatories.

For this purpose, RIs should be above laboratory-bench scale. The RIs associated with, but not limited to, the following will be considered: HEIs, public research organisations, state agencies, industry and non-governmental organisations. The RIs to be included in the database include those from the narrow definition of RI; however, the roadmap report for WRI in Ireland also examines the broader RI elements and associated resources that ensure the effective use and management of WRI.

1.4 Structure of the Report

Chapter 2 reviews other RI databases and defines the user needs to create the scope and requirements for the WRI database. Chapter 3 describes the data collection methodology and provides an overview of the WRI landscape, examining the research areas, types of RIs and funders. Chapter 4 documents the development of the WRI database and integration with the DROPLET website and outlines a sustainability plan for the management and development of the database post project. Chapter 5 presents the main conclusions and recommendations of the WRI roadmap report.

2 User Requirements and Scope

At the outset of this project to develop a WRI database and make it available online, the scope and user needs were defined. This was achieved through discussions with key stakeholders (the WRCG) and potential users of the platform. A review of existing platforms that provide information on RI in Europe was undertaken. From these tasks, the key parameters, or the information that would be important to include in the WRI database, were developed through an iterative process.

2.1 Review of Existing Research Infrastructure Platforms

A review of existing platforms that provide information on RI in Europe was undertaken. The objective was to understand (1) the purpose of the RI platform, (2) the types of RI data that are collected and made available and (3) how the data are presented, for example in visual, tabular or numerical format. A search for RI databases across all research areas, not just water, was carried out. This identified a number of RI platforms at the European level, some focusing on “more-than-national” RIs across all research areas, some being domain specific, for example relating to the marine sciences, and some being at the national level.

2.1.1 *MERIL (Mapping of the European Research Infrastructure Landscape)*

The MERIL portal provides access to a database that stores information about openly accessible RI in Europe, across all scientific and engineering domains, including the social sciences and humanities. It currently covers over 1000 RIs (MERIL, 2018), including a small number of Irish facilities. It aims to identify RIs in Europe of “more-than-national” relevance. The project was commenced in 2010 under FP7 and is currently supported under Horizon 2020, with a budget of €1.4 million for a duration of 3 years until 2019. The database features RI information regarding infrastructures ($n=1023$), services ($n=2808$), equipment ($n=2787$) and organisations ($n=1006$). There is a forum area for researchers from

all countries to engage with each other and share best practice. A news section disseminates MERIL portal updates and lists new RIs added. The portal aims to help policymakers analyse and optimise the national and European RI funding landscapes by, for example, pinpointing gaps and identifying synergies at the European level. Organisations can submit a “Self-Assessment Form for Prospective New Entries” to include their RI in the database. The MERIL team will check each proposal with the relevant national or international data intermediaries. If the check is positive, the team will create an entry for the RI and a user account for the contact person to complete the data for the RI through the back office of the portal. The RI profile page will be published once the core set of data has been provided by facility managers and has been quality checked by the MERIL team.

The MERIL portal provides RI data in tabular form, with the ability to search by keywords (Figure 2.1). Four types of RI are defined: single-sited, distributed, mobile and virtual. The following data are collected and displayed for all RI uploaded to the database:

- organisation name;
- RI category;
- location;
- RI keywords;
- co-ordinating country;
- type of infrastructure;
- contact person;
- ESFRI domain;
- lifecycle status;
- research services;
- description;
- equipment;
- scientific domain.

2.1.2 *RICH RI Observatory*

The Research Infrastructures Consortium for Horizon 2020 (RICH 2020) is the European Network of National Contact Points (NCPs) for RIs in Horizon 2020. The RICH RI Observatory is the central point for information on RI funded through Horizon 2020 (RICH 2020, 2018). The NCPs for Horizon 2020 RI

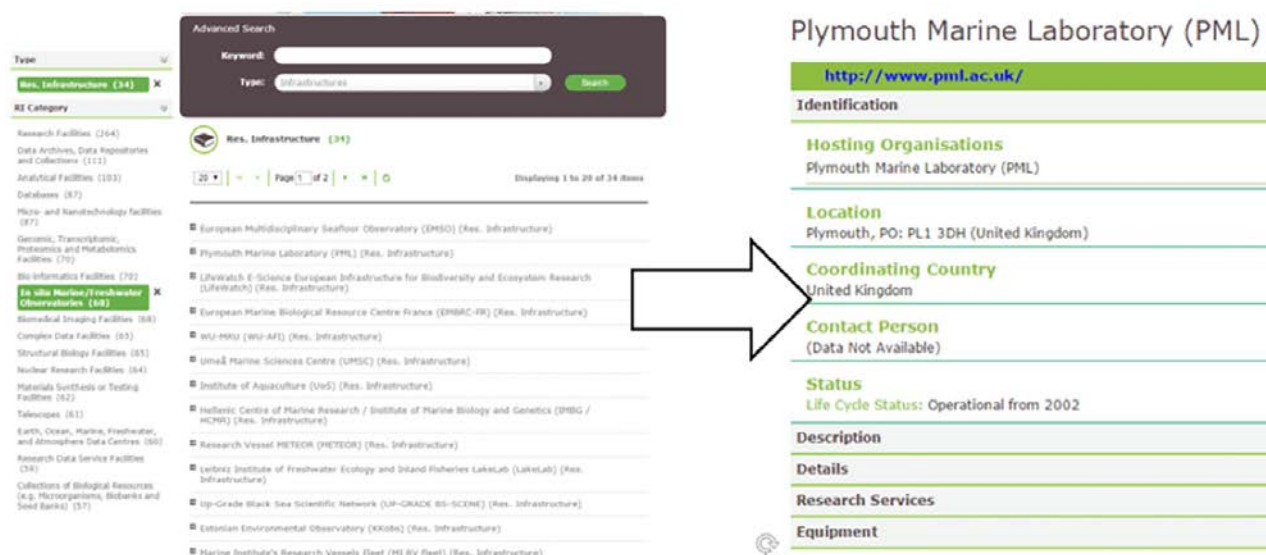


Figure 2.1. MERIL database search. This is an Open Access image distributed in accordance with the terms of the Creative Commons Attribution (CC BY-NC-ND 4.0) license, which permits others to copy and redistribute the material in any medium or format, provided the original work is properly cited. See: <https://creativecommons.org/licenses/by-nc-nd/4.0/>

programmes gather, organise and provide access to information on RI projects, transnational access opportunities, policy issues, stakeholders and national and regional initiatives on RIs. The information covers all countries and all thematic fields. The database provides information in tabular form on RI projects ($n=474$) funded through Horizon 2020 and FP7; RI from the MERIL portal; and organisations involved in RIs. It is possible to search these areas by keywords, country or specific domain. For example, Figure 2.2 presents the results for RI projects co-ordinated by Irish organisations. Visualisations related to RI projects are also presented for RI projects per country; RI projects per scientific domain; organisations per country; country co-operation networks; and national RI roadmaps published in Europe.

2.1.3 Networks of national research infrastructures

The networks of national RIs interactive map shows the location of RI funded by the EC to provide transnational access to researchers. These RIs are part of networks supported through Integrating Activity projects, with a view to making the most of existing facilities by optimising their use for the benefit of the scientific and engineering communities. The

map covers a number of research sectors including energy, ICT, engineering, life sciences, environmental sciences, materials sciences and analytical facilities, physical sciences and astronomy, social sciences and humanities. The data provided include organisation name and location, project name, project description, domain and subdomain, EU contribution, duration and website (Figure 2.3). The map is no longer available online.¹

2.1.4 Pan-European Research Infrastructures Map

The Pan-European Research Infrastructures Map shows the location of the pan-European RIs that are listed in the ESFRI roadmap 2010 (Figure 2.4). The RIs are located in the headquarter cities. In the case of distributed infrastructure, the locations of the partner facilities are also displayed on the map. About 400 facilities are part of these distributed pan-European RIs that have been set up with the support of the EC. The map also displays the European infrastructures that are established as part of ERIC (European Research Infrastructure Consortium). It covers a number of research sectors including energy, health and food, materials, e-infrastructures, environmental sciences, materials and analytical facilities, physical

¹ No reason has been given why the map is no longer online.

Browse Projects

This section provides access to Research Infrastructures that have been funded by the European Commission through Horizon 2020 and 7th Framework Programme for Research. Browse the projects per scientific domain, type of project, and/ or Coordinator's country.

Scientific domain	Type of project	Coordinator country	Funding Programme	All
Show 25 entries Coordinator country: 'Ireland' Search:				
Acronym	Title	Dates	Project URL	Funding Progr.
ASCENT	Access to European Nanoelectronics Network	2015/05/01 - 2019/04/30	http://www.ascent-network.eu	H2020
E-CAM	An e-infrastructure for software, training and consultancy in simulation and modelling	2015/10/01 - 2020/09/30	https://www.e-cam2020.eu/	H2020
EINFRANET	European Network for co-ordination of policies and programmes on e-infrastructures	2009/12/31 - 2012/12/31	http://www.infranet.eu	FP7
QNano	QNano Integrating Activities	2011/02/01 - 2015/01/31	http://www.qnano-ri.eu	FP7
Showing 1 to 4 of 4 entries				

Figure 2.2. Research infrastructure projects with Irish co-ordinators. This is an Open Access image distributed in accordance with the terms of the Creative Commons Attribution (CC BY-NC-ND 4.0) license, which permits others to copy and redistribute the material in any medium or format, provided the original work is properly cited. See: <https://creativecommons.org/licenses/by-nc-nd/4.0/>

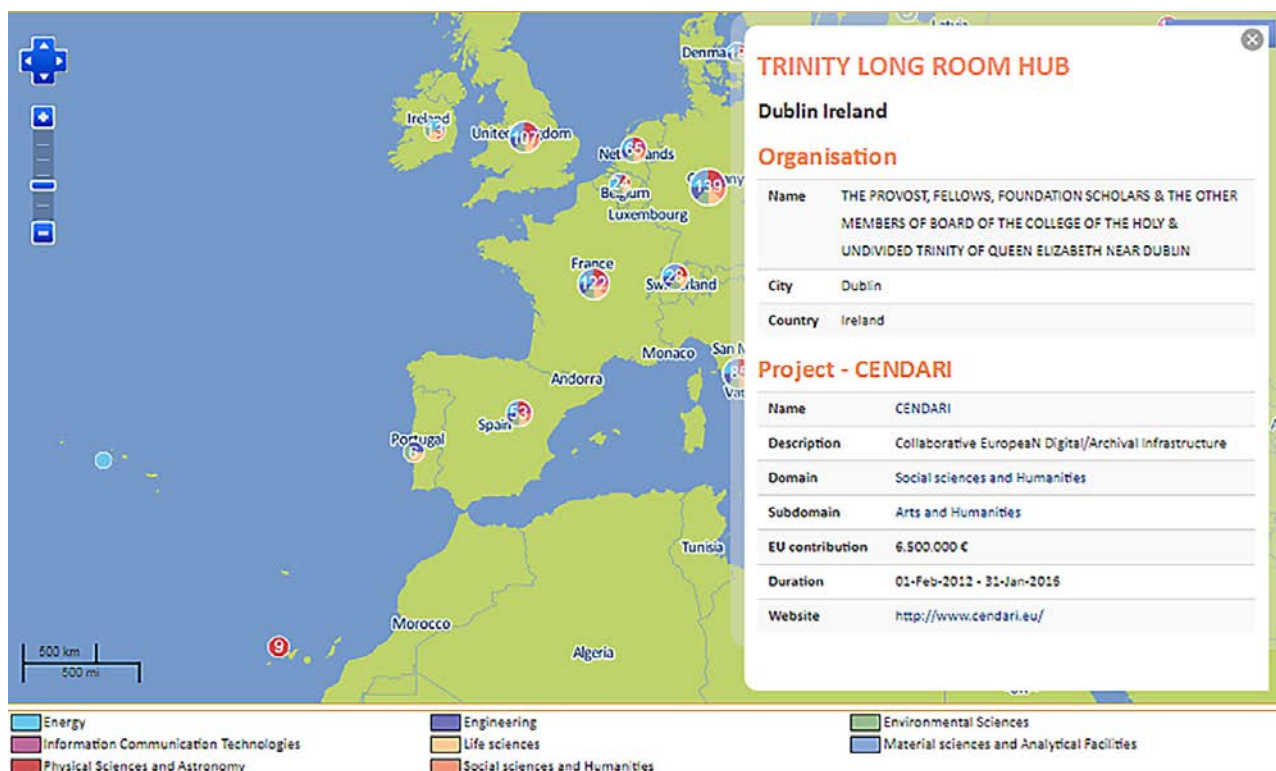


Figure 2.3. Networks of national RIs map.

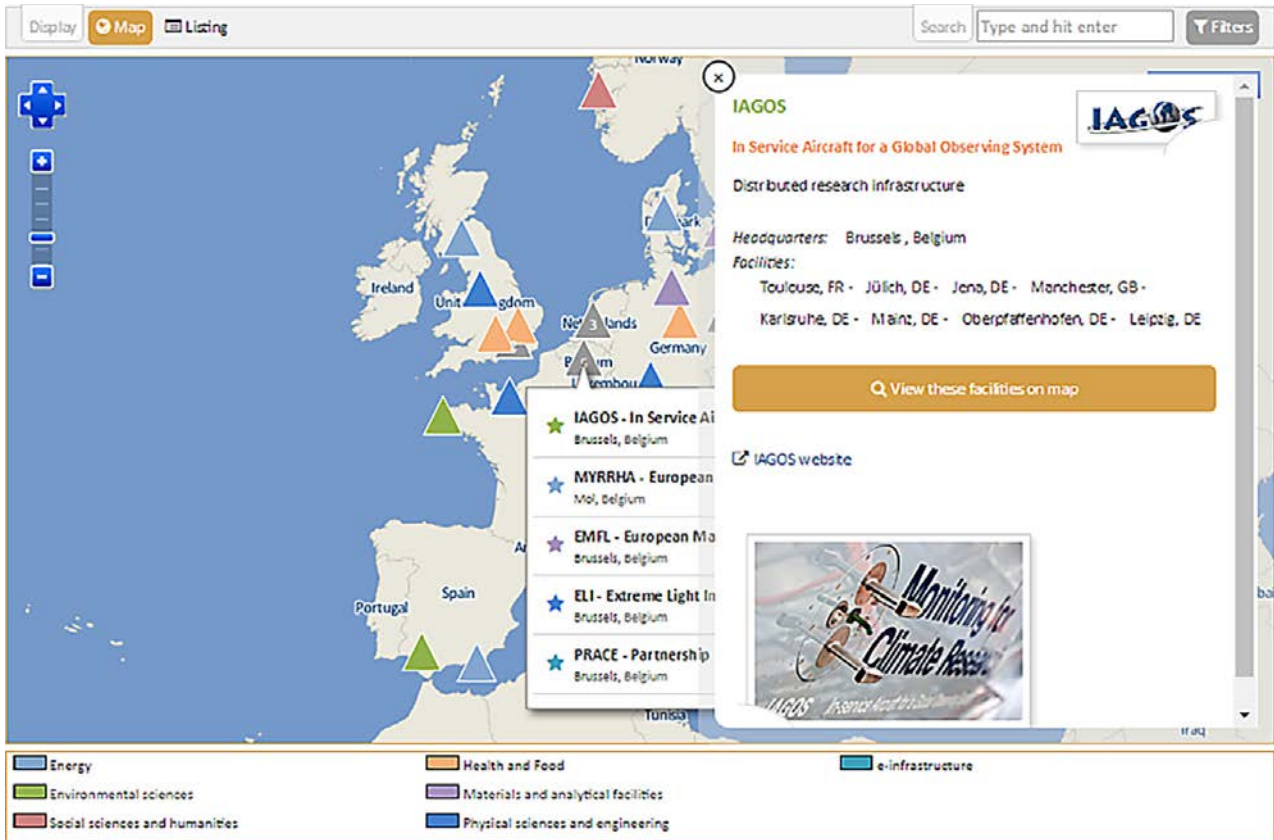


Figure 2.4. Pan-European Research Infrastructures Map.

sciences and engineering, social sciences and humanities. The map is no longer available online.²

2.1.5 EurOcean

The Marine Research Infrastructures Database (EurOcean) is a comprehensive database of over 900 facilities that are dedicated to marine science activities in Europe (EurOcean, 2018). It provides information on three main domains: marine knowledge management, marine RIs and ocean public outreach and awareness activities. It includes a number of RI types: research vessels and their underwater vehicles; *in situ* data acquisition systems; satellites for sea and ocean observations; marine data providers; land-based facilities and *in situ* testing sites for ocean engineering and ocean observation support; and experimental facilities for biology and ecosystem studies. It provides the key characteristics for each facility, including links and contacts for accessing further details provided by the operators of the facilities. Its aim is to facilitate information exchange between a wide range of

governmental and non-governmental bodies and generate value-added products in the field of marine sciences and technologies. The data are presented in both a map (Figure 2.5) and tabular format. The database is searchable by RI name, country, operator, category and subcategory, operating area and scientific discipline. Organisations and marine researchers can upload their marine infrastructure using an online form.

2.1.6 Research Infrastructure Database for EPOS

The Research Infrastructure Database for EPOS (RIDE) is reported on the EPOS website to contain information about RIs that are part of the European Plate Observing System (EPOS). It is a database and interactive map of RIs for solid earth science in Europe. It combines solid earth RIs ($n=256$) and their associated data and services together with scientific expertise into one integrated delivery system for the solid earth (EPOS, 2018). The EPOS vision

² No reason has been given why the map is no longer online.

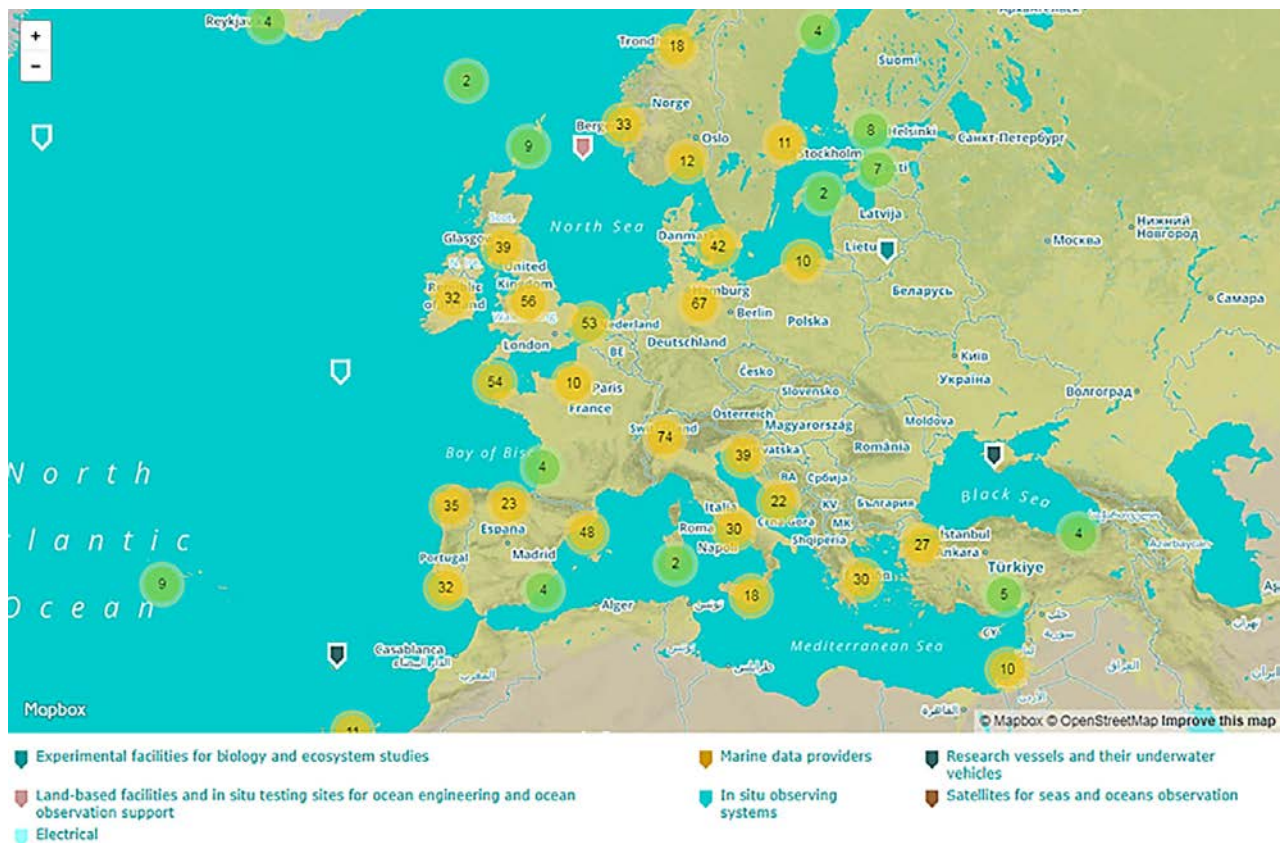


Figure 2.5. EurOcean RI map. Source: EurOcean (2018).

is that the integration of the existing national and trans-national RIs will increase access to and use of the multidisciplinary data recorded by the solid earth monitoring networks, acquired in laboratory experiments and/or produced by computational simulations. The platform lists a number of types of relevant RIs, including GPS networks, geological repositories, gravimetric infrastructure, induced seismicity, international data infrastructure, laboratory, marine RI, national data infrastructure and others. However, the online access to RIDE database itself has been deactivated.

2.1.7 Large Items of Research Equipment database

The HEA has reportedly completed a national inventory of “all significant publicly funded research infrastructure and equipment”. The Large Items of Research Equipment (LIRE) database is maintained by the HEA with the help and co-operation of each host institution. The LIRE database contains research equipment items with a value of at least €100,000 (HEA, 2018). As such, the database covers mid-sized

and large items of research equipment, and RIs in general. One of the main objectives is to increase the visibility and accessibility of such RIs in Ireland. Data entry relies on self-reporting by organisations and researchers. However, at the time of writing, the LIRE database is being updated and is not available. The database does not encompass the numerous smaller items of WRI in Ireland. It should be noted that the WRI database is focused on WRI. It has a wider remit within water, including infrastructure, facilities, equipment and databases. It extends to equipment outside of HEIs, including the private sector, and provides further information relevant to the water sector. The DROPLET website provides an easy-to-use dedicated portal for WRI, in both map and tabular form. It is envisaged that the WRI database would include water-related equipment from the LIRE database.

2.1.8 Austrian Public Database of Research Infrastructures

The Austrian Public Database of Research Infrastructures (APDRI) presents over 1200 selected

RIs across all scientific domains that are available for collaboration in R&D (APDRI, 2018). The database has three major objectives: (1) to act as an information-sharing platform for establishing future co-operation in science and innovation; (2) to promote and represent selected RIs and their roles in science and innovation; and (3) to promote transparency of research and RIs in Austria. It is possible to search the database by keywords, type of RI, research area, research institution and RI category. The RI data are presented in map and tabular format (Figure 2.6). Each RI is presented with the following information: picture, short description, contact person, research services, methods and expertise for RI, co-operation partners, projects and publications. The platform differentiates between five types of RI: large equipment, core facilities, electronic databases, spatial RI and other RI.

2.1.9 Comparison of research infrastructure platforms

Table 2.1 compares the RI platforms presented in the previous sections. The data outputs of the platforms are indicated (maps and/or tables), as well as the key data fields presented on each of the platforms (RI type, services, equipment/facilities, persons/organisation, funding, location, RI keywords, description, accessibility information, projects). These data are useful in assessing the common data across platforms and will be incorporated in the development of the EPA WRI database.

Each of the RI platforms has specific objectives to capture and present different types of RI. These may be of different sizes, costs or level and may range

from international pan-European RIs to national RIs and lists of equipment. Each of the platforms differentiates between the types of RI; however, these are not common across all platforms. The domain-specific platforms (e.g. EurOcean) provide a more detailed breakdown of the types of RI relevant to that domain. Also of interest is that a number of the RI database and mapping portals are no longer available. This highlights the need for a sustainability and maintenance plan for any RI platform, so that it is kept up to date and is maintained after it is created.

2.2 Design Thinking Workshop

To develop an effective and sustainable platform it is necessary to incorporate the user in each phase of the design. This project conducted a user requirements specification investigation to define user problems, needs and goals for the WRI platform. A Design Thinking Workshop was organised at the Nimbus Research Centre, Cork Institute of Technology, on 4 October 2017 with potential users of the platform, from universities, research institutes and state bodies (Figure 2.7). The attendees took part in a number of tasks in order to:

- define what key information users would look for on WRI;
- gather user needs to inform the features to be incorporated in the platform;
- understand how users will interact with the online tool through a Customer Journey Map; and
- consider the future development of WRI in Ireland in terms of the current strengths and weaknesses/ gaps and how Ireland can be established as a leader in WRI.



Figure 2.6. The APDRI platform map and RI data. Source: APDRI (2018).

Table 2.1. Comparison of RI platforms

Platform name ^a	Interactive map/table	RI type	Services	Equipment/facilities	Persons/organisation	Funding	Location	RI keywords	Description	Accessibility information	Projects
MERIL	Table	✓	✓	✓	✓	✓	✓	✓	✓		
RICH RI Observatory	Map and table	✓			✓	✓	✓		✓		✓
Network of national RIs	Map	✓			✓	✓	✓				✓
Pan-European Research Infrastructures Map	Map and table	✓		✓	✓		✓				
EurOcean	Map and table	✓	✓	✓	✓		✓		✓		
RIDE	Map	✓	✓	✓	✓		✓		✓		✓
HEA LIRE	Table	✓		✓	✓			✓		✓	
APDRI	Map and table	✓		✓	✓		✓	✓			

^aMERIL: <https://portal.meril.eu/meril/> (accessed 12/9/2018); RICH 2020 RI Observatory: <http://observatory.rich2020.eu/rich/> (accessed 12/9/2018); EurOcean: <http://rid.eurocean.org/> (accessed 12/9/2018); HEA LIRE: [http://hea.ie/funding-governance-performance-performance-guidelines-for-access/](http://hea.ie/funding-governance-performance-governance-performance-guidelines-for-access/) (accessed 12/9/2018); APDRI: <https://forschungsinfrastruktur.bmbwf.gv.at/en> (accessed 12/9/2018).



Figure 2.7. Design Thinking Workshop.

The outputs of the workshop facilitated the development of the key parameters, a software requirements specifications document (see Chapter 4) and a technology roadmap (see Chapter 5).

2.3 Key Parameters

To develop the WRI database, the key parameters needed to be defined, that is, what types of information need to be included in a WRI database. To achieve this a review and comparison of other RI platforms was conducted, noting, in particular, what types of information are recorded. A series of consultations took place between the project team and relevant stakeholders to define the key parameters:

- Project kick-off meeting (14 April 2017) – at the project kick-off meeting, a user needs discussion took place with the steering committee on what information on WRI was needed by the water research community. A preliminary set of key parameters was developed and circulated to the steering committee.
- WRCG meeting (6 June 2017) – the project team attended the WRCG group meeting to discuss the key parameters for the database.
- Steering committee meeting (1 August 2018 – the key parameters were reviewed and revised.

- Design Thinking Workshop (4 October 2018) – to understand what RI information is important to potential users of the platform. The key parameters were presented, debated and revised.
- WRCG and steering committee review (November 2017).
- Final draft of parameters definition submitted to the steering committee (November 2017).

From the review of RI platforms and discussion with stakeholders, the following key parameters were identified as being of importance for recording information on WRI in Ireland. Many of the description fields are banded, to allow consistent collection of WRI data. The banded field options were developed along with the key parameters. They were tested, modified and expanded through engagement with RI managers in the data collection phase.

- infrastructure name;
- research area: agriculture, aquaculture, climate, energy, groundwater, marine environment, surface waters, water and wastewater treatment, water ecosystems, water quality and monitoring and other;
- lead organisation;
- lead funding entity;

- platform type: coastal observatory, communication network, data analytics and modelling, dataset, field equipment, field trial site, laboratory, library, observation network, remote observation system, remotely operated vehicle, research vessel, satellite observation facility, sensor platform, special habitat, testbed site and other;
- sensor type: acoustic fish tag detector, acoustic Doppler current profiler (ACDP), air temperature, barometric pressure, conductivity, dissolved oxygen, flow velocity, geographical location, noise, particle count, pH, rainfall, turbidity, video, water level, water pressure, water temperature, water sample, wind direction, wind speed and other;
- communications type: 2G/3G/4G/5G, Bluetooth, fibre-optic cable, GSM phone, iridium, LoRa, NFC, RFID, satellite broadband, Sigfox, voice communication, WiFi, ZigBee, Z-Wave, and other;
- location;
- catchment: list of catchments;
- longitude, latitude: the approximate co-ordinates of the location of the RI;
- approximate date of deployment (or upload to the database);
- approximate date of planned retirement (or “no planned retirement date”);
- contact name: key contact point for the RI;
- contact email address;
- website: for the WRI or organisation;
- accessible: whether the RI is potentially accessible to other researchers and third parties (under conditions of use);
- platform description and application;
- RI keywords.

Once the key parameters were finalised, a Microsoft Excel data sheet was created for the data collection phase with WRI managers. Appendix 1 presents an example of a completed Excel data collection form.

3 Data Collection

3.1 Methodology to Survey the WRI Landscape

Work package 1 of the project involved identifying and mapping the location of all relevant WRI in Ireland and developing a comprehensive “inventory of use” database, listing all relevant operational details of the WRI. First, a definition of what WRI comprised for the database was formulated. Second, the key parameters relating to what WRI data were to be collected were developed with key stakeholders. Third, a data collection form was created in Microsoft Excel to allow RI managers to record their WRI data. These steps then allowed a researcher to carry out the WRI data collection. This was organised by:

- creating a list of all known WRI in Ireland;
- creating a list of organisations involved in water research;
- undertaking stakeholder engagement and collecting the data;
- developing a post-project data collection plan.

3.2 WRI Data Collection

Databases, reports and websites were searched to establish a list of WRI and organisations involved in water research in Ireland. The search included EPA research catalogues, the Knowledge Transfer Ireland (KTI) research database, the MERIL portal, the PRTL funding database and the Enterprise Ireland, SFI and institute and university websites. The WRCG was asked to provide a list of any WRI funded by its organisations. Two lists were created: (1) WRI in Ireland and contact details and (2) organisations involved in water research that may have WRI. Those in list 1 could be contacted and invited to directly input their WRI into the database. For list 2, organisations would need to be asked if they had any suitable WRI and to provide relevant contact information for the RI manager.

Stakeholder engagement with WRI managers and identified organisations took place between January and July 2018. The WRI managers identified were sent an invitation email to upload their WRI to the database by completing an Excel data collection

form. A follow-up telephone call was made to the RI manager within a week. If the RI manager did not respond a further email was sent and telephone call made over the coming weeks. The organisations involved in water research included research institutes and centres (Marine Institute, MaREI, iCRAG), state bodies (Geological Survey Ireland, Office of Public Works) and university and IOT schools of science and engineering and research offices. The list of organisations contacted is provided in Appendix 2. An email with information on the project and WRI database was sent to each of the organisations and was followed up by a telephone call. The aim was to ascertain whether there was relevant WRI at each organisation. If WRI was identified at an organisation, the WRI data collection form was sent to the RI manager or relevant person. Over 110 people were contacted about including their WRI in the database. To date, over 70 WRIs have been uploaded to the database from more than 20 organisations. Appendix 3 presents the list of WRIs and data gathered during the project.

After the completion of the project, it is essential that new and existing WRI are uploaded to the database to ensure that it is comprehensive and dynamic. RI managers will be able to upload their WRI by registering on the WRI database and completing a new infrastructure web form. These new WRI data will then be added to the database. The management and sustainability of the WRI platform are discussed in Chapter 5.

3.3 WRI Data Results

The WRI database provides an opportunity to assess the types of WRI that are available to the research community in Ireland. An overview of the Irish WRI landscape is presented from the WRI data collected, indicating where funding and expertise have been focused up to August 2018. This database is a work in -progress, as not all WRI managers in Ireland have uploaded their data to date. The database will need to be kept up to date and new WRI will need to be uploaded when it is funded and becomes operational. As mentioned in the previous section, at the time of

writing, over 70 WRIs have been uploaded to the new database by more than 20 organisations in Ireland. The funders of these RIs are diverse and include government departments, the National Development Plan (NDP), the EPA, the SFI, EU funding and HEIs (Figure 3.1).

These funding agencies have supported WRIs across a wide range of water-related research areas, with the marine environment ($n=29$), climate ($n=17$) and water quality and monitoring ($n=17$) being the most common areas (Figure 3.2).

The outputs of the mapping study provide an overview of the types of RIs funded and utilised in water research in Ireland. Figure 3.3 presents the many different types of WRI, with field equipment ($n=23$), remote observation systems ($n=15$) and datasets ($n=15$) being the most common.

The results of the WRI data collection process present an impression of the WRI landscape in Ireland. The hope is that this database will endure and continue to be populated and used beyond this project. The database provides the funders of WRI in Ireland with information on the research areas, funding organisations and types of infrastructure available. These data can be used by funders of WRI in Ireland to make decisions on the future funding of WRI and as an input into the WRI roadmap recommendations (described in Chapter 5 of this report). Some organisations with WRI have engaged with the project and uploaded their RI; however, other organisations have yet to add their WRI. RI managers and their organisations benefit from uploading their WRI to the database as it publicises the RI to the water research community in Ireland and abroad, increasing the opportunities for collaborative research and use of

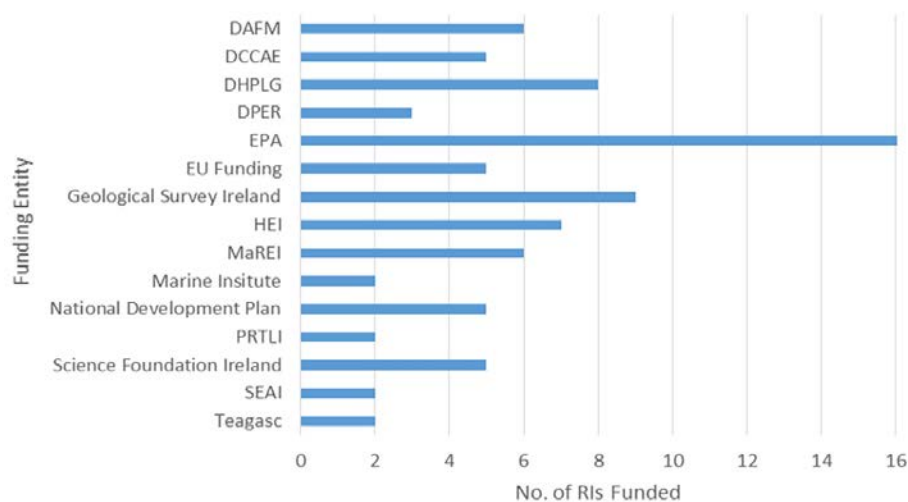


Figure 3.1. Funding entities of WRI.

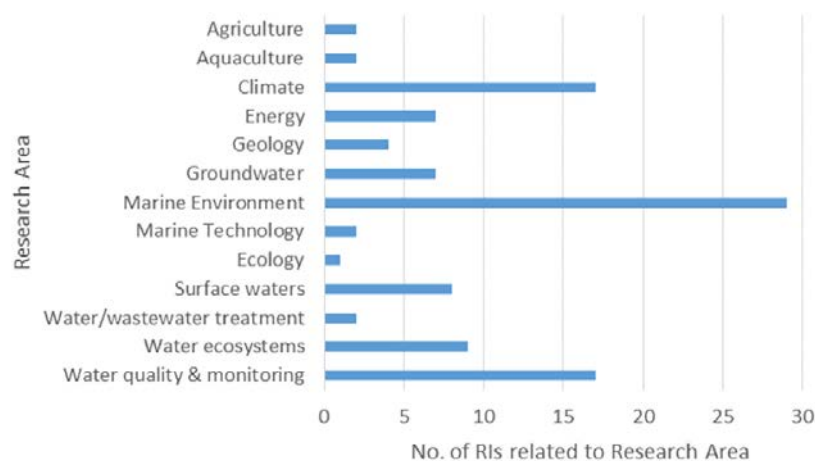


Figure 3.2. WRI research areas.

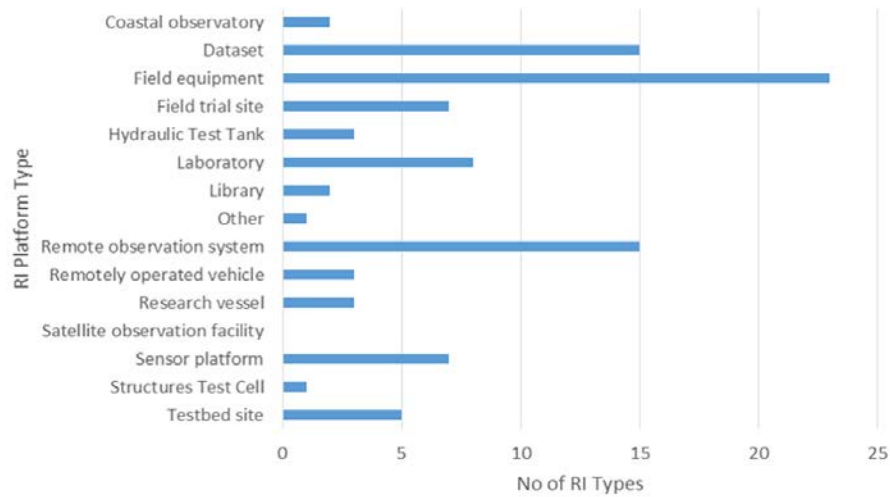


Figure 3.3. Types of WRI.

the RI. However, there is currently no compulsion on organisations or RI managers to populate the database. Future funding of WRI should come with a clause that WRI must be uploaded to the WRI

database and the information be kept up to date, as this would ensure that the database is comprehensive and dynamic.

4 Water Research Infrastructure Platform Development and Sustainability Plan

4.1 Introduction

The second work package of the project aimed to translate the WRI data from work package 1 into an online platform to be made available to the public. The objective of the WRI platform is to:

- develop a database listing all relevant details of the infrastructure purpose;
- simplify the recording of WRI through online forms and simple web interfaces;
- produce an online, interactive, easy-to-use user interface providing all of the WRI details.

Three options to develop and host the WRI database were evaluated:

1. use the existing DROPLET website and water projects database;
2. develop a new database and website;
3. develop a new WRI database and integrate it with the DROPLET website.

Option 3, to develop a new WRI database and integrate it with the DROPLET website, was judged to be the most feasible option as it allowed for a bespoke WRI database to be developed while still utilising DROPLET's functions and brand, which many water researchers would already be familiar with. This chapter outlines the development of the WRI platform, the development of the WRI database (back-end) and integration with the DROPLET website (front-end), piloting of the platform and the creation of the user guides.

As part of the development of the WRI platform, both back-end and front-end, solutions for the sustainable maintenance and management of the online database were investigated. The sustainability plan aimed to ensure (1) the management of the WRI database after the project had ended; (2) that a development roadmap for the WRI database and DROPLET website post project was created; and (3) that the database is a current and comprehensive reflection of WRI in

Ireland. A sustainability plan for the management of the WRI database post project is outlined in this chapter.

4.1.1 WRI database (back-end)

The WRI database interacts, either directly or indirectly, with the following significant users:

- EPA administrator: one or more administrator will be assigned to “manage” the WRI database. These users will have full access and permissions on the platform and will be able to add/delete/modify information within each module.
- Registered users: any RI managers who register on the website for access to upload data to the WRI database. These users will have a login to view and manage their own infrastructure data.
- Guest users: visitors to the DROPLET website who do not register will be able to use the website to search, view and export data made public from the WRI database.

The WRI database back-end consists of “Infrastructure Management”, “Organisation Management”, “User Management” and “Report Management” modules. In the Infrastructure Management module registered users will be able to edit the infrastructures that they have uploaded to the system. Registered users can upload new infrastructures once logged in and approved by an administrator. Please see the DROPLET user guide for a full description of how to upload RI data (<http://erc.epa.ie/droplet/>). The Organisation Management module presents information on the registered users' associated organisations. The User Management module allows users to edit their contact information.

4.1.2 DROPLET (front-end design and integration)

DROPLET is a searchable and editable database of water-related research projects, funding calls and water research events. The website provides a one-stop area where users can explore projects funded

nationally, in the past and present, and can find details of all national and international calls and events. The projects are searchable in map and tabular format. It is possible to download public information from the database on water-related research projects. DROPLET also provides information on funding organisations.

The WRI database is integrated with DROPLET so that WRI data are searchable and editable on the DROPLET website. The WRI database aims to leverage the DROPLET website, which water researchers may already be familiar with. Utilising the DROPLET website to present the WRI data will aid in disseminating the WRI database to water researchers, in Ireland and internationally. Interested water researchers are able to explore WRI data uploaded to the database in map and tabular format. The WRI data from the data collection phase are available to view on the DROPLET website. Website users have the ability to download RI information, which is made publicly available, as a CSV file.

4.2 Pilot and Testing

Front-end user testing of the WRI data on DROPLET was piloted at the EPA National Water Event on 20 and 21 June 2018. A special version of the DROPLET website was created, separate to the main DROPLET website, which included the WRI data. Full user testing of the DROPLET website and WRI database was conducted with members of the project steering committee. They were asked to follow a set of instructions to search for and explore WRI data on the DROPLET website, using both the map and the table view. They were then asked to register as a RI manager on the WRI database, to explore the back-end functionality and trial how an RI is uploaded. Access was also provided to trial the full back-end as an administrator. The feedback from the steering committee was captured and further revisions were made to the front-end and back-end of the platform.

4.2.1 User guides

To ensure that the WRI database and DROPLET website can be used effectively by the various users (EPA administrator, RI managers and guest users),

support material was created. The DROPLET website has a user guide to assist in searching, registering and managing research projects (<http://erc.epa.ie/droplet/>). With the integration of the WRI database and additional features to search the WRI, it was necessary to update the user guide. To complement the written user guide, a video tutorial on how to search WRI on the DROPLET website and upload WRI to the database was created. This video tutorial is available at <https://www.youtube.com/watch?v=IsbbRVeNMI0&t=2s>.

4.3 Responsibilities of the EPA Administrator

The EPA administrator for the WRI database has a key role in ensuring the management and maintenance of the WRI database and DROPLET website post project. The administrator is the central point of contact for the WRI database and has a number of responsibilities:

- It will be the role of the administrator to confirm the registration of any new users of the WRI database.
- The Organisation Management module in the WRI database will allow the administrator to view a list of all organisations stored in the system. The administrator can use this to create a new organisation, edit an organisation profile and delete an organisation if necessary.
- The administrator will be able to view all uploaded RI in the Infrastructure Management module. The administrator will have full permission to view, edit, create and delete RIs. The administrator should update the platform types, sensor types, communication types and research areas with additional options based on frequently-occurring “other” suggestions from the research community, twice per year. (suggested in January and July).
- The WRI database contains a number of reports that are available to export as CSV files: list of registered users; list of organisations; and list of infrastructures and data. These reports can be used to review the infrastructures, organisations and users on the WRI database. The WRCG may request these reports to review the WRI for its quarterly meetings.
- The DROPLET website provides analytics on website views and visits, as well as on DROPLET

projects. Website analytics should be monitored and reported on to assess whether the WRI database has increased the number of visitors to the DROPLET website since its launch.

4.4 Website and Database Development Roadmap

There are many areas of the WRI database and DROPLET website that can be further developed to improve their function. Suggestions for the post-project development of the WRI database and DROPLET website are provided in this section.

4.4.1 WRI database development

Research Infrastructure Supporting File

In the development of the WRI database it was made possible for RI managers to upload supporting files relating to the RI, such as datasets, factsheets and access guidelines. As this was outside the scope of this project, it was not included in the data collection phase. However, the project team has provided the option (in the database code) to add a module for RI supporting files.

Dashboard

A dashboard could be developed as the WRI homepage that would display key information about the WRI database in graphical format, for example number of WRIs, recent uploads, WRI by research area, WRI by platform type and a list of WRI that are retired or no longer in use.

Retired WRI

The database could be used to identify WRI that has been retired, using the “planned retirement date” data. Any WRI that has been retired could then be publicised to the water research community so that it can be repurposed or potentially new funding found for it.

4.4.2 Website roadmap

The development of the WRI database and integration with DROPLET has demonstrated the potential for a

single platform to manage and present research data and information for water research and infrastructures in Ireland. Furthermore, this work has shown the many possibilities for building on the research project and RI databases and the DROPLET website, as well as expanding into other research areas. This section presents a future roadmap for the development of the WRI database, following on from (1) feedback from the Design Thinking Workshop and (2) discussions with DROPLET’s developer, Peter Mooney, on a long-term vision.

Design Thinking Workshop

The Design Thinking Workshop considered the process of creating an online directory for Ireland’s WRI. The attendees defined what key information users would look for on the WRI database; their user needs were gathered to inform/guide features to be incorporated on the platform and a Customer Journey Map was developed to understand how users would interact with the online tool. As it was not possible to apply all of the ideas and suggestions to the current development of the WRI database and DROPLET, a roadmap was created for future development, which is presented under key areas below.

Dashboard:

- Provide insights/analytics data visualisation tools that present the number of sites, equipment, testbeds, etc. on the DROPLET homepage. These may be displayed on a dashboard user interface where data analytics visualisation charts and graphs are dynamically updated as new sites, equipment, testbeds, etc. are added.

Search functionality:

- Provide a filtering tool for searching both maps and lists (research type, location, sensors, availability). The mapping tool user interface will combine filtering tools, with pins dynamically updated based on search filtering input criteria. Pins may have different icons or colours to distinguish them.
- It was suggested to display the main research areas as the main search item on the user interface.
- Website users could register an account to specify their own research interests or equipment/

infrastructure that they are interested in. The online catalogue would then generate a list of recommended contacts/sites/equipment that they would most likely be interested in or that match their interests.

- Save infrastructure searches to favourites for guest users. This may be useful when users have searched multiple infrastructures that they wish to compare at a later time.

Feedback, updates and news:

- Allow users to easily register for updates on new WRI and news.
- Allow users to specify their requirements on the platform if an infrastructure that they are looking for is not currently available. These could be published on a forum or wanted list. The forum could also allow researchers to engage with each other and share best practice.
- Featured or new RI could be presented on the homepage, e.g. news section.
- Provide a feedback form/surveys where users can suggest improvements or track errors with the platform.

Engagement and social:

- Enable results to be shared, such as generating lists (PDF files) or maps with reference pins or lists with links.
- Provide incentives to generate higher levels of engagement with or retention to the platform. Social engagement or gamification techniques or strategies could be implemented for users to upload, share or contribute to the platform, similar to ResearchGate. Users could gain points, rewards or a status based on their level of contribution to the platform.
- To raise awareness of the WRI platform, sharing on popular social channels (Twitter, LinkedIn, etc.) is key, as well as creating higher levels of engagement through user engagement strategies and incentives. A social sharing tool could be provided to show the RSS/Twitter feed or activity feed of the latest WRI added.
- Allow users to embed the mapping tool of the WRI database in other websites, such as an iFrame widget (similar to ThingSpeak Chart).
- Allow users to register profiles that would be publicly viewable. The profiles could present users'

research areas, projects and RI used or owned. Researchers would be able to add connections, similar to ResearchGate.

Other:

- Show relevant WRI events and conferences.
- Allow users to rate/score WRI. The list of sites could then be sorted according to score (similar to booking.com, where hotels can be sorted based on, for example, ratings or reviews).

Long-term vision

A long-term vision for the EPA and DROPLET would consider a broadly thematic-based approach to the organisation, management and dissemination of research data and information. DROPLET was established to organise, manage and disseminate information on research carried out in the broad thematic area of water in Ireland. The integration of the WRI database sees this thematic area embrace not just the projects in the water domain but also the actual research equipment used in this work. This integration hints at the possibility of expanding the remit of DROPLET to include different thematic/ research areas. The major technical achievement of the integration of DROPLET and the WRI database is the combining and blending of information and metadata from two different databases. These two databases were designed independently but, by using a shared metadata approach, the DROPLET system can allow the dissemination of information from both systems in a seamless and efficient manner. In the future, other thematic areas (soils, waste, air, biodiversity, health and well-being, etc.) could be integrated in the same way. From an end-user perspective, this appears to be a natural platform for an organisation such as the EPA to present systems for the dissemination of environmental knowledge and data. Users who are looking for environmental research information could visit a platform such as DROPLET and search all of the thematic areas at the same time. The homepage would provide an overview of all of the environmental research areas and the user could search these areas in map or tabular form or choose a specific research area to search. When users are presented with their search or filtered results, a simple flagging system could indicate in a visual way which thematic area the results belong

to. Users could then proceed to explore this specific thematic area if they so wish. From a management perspective, the thematic area specialists would manage and organise the data at source or in a centralised system that is connected to DROPLET. Subsequently, users to DROPLET would always be presented with the most up-to-date information from all of the thematic areas included. This, of course, is similar to the vision that the INSPIRE Directive has for spatial data in Europe (INSPIRE, 2018). It is also similar in concept to systems such as OpenAIRE (OpenAIRE, 2018).

4.5 Disseminating and Updating the WRI Database

At the time of writing, almost 80 instances of WRI have been uploaded to the new database by more than 20 organisations across 120 locations in Ireland. Key to the success of the WRI database is that it is kept up to date in terms of the range of infrastructure that is available for water research in Ireland. This includes both existing WRI that has not yet been uploaded and new WRI that will become available in the future. This will be a continuous process and will need to be actively managed by the EPA and the funder of water research in Ireland, the WRCG. There are two aspects to ensuring that the database is current and comprehensive: WRI managers must ensure that their RI is up to date on the database and WRI managers and organisations must upload their new and existing WRI. Keeping the database current and up to date will ensure that it is a useful resource for the water research community in Ireland and abroad.

4.5.1 Keeping the database up to date

Water research infrastructure managers who have uploaded their RI to the database should be encouraged to keep the information on their WRI up to date. For example, if the WRI is upgraded or new sensors are added, this should be reflected in the database. Similarly, if the WRI is no longer in use by an organisation, possibly because of lack of funding or lack of staff, this should be updated in the database, as other organisations may be able to reuse the WRI. Keeping the database live can be achieved by communicating with WRI managers through multiple channels, for example email, the EPA Research

Newsletter, social media and the WRI database itself. Appendix 4 presents the communication plan for ensuring that WRI managers keep the database up to date (see Table A4.1).

4.5.2 Adding new and existing WRI

To ensure that the majority of WRI in Ireland is included in the WRI database, dissemination of the database to relevant organisations and water researchers should be carried out in a consistent and planned manner. The WRCG has a key role to play in ensuring that the database is comprehensive, as it has oversight of the funding for WRI in Ireland. The WRCG should champion the WRI database and disseminate the platform to its networks to ensure that publicly funded WRI is uploaded to the database. The WRCG could adopt the following tasks:

- insert a clause into publicly-funded research contracts related to WRI, requiring relevant information to be uploaded to the WRI database;
- publicise the WRI database and DROPLET website through its networks, newsletters, websites, events, etc.;
- publicise the WRI database and DROPLET website outside Ireland.

Appendix 4 presents the communication plan for ensuring that WRI managers and organisations upload their existing and new WRI to the database (see Table A4.2). The key communication channels suggested are inserting a clause in all funding streams for WRI, the WRCG's network, the EPA Research Newsletter, a launch event webinar and social media.

As the database is for the benefit of all WRI managers, it is in their interest to upload their WRI to the database and keep the information current. WRI managers will benefit from publicising their infrastructure on the database as it will increase the possibility of other researchers, from Ireland or abroad, being able to utilise their infrastructure. However, WRI managers and organisations have no compulsion at present to upload their infrastructure. The project team recommends that it be mandatory that all relevant infrastructure for water research that is publicly funded is uploaded to the database and kept up to date. All funding agencies (including government departments) for WRI should include the following suggested text

(once finalised) in all funded contracts and this clause should be included in the letter of offer when a project includes infrastructure:

If your funded research and/or development project includes “water related infrastructure (WRI)” (e.g. laboratories, facilities, equipment, sensors or communication platforms), this must be registered on the EPA’s DROPLET website at <http://erc.epa.ie/droplet/>. All EU General Data Protection Regulation (GDPR) requirements for compliance must be followed.

This website provides a portal to WRI for government, institutes, researchers, state agencies, semi-states and industry. It has been supported by EPA funding for the betterment of research and monitoring of the catchment areas in Ireland, together with activity in research institutes.

4.6 Disseminating to the Water Research Community

The addition of the WRI database to DROPLET is an opportunity to re-invigorate interest in DROPLET. Keeping the database current and up to date will ensure that it is a useful resource for the water research community in Ireland and abroad.

4.6.1 Launch event

To publicise the new WRI database to the water research community in Ireland, an online webinar was organised to officially launch the database on 9 October 2018. This was chosen as the ideal platform, to allow more people to view the launch event by leveraging communication technology. The aim of the webinar was to (1) officially launch the WRI database and publicise it to the water research community and (2) demonstrate how to use the website, search for WRI and upload WRI to the database. The target audience for the webinar was the WRCG, RI managers who had uploaded their WRI and any other water researchers in Ireland. The webinar consisted of an introduction, overview of the project and outputs, a recorded tutorial of how to use the WRI database and DROPLET and a question and answer session. In total, 43 people registered and 24 attended the webinar. The webinar was recorded and sent to those who registered but could not attend.

4.6.2 Water research community communications plan

Information about the WRI database and DROPLET should be disseminated to the water research community in a planned way to maximise the above benefits and opportunities. Appendix 4 presents the communication plan for achieving this and the multiple channels that can be leveraged (see Table A4.3):

- The organisations of the WRCG have a role to play in disseminating the platform to water researchers in Ireland and abroad through its networks, websites, newsletters and events.
- It is recommended that the EPA Research Newsletter includes a section on DROPLET and the WRI database. This section would highlight key WRI and link to the WRI web page. Additionally, new WRI uploaded to the database should be listed.
- Information on the WRI database and DROPLET would be disseminated by the EPA at any relevant water events, including the EPA National Water Event. Additionally, EPA Research staff could promote the platform if they are presenting at relevant events, i.e. by including a slide in their presentation.
- Social media can play an important role in reaching a wider audience and it can leverage the existing following on the EPA Research Twitter and LinkedIn pages. Each month a new WRI could be highlighted, or a “good news” story about a WRI could be added, and the link to the DROPLET web page provided, similar to the MERIL portal Twitter page. Additionally, social media could be used to notify when a new WRI is added to the database. Any posts should have a dedicated hashtag, such as #DROPLET.
- Marketing materials could be developed to promote the WRI database and DROPLET at events, e.g. flyers, brochures or pop-up banners.
- It will be important to advertise the WRI database outside Ireland. The EPA and WRCG can raise awareness internationally by disseminating information through the Water Joint Programming Initiative (JPI) forum (<http://www.waterjpi.eu/>) at international water events/conferences and through European projects. The MERIL portal (<https://portal.meril.eu/>) of European RIs, which is currently under redevelopment, provides another opportunity to disseminate information internationally.

4.7 WRI Database Conclusion

The main aim of this project was to comprehensively research, identify and map the location of all relevant WRI around Ireland and then transform the resulting database into an online website to allow the water research community to easily access the information. The WRI database will help to connect the water research community by giving researchers access to information on WRI in Ireland such as facilities, services and areas of research. This will help researchers to pursue new opportunities and to partner and collaborate with colleagues, particularly those in interdisciplinary teams. In addition, the database will help to ensure effective planning for future WRI, by identifying gaps in existing infrastructure and opportunities for new infrastructure. The WRI database, with access through the DROPLET website, will benefit the water research community in a number of ways. In particular, the database:

- acts as a central hub for information on all WRI in Ireland, including the types of WRI available for various research areas and applications, from freshwater to the marine environment, climate and agriculture;
- raises the profile of individual WRIs, providing opportunities for collaborations and projects;
- provides opportunities for researchers and organisations to utilise existing available WRI;
- helps identify WRI that may no longer be utilised and that can be repurposed or sold to other organisations;
- highlights the types of WRI and water research areas in Ireland to international water researchers and organisations, increasing the opportunities for collaboration and new projects;
- aids policymakers and funders of WRI to analyse and optimise the national WRI funding landscape by, for example, identifying gaps and opportunities at a national level.

Data submission by organisations and RI managers currently occurs on a voluntary basis. HEIs, research institutes, state bodies and water researchers have been invited to contribute to the database. This means that the range of RIs included in the database at the conclusion of this project is not yet exhaustive. The data are provided by the RI managers who are responsible for the WRI, so the accuracy and

completeness of the information provided is reliant on the research community itself. In future, it is envisaged that uploading such information should be made a requirement of the funding agreement for WRI projects.

The database has been designed to make it easy to navigate. Many of the description fields are banded, for example for platform type, research area, sensor type and communications type. However, these can be updated by the EPA administrator. The WRI database is open access meaning that users can access the data freely; however, they must acknowledge the WRI database or DROPLET in all publications that use WRI data. For example, a researcher could find a WRI by platform type, research area or geographical location, or policymakers may wish to see what is currently being funded and by which funding entities. Data protection issues have been considered in the design of the database. It complies with all data-hosting regulations, and personal data are treated in line with data protection laws (including GDPR) established in Europe.

The major technical achievement of the project is the creation of the new WRI database and its integration with DROPLET. These two databases were designed independently, but by using a shared metadata approach the DROPLET system can allow the dissemination of information from both systems in a seamless and efficient manner. The ambition for the WRI database and DROPLET platform is for it to be much more than a simple repository of information. The aim is to provide a destination website with dynamic content about WRI, which will enable better use of existing resources and planning of future resources than is currently possible.

A future vision for the EPA and DROPLET would be to consider a broadly thematic-based approach to the organisation, management and dissemination of research data and information. This integration hints at the possibilities of expanding the remit of DROPLET to include different thematic/research areas (soils, waste, air, biodiversity, health and well-being, etc.). The development of the WRI database has been funded by the EPA; however, in order to ensure that the data are kept up to date, and to deliver sustained impact, the portal needs to be managed and funded on an ongoing basis.

5 Water Research Infrastructure Roadmap

5.1 WRI Literature Review

Large RI is among the biggest scientific expenditure; frequently, large capital investments are required, as well as there being associated ongoing operational costs. Therefore, there is a need to bring resources together and for collaboration on a national, European or even global scale. At the European level, the European Commission (EC) has set out its position in a number of papers (EC, 2011), (EC, 2012), (EC, 2016); and the ESFRI roadmap (ESFRI, 2016) and the RI support schemes under the EU Framework Programmes address the collaboration challenge. Through international collaborations and participation in EU-funded projects, researchers are able to increase access to and secure funding for infrastructures. At the national level, many countries have developed an RI roadmap; Ireland developed such a roadmap in 2007, called “Research Infrastructure in Ireland – Building for Tomorrow” (Forfás, 2007).

A literature review was conducted for the WRI roadmap. This included an overview of the European RI roadmap from ESFRI and EU supports for RI. WRIs (freshwater, marine, biosphere) in the ESFRI roadmap 2016 (ESFRI, 2016) with a focus on RI projects in which Ireland is a participant were also reviewed. To learn from other national RI strategies, the national RI roadmaps of five European countries (Germany, Finland, France, the Netherlands and the UK) that lead in innovation and research funding were examined.

The literature review also examined relevant Irish science, technology and innovation (STI) strategies to gain an understanding of the research landscape and priority areas and how they relate to water research. Ireland’s strategy for STI to 2020, Innovation 2020 (DBEI, 2015), sets out a roadmap for making Ireland a global innovation leader. Key to delivering this vision is a commitment to increasing public and private investment in research, which will target RI, including an action to scope out and develop a successor to the PRTLTI to support investment in new and existing RI.

Ireland’s RI roadmap and strategies were reviewed, including funding and accessibility. It is important to

note that these strategies and documents principally relate to RI of national, and even European, importance. Ireland’s national RI roadmap was published in 2007 by the HEA and Forfás (Forfás, 2007). The purpose of the report was to internationally benchmark RI in the higher education sector, in particular, and to identify gaps in the national platform of RI, which could be addressed in the short to medium term. The National Research Prioritisation Steering Group issued a Report in 2012 (Forfás, 2012); and a First Progress Report in 2014 (Forfás, 2014). In 2015, an update of Ireland’s RI strategy was published, called “Ireland’s Future Research Infrastructure Needs” (Technopolis, 2015). That study focused on investments of greater than €700,000 and had the following objectives: (1) take stock of the RI investments made to date, in light of the national STI priorities, and (2) identify any future investment needs in the period to 2020 (and beyond) that may be strategically required for the achievement of national STI priorities. The emphasis of the study was on meeting the second objective, and the approach combined desk research, interviews, a survey about future RI needs and six workshops.

Substantial investment in RIs in Ireland has taken place through programmes such as PRTLTI, run by HEA, and through funding from the SFI. Other investments in RI have been made by the EC, mainly through FP7, by universities and IOTs (e.g. from core funding), by research institutes such as Tyndall, Teagasc and the Marine Institute (e.g. from block grants) and as part of research calls by domain-specific departments and public agencies (Enterprise Ireland, Health Research Board, EPA, etc.). The PRTLTI was funded under the NDPs (2000–2006, 2007–2011) with assistance from the European Regional Development Fund (ERDF) and with private funding through a public/private financial framework. The programme has invested in five types of RI: buildings (large RIs), specific items of research equipment, research centres, research programmes and structured PhD programmes.

The SFI supports investment in RIs through dedicated funding calls and other programmes, including the

Research Infrastructure Programme. The emphasis is on collaborative efforts and on liaising with industry, with the goal of strengthening and sustaining Ireland's research base. The SFI's 2020 Agenda sets out its strategic plan for the period 2013–2020 (SFI, 2012). The current SFI Research Infrastructure Programme 2018 (SFI, 2018) encourages the efficient use, renewal and development of existing national RIs, whilst also recognising the need for continued investment in cutting-edge research equipment and infrastructure, in areas of national priority of particular relevance to SFI's prior and future investments. SFI funding calls for RI are focused on RI valued at over €500,000, and it is highly encouraged that significant (~30%) non-SFI in-kind cost share contributions will be obtained, including a minimum of 10% cash support from the research body. The eligible costs include the costs of new equipment or equipment upgrades, maintenance or service contracts (for up to 2 years from the purchase date) and materials and consumables required to set up or operate the equipment and large equipment installation costs and software and training costs.

The importance of access models for RI is addressed by the SFI in its *Guidelines for Preparing a Research Infrastructure Access Charge Plan* (SFI, 2016), as well as by the HEA in its *National Guidelines for Access by Researchers to Research Infrastructure Hosted by Higher Education Institutions or other Research Bodies in Ireland* (HEA, 2017). The widest possible access to RI is considered to increase the value for money for the state and for the research community in general. The HEA national guidelines should apply, in so far as is practicable, to all items of RI hosted in publicly funded higher education and research institutions. The HEA acknowledges that the enabling of access to RI by other researchers from Ireland and internationally, as well as industry, has cost implications. It also recognises that proper access to RI requires that there be in place a professional and customer-orientated support service. The HEA guidelines also cover institutions' access policies, access rates (full commercial rates for industry), use of RI by external users and the role of research funders. These accessibility guidelines from the HEA, as well as those from the SFI, are most applicable to medium to large RIs, with a value of greater than €100,000.

Water is a broad research area and consists of a number of sub-areas, ranging from freshwater

(rivers, lakes, catchments and groundwater) to the marine environment (coasts, oceans and ice caps) and the biodiversity of these ecosystems. This results in numerous and diverse organisations being involved in setting the strategy and funding for water research and, in turn, RI. The EPA Research Water Pillar covers groundwater, surface water and transitional and coastal water, as well as wastewater, drinking water, bathing water and shellfish waters. There are five thematic areas under the EPA Research Water Pillar for 2014–2020 (EPA, 2014) through which organisations can apply for research funding to address a particular call: safe water; ecosystem services and sustainability; innovative water technologies; understanding, managing and conserving our water resources; and emerging and cross-cutting issues. Through these calls, small RI such as equipment, with a value of less than €500,000, may be procured or developed.

The WRCG is a research funders' forum where research priorities for inclusion in calls for research proposals and longer-term objectives are presented and discussed, with the aim of enhancing synergies and collaboration with other national funders. It currently comprises the EPA, Enterprise Ireland, the Department of Communications, Climate Action and Environment, the Department of Agriculture, Food and the Marine, the Department of Housing, Planning and Local Government, the National Parks and Wildlife Service, Teagasc, the SFI, the Irish Research Council, the Geological Survey Ireland, the Marine Institute, Inland Fisheries Ireland, the Office of Public Works, Met Éireann, the Sustainable Energy Authority of Ireland (SEAI), Irish Water and the Irish Environmental Network. The wide-ranging array of 17 funding organisations shows the diversity of water-related research across areas and stakeholders.

Innovation 2020 commits to marine research and harvesting the energy of the sea. The National Marine Research and Innovation Strategy 2017–2021 provides a framework for research funders to assess the impact of and likely return to the state from research investment in marine-related research themes and to ensure that Irish marine research can compete at an international level (Marine Institute, 2017). Part of the Research Maturity Capability Assessment examines RI and applies one of five levels of capability ranging from “ad hoc” to “translational”.

Water research in Ireland is well connected to water research programmes in Europe. HEIs and research-performing organisations have participated in European water-related research projects under Interreg Europe, the EU Framework Programme for research and innovation, Horizon 2020 and the JPIs. The EPA has been involved in two of the 10 JPIs since their inception: the Water JPI, as a full member and co-chair since 2014, and the Climate JPI, as a full member and chair since 2017. The European Innovation Partnership (EIP) on Water facilitates the development of innovative solutions to address major European and global water challenges. At the same time, the EIP on Water supports the creation of market opportunities for these innovations, both inside and outside Europe. It was implemented in May 2013 with the main objective being to initiate and promote collaborative processes for change and innovation in the water sector across the public and private sector, non-governmental organisations and the general public. EPA Research had been participating in the working groups of this EIP; however, because of the recent lack of activity of this initiative, it has had no involvement since 2016/17. As the definition of water research can be quite broad, to include both freshwater and marine environments, there is a similarly diverse range of organisations involved in the research strategies and funding for water research in Ireland. These organisations fund small WRIs. Presently, there is no one organisation that oversees all water research and WRIs in Ireland.

5.2 Engagement of WRI Managers

Stakeholder engagement with 14 WRI managers in Ireland was undertaken during the data collection phase of the project (see Appendix 5 for a list of the WRI managers interviewed). From the literature review, key topics were identified that are important in developing a roadmap for WRI in Ireland. These key topics were discussed with WRI managers using semi-structured interviews, in person or by telephone, during the data collection phase of the project. The key topics discussed were as follows:

1. Strengths/weakness: what is your opinion on Ireland's current WRI?
2. Accessibility: how does a researcher/organisation access your RI? Are there any issues in relation to making your RI accessible?

3. Sustainability: is the sustainability of WRI an issue for WRI managers? What happens to a RI after a project or funding ends?
4. Funding: is there sufficient funding for WRI in Ireland? Are there any funding gaps for WRI in Ireland, for example water research areas, types of RI, cost bands (<€100,000, €100–500,000, >€500,000), accessibility and sustainability?
5. Promotion and international collaboration: how can we promote Ireland's WRI both nationally and internationally to increase collaboration?
6. EU R&D calls: in your opinion, does Ireland have the necessary WRI to address European drivers and societal challenges?
7. Gaps and opportunities: could you suggest three key areas of Ireland's WRI that need to be improved?

5.3 WRI Roadmap Conclusions and Recommendations

This study examined the WRI landscape in Ireland through a literature review of international and national strategies and documents, an appraisal of the RI uploaded to the WRI database and interviews with WRI managers. The following observations are made on the present status of WRI in Ireland, as well as recommendations on how best to develop WRI in the future. This is not intended to be a comprehensive detailed roadmap, which is beyond the scope of this project.

5.3.1 Strengths

In general, the quality of water research in Ireland is excellent: there is good WRI nationally and an active research community in the water area. There are a number of funding organisations of water research and infrastructure in Ireland, brought together by the WRCG. Ireland has national WRIs such as Lir National Ocean Test Facility and the Coastal & Marine Research Centre Beaufort Laboratory (MaREI), the Coastal Observing Radar System (CODAR), SEAL's Atlantic Marine Energy Test Site (AMETS), SmartBay Ireland's Galway Bay Sub Sea Cable Observatory, the Marine Institute's research vessels fleet and remotely operated vehicles, the National University of Ireland Galway/EPA water research facility at Tuam

Wastewater Treatment Plant, Queen's University Belfast's wave test sites and real-time water level data from the Office of Public Works. RI managers noted the excellent marine RI that has been developed and supported in Ireland. Although Ireland also has national RI for freshwater research, some RI managers felt that Ireland's freshwater RI was not at same high level as Ireland's marine RI.

5.3.2 Size

A detailed (future) WRI roadmap should focus on large RI of national and international importance, with the aim of attracting international researchers and advancing world-class research. There are currently national funding calls that focus on RI with a value of greater than €500,000. Funding for RI, in particular for WRI, with a value of less than €500,000 is spread across a number of funding agencies. Specific funding streams are required for both large RI and smaller RI, which should be part of an overall strategy for WRI.

5.3.3 Research area

A roadmap for WRI in Ireland should incorporate a top-down approach by taking account of ESFRI strategy areas and Irish STI priority areas and a bottom-up approach by engaging with the water research community to assess their infrastructure needs. This can be achieved through stakeholder engagement interviews and analysis of the WRI database.

5.3.4 Accessibility

The HEA has set out national guidelines to allow researchers and industry to access and use RI hosted in publicly funded higher education and research institutions. For large RI, the SFI requires well-developed access plans, including indications about access charges, as part of proposals for RIs. In general, large WRIs have an accessibility procedure in place and medium to smaller RIs operate on an ad hoc or informal basis. Marine RIs benefit from several funding streams that provide access to the RI; freshwater RIs would benefit from similar access funding streams. The accessibility to RI depends on having the necessary resources/staff to operate the equipment or facility and deal with incoming requests. Some RI managers noted that they do not have the

resources/staff to engage with external researchers and industry.

5.3.5 Sustainability

A long-term financial commitment should underpin any roadmap for WRI. RI investments require a dedicated and long-term strategy to allow for directed and sustainable funding. A sustainability plan is a requirement for large RIs, to show value for money. Having an operational model for WRI is very important and requires the support of the research organisation or university where it is hosted. The sustainability of smaller RIs is difficult as they may be associated with particular projects, principal investigators or researchers; they are less visible and may not have long-term funding to maintain and operate them. RI managers suggested that more responsibility needs to be taken on by the hosting organisation or university to ensure that, after the initial funding ends for the RI, project or staff, there is a plan and funding in place to maintain the RI and make it available to the research community. It was suggested that an RI sustainability plan could include the condition that the research centre or university ensures the funding and sustainability of the RI for a minimum of 2 years after the initial funding or project ends. This points to a need for sustainability planning at an early stage for larger RI, including development of a suitable "business model" or financial plan, to clarify and delineate opex expectations of the host organisation compared with future project funding and industry contributions. RI managers also noted that there is a great deal of small WRI and equipment with a value of less than €500,000 in HEIs and research organisations that is not in use or is unavailable as there are no resources or staff to operate it. This highlights an opportunity to share, recycle or sell small RI after an organisation is finished with it or can no longer operate it. This could be achieved through an online disposal or swapping forum for RI that is no longer in use, with RI disposed of or swapped for free or for a cost.

5.3.6 Funding

Substantial investment in WRI in Ireland has taken place through programmes such as PRTL and through the SFI, EU funding (Horizon 2020 and FP7), EPA Research, HEIs and research institutes, such

as the Marine Institute. These organisations provide a range of funding for WRI of various sizes and costs, for example the SFI Research Infrastructure Programme 2018 is focused on RI with a value of greater than €500,000. Various types of funding needs were discussed with RI managers, ranging from funding for specific research areas to funding for different types of RIs, different cost bands, accessibility, operation and sustainability. Prioritising funding for RIs across these areas is a difficult task. Large-scale, national WRI is required to engage in and attract international research; however, there is also a need to fund smaller RI across a diverse research area. Additionally, there is the issue of investing in new RI needs, while supporting existing RI and ensuring that it is operational and sustainable. A WRI roadmap should take account of the various funding needs and the diverse funding organisations. Specific funding for the operation and management of WRI would be beneficial. It was noted that funding for the maintenance and running of RIs should increase, even if this means that there is less funding for new RI, as there is already a lot of duplication of RI in Ireland. If it meets certain criteria and is deemed valuable, funding to extend a project using WRI would improve sustainability. Large-scale funding for national WRI is needed and a long-term financial commitment should underpin the investment. Additionally, a specific fund should be set up by the government for WRI with a value of less than €500,000, similar to Action 4 of the National Marine Research and Innovation Strategy 2017–2021, which proposes a call for marine-related equipment and small-scale infrastructure to complement calls by other funders such as the SFI. The WRCG should co-ordinate funding for WRI and develop a strategy to fund WRI with regard to:

- WRI size: large (>€500,000), medium (€500–100,000) and small (<€100,000);
- specific water research areas;
- accessibility programmes, to fund access to the WRI;
- sustainability programmes, to continue funding of the management and operation of existing WRI or repurposing of old WRI.

5.3.7 Co-ordination of the WRI strategy

The definition of water research is broad and thus there is a diverse range of organisations involved

in research strategies and the funding of WRI in Ireland. Presently, there is no one organisation that oversees all WRI funding and planning in Ireland. The co-ordination of all funding of WRI in Ireland, for different research areas and RIs of different sizes, is lacking. The WRCG, which brings together the funders of water research in Ireland, should take on the role of managing WRI strategies and funding.

5.3.8 Irish Water's infrastructure

Having access to operational water and wastewater treatment plants is key for trialling and demonstrating new technologies. Irish Water, as Ireland's national water utility, is ideally placed to be a key actor in Ireland's water research and innovation activities, having a wide range of water- and wastewater-related assets under its remit. Irish Water actively engages with research organisations and private sector companies to facilitate requests for data and/or physical samples from Irish Water-owned/controlled assets and to trial technologies and is involved in R&D collaborations for both nationally and internationally funded projects. These activities are worth supporting and encouraging as they provide a cost-effective route to access such infrastructure for research and innovation, even though the sites in question are not dedicated RIs but rather exist primarily to serve the water and wastewater needs of the public. Irish Water is amenable to facilitating third parties in research projects and testing of pilot or demonstration-scale systems that address core business needs using Irish Water assets, subject to all associated costs (i.e. relating to installation, commissioning, operation, monitoring and decommissioning) being covered by external funding. When access to Irish Water assets is involved, this will be subject to all health and safety, insurance and contractual obligations being addressed.

5.3.9 Promotion and international collaboration

Promoting Ireland's WRI and facilitating international collaboration is important to efficiently utilise the RI that is currently available and increase international research activity. The WRI database will be of assistance to the research community to advertise the available RI and who owns it. The database should be promoted internationally, at conferences

and in EU projects, for example using brochures and marketing material for the database. Social media can also play a role in raising the profile of individual WRI in Ireland and disseminating the WRI database and DROPLET.

5.3.10 Addressing EU R&D calls

Aligning infrastructure funding with upcoming calls of programmes such as Horizon 2020, Interreg and JPIs to increase what Ireland can bring to the table is critical. In addition, importantly, human capacity must be supported to run, maintain and fully utilise the output of the infrastructure. Regarding marine RI, Ireland has excellent national research facilities, as discussed previously, that can compete at an international level. Ireland also has new international WRI coming on stream, such as the ExStream MesoCosm, and the DANUBIUS-RI has its Technology Transfer Office in Ireland. Ireland also has a number of national water quality monitoring projects such as SmartCoast, Pathways and the Agriculture Catchments Programme. However, some RI managers felt that Ireland's freshwater RI was not at the same high level as Ireland's marine RI. Therefore, international researchers may not consider Ireland when developing project proposals around freshwater research areas.

5.3.11 WRI gaps and opportunities

The RI managers were asked how Ireland's WRI could be improved and to suggest specific water research areas and infrastructure that should be funded. Although Ireland has national marine RI, some RI managers suggested that it is not as well known as a leader internationally in freshwater research and does not have national freshwater RI on the same scale as in the marine sector. The gaps identified and opportunities for future investment are presented below. Further appraisal is needed of the suggested WRI gaps and these should be evaluated in line with current WRI investments and strategies, which is outside the scope of this report.

- A national research centre for freshwater (including drinking water and wastewater treatment) research, similar to the Marine Institute – this could operate as a hub-and-spoke model, incorporating the existing infrastructures and

research capabilities in organisations already in this area in Ireland.

- A national water monitoring network, leveraging the internet of things for Ireland's water sector – this should combine existing water monitoring networks and add new ones to create a national RI.
- A centre of excellence for hydraulics research – the Laboratory of Hydraulic Constructions of the Swiss Federal Institute of Technology Lausanne (EPFL) is a best-in-class example of this. It focuses on hydroelectric structures and dams, water supply systems in rural and urban areas and river draining works, as well as extreme flood determination and the safety of hydraulic structures.
- An Irish stable isotope research centre for water testing and research – testing for isotopes must currently be carried out in the USA or Germany; this is particularly relevant for the emerging contaminants in wastewater, as it is not possible to test for these in groundwater and drinking water in Ireland, as it is either too expensive or too time-consuming.
- Increasing the available water-related data in Ireland, building on existing open data portals (e.g. the HYDRONet and WISKI portals), would benefit the research community. Potential areas include a national soil hydrology map for water; a national LIDAR map to predict water movement of < 1 metre for agriculture land drainage maps; increased monitoring of and data on estuaries and rivers; and alignment of EPA sampling sites for chemical and biological testing.
- Regional projects and infrastructure to address social, environmental and economic challenges related to water that engage all stakeholders from research, industry and government and the general public, for example the Lungs of the City Eindhoven project (ENS Clean Air, 2018) or ESB Networks' Dingle Project (ESB Networks, 2018).

The outcomes and data from this project can aid policymakers regarding:

- Ireland's future STI strategies, building on Innovation 2020 (DBEI, 2015);
- the preparation of future national RI roadmaps;
- the planning and funding of future WRI for the funders of water research via the WRCG;

- the next funding cycle of the PRTL to support investment in new and existing RI;
- the SFI's RI programme;
- the design of future funding calls in the EPA's Research Programme 2014–2020 on specific WRI or further development of DROPLET to include other research areas;
- the current and future EPA Research Programme Strategy;
- the current and future National Marine Research and Innovation Strategy.

To conduct excellent water research, appropriate RI is required that has ease of access and support services and that is open to innovation. Smart and connected WRI is critical to help meet this need across the water sector (e.g. water/wastewater treatment, marine environment, freshwater, catchments). The existing WRIs in Ireland are diverse and in most cases state of the art. This report provides a review of the WRI landscape and recommendations for a roadmap for WRI in Ireland.

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Abbreviations

APDRI	Austrian Public Database of Research Infrastructures
CODAR	Coastal Observing Radar System
DROPLET	Database of Research Outputs: Projects Literature and Environmental Technologies
EC	European Commission
EIP	European Innovation Partnership
EPA	Environmental Protection Agency
EPOS	European Plate Observing System
ERDF	European Regional Development Fund
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
FP7	Framework Programme 7
HEA	Higher Education Authority
HEI	Higher education institute
iCRAG	Irish Centre for Research in Applied Geosciences
ICT	Information and communications technology
IOT	Institute of technology
JPI	Joint Programming Initiative
LIRE	Large Items of Research Equipment
MaREI	Centre for Marine and Renewable Energy
MERIL	Mapping of the European Research Infrastructure Landscape
NCP	National Contact Point
NDP	National Development Plan
PRTL	Programme of Research in Third Level Institutions
R&D	Research and development
RI	Research infrastructure
RICH	Research Infrastructures Consortium for Horizon 2020
RIDE	Research Infrastructure Database for EPOS
SEAI	Sustainable Energy Authority of Ireland
SFI	Science Foundation Ireland
STI	Science, technology and innovation
WRCG	Water Research Coordination Group
WRI	Water research infrastructure
WSSIC	Water Systems and Services Innovation Centre

Appendix 1 Water Research Infrastructure Data Collection Form

The chart below has been completed for illustrative purposes only.

Infrastructure name	Water quality monitoring buoy					
Research area	Surface waters	Water quality and monitoring				
Lead organisation	Nimbus Centre, Cork Institute of Technology					
Lead funding entity	Nimbus Centre, Cork Institute of Technology					
Platform type	Remote observation system	Sensor platform				
Sensor type	Flow velocity	Water level	Turbidity	Temperature	pH	
Communications type	LoRa					
Location	Blackwater River, Mallow, Co. Cork					
Catchment	Blackwater (Munster)					
Longitude, latitude	51.886469, -8.535401					
Approximate date of deployment	10/02/2015					
Approximate date of planned retirement	10/10/2015					
Website	http://nimbus.cit.ie/					
Accessible	Yes					
Contact point	Kevin Fitzgibbon					
Contact point email	Kevin.Fitzgibbon@cit.ie					
RI keywords	Water monitoring, water quality, sensors, communications					
Platform description and application	Low-cost monitoring buoy to gather, analyse, transmit and use water quality data from Ireland's river network. Collecting data on water depth, current speed, pH, temperature and turbidity; trialling of new sensors in the water environment; trialling of new data communications methods					

Appendix 2 Organisations Contacted

WRCG

- EPA
- Enterprise Ireland
- Department of Housing, Planning, Community and Local Government
- Department of Agriculture
- Department of Culture, Heritage and the Gaeltacht
- Teagasc
- SEAI
- SFI
- Irish Research Council
- Geological Survey Ireland
- Marine Institute
- Inland Fisheries Ireland
- Office of Public Works
- Irish Water
- Met Éireann
- Health Service Executive National Drinking Water Group
- Health Service Executive Health and Wellbeing Division
- Northern Ireland Department of Agriculture, Environment and Rural Affairs

University Research Offices

- Dublin City University (DCU)
- Maynooth University (MU)
- National University of Ireland Galway (NUIG)
- Trinity College Dublin (TCD)
- University College Cork (UCC)
- University College Dublin (UCD)
- University of Limerick (UL)

Institute of Technology Research Offices

- Athlone Institute of Technology (AIT)
- Cork Institute of Technology (CIT)
- Dublin Institute of Technology (DIT)
- Dundalk Institute of Technology (DkIT)
- Galway-Mayo Institute of Technology (GMIT)
- Institute of Technology Carlow (ITC)
- Institute of Technology Tralee (ITT)
- Letterkenny Institute of Technology (LYIT)
- Limerick Institute of Technology (LIT)
- Sligo Institute of Technology (SIT)
- Waterford Institute of Technology (WIT)

College Research Offices

- National Maritime College of Ireland (NMCI)

Research Centres and Groups

- Aquaculture & Fisheries Development Centre (UCC)
- Aquatic Services Unit (UCC)
- Atmospheric Science Research Group (NUIG)
- Bernal Institute (UL)
- Centre for Biodiversity Research (TCD)
- Centre for Climate and Air Pollution Studies (NUIG)
- Centre for Environmental Research (UL)
- Centre for Freshwater and Environmental Studies (DKIT)
- Centre for Ocean Energy Research (MU)
- Centre for Water Resources Research (UCD)
- Dairy Processing Technology Centre (UL)
- Earth Institute (UCD)
- Environmental Research Institute (UCC)
- Halpin Research Centre – National Maritime College of Ireland (NCMI)
- ICARUS (MU)
- iCRAG
- Lir National Ocean Test Facility
- MaREI
- Marine and Freshwater Research Centre (GMIT)
- Marine Institute
- Materials and Surface Science Institute (UL)
- Mobile and Marine Robotics Research Centre (UL)
- Ryan Institute (NUIG)
- SmartBay Ireland
- Trinity Centre for the Environment (TCD)
- Tyndall Institute
- Water Innovation Research Centre (DIT)
- Water Institute (DCU)
- Water Technology Research Group (TCD)

HEI schools and departments

- DIT School of Chemical and Pharmaceutical Sciences
- MU Department of Electronic Engineering
- NUIG College of Engineering and Informatics
- NUIG Natural Sciences Department
- TCD School of Engineering
- TCD School of Natural Sciences
- UCC Civil and Environmental Engineering
- UCC School of Biological, Earth and Environmental Sciences
- UCC School of Chemistry
- UCC School of Chemistry
- UCC School of Microbiology
- UCC School of Zoology
- UCD School of Biology and Environmental Science

Appendix 3 Water Research Infrastructure Database

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
Agricultural Catchments Programme	Water Quality and Monitoring	Teagasc	Department of Agriculture, Food and the Marine	Dataset Field Equipment Field Trial Site	Catchments: Sreenty/Corduff (Co Monaghan), Dunleer (Co Louth), Cregduff (Co Mayo), Ballycanew (Co Wexford), Castledockerell (Co Wexford) and Timoleague (Co Cork).
Cells Hydroponic Environmental Growth Chamber facility	Agriculture	Controlled Environmental Life Science Research Group	Limerick Institute of Technology (LIT)	Laboratory	Limerick Institute of Technology, Moylish Park, Limerick
Climate Reanalysis dataset	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Dataset	MÉRA model domain covers Ireland, UK, parts of Atlantic Ocean and NW France (Graphic is available on website below)
Daily Rainfall Observations	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Dataset Observation Network	Nationwide - 25 Hourly rainfall stations
Data Buoy/Irish Weather Buoy Network	Marine Environment	Met Éireann	Department of Transport, Tourism and Sport (DTTAS) Marine Institute	Sensor platform	5 buoy positions (see website)
Deepwater Remotely Operate Vehicle (ROV) Holland 1	Marine Environment	Marine Institute	Department of Agriculture, Food and the Marine National Development Plan (NDP)	Remotely Operated Vehicle	Marine Institute, Galway
Dive Gear	Marine Environment Water Ecosystems	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Field Equipment	MaREI Centre, Ringaskiddy, Co. Cork
Ecological Research Facility	Other Water Ecosystems (Ecology)	Teagasc		Field Trial Site	3 sub-catchments in Kerry
Electrical Resistivity Tomography	Other (Geology)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Geological Survey Ireland
EPANUI Galway Water Research Facility	Water and Wastewater Treatment	NUI Galway	Environmental Protection Agency (EPA)	Field Trial Site	Tuam, Co. Galway

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
ESB Hydrometric Data	Surface Waters	ESB		Dataset Remote Observation System	Multiple locations on ESB dams and reservoirs: Clady Hydro Station, Cathleen's Fall Generating Station, Beleek Road, Tully, Ballyshannon, County Donegal, Leixlip Dam, Golden falls Dam, Poulaphouca Dam, Ardnacrusha dam, Inniscarra Dam, Carrigadroh
ExStream System	Climate Water Ecosystems	University College Dublin	University College Dublin (UCD)	Field Trial Site	University College Dublin, Belfield, Dublin 4
Galway Bay Radar System	Marine Environment	NUI Galway	PRTL	Remote Observation System	Two masts - one at Mutton Island and one at Spiddal Pier
Gridded Daily Rainfall Observations	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Dataset Observation Network	Nationwide
Ground Penetrating Radar	Other (Geology, geotechnical engineering)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Haddington Rd, Beggar's Bush, Dublin
Ground Penetrating Radar	Other (Geology, geotechnical engineering)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Haddington Rd, Beggar's Bush, Dublin
GSI Groundwater Data	Groundwater	Geological Survey Ireland	Department of Communications, Climate Action and Environment	Dataset	Geological Survey of Ireland, Haddington Rd, Beggar's Bush, Dublin
HARMONIE - Numerical Weather Prediction Forecast Dataset	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Data Analytics and Modelling Dataset	The HARMONIE model domain covers Ireland, UK, parts of Atlantic Ocean and NW France
Hourly Rainfall Observations	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Dataset Observation Network	Nationwide - 25 hourly rainfall stations
Hydraulic Structures Test Rig	Energy Marine Environment	NUI Galway	Industry Funding	Laboratory Equipment	Hydraulics and Aerodynamics Laboratory, NUI Galway
Hydrometry CBS Tide Gauges	Marine Environment Other (Marine Technology)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Geological Survey of Ireland, Haddington Rd, Beggar's Bush, Dublin
Ireland's National Argo Programme	Climate Marine Environment Water Quality and Monitoring	Marine Institute	Department of Agriculture, Food and the Marine	Field Equipment Remote Observation System Sensor platform	Galway docks, Co. Galway
Ireland's National Glider Programme	Climate Marine Environment Water Quality and Monitoring	Marine Institute	European Regional Development Fund (ERDF)	Remote Observation System Remotely Operated Vehicle Sensor platform	Galway docks, Co. Galway

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
Irish Hydrometric Reference Network	Climate	Irish Climate Analysis and Research Unit (ICARUS), Maynooth University	Environmental Protection Agency (EPA)	Data Analytics and Modelling Dataset	National - held at Maynooth
Irish National Seabed Survey Data	Sea and Ocean	Marine Institute	Department of Communications, Climate Action and Environment	Dataset	Marine Institute Headquarters, Rinville, Oranmore, Co. Galway
Irish National Tide Gauge Network	Surface Waters	Marine Institute	Marine Institute National Development Plan (NDP)	Sensor platform	30 sites with latitude and longitude (see website)
Lab Fluorometer	Groundwater	Geological Survey Ireland	Department of Communications, Climate Action and Environment	Other ()	GSI, Beggar's Bush, Haddington Road, Dublin D04 K7X4
Lab-based Analytical Instrumentation	Water Quality and Monitoring	School of Chemistry, UCC		Laboratory	School of Chemistry, University College Cork
Large Structures Test Cell	Energy	NUI Galway	European Commission Science Foundation Ireland (SFI)	Other (Structures Test Cell)	Alice Perry Engineering Building, Central Campus, National University of Ireland Galway
Leica GS10 GPS Systems	Other (Geology)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Geological Survey of Ireland, Haddington Rd, Beggar's Bush, Dublin
Lir-NOTF wave and current basins	Energy Marine Environment	Marine and Renewable Energy (MaREI) centre	Science Foundation Ireland (SFI)	Testbed Site	MaREI Centre, Ringaskiddy, Co. Cork
Mace Head Atmospheric Research Station	Climate	NUIG Centre for Climate and Air Pollution Studies	Environmental Protection Agency (EPA) European Commission Science Foundation Ireland (SFI)	Coastal Observatory Remote Observation System Testbed Site	Mace Head, Co. Galway
MaREI Library	Climate Energy Marine Environment Water Ecosystems	Marine and Renewable Energy (MaREI) centre	Science Foundation Ireland (SFI)	Library	MaREI Centre, Ringaskiddy, Co. Cork
MaREI Research vessel	Marine Environment Water Quality and Monitoring	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Research Vessel	MaREI Centre, Ringaskiddy, Co. Cork
Marine Data Online/National Marine Data Centre	Marine Environment	Marine Institute	Marine Institute	Dataset	Marine Institute, Rinville West, Oranmore, Co. Galway
Marine Institute Library / Repository	Marine Environment Sea and Ocean	Marine Institute	Marine Institute	Library	Marine Institute Headquarters, Rinville, Oranmore, Co. Galway, H91 R673

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
Marine Institute Research, Monitoring and Testing Laboratories	Marine Environment Sea and Ocean	Marine Institute	Department of Agriculture, Food and the Marine	Laboratory	Marine Institute Headquarters, Rinvile, Oranmore, Co. Galway, H91 R673
Marine survey equipment	Marine Environment	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Field Equipment	MaREI Centre, Ringaskiddy, Co. Cork
Mobile Remote and Monitoring Control System (MRMC)	Water and Wastewater Treatment	NUI Galway	Environmental Protection Agency (EPA)	Remotely Operated Vehicle	NUI Galway
Monthly Rainfall Observations	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Dataset Observation Network	Nationwide - over 500 daily rainfall stations
Newport Research Facility	Aquaculture Water Ecosystems	Marine Institute	Marine Institute	Research Facility	Marine Institute Catchment Research Facility, Furnace, Newport, Co. Mayo
Nimbus Tide Gauges	Other (Marine Technology)	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Geological Survey of Ireland, Haddington Rd, Beggar's Bush, Dublin
NUIG 10m Wave Tank/Flume	Energy	NUI Galway	Multiple	Laboratory Equipment	Hydraulics and Aerodynamics Laboratory, NUI Galway
Numerical Weather Prediction Forecast Dataset	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Data Analytics and Modelling Dataset	HARMONIE model domain covers Ireland, UK, parts of Atlantic Ocean and NW France (Graphic is available on website below)
Plankton Sampling Equipment	Marine Environment Water Quality and Monitoring	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Field Equipment	MaREI Centre, Ringaskiddy, Co. Cork
Portable automatic sampler fluorometers	Groundwater	Geological Survey Ireland	Department of Communications, Climate Action and Environment	Field Equipment	GSI, Beggar's Bush, Haddington Road, Dublin, D04 K7X4
QIMS (Quantifying Impacts of Multiple Stressors on marine benthic resources)	Marine Environment	Trinity College Dublin	Trinity College Dublin (TCD)	Field Equipment Field Trial Site	Rush North Beach, Co. Dublin
Rain Gauge Network - 69 Rain Gauges	Climate	Office of Public Works	Department of Public Expenditure and Reform	Field Equipment Remote Observation System	Hydrometric Section, Headford, Co. Galway
Rainfall Radar	Climate	Met Éireann	Dept. of Housing, Planning and Local Government	Remote Observation System	Shannon Airport and Dublin Airport
Range of Open Channel Flumes	Surface Waters	NUI Galway	NUI Galway	Other (Hydraulic Test Tank)	NUI Galway

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
Research Vessel Celtic Explorer	Climate Marine Environment Water Ecosystems Water Quality and Monitoring	Marine Institute	Department of Agriculture, Food and the Marine National Development Plan (NDP)	Research Vessel	Galway Dock, Dock Road, Galway
Research Vessel Celtic Voyager	Climate Marine Environment Water Ecosystems Water Quality and Monitoring	Marine Institute	Department of Agriculture, Food and the Marine National Development Plan (NDP)	Research Vessel	Galway Docks, Dock Road, Galway
River Flow Measurement Network	Surface Waters	Office of Public Works	Department of Public Expenditure and Reform	Field Equipment Remote Observation System	Hydrometric Section, Headford, Co. Galway
River Gauge Network - 410 water level stations located across Ireland	Surface Waters	Office of Public Works	Department of Public Expenditure and Reform	Remote Observation System	Hydrometric Section, Headford, Co. Galway
Shannon Applied Biotechnology Centre	Marine Environment	Shannon ABC	Shannon ABC	Laboratory	Limerick and Tralee
Silixa XT-DTS Temperature sensor	Groundwater Surface Waters Water Ecosystems	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Field Equipment	Geological Survey Ireland, Haddington Rd, Beggar's Bush, Dublin
SmartBay Marine and Renewable Energy Test site	Energy Marine Environment	SmartBay Ireland	Sustainable Energy Authority of Ireland (SEAI)	Testbed Site	Spiddle, Co. Galway
Sub-Sea Cabled Observatory	Energy Marine Environment Water Quality and Monitoring	SmartBay Ireland	Sustainable Energy Authority of Ireland (SEAI)	Sensor platform Testbed Site	Spiddle, Co. Galway
System for Bathing Water Quality Monitoring (SWIM)	Water Quality and Monitoring	UCD, School of Computer Science	EU Interreg	Field Equipment Sensor platform	Six weather stations and five water level sensors located at beaches in Northern Ireland
Tank room for fish experiments	Aquaculture Water Ecosystems	Aquaculture and Fisheries Development Centre, UCC	European Research Council (ERC) Science Foundation Ireland (SFI)	Laboratory	North Mall Campus, UCC, Cork
Teagasc Analytical Laboratory	Water Quality and Monitoring	Teagasc	Teagasc	Laboratory	Teagasc, Johnstown Castle, Wexford
Tidal Basin	Marine Environment	NUI Galway	PRTL	Other (Hydraulic Test Tank)	NUI Galway
Turlough hydrograph datasets	Groundwater	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Dataset	Haddington Rd, Beggar's Bush, Dublin
Turlough water level monitoring station	Groundwater	Geological Survey Ireland	Geological Survey of Ireland (GSI)	Remote Observation System	Castleplunket, Turlough/Blackrock, Turlough/Caherglassaun, Turlough
Underwater acoustic monitoring device	Marine Environment Water Quality and Monitoring	Marine and Renewable Energy (MaREI) centre	Marine Institute	Remote Observation System	MaREI Centre, Ringaskiddy, Co. Cork

Infrastructure name	Research area	Lead organisation	Lead funding entities	Platform type	Infrastructure location
Vemco acoustic equipment	Marine Environment Water Quality and Monitoring	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Field Equipment	MaREI Centre, Ringaskiddy, Co. Cork
Visual survey equipment	Marine Environment	Marine and Renewable Energy (MaREI) centre	Marine and Renewable Energy Ireland (MaREI)	Field Equipment	MaREI Centre, Ringaskiddy, Co. Cork
Water level recorder	Groundwater	Geological Survey Ireland	Department of Communications, Climate Action and Environment	Field Trial Site	GSI, Beggar's Bush, Haddington Road, Dublin, D04 K7X4
Water pipeline testbed	Water Quality and Monitoring	Nimbus Centre, Cork Institute of Technology		Testbed Site	Nimbus, CIT, Cork
Water Quality Monitoring Buoy	Surface Waters Water Quality and Monitoring		Nimbus Centre, Cork Institute of Technology (CIT)	Remote Observation System Sensor platform	Nimbus Centre, Cork Institute of Technology Campus, Bishopstown, Cork
Water Quality Monitoring Network	Water Quality and Monitoring	Teagasc	Teagasc	Field Trial Site	Johnstown Castle, Wexford
Water Sampling Kit - 6x Carboys	Marine Environment Water Quality and Monitoring	Irish Naval Service	Environmental Protection Agency (EPA)	Field Equipment	East Coast of Ireland
Waterways Ireland Hydromet Data	Surface Waters	Waterways Ireland		Dataset Field Equipment Observation Network	River Shannon, Grand Canal, Royal Canal, Lough Erne, River Bann
Wave Tank	Marine Environment	NUI Galway	NUI Galway	Other (Hydraulic Test Tank)	NUI Galway
West Coast Radar System	Marine Environment	NUI Galway	EU Interreg	Remote Observation System	Two masts - one at Inisheer Lighthouse and one at Loop Head Lighthouse

Appendix 4 Communication Plans

Table A4.1. Communication plan for ensuring that WRI managers keep the database up to date

Channels	Why did you choose this channel?	Goal	Time frame	Evaluation method	Responsible
Email	To remind WRI managers on the database to keep their RI up to date	Send an email to the RI managers once a year asking them to update the database. Utilise the “User” and “Organisation” export reports for contact information.	Once per year	One email sent per year	EPA administrator
EPA Research Newsletter	To remind WRI managers on the database to keep their RI up to date	The EPA Research Newsletter to have a section about the WRI database and DROPLET platform. This should include a reminder for RI managers to keep the database updated. There should be a hyperlink to link directly to the database and website	Ongoing	Use Google Analytics to monitor traffic from the newsletter to the database on the website through the hyperlink and MailChimp	EPA administrator and communications manager
Social media	To remind WRI managers on the database to keep their RI up to date	Post on Twitter and LinkedIn about the DROPLET website and WRI database to raise awareness among the water research community. Use a dedicated hashtag to differentiate the Tweets, e.g. #DROPLET Post reminders for WRI managers to keep their WRI data up to date	Ongoing	Twitter – one Tweet per month about the WRI database, DROPLET and examples of WRI Record engagement and impressions	EPA administrator and communications manager

Table A4.2. Communication plan for ensuring that WRI managers upload their existing and new WRI to the database

Channels	Why did you choose this channel?	Goal	Time frame	Evaluation method	Responsible
WRCG and clause	To encourage new WRI to be uploaded to the database	All funders of WRIs should make it a condition of funding that WRI data are uploaded to the WRI database and DROPLET platform	Immediately	Clause inserted into all WRCG funding streams for WRI	WRCG
WRCG	To encourage new and existing WRI to be uploaded to the database	The WRCG to champion the WRI database and DROPLET platform by disseminating it through their network, websites, newsletters and events	Ongoing	WRCG to report on dissemination of the WRI database at WRCG meetings	WRCG
EPA Research Newsletter	To encourage new and existing WRI to be uploaded to the database	The EPA Research Newsletter to have a section about the WRI and DROPLET platform. There should be a call to action for WRI managers to upload their WRI data. A link should be included to the DROPLET platform and WRI database	Ongoing	Use Google Analytics to monitor traffic from the newsletter to the database on the website through the hyperlink	EPA administrator and communications manager
Launch event webinar	To encourage WRI managers who have not uploaded their RI to do so	Water researchers will be invited to the WRI database and DROPLET launch event webinar. The new WRI database will be demonstrated and water researchers will be invited to upload any relevant WRI	Second week of October	Number of registrations for the launch event webinar	Water Systems and Services Innovation Centre (WSSIC) project team
Social media	Encourage new and existing WRI to be uploaded to the database	Post on Twitter and LinkedIn about the DROPLET website and WRI database to raise awareness among the water research community. Use a dedicated hashtag to differentiate the Tweets, e.g. #DROPLET	Ongoing	Twitter – one Tweet per month about the WRI database, DROPLET and examples of WRI Record engagement and impressions	EPA administrator and communications manager

Table A4.3. Communication plan for disseminating information about the WRI database and DROPLET to the water research community

Channels	Why did you choose this channel?	Goal	Time frame	Evaluation method	Responsible
WRCG	To keep the water research community up to date about the WRI database	The WRCG to champion the WRI database and DROPLET platform by disseminating it through their network, websites, newsletters and events	Ongoing	WRCG to report on dissemination of WRI database at WRCG meetings	WRCG
EPA Research Newsletter	To keep the water research community up to date about the WRI database	The EPA Research Newsletter to have a section on the DROPLET platform and WRI database. Highlight a national WRI and link to the DROPLET web page. List any new WRI added to the database in the last quarter and link to the WRI database on the DROPLET platform	Ongoing	Use Google Analytics to monitor traffic from the newsletter to the database on the website through the hyperlink	EPA administrator and communications manager
Launch event webinar	To keep the water research community up to date about the WRI database	Water researchers will be invited to the WRI database and DROPLET launch event webinar. The new WRI database will be demonstrated and water researchers will be invited to upload any relevant WRI	Second week of October	Number of registrations at the launch event webinar	WSSIC project team
Events	To keep the water research community up to date about the WRI database	Disseminate the DROPLET website and WRI database at any relevant water events, including the EPA National Water Event Ask EPA Research staff to promote the platform if they are presenting at events, e.g. include a slide on the WRI database	Ongoing	Any event/ conference attended is recorded, including details of the event, stakeholders present and attendance	EPA research staff and communications manager
Social media	To keep the water research community up to date about the WRI database	Post on Twitter and LinkedIn about the DROPLET website and WRI database to raise awareness among the water research community. Use a dedicated hashtag to differentiate the tweets, e.g. #DROPLET Include a post per month that highlights a WRI. Provide the link to that WRI on DROPLET. Post when there is a new WRI added to the database and link to the WRI on DROPLET.	Ongoing	Twitter – one Tweet per month about the WRI database, DROPLET and examples of WRI Record engagement and impressions	EPA administrator and communications manager
Marketing material	To keep the water research community up to date about the WRI database	Create marketing material for DROPLET and the WRI database, e.g. flyers/ brochures. These can be used to disseminate information about the WRI database at events Develop a pop-up banner for DROPLET and the WRI database that can be used at events for promotion	Ongoing	Development of marketing material	EPA administrator and communications manager
Water JPI and international events and projects	Raise awareness internationally about the WRI database	The EPA and WRCG to raise awareness of the WRI database internationally by disseminating information through the Water JPI forum, at international water events/conferences and through European projects Collaborate with the MERIL portal (https://portal.meril.eu/) to raise awareness	Ongoing	EPA and WRCG to report on international dissemination of information about the WRI database at WRCG meetings	EPA, WRCG and EPA communications manager

Appendix 5 Research Infrastructure Manager Interviews

Name	Organisation	Research infrastructure
Karl Richards	Teagasc	Water research laboratory and lysimeter
Per-Erik Mellander	Teagasc	Agriculture Catchments Programme
Owen Fenton	Teagasc	Agricultural Groundwater Monitoring Programme
Daire O'hUallacháin	Teagasc	Ecological research facility
Stephen Nash	NUI Galway Engineering	CODAR
Eoin Clifford	NUI Galway Engineering	Tuam Waste Water Treatment Plant
Sean Mulligan	NUI Galway Engineering	Structures laboratory
Paul Bolger	University College Cork	Environmental Research Institute RI
Liam Curran	Enterprise Ireland	Industry RI
Paul Butler	Enterprise Ireland	Industry RI
Kevin Fitzgibbon	WSSIC	Nimbus RI
Niall McDonagh	Marine Institute	Policy innovation and support
Jenny O'Leary	Marine Institute	Policy innovation and support
John Breslin	SmartBay Ireland	SmartBay Ireland

NUI, National University of Ireland; WSSIC, Water Systems and Services Innovation Centre.

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Gníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: Déanaimid córais éifeachtacha rialaithe agus comhlionta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.

Eolas: Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

Tacaíocht: Bimid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola*);
- gníomhaíochtaí tionsclaíocha ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe (*OGM*);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha*);
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídionn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuisc; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsiúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainaitheint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórfhleananna forbartha*).

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d’earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosaint agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d’Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.

Authors: Eoin Byrne, Kevin Fitzgibbon and Anca Minescu

Identifying Pressures

In order to conduct excellent water research, researchers require access to appropriate water research infrastructure (WRI); as well as suitable support services (e.g. assisting with use of the WRI), and openness on the part of owners & managers of existing WRI to assisting public and private sector innovation (e.g. through trialling new technologies). Much of the water-related research and monitoring facilities in Ireland are operated on a stand-alone model, neither connected to other pieces of infrastructure, nor easily accessible to other research activities for reasons including lack of knowledge of them, unclear access procedures or financial constraints in relation to staff or maintenance costs. This is a major challenge that needs to be addressed to enable more effective water research.

The origins of this project lie in perceived gaps in the overall planning, management and communication of information about the wide range of WRIs in Ireland. At the outset of the project, there was no national database of Ireland's WRI available to the public or to researchers.

Informing Policy

At the European level, the European Strategy Forum on Research Infrastructures (ESFRI) roadmap and the RI support schemes under the European Union (EU) Framework Programmes co-ordinate investment in large RIs across Europe. At the national level, Ireland has science, technology and innovation strategies in which RI plays a key role. Organisations such as Science Foundation Ireland (SFI) and the Higher Education Authority (HEA) have funded RI programmes and provided guidelines on accessibility. Although Ireland's National Research Infrastructure Roadmap addresses RI needs in overall terms, the water sector is not identified in that plan as a specific area, and WRI per se is not specifically identified. Water research is a broad research area and consists of a number of sub-areas, ranging from freshwater and catchments to the marine environment

and the biodiversity of these ecosystems. This has resulted in numerous and diverse organisations in Ireland being involved in setting the strategy and providing funding for water research and associated WRI, coordinated by the Water Research Coordination Group (WRCG).

Through this study, key factors were identified that are important in the development, management and planning of WRI in Ireland, including building on strengths, taking account of various RI scales, accessibility issues, sustainability, funding and WRI gaps and opportunities. The outcomes and data from this project will help define future RI priorities and inform national policy on water-related infrastructure development.

Developing Solutions

This project was tasked with identifying and mapping the location of relevant WRI in Ireland and developing a database of this key information on WRI, making it available online to the public and the water research community in an easy-to-use format. At the conclusion of the project, almost 80 WRIs had been uploaded to the database by over 20 organisations in Ireland across 120 locations. The results were collated in a new database and made available online, through the EPA's DROPLET (Database of Research Outputs: Projects Literature and Environmental Technologies) website (<http://erc.epa.ie/droplet/>). The WRI database raises the profile of individual WRIs and helps connect the water research community by giving access to information on WRIs and their facilities, services and related areas of research. This will help researchers pursue new opportunities, and partner and collaborate with colleagues, particularly in the case of interdisciplinary teams. The data will also help ensure effective planning for future WRI, by identifying gaps in existing infrastructure and opportunities for new infrastructure. Looking forward, the project developed a WRI roadmap, including recommendations on how best to advance WRI in Ireland, which included interviews with RI managers.