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# Connecting Data and Environmental Research at the Environmental Protection Agency

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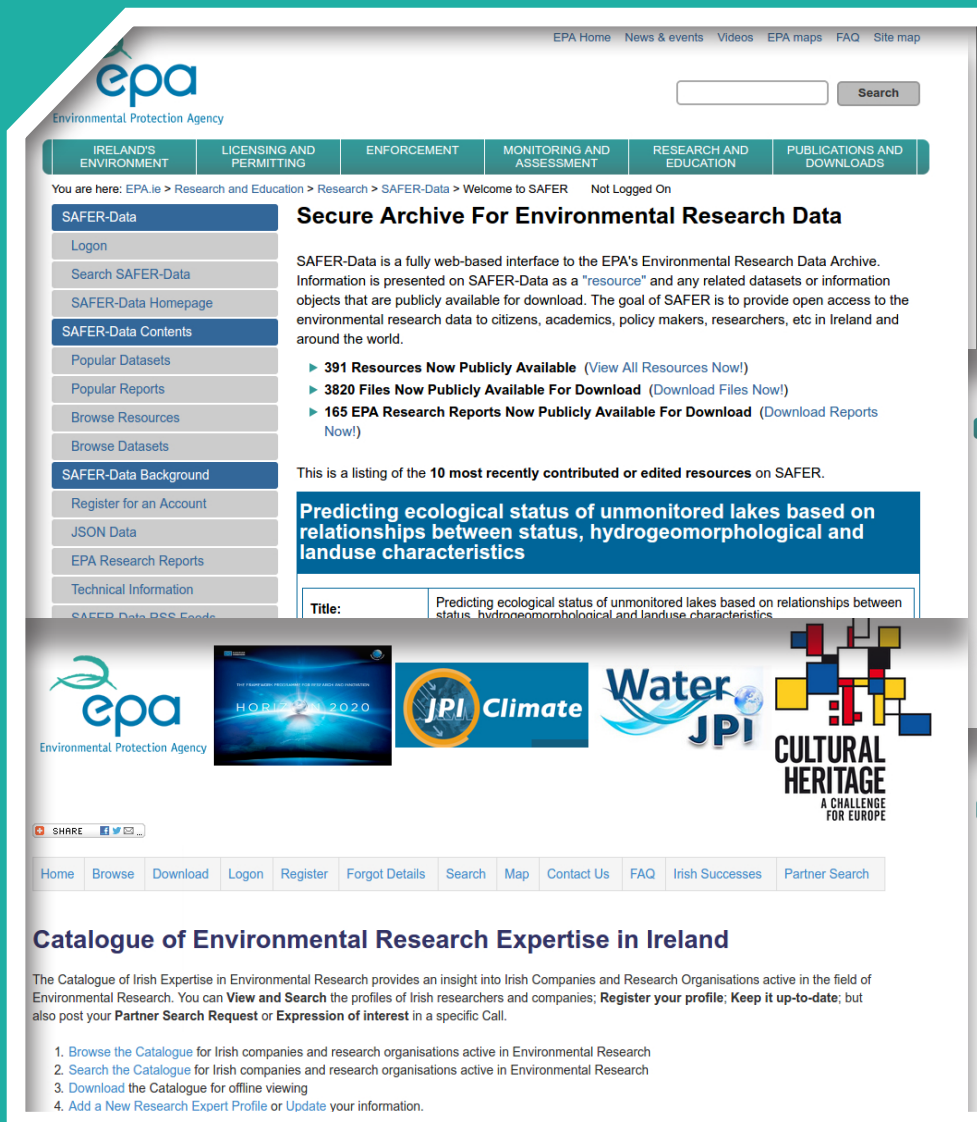


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Environment, Community and Local Government

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**ENVIRONMENTAL PROTECTION AGENCY**

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

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

Regulation: *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

Knowledge: *We provide high quality, targeted and timely environmental data, information and assessment to inform decision making at all levels.*

Advocacy: *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

## Our Responsibilities

### Licensing

We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities *(e.g. landfills, incinerators, waste transfer stations)*;
- large scale industrial activities *(e.g. pharmaceutical, cement manufacturing, power plants)*;
- intensive agriculture *(e.g. pigs, poultry)*;
- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
- sources of ionising radiation *(e.g. x-ray and radiotherapy equipment, industrial sources);*
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

### National Environmental Enforcement

- Conducting an annual programme of audits and inspections of EPA licensed facilities.
- Overseeing local authorities' environmental protection responsibilities.
- Supervising the supply of drinking water by public water suppliers.
- Working with local authorities and other agencies to tackle environmental crime by co-ordinating a national enforcement network, targeting offenders and overseeing remediation.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Prosecuting those who flout environmental law and damage the environment.

### Water Management

- Monitoring and reporting on the quality of rivers, lakes, transitional and coastal waters of Ireland and groundwaters; measuring water levels and river flows.
- National coordination and oversight of the Water Framework Directive.
- Monitoring and reporting on Bathing Water Quality.

### Monitoring, Analysing and Reporting on the Environment

- Monitoring air quality and implementing the EU Clean Air for Europe (CAFÉ) Directive.
- Independent reporting to inform decision making by national and local government *(e.g. periodic reporting on the State of Ireland's Environment and Indicator Reports)*.

### Regulating Ireland's Greenhouse Gas Emissions

- Preparing Ireland's greenhouse gas inventories and projections.
- Implementing the Emissions Trading Directive, for over 100 of the largest producers of carbon dioxide in Ireland.

### Environmental Research and Development

- Funding environmental research to identify pressures, inform policy and provide solutions in the areas of climate, water and sustainability.

### Strategic Environmental Assessment

- Assessing the impact of proposed plans and programmes on the Irish environment *(e.g. major development plans)*.

### Radiological Protection

- Monitoring radiation levels, assessing exposure of people in Ireland to ionising radiation.
- Assisting in developing national plans for emergencies arising from nuclear accidents.
- Monitoring developments abroad relating to nuclear installations and radiological safety.
- Providing, or overseeing the provision of, specialist radiation protection services.

### Guidance, Accessible Information and Education

- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (*e.g. My Local Environment, Radon Maps).*
- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

### Awareness Raising and Behavioural Change

- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

### Management and structure of the EPA

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:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- 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**

# Connecting Data and Environmental Research at the Environmental Protection Agency

# (2008-FS-DM-14-S4)

# EPA Research Report

Prepared for the Environmental Protection Agency

by

Maynooth University

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# Executive Summary

Environmental data and information, like the natural and urban environments they describe, are very precious resources. The importance and value of access to high-quality environmental data is almost universally understood and accepted. Today, there are growing numbers of stakeholders demanding access to environmental data and information. These stakeholders are drawn from a very wide and diverse audience, which includes government and public service agencies, decision makers and policymakers, researchers and the general public. The onset of a digital society, with the Internet becoming more influential in our daily lives facilitated by ubiquitous intelligent smart devices, has increased the need to make scientific data and information accessible in a public and open way.

In 2008, the EPA awarded a fellowship entitled "Improved Geomatics Services for Access to Environmental Information". This report outlines the key achievements of this fellowship in improving access to environmental information in Ireland. The development of SAFER (Secure Archive for Environmental Research Data) was discussed in a previous EPA report (EPA, 2009). The report concluded by recommending that the development of SAFER is continued, and that additional environmental research data management strategies are explored and implemented. These environmental data and the information in SAFER are generated by EPA-funded research in Ireland, and are also generated or collected directly by the EPA itself in response to its statutory reporting and monitoring obligations. Environmental data and information are examples of a public good and, in sharing that data, their value is in no way diminished.

This report relates to further research work that has been carried out in several areas of information and communications technologies, including open access and open data, data visualisation, mobile application development and web-based delivery, and reporting of information. By developing software and applications, such as SAFER and the Horizon 2020 Catalogue for Environmental Expertise, this fellowship has assisted the EPA Research Section in the management of its growing quantities of environmental research data and information, as well as increasing its dissemination and the profiles of Irish researchers.

This additional research work carried out as a result of this fellowship has played a key role in increasing and enhancing the EPA's potential to assist, encourage, promote and facilitate scientific and social research and knowledge transfer by providing innovative and effective means of accessing environmental data and information in Ireland. The fellowship focused on working with the EPA to develop software and services that use international standards and were built using free and open-source software. This low-cost approach means that the EPA avoids expensive commercial software contracts and license agreements. However, with this free and open-source software approach, there is a resource cost in relation to the EPA staff capacity and expertise to maintain these systems. In addition, this approach allows the EPA to have greater flexibility and control in developing and managing these services in a way that will meet the changing needs of its stakeholders and the general public in the future.

Although this fellowship is now complete, by the very nature of environmental data management, the work does not stop here. The EPA has gained significant stakeholder buy-in for the services developed as part of the work. As the EPA has embarked on a new research programme, the EPA Research Programme 2014–2020, this fellowship has developed a number of systems with which environmental data and information can be managed and disseminated to all stakeholders efficiently, securely and in a timely manner in the future.

The list below outlines the key achievements of this project and provides URL links for all of the services and applications developed during this fellowship:

- SAFER: the Secure Archive for Environmental Research Data (http://erc.epa.ie/safer);
- SAFER Reports: a special area of SAFER from which all EPA Research Reports (including larger technical reports and manuals) are available for public access and download (http://erc.epa.ie/safer/reports);
- H2020 Catalogue: the Horizon 2020 Catalogue of Environmental Research Expertise in Ireland (http://erc.epa.ie/h2020catalogue);
- Air Quality Index for Health open data: a direct access open-data feed to the Air Quality Index for

Health for application developers (http://www.epa.ie/air/quality/dev/);

- all annual EPA drinking water data (http://erc.epa.ie/safer/resourcelisting.jsp?oID=10206&username=EPA\%20Drinking\%20Water);
- a complete archive of air quality data from the EPA Air Quality Network (http://erc.epa.ie/safer/resourcelisting.jsp?oID=10136&username=EPA\%20Air\%20Quality);
- Ireland's National Greenhouse Gas Inventory (http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=21);
- DROPLET: Database of Research Outputs, Publications and Environmental Technologies (http://erc.epa.ie/droplet);
- EPA Research Searchable Projects Database: publicly accessible interface to all EPA-funded research projects (http://erc.epa.ie/smartsimple).

At the time of writing, the EPA are making very good progress in terms of open access to environmental information and environmental data. The EPA's ENVision GIS interface is an excellent example of open access to environmental data. Applications such as the H2020 Catalogue is a leading example of such a catalogue in Europe.

Outputs from this fellowship (user guides, reports, etc.) will be available on SAFER and can easily be found on the SAFER Reports web page (http://erc.epa.ie/safer/reports).

# 1 Introduction and Current Situation

## 1.1 Environmental Data

Stakeholders (citizens, governmental agencies, commercial companies, non-governmental organisations, etc.) are increasingly demanding timely and more public open access to environmental data and information produced by bodies such as the Environmental Protection Agency (EPA) (Granell *et al.*, 2016). In her speech at the launch of the European Digital Single Market, Commissioner Neelie Kroes (Kroes, 2013) stated that public authorities produce large amounts of data that could become the raw material for new, innovative cross-border applications and services. By making scientific data available for wider dissemination and re-use, Kroes argues that "this public data could generate new businesses and jobs and give consumers more choice and more value for money." In terms of environmental data and information, wider dissemination and re-use could provide us with a better understanding of the current state of our environment. In 2008, the EPA awarded a fellowship entitled "Improved Geomatics Services for Access to Environmental Information".

Every project funded and supported by the EPA Research Programme is involved with the generation, collection, production, analysis or review of environmental data and information in some way. This includes all types of projects funded by the EPA Research Programme from large multi-annual projects to short desk-based projects. As outlined in a 2009 EPA report, the EPA Research Programme found that, in previous years, most projects that were funded and supported would be completed, but the only outputs from these projects were usually in the form of written reports or papers (EPA, 2009). It was difficult, if not impossible, to access the actual environmental data or information that had been generated by the projects. With the development of SAFER (Secure Archive for Environmental Research Data), as also described in the 2009 EPA report, research projects funded by the EPA are expected to deliver the resources generated during the course of the project.

The term "resources" has a very broad definition here. It can mean quantitative or qualitative data and information generated or collected by projects, models or simulations developed by the projects, best-practice guides and methodologies, decision support systems, computer software, web applications, etc. The concept of resources can even include Powerpoint presentations from conferences and workshops, as these are important vehicles for the dissemination of environmental knowledge. This so-called grey literature is a vital adjunct to the traditional reference. There is often a significant time lag between research and publication. Some research is never published. Grey literature often represents research at its initial development stage and may be a tool both to uncover innovative information and to shorten the time between research and practice. It can also introduce complex scientific research and ideas to a broader, less specialised audience. Every project funded by the EPA Research Programme generates and manages some type of resource given the broad definition of the term. The key challenge is in developing a systematic approach to capturing these resources, managing them and subsequently making them available for public access.

This report relates to further research work carried out into several areas in information and communications technologies (ICT), including open access and open data, data visualisation, mobile application development, and web-based delivery and reporting of information. This report outlines the key achievements of the fellowship in terms of improving access to environmental information in Ireland.

The focus of this report is on the management of environmental data and information generated by EPA-funded research in Ireland. The report also reviews research and development carried out to assist the EPA in openly disseminating some specific environmental datasets it collects directly. These datasets include ambient air quality monitoring data and annual water quality reporting.

The importance and value of access to high-quality environmental data is almost universally understood and accepted. This is one of the principal reasons why, historically, research groups or institutions and government agencies have an innate tendency to protect their data in an attempt to guarantee control of the scientific findings that could be associated with these datasets and information flows. Environmental data and scientific

data, if used or interpreted incorrectly, can result in the wrong messages being transmitted to user groups, such as the general public or special interest groups. Sound data management practices must be in place to ensure that environmental data and information are disseminated in such a way to minimise the opportunities for misinterpretation and mis-use. However, yesterday's strategy of keeping data and information hidden from public access is no longer acceptable. Environmental information and data are generated by research and monitoring programmes. This must be managed in databases and archives from which knowledge extraction and decision making takes place. The outputs of this process must be disseminated widely, which in turn supports on-going research and environmental monitoring. This fellowship was tasked with building services to provide access to environmental datasets and information which had previously been unavailable or difficult to access, to ensure that the flow of environmental data and information within this cyclical process is as efficient and open as possible.

The situation where scientific data and information remains hidden, possibly indefinitely, may lead to situations that are not always consistent with the advance of scientific knowledge or with the coherence of the scientific methods (Janssen, 2010). The public, as citizens, also have rights to access these information flows under instruments such as the Public Sector Information (PSI) Directive (EC, 2003). A common argument is that data obtained using public money should be used to maximise the benefits for the general public (Nelson, 2009). While this is, for the most part true, the proper management of these data can ensure that they are disseminated and made available for future access in the most technically efficient, secure, cost-effective and relevant means. Making data publicly available and accessible is not an easy task. The best data management and dissemination strategies very often depend on the agency/body undertaking this approach making additional resources available, such as skilled information technology (IT) personnel.

In recent years, there has been an improvement in the situation. The onset of a digital society, the influence of the Internet in our everyday lives, powerful intelligent smartphone devices, etc. have resulted in a much greater awareness of the advantages of making scientific data and information publicly available. Consequently, the key overarching philosophy of this fellowship is to connect environmental data and information with reporting and applications. While information about the environment, outcomes of environmental research, etc. are becoming more universally available, it is still often very difficult to access the actual data and information which lies behind these policy decisions, reporting outcomes and recommendations and decision making (Bolukbasi *et al.*, 2013). Very often, reports are produced, web documents developed, etc. without any real connection to the raw or derived environmental/scientific data and information behind them. As Vision (2010) remarks, "data have been largely left out of these arrangements" and most users and consumers of these outputs have "grown accustomed to reading papers and reports in which tables, figures and statistics summarise the underlying data, but the data themselves are unavailable (or difficult or expensive to access)" (Vision, 2010). More often, they are left for authors, creators, or generators to share only upon request. Data are a classic example of a public good, in that shared data does not diminish in value (Hawkes, 2012). On the contrary, shared data can serve as a benchmark that allows others to study and refine methods of analysis and, once collected, they can be creatively re-purposed by many hands and in many ways, for an indefinite time. This also demonstrates transparency and openness to the users of these data and information resources.

## 1.2 Managing Environmental Research Data at the EPA

Every EPA-funded research project is required to make public all relevant data and information resources which were generated during the lifetime of the project. This requirement is part of the terms and conditions of the funding agreement. The EPA then ensures that these data and information resources remain available for public access and reuse using best practices in international data management and Internet-based dissemination techniques. In addition to this, where appropriate, EPA data and information resources will also be made publicly available for the benefit of a wide-range of stakeholders, including researchers, small and medium-sized enterprises (SMEs), other governmental organisations, non-governmental organisations (NGOs) and the general public. In 2009, the Environmental Research Centre (ERC) Report 13 "Managing Environmental Research Data at the EPA" (EPA, 2009) was published. This report outlined the research and development work leading to the launch of SAFER. SAFER was the first web-based application

used by the EPA to manage and disseminate the data and information generated and collected by EPA-funded projects. At the time of the report, the use of web technologies to provide open and accessible access to environmental data and information was not widely used (Vision, 2010). The 2009 report was the first EPA Research Report which dealt specifically with the topic of the management of environmental research data and the provision of public and open access to those datasets.

During the period 2007–2013, there were over 45,000 downloads of environmental data from SAFER during the STRIVE (Science, Research, Technology and Innovation for the Environment) programme. In the public service reform plan 2014–2016, the Irish Government announced in January 2014 (Department of Public Expenditure and Reform, 2014) that public services must embrace technological change and make maximum use of digitalisation and open data to deliver services and information in innovative ways. This report highlights research and development which has been undertaken over the course of this fellowship, maximising the use of open-data and open-source software to deliver environmental information services and environmental data in innovative and efficient ways.

## 1.3 Current Situation of Environmental Research Data Management

Since the publication of ERC Report 13,[1] there has been an unprecedented rate of technological change. This change has manifested itself in all aspects of ICT, including software, networking, hardware, databases, etc. The most profound changes have specifically emerged on the Internet and in computer hardware. The use of social media has become global and pervasive on the Internet today. The EPA, which had little or no social media presence in 2008 and 2009, is now actively maintaining several Twitter, YouTube, Slideshare and other related social media accounts to continue to engage with stakeholders. In terms of hardware, the smartphone and tablet device have become almost ubiquitous. The accelerating use of smartphones and tablets has given people increased mobility and access to Internet applications and social media.

With this unprecedented rate of technological change comes a much higher public expectation of open access to environmental data and information. The Digital Single Market (https://ec.europa.eu/digital-single-market/) in Europe, the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive, the Open Data movement, etc., are now all drivers of open access to environmental data and information.

The Digital Single Market presented by the European Commission forms one of the seven pillars of the Europe 2020 Strategy which sets objectives for the growth of the European Union (EU) by 2020. The Digital Single Market proposes to improve the exploitation of the potential of ICTs to foster innovation, economic growth and progress. There are a number of obstacles which have been encountered by the Digital Single Market, including the lack of interoperability between systems, insufficient research and innovation efforts and lack of digital literacy and skills across Europe. The INSPIRE Directive aims to create a common infrastructure for spatial data across Europe. Spatial data are data that have a spatial component, meaning that data can directly refer to a location or area. This infrastructure will assist sharing of environmental spatial data to the public and other public sector organisations. Spatial data must be provided in a consistent harmonised format, and Member States must provide networked and Internet-based access to these data. “Open data” is the concept that some datasets should be freely available to any citizen to use as they wish, without restrictions from copyright, patents or other restrictions. The term “open data” itself is recent, gaining popularity with the rise of the Internet and World Wide Web and especially with the launch of open-data government initiatives such as Data.gov and Data.gov.uk.

The European Commission’s OpenAire 2020 project features 50 partners, from all EU Member States and beyond, who are collaborating in large-scale open scholarship. The key mission of OpenAire is to substantially improve the discoverability and reusability of research publications and data. The initiative brings together professionals from research libraries, open scholarship organisations, national e-infrastructure and data experts, IT and legal researchers. The European Commission’s H2020 Open Research Data Pilot is supported by OpenAIRE. The OpenAIRE platform can connect to archives and other open-access systems all over Europe to interconnect large-scale collections of research outputs.

1 http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=115

The increasing expectation from all stakeholders that data and information be made available in an open, accessible and frequently cost-free (or low-cost) way means that it is now absolutely imperative that agencies such as the EPA put ICT policies and systems in place to meet these expectations. It is interesting to note that, as open access to data and information become more commonplace and stakeholder and user expectation grows, the field of data management has focussed less on the specific technologies used but rather on what can be delivered by available technologies.

# 2 Key Achievements

This fellowship has improved access to environmental datasets and information which previously may have been unavailable or difficult to access. These improvements are summarised as follows:

- Linking data to research: SAFER demonstrates how to successfully link environmental research to the data and information which instigated/generated it. Over 3800 dataset and information files are available for direct download, including over 160 EPA Research Reports.
- Making research reports widely accessible: SAFER now makes it possible for a range of reporting outputs from EPA-funded projects to be made publicly available. On the web page "SAFER Reports" additional reports such as large technical final reports and appendices are easily accessible for download.
- Accessing environmental research data: there have been over 48,000 dataset and information files downloaded from SAFER since 2008.
- Showcasing Ireland's environmental research: the development of the EPA's "Searchable Projects Database" system has provided public access to information on over 700 projects funded by the EPA over the past 10 years.
- Promoting Irish environmental research expertise: the EPA has worked to increase the networking and integration options for Environmental Researchers in Ireland for funding programmes such as Horizon 2020 by developing and delivering the Catalogue of Environmental Expertise, which was launched in December 2013 and currently has the profiles of over 270 Irish environmental research experts and SMEs listed. The Horizon 2020 Catalogue of Environmental Expertise in Ireland (H2020 CEE) proceeds from the previous FP7 Catalogue of Environmental Expertise in Ireland which was designed specifically for the Seventh EU Framework Programme for Research and Technological Development (FP7).
- Facilitating high-level expert communication: the EPA is involved as a national expert in a number of Horizon 2020 (and previously FP7) Working Groups. A private document review repository was developed and delivered to facilitate the exchange of confidential pre-release Horizon 2020 documentation among the network of experts in Ireland. This document review repository allowed any documentation in relation to Horizon 2020 work programmes to be exchanged securely and privately in accordance with requirements for confidentiality.
- Facilitating public consultation: the SAFER infrastructure provided secure public access to 1356 public consultation submissions on Unconventional Gas Exploration and Extraction (UGEE). All public consultation submissions were made available as PDF documents. During the period November 2013 to July 2014 there were over 5200 downloads of these public submission documents.
- Real-time air quality data visualisation: open-source and open-data solutions were developed to assist the EPA in the delivery of real-time air quality data and information, including an automated Twitter feed which has over 400 followers.
- Successfully achieving EPA air quality reporting targets: this fellowship was directly involved with the EPA in meeting new reporting requirements under the European Air Quality Directive. Using a pragmatic open-source software approach, a robust but easily maintained, configured and extendible software system was developed for the production, management and dissemination of INSPIRE-compatible data to the European Commission and the European Environment Agency (EEA).
- Developing environmental research potential: in related university-based research to this fellowship over 17 fully peer-reviewed journal papers were published in the subject areas of open data, volunteered geographic information and crowdsourcing over the past five years.
- DROPLET provides open-data access to all water-related projects in Ireland: in DROPLET, the EPA has stored information about over 400 water-related research projects which were funded in Ireland over the past decade. The innovation from DROPLET is that these projects are from many funding agencies and organisations including the EPA. DROPLET differs from SAFER in the type of information it manages. DROPLET manages information about projects, funding events and

calls for funding. Other funding agencies such as Science Foundation Ireland, Marine Institute, etc. can access DROPLET and upload information about environmental projects, funding events and relevant calls for funding. DROPLET does not store any environmental data or datasets.

- Low-cost high-return approach: all of the software used to develop the services and systems outlined in this report are based on free and open-source software, meaning that the EPA is not locked into expensive commercial software contracts and licenses and have greater flexibility regarding the development and deployment of these services and systems. All of the systems described in this report originated from research work within the fellowship and began as software development projects which used open-source software. The EPA will have to consider how these systems are supported technically in the future as staff resources will need to be allocated to the maintenance of these systems.
- Open data web services are provided: several of the systems and applications developed in this fellowship and discussed in this report allow open-data web service access to catalogues of data. DROPLET, H2020 Catalogue, SAFER and the Searchable Projects Database all allow direct download in open-data formats such as JavaScript object notation (JSON) and comma separated values (CSV). This means that stakeholders and indeed other software applications can access these data and information resources automatically without needing to visit the websites associated with these interfaces.

The EPA Research Open Access Policy states that all projects funded by the EPA Research Programme from 2014 onwards will be required to ensure open access via “Gold” or “Green” methods[2] which means that any peer-reviewed journal article which they publish is openly accessible free of charge. This “Green” and “Gold” open access concept does not yet apply strictly to data and information generated by scientific research but such a policy will continue the EPA’s work in delivering open access to environmental information.

2 http://legacy.earlham.edu/~peters/fos/overview.htm

# 3 The Current Status of SAFER

SAFER was launched in 2008. SAFER has steadily grown from being a web application developed as a prototype for the management of environmental research data to what is now an important part of the EPA's communication of environmental research (EPA, 2014, 17). Over 49,000 datasets, information files and reports have been downloaded from SAFER during this period. Software support for SAFER is provided by an external contractor. As SAFER runs on a server within EPA (erc.epa.ie), the hardware infrastructure is supported by the EPA.

Given the very large numbers normally used in the discussion of website traffic statistics, at a first glance 49,000 over a 7-year period does not appear very large (Table 3.1). However, closer examination of this download figure indicates that this represents a genuine number of downloads. SAFER only allows download of datasets, information files and reports by users when they have passed a visual or aural test before download commences. In the next two sections, SAFER's role in the management of outputs from both EPA-funded environmental research and EPA operational activities is discussed.

In Figure 3.1, a word cloud is provided to illustrate the terms most frequently searched for on SAFER during the period July 2010 to July 2016, during which over 17,000 searches were performed. The word cloud illustrates the frequency with which each search term was used. Due to the constraints of the visualisation, the word cloud is limited to the 100 most frequently occurring search terms. The term water with the terms "quality", "drinking", "soil", "monitoring", "Ireland" and "air" are among the most frequently used terms. Water and water-related search terms account for approximately 20% of all searches conducted.

**Table 3.1. Summary of key statistics on SAFER usage**

| Statistic | Description |
|---|---|
| Number of publicly available resources on SAFER (July 2016) | 387 are publicly accessible; there is a total of 413 resources contained in SAFER, including resources which are currently subject to the post-project privacy embargo |
| Number of publicly available files for download on SAFER (July 2016) | 3786 files that are publicly available; there is a total of 3817 files contained in SAFER, including resources which are currently subject to the post-project privacy embargo |
| Number of resources on SAFER which contain EPA Research Reports (July 2016) | 165 resources on SAFER provide access to EPA Research Reports and associated documents |
| Total number of downloads from SAFER (July 2016) | 49,415 |
| Number of text searches performed on SAFER (July 2010 to July 2016) | 17,323 |
| Average number of downloads per month on SAFER | 465 |
| Number of registered user accounts on SAFER | 280 registered user accounts on SAFER – this does not include EPA research user accounts created for SAFER management. |
| Number of web visitor sessions to SAFER during the year 2015 | 69,108 visitor sessions; a visitor session is an individual user visiting SAFER. A user might look at a single page or visit several pages and may also log on and update metadata resources on SAFER. Multiple visits by the same user will count as distinct sessions: the same user visiting SAFER in the morning and then again in the evening would be considered as two visitor sessions |
| Most popular resources on SAFER | The 10 most popular resources on SAFER in relation to the number of downloads account for 18,924 downloads. This represents over 38% of all downloads on SAFER |
| Single most popular resource on SAFER | The most popular resource is the "Towards a National Soil Database"[a] and files attached to this resource were downloaded 3567 times in 2007 |

[a] **http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=7**


**Figure 3.1. A word cloud of the terms most frequently used in searches on SAFER between 2010 and 2016.**

## 3.1 Overview of Management of Outputs from EPA-funded Environmental Research

Over the past 10 years, the EPA has managed the successful ERTDI (Environmental Research, Technological Development and Innovation) and STRIVE environmental research funding programmes in Ireland. The initial development and deployment of SAFER is outlined as the principal means of managing the outputs from EPA-funded projects in an EPA report (EPA, 2009). A problem identified in this report (EPA, 2009) was that when funded research projects were completed it was difficult for other researchers, stakeholders and even the EPA to access the data and information generated during the project. Final reports and peer-reviewed journal and conference papers were produced from most projects. However, few, if any, provided access to the raw data and information generated or collected during the lifetime of the project. The work described in the 2009 EPA report led to the addition of clauses in EPA research funding documentation requiring project participants to make data and information outputs generated during the project available to the EPA for the purpose of public dissemination and safeguarding. In EPA research call documentation, these requirements are outlined as follows: "All significant datasets produced during the research project must be submitted to the EPA at the end of the project for archiving in SAFER. It will be the responsibility of the Grantee to ensure that all project participants provide their respective datasets as detailed in the Guidelines for Submission of Datasets, available from the EPA website. The Grantee should also complete and submit to the EPA the metadata for each dataset provided. Descriptions of the datasets (using the metadata provided) will be made available publicly, while access to the datasets will be restricted to the data originators and EPA staff for a period up to 12 months after the publication date of the project report. Upon expiry of that period, datasets will be made publicly available" (EPA, 2016).

Significant datasets are not restricted to quantitative data, such as measurements or observations, but is applicable to a very wide spectrum of data and information resources. These include software models, software computer code, imagery, databases, presentations, etc. Consequently, every research project funded by the EPA becomes familiar with SAFER and the requirements to make data and information resources from that project available to the EPA for the purposes of public dissemination.

During the EPA-funded projects kick-off meetings, EPA staff introduce SAFER and the requirements to make outputs from the project publicly accessible. Support and advice is available to the research project team when they are preparing data and metadata for upload

to SAFER. There are often legitimate concerns for funded researchers in regards to losing control over their data and information resources once they are uploaded to SAFER and made publicly available. The EPA research team provides support for researchers at this time and each project is dealt with on an individual basis to develop a plan for the dissemination of project outputs. This plan takes account of license, copyright and patent issues, in addition to outputs currently under review in the peer-review process. An embargo period is introduced at this time. This is a minimum of six months and ensures that all resources provided by the project remain private. After a period of 12 months the resources are made publicly available.

SAFER uses metadata to order and catalogue the resources generated. The core unit of information on SAFER is the metadata resource. This is simply a catalogue entry with a number of descriptive attribute fields which must be supplied with the information. SAFER uses a subset of the ISO19115 Metadata Standard for Geographic Data. When data or information is ready for upload to SAFER, a metadata resource must be created. This requires the owner of the data or information to fill in a metadata resource with the following metadata fields:

- dataset or resource title (text);
- dataset abstract or description (text);
- EPA research project code;
- geographical description (open text);
- time start (date and time) – this represents the earliest date or time which is related or relevant to the dataset or information;
- time end (date and time) – this represents the more recent date or time which is related or relevant to the dataset or information;
- data usage information (open text) – this is a description of any restrictions to the use of the dataset or information;
- Name and contact information of the person(s) responsible for the dataset or information; these people must be available to answer questions or queries about the dataset or information going forward.

In the descriptions of the fields above, “text” refers to text typed in by a user but with an upper limit to the number of characters, whereas “open text” refers to text typed in by a user without an upper limit to the number of characters.

Although the metadata requirements of SAFER are straightforward, they still present a challenge and barrier to many researchers. In many cases, researchers are unclear about what level of detail they need to provide to satisfy some of the metadata fields, for example data usage information.

The current process in place includes the submission of metadata by the project team via the EPA grant application and project management system (SMARTSIMPLE) on completion of an EPA-funded project, while submitting the project resources to SAFER.

> A simple recommendation for the future would be for the EPA to consider consolidating or combining the metadata from the SMARTSIMPLE grant application and project management system with that of SAFER. When a project is awarded funding by the EPA, a grant and project profile is created within the SMARTSIMPLE system. The EPA should investigate how the metadata information created in the SMARTSIMPLE metadata profile could be automatically transferred to SAFER, following which a metadata resource could be created automatically. This would remove the need for researchers to individually create metadata resources on SAFER when providing datasets and other information resources.

## 3.2 Overview of Management of EPA Research Datasets

As SAFER began to establish itself nationally and internationally as a principal source for the dissemination of environmental research data, the EPA began to consider using SAFER for the management and public dissemination of EPA-generated data and information. Rather than duplicate the functionality of SAFER, the EPA decided that it would be more efficient to use SAFER as the primary distribution location for the following datasets: Air Quality historical data archive, Ireland’s Greenhouse Gas Inventory, Ireland’s Drinking Water Annual Report data, United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP), etc. These datasets are sought after by many scientists involved in environmental research in Ireland and beyond.

This was a very important endorsement of SAFER by the EPA, which was instrumental in moving SAFER from being a system developed primarily for the management and distribution of outputs from EPA-funded environmental research projects to a system for management and distribution of specific and selected EPA-generated data and information. EPA staff have been trained on how to use SAFER. These staff can now upload data and information resources to SAFER for public dissemination. A series of internal user guides and associated documentation has been created for this purpose and is available to EPA staff.

SAFER is, of course, only one of many data management systems used within the EPA. Some of these data management systems are not publicly available as they perform their function behind the scenes. The EPA ENVision map system allows members of the public to view environmental information interactively on a map and download the corresponding data for further use if required. ENVision is a very large data management system which is the front-end to the EPA's Geographical Information System (GIS) data management system. The EDEN system provides an online gateway to environmental and radiological protection licensing, monitoring, GIS and reporting applications for organisations to communicate with the EPA and share data with each other.

## 3.3 Resource Savings Using SAFER

As outlined in the previous sections, SAFER has provided a secure, efficient and reliable platform for the dissemination of environmental data and information for both EPA-funded researchers and the EPA itself. What impact has SAFER had from a resource savings viewpoint? Crucially, the greatest resource saving for the EPA through their use of SAFER for the management and dissemination of key EPA datasets such as Drinking Water and Air Quality is realised by the reuse of SAFER as an in-house data management tool and software asset. As SAFER has been developed using open-source software, there are no costly software licenses or "vendor lock-in" scenarios. SAFER is now a key component in the EPA's data management architecture, moving it directly into mainstream activities. However, SAFER continues to play roles in hosting, managing and disseminating outputs from both EPA-funded environmental research and selected datasets as a result of the EPA's day-to-day operational activities. SAFER is part of the EPA's server hosting, security and backup management strategy which ensures SAFER's continued operation for the long-term future. The ongoing responsibility for SAFER's software management and future development is managed by an external consultant. The EPA research team have been trained on how to manage SAFER as administrators (add users, add metadata, add resources, change users, change metadata, etc.).[3]

The data management plan for the EPA before it began using SAFER for the management and distribution of operational datasets, was simple but time consuming. If a researcher, member of the public or other stakeholder required a dataset, they would telephone or email the relevant person in the EPA with this request. The EPA staff member would then extract this dataset from a database or file data storage area and return the dataset to the person(s) who requested it. EPA staff working with data flows such as Air Quality and Drinking Water indicated that these data flows generated a large number of requests on an annual basis.

The simple equation outlined in Equation 3.1 is used to estimate the total staff time saved by allocating the task of public data dissemination to SAFER. Appropriate EPA staff provided an accurate estimate of the time per task (TPT) to answer queries for access to data using the old request scheme. This equation provides an estimation of the number of person-hours saved (PHS) which is computed by dividing the total time in minutes to complete the tasks by 60 minutes. Table 3.2 summarises the number of person-days saved (PDS) by the EPA through using SAFER as the principal means of providing public access to EPA datasets. Three datasets are shown. The number of downloads per year is provided with the estimated TPT in minutes. The PHS are calculated using Equation 3.1. Finally, the number of PHS is divided by 7.5 hours to obtain an estimate of the number of PDS by this approach. In 2012 and 2013, it is estimated that 82 person-days were saved by the EPA by using SAFER to provide access to EPA datasets and to make responses to public requests for these datasets available 24 hours/day and 7 days/week.

3 There is a series of internal user guides to assist EPA staff in using and managing SAFER. These include: "Creating New Users on SAFER", "Creating a New Metadata Resource on SAFER", "Uploading Reports and Datasets to SAFER", "Editing User Details on SAFER" and "Editing Metadata Resources on SAFER".

**Table 3.2. Number of person-days saved by the EPA through using SAFER as the principal means of providing public access to EPA datasets**

| EPA dataset | Year | Downloads | TPT (mins) | PHS (hours) | Person-days |
|---|---|---|---|---|---|
| Air Quality | 2014 | 2954 | 10 | 492 | 65 |
| Air Quality | 2013 | 1138 | 10 | 190 | 25 |
| Air Quality | 2012 | 964 | 10 | 161 | 21 |
| Drinking Water | 2014 | 1639 | 7 | 191 | 25 |
| Drinking Water | 2013 | 824 | 7 | 96 | 13 |
| Drinking Water | 2012 | 909 | 7 | 106 | 14 |
| GHG Inventory | 2014 | 250 | 5 | 20 | 2 |
| GHG Inventory | 2013 | 303 | 5 | 25 | 3 |
| GHG Inventory | 2012 | 543 | 5 | 45 | 6 |

**GHG, greenhouse gas.**

Person-hours saved =
(number of tasks × time per task)/60 Equation 3.1

## 3.4 The EPA Research Searchable Projects Database

The EPA research "Searchable Projects Database" (http://erc.epa.ie/smartsimple) is a specially designed web-based application for accessing information on all of environmental research EPA-funded projects in Ireland over the last 12 years. The database contains information on all projects from the two previous EPA research programmes, namely ERTDI and STRIVE, as well as those funded under the current EPA research programme 2014–2020. Most researchers in Ireland who have been funded by the EPA in the past will be very familiar with the EPA's SMARTSIMPLE grant application and project management system (http://epa.smartsimple.ie). SMARTSIMPLE is used by the EPA to manage all aspects of EPA-funded projects including finance and budget, personnel, progress tracking, outputs, etc. While several levels of access are provided via SMARTSIMPLE (for applicants/grantees, research offices, finance offices, reviewers/evaluators, EPA research managers, etc.), the contents of the SMARTSIMPLE system are not available to the general public. Each co-ordinator of an EPA-funded project is provided with security credentials which he/she can use to access the SMARTSIMPLE system. These credentials allow authorised project staff to access information relating to projects that they are specifically linked to. These credentials do not allow browsing of other EPA-funded projects in SMARTSIMPLE.

So does the Searchable Projects Database replace SAFER? The answer is no. The Searchable Projects Database and SAFER are complimentary and are linked automatically. SAFER is primarily used for the data management of EPA research projects that are nearing completion or have been completed. The projects available for browsing on SAFER are a subset of all the projects that the EPA has funded over the years.

In the Searchable Projects Database, the public and other stakeholders can browse and read information on all of these projects. If a particular project in the Searchable Projects Database has data and/or other information resources available for download on SAFER, the website offers a link to these resources. This is an example of service chaining (as illustrated in Figure 3.2); where SAFER and the Searchable Projects Database can operate independently of each other (and subsequently be maintained and updated independently) but can link automatically when appropriate. This prevents users of the Searchable Projects Database physically searching on SAFER themselves for specific projects or project resources. The Searchable Projects Database is a self-sustaining interface; no management is required of the projects display. The Searchable Projects Database is automatically updated directly from SMARTSIMPLE on a monthly basis. In April 2016 there were 820 projects in the database.

The Searchable Projects Database can be searched in a number of ways: an open text term search, an autocomplete text search where the user is given suggestions of search terms, and a search by project code, project co-ordinator and lead organisation.


**Figure 3.2. Example of the automatic linkage between the Searchable Projects Database and SAFER. The project information for project 2013-W-DS-12 is displayed in this screenshot.**

Since its launch in 2013, there have been over 6000 searches performed. This indicates that there is interest among the public and EPA stakeholders in understanding what projects, thematic areas, etc. the EPA has been active in funding over the past number of years. The word cloud in Figure 3.3 is a visual representation of the terms users searched for in the Searchable Projects Database. Among the most popular terms are “waste”, “water”, “wastewater”, “climate”, “biodiversity” and “pollution”. The Searchable Projects Database is updated automatically to reflect changes in the SMARTSIMPLE system.

The contents of the Searchable Projects Database cannot be downloaded directly by users. However this is a recommendation for future development work as this would be a very valuable source of open data for EPA research. The Searchable Projects Database could be extended to allow the download of the contents of the database in open-data-friendly file formats such as CSV and JSON. The Searchable Project Database also needs to be updated to ensure that there is direct mapping between the STRIVE programme sub-themes and themes and the current EPA research pillars and sub-themes.

## 3.5 EPA Horizon 2020 Catalogue of Irish Environmental Expertise

The Horizon 2020 Catalogue of Irish Environmental Expertise (http://erc.epa.ie/h2020catalogue) was developed to support the dissemination of information about environmental research skills and expertise in Ireland for the purposes of fostering collaborations capable of challenging for Horizon 2020 funding and other funding programmes. Horizon 2020 is the name of the 2014–2020 European research programme covering research and innovation funding. It brings together, in a coherent and flexible manner, all research and innovation funding currently provided through the Framework Programme for Research and Technical Development (FP7), the Competitiveness and Innovation Framework Programme (CIP) and the European Institute of Innovation and Technology (EIT). Horizon 2020, which runs from January 2014 to December 2020, aims to secure the EU’s global position in research, innovation and technology and is designed to create new growth and jobs in Europe. The EPA has a national role in promoting, encouraging and facilitating the successful participation of Irish researchers in Horizon 2020 via its role as national delegate and contact point for the Societal Challenge 5 “Climate Action, Environment, Resource Efficiency and Raw Materials” (climate action), in partnership with Enterprise Ireland.


**Figure 3.3. Word cloud displaying the 100 most-frequently occurring search terms in the Searchable Projects Database between 2013 and 2016. The larger the word or term the more frequently it was used for searching the database.**

To help promote, encourage and facilitate successful participation of Irish researchers in Horizon 2020, the EPA decided to develop, operate and manage a special web-based Catalogue of Environmental Expertise in Ireland. This fellowship undertook the task of development of the H2020 CEE. The development of the H2020 CEE followed on from the predecessor system called the "FP7 Catalogue" which had been in operation for about three years. The H2020 CEE provides insight into both Irish companies and research organisations active in the field of environmental research. Public visitors to the catalogue can view and search the profiles of Irish researchers and companies. Irish researchers and companies can register their research profile, keep it up-to-date and also post partner search requests or expressions of interest in a specific call in Horizon 2020. The primary audiences for the H2020 CEE are researchers in Ireland and the EU. No restrictions are placed on who can view or register for the catalogue. The H2020 CEE aims to provide Irish researchers and Irish companies with a platform from which they can advertise their expertise and interest in Horizon 2020 to a European audience. The spatial distribution of web visitors to the H2020 CEE between November 2015 and July 2016 is shown in Figure 3.4.

When a researcher or company registers a research profile on the H2020 CEE, it is retained in a holding area in the catalogue administrator section. This section allows authorised EPA staff to verify that the new research profile submitted is valid (i.e. not spam, advertising, etc.). When the EPA staff verify the research profile it becomes publicly available on the H2020 CEE immediately. Crucially, from this point onwards, there is no bottleneck as the researcher or company can then freely update their profile over time. Between December

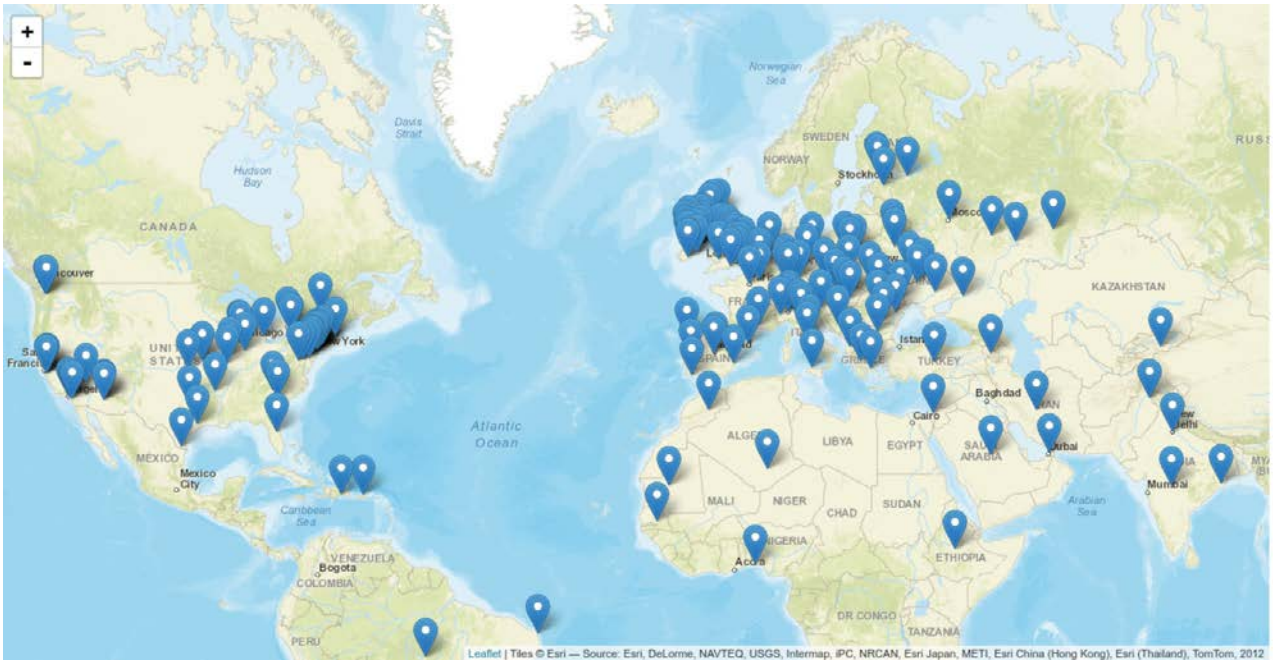


**Figure 3.4. Map illustrating the spatial distribution of visitors to the H2020 CEE in Ireland between November 2014 and July 2016.**

2013 and July 2016, over 260 profiles were registered on the H2020 CEE. Verification of profiles takes only a matter of seconds. Using Equation 3.1 from section 3.3, the estimated PDS for the H2020 CEE was calculated. The H2020 CEE allows researchers and companies to submit and subsequently maintain their profiles and this requires no assistance from EPA staff. The TPT is estimated at 10 minutes. The PDS is estimated at 3.4 person-days per year. There have been over 48,000 views from visitors from Ireland and over 18,000 views generated from visitors from the United Kingdom. The H2020 CEE is also being viewed by people in many European countries and beyond. The total number of views of the H2020 CEE is over 150,000.

**Summary statistics for H2020 CEE**

- 278 research profiles (July 2016);
- 189 profiles from higher education, 15 from industry/other, 21 from research institutes, 46 from SMEs and 7 from government agencies;
- 12 partner searches posted;
- 179,000 views or hits on the H2020 CEE since it was launched;
- on average, the H2020 CEE attracts 7750 views or hits on a monthly basis.

EPA research staff have been trained[4] on how to use the H2020 CEE from an administrative viewpoint. This allows these staff to manage user profiles in the H2020 CEE, edit the content of these profiles and retrieve information about the usage of the catalogue system.

## 3.6 Public Consultation Website for UGEE

A special website application was developed at http://erc.epa.ie/public_consultation to support the EPA during the launch of a public consultation on the draft terms of reference of the UGEE EPA/DECNR/NIEA Joint Research Programme on 11 January 2013, which closed on 8 March 2013. 1356 submissions were received, and, as part of the public consultation process, the submissions must be made publicly available. A simple website was developed in October 2013 which provided public access to all of the submission files. The website was developed to collect some simple statistics on the patterns of access to these submission files. The name of the submission file and timestamp of download are recorded on each occasion a submission file is downloaded. No Internet Protocol (IP) addresses

4 Internal user guides: "Verifying Research Profiles on the H2020 Catalogue", "Verifying Partner Searchers on the H2020 Catalogue" and "Retrieving Passwords on the H2020 Catalogue".

**Recommendations for future developments**

There are other similar systems available in Europe. The National Contact Points (NCPs) CaRE Partner Search tool is available at http://partnersearch.ncps-care.eu/. This partnering tool supports potential applicants for the Horizon 2020 Work programme of the Societal Challenge 5 "Climate Action, Environment, Resource Efficiency and Raw Materials" in finding partners and building a consortium for a project proposal. The major difference between the NCPs CaRE Partner Search tool and the H2020 CEE is that in the NCPs CaRE Partner Search all users must register with the system in order to search for a partner or view the partners already in the partner catalogue. The Community Research and Development Information Service (CORDIS) Partners Service (https://cordis.europa.eu/partners/web/guest/home), offered by the European Commission, contains partnership offers and requests, which can be sorted by fields of expertise or specific topics. The CORDIS system has over 10,000 partner profiles. The H2020 CEE has a key advantage over the CORDIS system in that it allows for much more detailed partner profiles to be created. The H2020 CEE allows partners to describe in detail their profile, skills, aims for research, etc.

or other information are stored. At the time of writing (July 2016), there have been 6076 downloads of public submissions. It is worth noting that, during the period of October 2013 to December 2013, there were almost 2000 downloads.

The website will remain available in the future. It is a static page which will continue to make submissions of this public consultation available. This approach could be used for future public consultations launched and managed by the EPA.

## 3.7 Air Quality Data Management

The EPA manages the national ambient air quality monitoring network in Ireland. The EPA also measures the levels of a number of atmospheric pollutants in Ireland. Due to the nature of air quality, it is imperative that monitoring is carried out on a continuous basis and that there are legal requirements specifying that information and data about the current air quality situation must be reported to the general public in real-time. A key part of this fellowship was to assist the air quality management team in the EPA to upgrade their software systems, using best practice approaches and open-source software, to meet the changing needs of the public and other EPA stakeholders for air quality data. As discussed in Chapter 2, the use of SAFER to freely disseminate historical air quality data to the public has been very successful. In this section and subsequent subsections the deliverables from this fellowship in relation to real-time air quality data management and new European Commission reporting rules, which became effective in January 2014, will be discussed.

### *3.7.1 Air Quality Index for Health (AQIH)*

The EPA's Air Quality Index for Health (AQIH) is a number from 1 to 10 that indicates the air quality in a particular region and whether or not this might affect the health of an adult or child. A reading of 10 means the air quality is very poor and a reading of 1 to 3 inclusive means that the air quality is good. The AQIH is generated from the previous hour of air quality data measured at air quality stations in the national monitoring network. The AQIH is reasonably easy to compute. For each AQIH region, there is a simple formula involving the number of air pollutants measured in that region. The AQIH is computed from the quantitative values of the air pollutants measured. The AQIH must be made freely and openly available to the public. The AQIH must be updated automatically on an hourly basis. Several dissemination channels must be used including an automatically updated Twitter feed, a Google Maps application and web-based images. This fellowship undertook the research and development into the delivery of a software system to meet these requirements.

Figure 3.5 illustrates the dynamic workflow for the generation of the AQIH and its subsequent delivery to a number of information dissemination endpoints: a dynamic web-based map on the EPA Air Quality website (see Figure 3.7), graphical output on EPA Air Quality web pages outlining the current AIQH, the open-data JSON data stream for developers on the EPA Air Quality website (see Figure 3.8) and, finally, as a Twitter status feed update under the @EPAAirQuality user profile (Figure 3.6). For more accessible reading for non-ICT experts, some of the more technical details

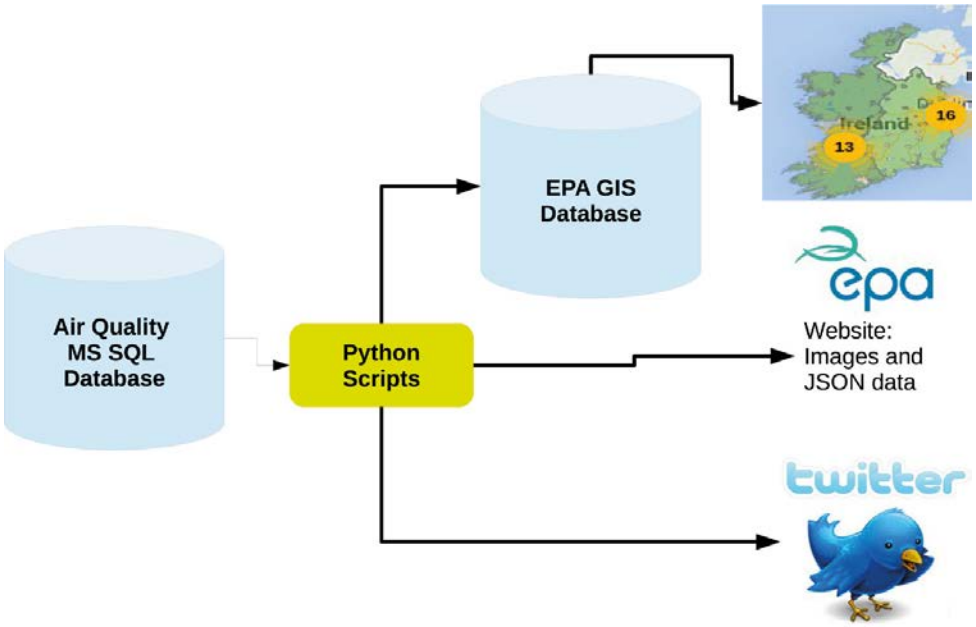


**Figure 3.5. Flowchart illustrating the dynamic workflow for the generation of the Air Quality Index for Health and the delivery of the computed Air Quality Index for Health to several destinations, including an online map and graphical output on the EPA website and a Twitter status feed (@EPAAirQuality).**


**Figure 3.6. An example of automated information dissemination for two consecutive days using Twitter for the Air Quality Index for Health.**

of the entire process have been removed. However, the flowchart illustrates the key processes in this dynamic workflow which is repeated every 30 minutes. As air quality data are delivered from the monitoring network to the Air Quality Microsoft SQL Server database, a specially designed set of Python software scripts extract the relevant raw data for AQIH calculation. When the calculation has been completed, the AQIH values for all regions are then inserted automatically into the EPA's GIS Databases, delivered directly to the EPA website and transmitted as a Twitter status feed update. This process is repeated every 30 minutes which ensures that users of the AQIH information on any of these output endpoints always receive the most up-to-date information available. The Twitter status is updated twice daily at 08:00 and 17:00 (see Figure 3.6 for a screenshot). The Python software has been specifically designed to issue Twitter status updates hourly if the AQIH becomes poor or very poor.

The process illustrated in Figure 3.5. is an operational example of truly real-time reporting to the public by the EPA. Raw air quality data which is monitored and captured at all of the stations in the National Monitoring Network is transmitted to the EPA's Air Quality Database. Calculation of the AQIH is performed every 30 minutes. Consequently, the AQIH information published to the online dynamic map (see Figure 3.7), JSON data stream (see Figure 3.8), the EPA website and Twitter is very much real-time data, reflecting the current AQIH for the previous hour. Real-time AQIH


```
{
   "generatedAt":"2016-08-04 16:20",
   "generatedBy":"Environmental Protection Agency",
      "aqihsummary":[
      {
         "aqih-region":"Rural_East",
         "aqih":"2,Good"
      },
      {
         "aqih-region":"Cork_City",
         "aqih":"1,Good"
      },
      {
         "aqih-region":"Rural_West",
         "aqih":"1,Good"
      },
      {
         "aqih-region":"Large_Towns",
         "aqih":"2,Good"
      },
      {
         "aqih-region":"Small_Towns",
         "aqih":"2,Good"
      },
      {
         "aqih-region":"Dublin_City",
         "aqih":"2,Good"
      }
   ]
}
```


**Figure 3.8. An example of the Air Quality Index for Health delivered as a JSON data feed on the EPA website. JSON data are very easily consumed and displayed by web applications and mobile-device applications and software. JSON data are usually passed between computing applications, and thus it is not directly designed for readability.**

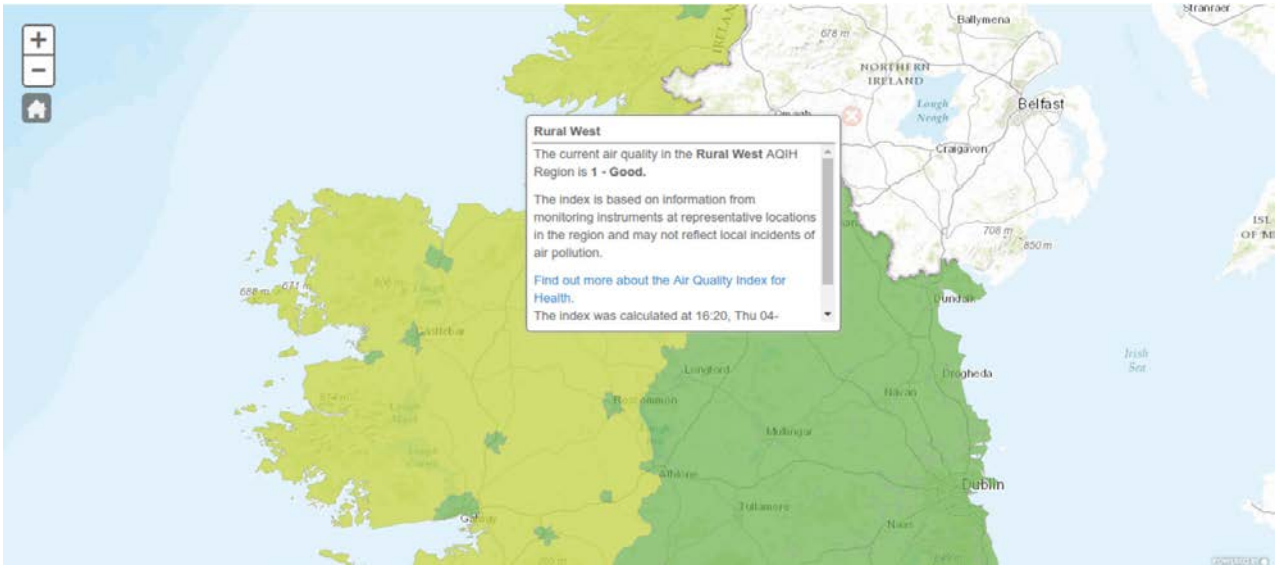


**Figure 3.7. A screenshot of the Air Quality Index for Health as displayed on the EPA website. The Air Quality Index for Health regions are coloured according to the Air Quality Index for Health colour scheme. Stations (as shown) and regions are clickable, where users can find real-time information about the Air Quality Index for Health for their region or location.**

values are archived on a continuous basis and a historical database of AQIH values will be made publicly available in the future, allowing researchers to use this AQIH in other investigations and research.

### *3.7.2 Real time air quality data visualisation*

The EPA manages the National Ambient Air Quality Network. Air quality monitoring and assessments are made at 30 monitoring stations in Ireland. The EPA requires that dynamically updated time-series charts of all pollutants at all of these monitoring stations are made available to the public on the EPA website. The time-series charts for these pollutants should be updated automatically every hour on a continuous basis. An example of one such time-series chart is shown in Figure 3.9. This fellowship developed, designed and deployed a software solution to meet these requirements. The data flow is very similar to that illustrated in Figure 3.5. Air quality monitoring and assessment data are stored in the EPA's Air Quality database on a continuous basis. A specially designed set of Python software scripts extracts the up-to-date data for all selected pollutants from all monitoring stations in Ireland and automatically generates time-series graphical plots similar to that in Figure 3.9. The Air Quality team at EPA provided the precise specifications for the visual appearance of the time-series graphical plots (fonts, headers, axes labels, time-span, legend, etc.).

To ensure that the most up-to-date data are available, the software updates every 45 minutes. The generated images can be used by the public, researchers or other EPA stakeholders on other websites, provided that the EPA is acknowledged as the source of the data and the generated visualisations. One of the key advantages to this approach is that the software is easily configured to allow changes to the visual appearance of the graphical plots or the addition/removal of a specific air quality parameter or station from the automated plotting routine.

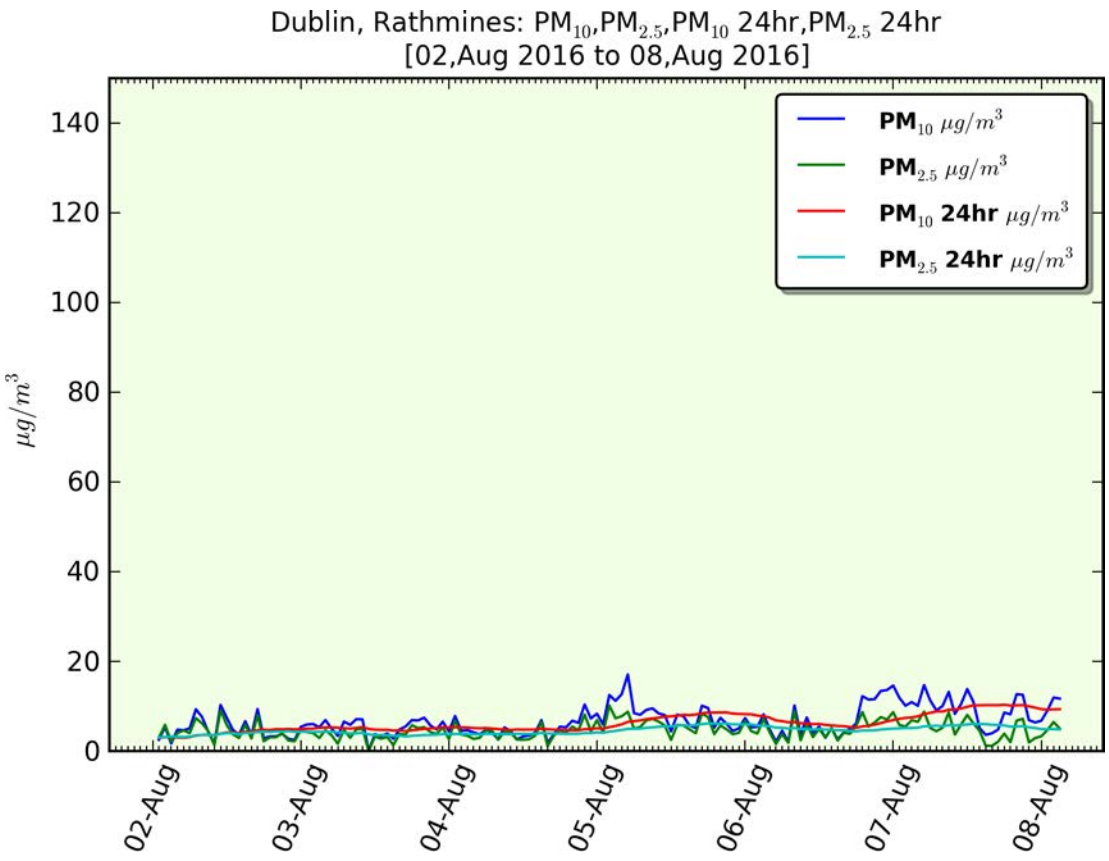


**Figure 3.9. An example of particulate matter data from the Rathmines Station in Dublin plotted as a time-series plot. This plot is regenerated every 45 minutes and automatically placed on the EPA website for public view.**

### 3.7.3 New EU air quality INSPIRE-compliant reporting

In the last number of years, there have been a number of important changes to how Member States must collect and exchange air quality data with the European Commission and the EEA. The Commission Implementing Decision of 12 December 2011 lays down rules for the reciprocal exchange of information and reporting on ambient air quality (Decision 2011/850/EU). Among the air quality community, this is also known as the Implementing Provisions on Reporting (IPR) Decision. The IPR Decision establishes rules regarding the Member States' obligations to report on the assessment and management of ambient air quality, as well as the reciprocal exchange of information. The IPR Decision applies in Europe from 1 January 2014. In other words, it applies to air quality information collected by Member States from January 2013 that is to be reported in 2014. While the IPR Decision does not change how air quality monitoring is carried out, it represents a radical change in how air quality must be reported. Before the implementation of Decision 2011/850/EU, air quality data was exchanged between Member States using MS Excel and CSV formats, as well as an internal format called DEM produced by the European Topic Centre for Air. One of the biggest drawbacks of exchanging data using these formats is that the EU Commission could not very easily build a consistent picture of air quality in Europe because of differences in file formats and differences in how the Member States reported using these formats. Decision 2011/850/EU brings air quality reporting into the "eReporting" realm and into the INSPIRE-compliant reporting workflow.

The INSPIRE Directive (2007/2/EC) (EC, 2007) lays down a general framework for a spatial data infrastructure (SDI) for the purposes of European Community environmental policies and policies or activities which may have an impact on the environment. The INSPIRE Directive entered into force on 15 May 2007. While a discussion of the INSPIRE Directive is outside the scope of this report, it is important to understand what it means in relation to air quality. One of the many objectives of the INSPIRE Directive is the harmonisation of spatial data reporting in Europe. Essentially, this means that the INSPIRE Directive will provide rules and templates on how Member States should report and store spatial data. By introducing a set of rules, templates and standards for spatial data agreed by all the Member States it will be much easier to deliver enhanced services to the citizens of Europe which are difficult to implement when all Member States report and store spatial data in different ways.

A discussion of the precise details of the Decision 2011/850/EU is beyond the technical scope of this report. However, the major change for air quality reporting is that air quality monitoring and assessment data must now be reported in XML format using rules from the INSPIRE Directive. These implementing rules in the IPR Decision are complex. Every facet of the air quality monitoring and assessment network architecture must be described using XML. This is a wide spectrum, ranging from the geographical co-ordinates of where an air sample is taken to the specifications of the machines and physical procedure used to measure the parameters in the air quality, to the characteristics of the air quality monitoring station itself and its surroundings. For example, Figure 3.10 shows a screenshot of XML which is used to report real-time ozone data from all EPA ozone stations to the EEA. This must be reported every hour relating to the values of the preceding 24 hours. Some elements of the XML in Figure 3.10 have been omitted for clarity and to allow the screenshot version to fit within the page dimensions.

To meet the requirements of Decision 2011/850/EU, the EPA must provide the following datasets and dataflows in INSPIRE-compatible XML format:

- information on zones and agglomerations (Article 6);
- information on the assessment regime (Article 7);
- information on the assessment methods (Articles 8 and 9);
- information on primary validated assessment data-measurements (Article 10);
- information on primary up-to-date assessment data-measurements (Article 10);
- information on the attainment of environmental objectives (Article 12);
- information on air quality plans (Article 13);
- information on measures (Articles 13 and 14).

This fellowship included the task of delivering a scalable, robust, low-cost and easy-to-use software solution which would allow the EPA to meet the legal obligations of the Decision 2011/850/EU from 1 January 2014. This was a large and complex task and is now one of the first examples of a fully INSPIRE-compliant dataflow in the EPA. The EEA and European Commission


**Figure 3.10. A screenshot of a partial subset of the up-to-date data for an hourly submission to the EEA. In the screenshot, the past 24 hours of ozone values for Laois Emo Court (IE011A) are shown. Some eXtensible Markup Language (XML) elements have been omitted or truncated for clarity. The final row of data indicates that, between 21:00 and 22:00 on 17 April 2016, the hourly average ozone in units of µg/m$^3$ is 18.799.**

organised a series of Pilot Group meetings in Brussels and Copenhagen between 2011 and 2013 to assist Member States in understanding the requirements of the IPR Decision and to suggest best practice ways of implementing software solutions. The scale of this task was underlined by the fact that meeting the requirements of the IPR Decision and Decision 2011/850/EU required the development of an entirely new software system. The EPA attended 10 of the Pilot Group meetings and, over a period of 10 person-months, delivered a fully free and open-source software solution to the EPA for the IPR Decision reporting obligations on time for the implementation day on 1 January 2014. The key outcomes from the successful completion of this task are summarised as follows:

- The total project duration, from the gathering of initial requirements to delivery and deployment of the final software solution to the EPA in December 2013, was 10 person-months. Ireland was a very successful participant at the IPR Pilot Group meetings in Brussels and Copenhagen and, as a result of the involvement of this fellowship, was able to meet the requirements of Decision 2011/850/EU from 1 January 2014 without any external contractors or assistance.
- The software was written using the Python programming language. This is free and open-source software. There were several reasons for choosing Python for the implementation of these requirements. The most important reasons included ability to develop robust software quickly and easily, very good XML handling capabilities and ease of maintenance going forward. The EPA will employ an external contractor to manage the maintenance of this system on an ongoing basis in the future.
- All of the Python software is controlled using configuration files. This allows the EPA Air Quality team to easily control how the IPR XML data are generated and reported without needing to have expertise in the Python programming language.

## 3.8 DROPLET

At the beginning of Horizon 2020, the European Commission identified channels of external advice for the development and implementation of the ambitious research programme.[5] Among the relevant supporting

5 http://www.waterjpi.eu/index.php?option=com_content&view=article&id=76&Itemid=474

This fellowship has successfully carried out a wide variety of work with the EPA on air quality data management. The delivery of up-to-date (real-time) air quality monitoring data from Ireland happens on a continuous basis. The EEA provide a web-based interface[1] to the real-time data collection system. Ireland's compliance with the delivery of real-time data is quickly and easily observed here. Indeed, through the assistance of this fellowship, Ireland was one of the first Member States to successfully delivery real-time air quality data and annual report air quality data in the new INSPIRE XML format.[2,3] The Air Quality team have been trained in uploading validated air quality data to SAFER for public access and dissemination.[4]

The automated Twitter account for the AQIH has over 600 followers at the time of writing in July 2016.

The EPA Air Quality team were supplied with a number of user guides which are only available to the Air Quality team.

The submission of the IPR XML was completed with assistance from an externally contracted consultant from August 2015. Assistance is provided for the maintenance and management of the software developed during this fellowship.

Currently, the EPA host all of its air quality data access applications on the EPA website. While there is an air quality layer in ENVision and there is a map-based interface[5] to the AQIH, it is recommended that a fully map-based interface is developed for public access to the graphically represented time series of air quality, download of air quality data, etc.

1 https://tableau.discomap.eea.europa.eu/t/Aironline/views/Airquality_E2a_monitoring/DashboardE2a?:embed=y&:showShareOptions=true&:display_count=no

2 http://ec.europa.eu/environment/air/quality/legislation/pdf/IPR_guidance1.pdf

3 http://ec.europa.eu/environment/air/quality/legislation/pdf/IPR_guidance2.pdf

4 http://erc.epa.ie/safer/resourcelisting.jsp?oID=10136&username=EPA%20Air%20Quality

5 http://www.epa.ie/air/quality/

structures, European Technology Platforms, Joint Programming Initiatives (JPIs) and European Innovation Partnerships would play an important role. According to the new EU research and innovation strategy, the partnership between the European Commission and the Member States will be improved and designated EC representatives, belonging to various Directorates-General, will actively participate in the workings of the European Technology Platforms, and of the JPI and European Innovation Partnerships. There is a specific Water JPI.

The Water JPI is currently composed of 20 partner countries: Austria, Cyprus, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Turkey, United Kingdom, Moldova and Sweden. One of the issues that arose at Water JPI meetings was a need for consolidated and co-ordinated national databases of metadata and information on all water-related environmental and scientific research carried out. This information was, like many other thematic areas, scattered among multiple databases and systems, poorly managed and often difficult to access. Stakeholders at any level or for any purpose attempting to access information on water-related research found many of these problems providing obstacles to actually accessing information.

The EPA has a role in co-ordinating environmental research in Ireland. In the Irish context, water research is funded by several different funding agencies and organisations. The EPA's involvement in the Water JPI and in the Irish Water Research Co-ordination Group (including all major funders of water research in Ireland) means that it can discuss the problems related to access to information about water-related environmental and scientific research with other government organisations and funding organisations. Discussions at meetings of these groups agreed that addressing the problems of accessing information about water-related environmental research should be a priority. This is important, as it will ensure a better understanding of what research is actually being funded, facilitate the support of state-of-the-art research and avoid duplication. It will also support improved co-ordination of publicly funded research at national and EU levels in the context of the JPI.

This fellowship proposed building a web-based application specifically to address these issues. The EPA

research team had begun to compile a very large spreadsheet-based database of metadata concerning all water-related research conducted in Ireland over the past 10 years. A unique and novel aspect of this database was that it did not only contain metadata from EPA-funded research. Rather, it included all Irish funding agencies and European funding mechanisms, such as Horizon 2020, Framework Programme 7 and COST Networks. However, storing this extensive dataset within a spreadsheet had the effect of greatly limiting access and reduced its value as a database or library of information which could be useful to a very wide range of stakeholders.

With this as a key driver, the DROPLET (Database of Research Outputs Publications and Environmental Technologies) was developed by this fellowship. DROPLET represents a new generation of web-based applications. DROPLET is a responsive web application; this means that it targets mobile and smart devices. This enhances its usability across all the types of platform stakeholders currently use to access environmental information. DROPLET combines elements of SAFER, Horizon2020 CEE and the Searchable Projects Database to deliver a modern and highly user-friendly interface to access a database of over 450 metadata resources on water-related research projects, outputs and associated technologies (see Figures 3.11 and 3.12).

In addition to managing a metadata catalogue, DROPLET also maintains an events and funding catalogue, where research events and open calls for funding competitions can be advertised. The events catalogue (http://erc.epa.ie/droplet/events_calendar.php) lists research events which are of interest to the environmental research community in Ireland. Events can be posted on DROPLET by users with specific access privileges. These access privileges are provided by EPA research staff who are DROPLET administrators to designated members of other research funding organisations. Similar access privileges are required to post funding calls and announcements to DROPLET. The funding calls page at http://erc.epa.ie/droplet/funding_calendar.php maintains this list. DROPLET administrators can delete or modify both the research events and research funding calls.

DROPLET allows stakeholders to sign up and create accounts on the system. This provides users with extended functionality. Users who are signed up as staff or personnel from a funding agency can create and edit funding call events, research event advertisements and research projects. Standard research users who sign up for an account can manage the creation and editing of research projects. There is a very extensive administrator and security interface to DROPLET. DROPLET was launched in early 2015 and during that year there were over 92,000 hits or views. At the time of writing in July 2016, there have been 64,000 hits or views in year-to-date (Figure 3.13).

In summary, EPA staff have been trained to use DROPLET and manage the DROPLET administrative system.[1] There is also a user guide for external users of the DROPLET system which is available on the DROPLET website.[2]

One of the major challenges for DROPLET in the future is ensuring that it is updated and maintained with accurate and timely project information. This is the case with any online catalogue system. At the time of writing in July 2016, 480 projects are listed and catalogued in DROPLET. This number should grow steadily in the future as new projects, literature, funding schemes, events etc. occur. The associated metadata and information etc. for these projects will need to be inserted into DROPLET.

1 Internal User Guide: “Managing Users and Projects in DROPLET” (http://erc.epa.ie/droplet/about.php).

2 http://erc.epa.ie/droplet/userdocumentation/DROPLET_User_Guide.pdf

## 3.9 Summary of Key Outputs

The services and applications described in this report have played a very important role in assisting the EPA research programme to develop environmental research and innovation capacity nationally and internationally. SAFER has assisted with research data management within the EPA over the last seven years. At the beginning of the fellowship, SAFER was the label for a dedicated web-based data management application for the Environmental Research community in Ireland supported by the EPA. Today, as outlined in the EPA’s Environmental Protection Through Research

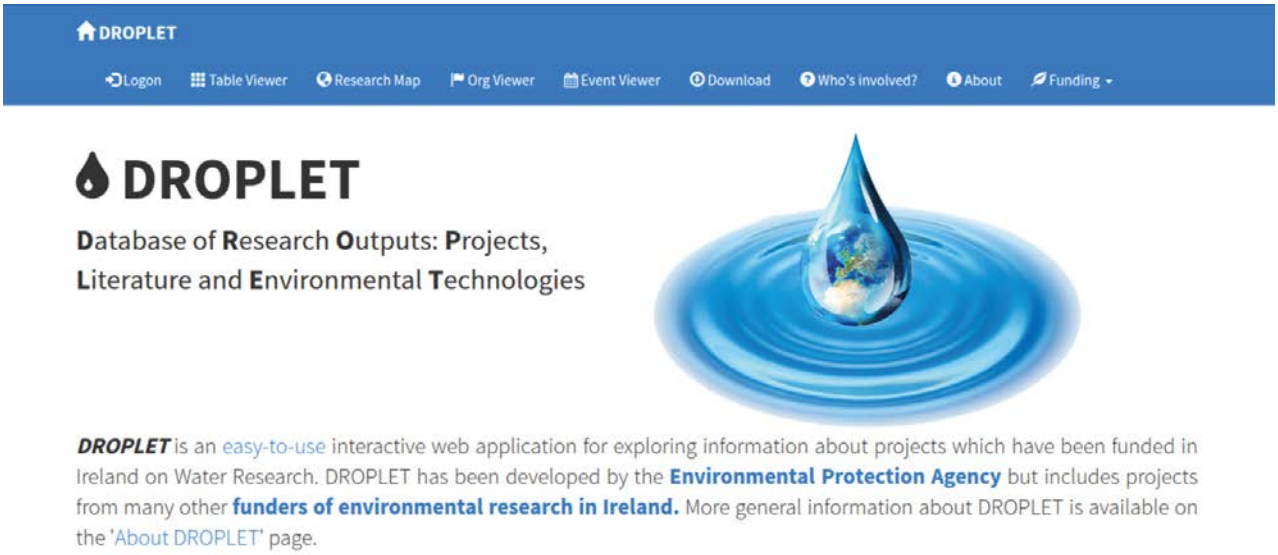


**Figure 3.11. The DROPLET homepage.**

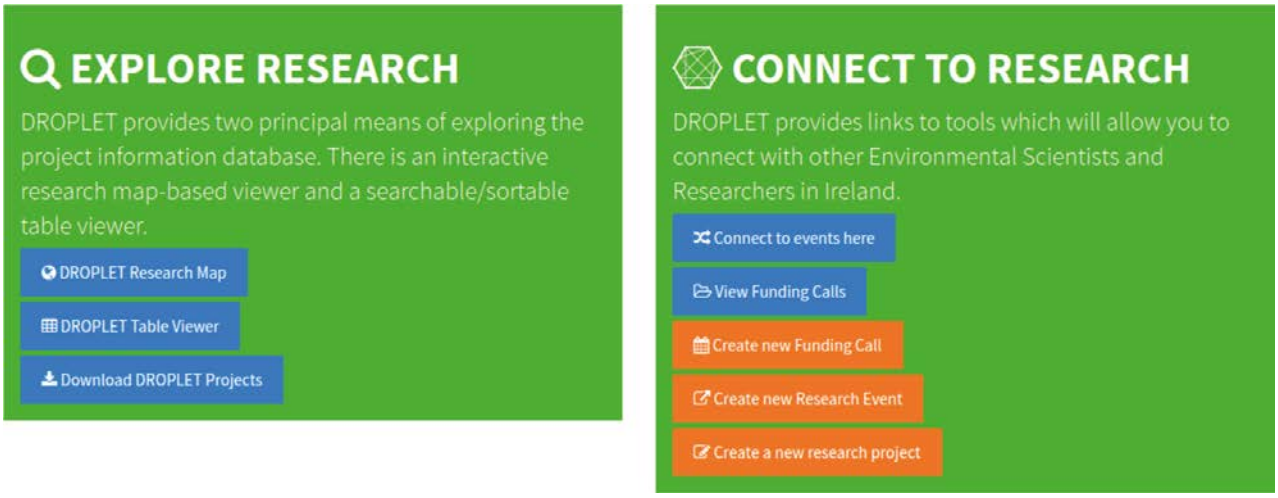


**Figure 3.12. DROPLET offers several ways to explore the contents of the DROPLET database. It also allows logged-on users to create new funding calls, create new research events and add new research projects.**

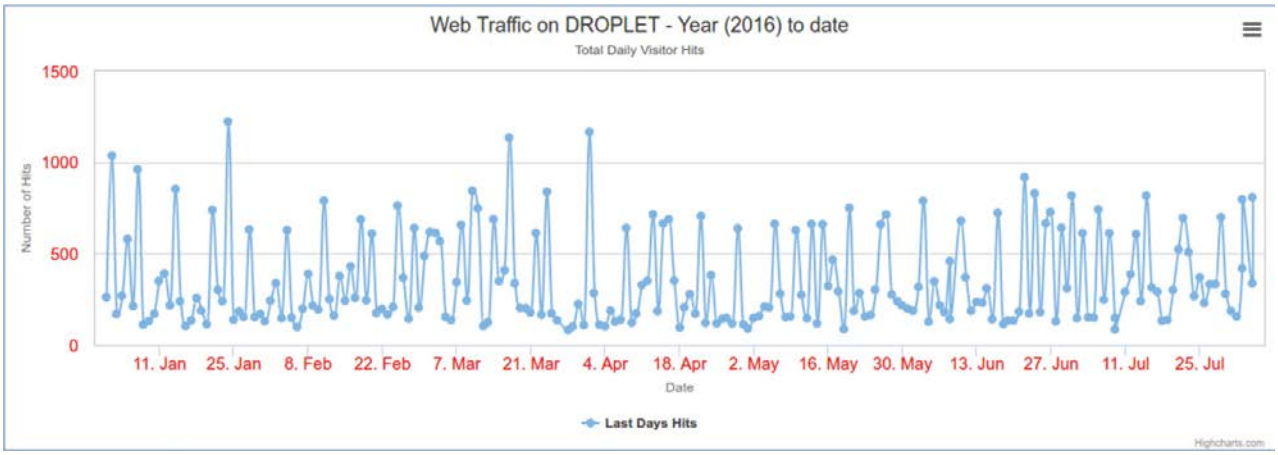


**Figure 3.13. A time series displaying the total daily hits/visit to DROPLET in the time period 1–8 January 2016.**

report,[6] SAFER is a "key pillar of building capacity in Ireland for environmental research". SAFER has exceeded expectations and now describes much more than just the original dedicated web-based data management application. As Figure 3.14 illustrates, SAFER now describes the entire environmental research data management architecture at the EPA. The backbone of SAFER is formed by several databases and file-storage archives. The service layer is the principal means by which all users of applications in the SAFER architecture interact with and use these databases. The design of the SAFER architecture is such that complex ICT setup and configuration details are encapsulated by simple and easy-to-use interfaces, such as those for SAFER, the H2020 CEE, the Searchable Projects Database, etc. The design and implementation of the SAFER architecture is robust and flexible and allows for future expansion to incorporate new applications and services. While this will require external assistance, the EPA have options to decide which direction these future expansions take. This greatly reduces duplication of effort and maximises use of in-house resources for EPA responsibilities such as reporting and dissemination of data and information about the environment to the public. A summary of the key deliverables from this fellowship will now be provided.

The key outputs from this fellowship have assisted the EPA in providing public access to environmental data and information in a number of thematic areas. Resource savings have been realised through the implementation of open-data strategies and the extensive use of free and open-source software. Maintaining these systems and extending them to incorporate new functionality or new technologies will require additional EPA resources. The technologies and solutions outlined in this report integrate very well with the Government's Reform Plan for the Public Service (Department of Public Expenditure and Reform, 2014) announced in January 2014. In the Reform Plan the government states that technology is moving at an ever faster pace and that the Public Service must embrace this and "make maximum use of digitalisation and open data to deliver services and information in innovative ways". This fellowship has assisted the EPA in improving access to the environmental data from their own statutory obligations and their funded research programmes. Innovation and open-data are both pillars of the success of this fellowship. This fellowship has provided the EPA with a platform upon which emerging technologies can be used to continue

6 http://www.epa.ie/pubs/reports/research/abouteparesearch/petrreport.html

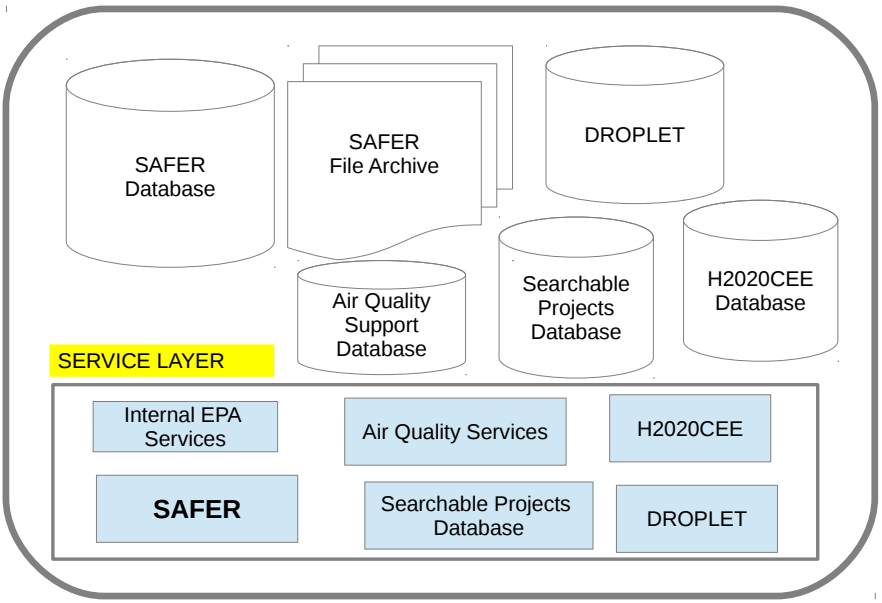


**Figure 3.14. A conceptual illustration of the SAFER architecture. At the top of the diagram, all of the databases and file storage areas are shown. These are the backbone of the case studies described in Chapter 3. The service layer is the principal means by which all users of the SAFER architecture interact with and use these databases. The service layer is delivered primarily using web-based applications and dedicated websites.**

to deliver environmental data and information to the public and other stakeholders. This will see the EPA take a leading role both nationally and internationally in eGovernment and eReporting. Crucially, this fellowship has assisted the EPA in increasing the number of electronic transactions stakeholders can perform with the EPA through data automation. This enhances customer service, improves information sharing and has been shown to make significant cost savings.

Through the software and services developed here, savings have been made in resources for the EPA, most importantly with regard to staff time and software licensing. In the next chapter, some recommendations for immediate and longer-term future work are provided. Data management strategies and policies for scientific data, such as environmental data, will always be strongly influenced by the current state-of-the-art in ICT. It is important that advances in ICT are embraced quickly to ensure stakeholders are provided with the most efficient tools and services to access these data and information stores. This report should not merely act as the final retrospective showcase of successful outcomes from the fellowship. Rather, it should be interpreted as an outline of a set of achievements in the area of environmental research data management at EPA.

**SAFER: the Secure Archive for Environmental Research Data**

- There have been over 49,000 downloads from SAFER in the past five years.
- Using a simple task–time analysis of the resource savings gained from open access to environmental data, it was estimated that in 2012 and 2014 the EPA saved 199 person-days from providing datasets such as the Greenhouse Gas Inventory, Air Quality Archive and Drinking Water databases as open access using SAFER.
- Many additional person-days were saved by using SAFER for other operational EPA datasets, research reports, etc.
- As part of skills and knowledge transfer, SAFER training has been provided to EPA research staff. A series of internal user guides and documentation has been written and delivered to the EPA.
- SAFER has greatly reduced duplication of effort and maximises use of in-house resources for EPA responsibilities such as reporting and dissemination of data and information about the environment to the public.
- SAFER has extended usage beyond EPA-funded researchers. The EPA has now begun to invite researchers, institutes, etc. who feel that they have environmental data or information that would benefit from wider dissemination but who do not have the web systems in place to complete the task. In the spirit of sharing, open-data and service chaining there is mutual benefit in using SAFER as a shared resource for the dissemination of environmental data and information.

**The Searchable Projects Database**

- There are now over 800 projects descriptions available on the EPA Searchable Projects Database which can be searched and browsed in a number of ways.
- Over 6300 searches have been performed on the Searchable Projects Database up to July 2016.
- The Searchable Projects Database has allowed the EPA to provide public access to the SMARTSIMPLE research grant management system.
- The Searchable Projects Database and SAFER are linked automatically so that users are provided with search results from both systems.
- The success of the Searchable Projects Database demonstrates that there is interest among the public and EPA stakeholders in understanding what projects, thematic areas, etc. the EPA has been active in funding over past years.

**Horizon 2020 Catalogue of Environmental Expertise in Ireland**

- Using the task–time analysis from section 3.3, it was calculated that the H2020 CEE has already saved the EPA 3.4 person-days during the period November 2015 to February 2015.
- The H2020 CEE has been effective in assisting the EPA in promoting, encouraging and facilitating successful participation of Irish researchers in Horizon 2020.
- As illustrated in Figure 3.4, the H2020 CEE is already attracting website traffic from Ireland, Europe and beyond. Since its launch, there have been over 170,000 web views of the H2020 CEE from locations in Europe and elsewhere.
- As of July 2016, over 270 profiles are registered on the H2020 CEE. Of these profiles 68% are higher education, 17% SMEs, 9% research institutes and 6% government agencies.
- The H2020 CEE is completely self-sufficient. For security, it is monitored by EPA research staff, but researchers can sign up for user access to the catalogue and subsequently post and maintain their expertise profile on the catalogue. The catalogue is designed for optimal viewing on all screen and device types.
- The H2020 CEE catalogue is not restricted to Irish researchers and can be used by other researchers in any EU Member State working in any scientific discipline.
- The SAFER infrastructure provided secure public access to 1356 public consultation submissions on UGEE.
- There have been over 6000 downloads of these public submission documents up to November 2015.
- Using the task–time analysis from section 3.3, it was calculated that the provision of secure public access to the public consultation documents has already saved the EPA 40 person-days during the period November 2013 to February 2014 due to the high volume of downloads which otherwise would have to have been handled by EPA staff through phone and email requests. This period proceeded the initial launch of the website and the period of highest public interest.

**The Air Quality Index for Health**

- An automated Twitter feed[1] for the AQIH was developed. This Twitter feed (see Figure 3.6) is automatically updated in the morning and the evening every day with the AQIH summary for all regions. The software monitors the AQIH continuously and is configured to automatically tweet at greater frequency if this is necessary for the protection of public health or to warn the public of poor air quality.
- A completely free and open JSON data feed has been developed to provide access to the AQIH values in real time (see Figure 3.8). This provides mobile, web and desktop application developers with automated access to the AQIH. This is one of the first real-time open-data feeds provided by the EPA.
- Working closely with the Office of Environmental Assessment and EPA Informatics, a fully web-based dynamically updating map for display of the AQIH was developed and deployed on the EPA website (see Figure 3.7). This is the first real-time data-driven web map application to be developed and deployed directly to the EPA website.
- The technologies used in the development of the fully web-based dynamically updating map for AQIH will be reused to support the web-based mapping needs of the EPA's Air Quality Forecasting fellowship (2012-EH-FS-6)[2] resulting in significant resource savings for the EPA.

1 https://twitter.com/EPAAirQuality

2 http://erc.epa.ie/smartsimple/displayFullProjectDetails.php?internalID=689

**Real-time air quality data visualisation**

- Software was developed to provide dynamically updating time-series visualisations for air quality pollutants on the EPA website.
- This software is easily configured and managed by the EPA Air Quality team. Configuration allows the Air Quality team to change the look-and-feel of the visualisations, to add or remove pollutants from the visualisations or to add or remove station locations.
- The software developed to generate dynamically updating time-series visualisations for air quality pollutants at all station locations in the National Ambient Air Quality Network uses open-source software. There are no additional software licensing costs incurred by the EPA.

**New EU air quality INSPIRE-compliant reporting**

- The fellowship holder worked with the EPA Air Quality team to manage the radical technical change required to meet the new INSPIRE-compliant reporting requirements.
- Software developed for the EPA Air Quality team is now transmitting real-time up-to-date air quality data in the new INSPIRE-compliant XML format to the EEA continuously on an hourly basis.
- No additional contractors or assistance were required to meet the new air quality reporting requirements. In-house assistance from EPA Informatics and their contractors completed this task.
- The entire work package to develop software to upgrade EPA air quality reporting systems to become compliant with the new IPR Decision took 10 person-months.
- The fellowship holder participated as Irish delegate to 10 IPR Pilot Group meetings in Brussels and Copenhagen to discuss the development of the new IPR Decision implementation.
- Ireland's air quality reporting became compliant with INSPIRE guidelines and the guidelines outlined in the IPR Directive by the implementation date of 1 January 2014.

**DROPLET: Database of Research Outputs, Publications and Environmental Technologies**

- DROPLET has provided an open-data-driven modern and sophisticated web-based application to access and manage a large database of metadata on water-based research in Ireland.
- DROPLET is unique in that it includes information on projects funded by almost all research funding agencies in Ireland and other agencies such as the European Commission.
- The software developed to deliver DROPLET uses open-source software. There are no additional software licensing costs incurred by the EPA. EPA research staff have been trained on how to configure, manage and use this software.
- DROPLET provides several open-data methods to access the entire database of metadata on water-based research. This means that external stakeholders can easily and intuitively access DROPLET using a variety of means without the need for EPA staff to deal with these information access queries.

# 4 Future EPA Research Data Management

This report has outlined the success of a fellowship which sought to improve the connection between environmental data, environmental research and the general public. While the fellowship has come to an end, the work for environmental research data management does not stop here. As mentioned above, research data management is part of a continuous spectrum of technological evolution and change. Through the vehicle of this fellowship, the EPA has embraced technological evolution and change. Section 3.3 shows that the EPA, through the use of the software tools and systems developed in this fellowship, are making resource savings in the form of staff hours and days. The services offered through the SAFER infrastructure (see Figure 3.13) are delivering data and information services to EPA stakeholders efficiently and effectively. The EPA can offer agencies with resource pressures the use of the SAFER infrastructure to make their own environmental data available. This service chaining will be of significant benefit to the EPA and the other agencies involved. However, it will ultimately be the public, the research and scientific community in Ireland and beyond, along with other stakeholders, who will benefit most. The final chapter of this report outlines some directions for the future of environmental research data management in the EPA. The EPA must continue to manage environmental research data in an innovative way (section 3.1) which should include open data (section 3.2) and mobile technologies (see section 3.3). This chapter closes with an overall vision for the future of environmental research data management.

## 4.1 Continued Management and Innovation in Environmental Research Data

Today's environmental research data will support tomorrow's research, decision making and policy-making and environmental protection. The success of this fellowship has demonstrated that there are many mutual benefits for both the EPA and the environmental research community in continuing to commit resources and effort to reshape the scientific data-sharing landscape. The EPA is "doing more with less", while the research community is benefiting from dissemination of their data and research outputs to a growing audience in Ireland, Europe and beyond. The EPA must continue to encourage the environmental research community in Ireland to embrace the benefits of making the outputs of environmental research publicly available in a timely manner. This will involve continued and regular proactive engagement with the research community through social media, newsletters, workshops and presentations. Data management advice and assistance can be provided to funded researchers by means of these presentations and workshops. Many researchers struggle with the skills required for scientific data management (Overpeck *et al.*, 2011).

The encouragement of continued interaction and support from the environmental research community in Ireland is crucial. One of the most pressing issues in this area is to ensure that datasets are correctly cited. Nelson (2009) and Piwowar *et al*. (2007) argue that organisations such as the EPA must make the benefits of sharing scientific data more obvious and tangible to those who go to the trouble of sharing in the first place. As a first step in this direction, it is recommended that research data management is included as a component of "kick-off meetings" for newly funded EPA research projects. Good research data management practice means different things to different projects. One of the most important aspects of good research data management practice is the planning and design of the capture, storage and use of environmental data and information. During this fellowship, it was observed that Microsoft Excel is by far the most dominant software tool used for the capture, storage and analysis of environmental data and information. While Excel has many advantages, it is not designed for scientific data. Project teams should be advised to consider the use of a relational database such as PostgreSQL, MySQL, Microsoft Access, etc. for the capture and storage of data and information as a database offers a more robust solution. However, such an approach requires the project team to plan and design their experimental approach or data capture programme carefully. Metadata (information about the processes used, quality standards, assumptions made, etc.) is very important to the future re-use of the data and information collected or generated by a project.

## 4.2 Open Data in the EPA

"Open data" is the concept that governmental data should be available to anyone with the possibility of redistribution in any form without any copyright restrictions (Kassen, 2013). Essentially, this means making these datasets available in machine-readable formats. CSV is one of the simplest examples of a machine-readable format, with JSON becoming a very popular choice for open-data access. Figure 3.8 in section 3.7.1 demonstrates how air quality information is distributed as open data. Overall, the main value of open data is that by providing free public access to various official governmental datasets, these government departments "not only become more transparent but also more efficient potentially promoting civic engagement" (Janssen, 2010). There are many opportunities for the EPA to become involved in open data and become a leader in the field within Ireland and internationally.

The EPA is already involved in several open-data initiatives. These include the Irish Spatial Data Exchange (ISDE) and the portal of Department of Public Expenditure and Reform (DPER), data.gov.ie. The ISDE (http://www.isde.ie/) is a spatial data catalogue or repository for the publication of descriptive metadata. ISDE allows users to search for data; to find out what data exists and where and how to access it; the fitness for purpose of the data; who created the data, and when and how it was created; how often the data are updated; the geographic extent of the data; and licence conditions on rights and use of the data. The ISDE was developed and is operated by the Marine Institute in collaboration and partnership with the All-island Research Observatory, Department of Arts Heritage and the Gaeltacht, Environmental Protection Agency, Geological Survey of Ireland and the Department of the Environment Community and Local Government. Data.gov.ie is intended to provide easy access to datasets that are free to use, re-use and redistribute. The portal is operated by the Government Reform Unit of the Department of Public Expenditure and Reform. The data.gov.ie portal brings these datasets together in a single searchable dataset. As of April 2016, the EPA has over 130 datasets listed in data.gov.ie (see https://data.gov.ie/publisher/environmental-protection-agency).

Several data flows in the EPA discussed in this report, Air Quality, Drinking Water, etc., are immediately suited to open-data access. The data can be converted and transformed to an open-data format and made available relatively easily. Such an approach to these datasets (and others) will increase their accessibility and provide even further resource savings in the long-term for the EPA.

However, for an organisation such as the EPA, there are some serious considerations which should be taken into account before the implementation of an open-data policy. The most serious of these considerations arises from data misuse and misinterpretation. As outlined in Chapter 2, the data and information which is currently disseminated by the EPA is usually accompanied by reports, information and advice on the usage and interpretation of the data. The incorrect assumption can be made that the process of making data open access and distributing it as open data means that is in some sense "free". There are costs inherent in open data (Bolukbasi *et al*., 2013). These include IT budget costs and the resources for implementing the software and hardware services that are required to provide open-data services. However, as outlined in Chapter 2, these type of resource costs are par for the course and a significant return on investment is soon apparent, for example the overall number of PDS by the EPA using SAFER as a means of distributing data (section 3.3). The use of industry-standard and compliant open-source software will reduce the overall costs in implementing an open-data strategy.

SAFER and DROPLET, as described above, are based on open-access/open-data principles. The EPA Research Programme requires grantees to align with open-data principles and requirements. These requirements are outlined in the grant award documentation.[7]

The H2020 Catalogue of Environmental Expertise provides direct open access to a download of the entire catalogue of environmental researcher profiles (http://erc.epa.ie/h2020catalogue/downloadCatalogue.php). DROPLET also provides direct open access to a download of the entire catalogue of projects. It provides open-data web-service access by JSON data transfer (http://erc.epa.ie/droplet/download.php). Providing access in this way by direct access to formats of data such as CSV and JSON means that these EPA applications can be directly linked to European initiatives such as OpenAIRE2020 (https://www.openaire.eu/). OpenAIRE2020 will assist in monitoring H2020 research

7 http://www.epa.ie/researchandeducation/research/usefuldocuments/

outputs and will be a key infrastructure resource for reporting H2020's scientific publications. It also seeks to build collaboration with national funders to reinforce the infrastructure's research analytic services.

## 4.3 Technical Enhancements to EPA Research Data Management

The EPA now embarks on a new generation of environmental research for 2014 to 2020. It is very difficult to predict the evolution of Internet and computing technologies which will take place during this period. However, EPA stakeholders will continue to demand increased access to environmental data and information. This report has outlined a number of very successful services developed to provide enhanced and improved public access to environmental data and information. It is recommended that these services are consolidated and integrated to deliver a single point of entry for environmental research data in the EPA. This will involve linking SAFER, the Searchable Projects Database, the H2020Catalogue, etc. As illustrated in the SAFER architecture in Figure 3.13, there is a technological platform on which the public and other EPA stakeholders can access all of these SAFER services by visiting one website or using a web application. The realisation of these enhancements will require considerable technological effort.

The DROPLET system provides all of the functionality provided by SAFER for water-related projects. DROPLET offers web-service download[8] of its entire catalogue as open data. It provides EPA research staff with very fine-grained control over access to DROPLET itself and over editing and reviewing of the catalogue contents. While SAFER and DROPLET can work in parallel without any technical problems or inconsistencies, there is a risk that multiple points of reporting could confuse stakeholders and discourage use of the systems. The EPA's SMARTSIMPLE grant management system is the primary point of reporting for EPA-funded researchers. The distinction is not always clear between the purposes of SAFER, SMARSTIMPLE and DROPLET which are working simultaneously. In the long term, this report recommends that the EPA should consider how to streamline the use of SAFER, SMARTSIMPLE and DROPLET in the future. SAFER manages datasets and associated resources with metadata specific to the datasets themselves or to the projects that generated them. DROPLET has a wider scope than the EPA and involves direct data input from other Irish funding organisations. DROPLET has a catalogue of metadata about projects in the environmental domain but also has information about funding events and calls for funding. The report also recommends that, after this merger, DROPLET should be more closely integrated with the SMARTSIMPLE grant management system. This integration would take the following form. When a project is awarded funding by the EPA, a profile or space is created on SMARTSIMPLE by the EPA scientific officer. Upon creation of this profile, a new profile for that project should simultaneously be automatically created on DROPLET. This would greatly help to clarify how the integration between the systems works to researchers and stakeholders.

The management of environmental research in the EPA involves many different technologies. Most of these technologies, such as SAFER, are desktop-based systems. The EPA must consider the role of mobile technologies for the communication of environmental research and for access to environmental research data. A survey from Forrester Research predicts a global dissemination of one billion smartphones in 2016 (Schadler and McCarthy, 2012). There is no doubt that smartphones and mobile applications will become prevalent and will consequently increase the use of social media and other online services. Schadler and McCarthy (2012) predicted that industry spending on mobile projects would double by 2015, with more than half of business decision-makers increasing their mobile applications budgets as they look for better ways to engage with customers and stakeholders. The landscape for SAFER, the EPA searchable databases, etc. will undergo a radical shift towards mobile platforms over the next few years. Along with these changes will come rising user expectations. As stated by Schadler and McCarthy (2012) "mobile is the flash point for a much more holistic, far-reaching change. Your app is in your customer's or stakeholder's pocket". The EPA must ensure that the delivery of data and information services for the future are designed with this in mind.

8 http://erc.epa.ie/droplet/download.php

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# Abbreviations

| | |
|---|---|
| **AQIH** | Air Quality Index for Health |
| **CORDIS** | Community Research and Development Information Service |
| **CSV** | Comma separated values |
| **DROPLET** | Database of Research Outputs Publications and Environmental Technologies |
| **EEA** | European Environment Agency |
| **EPA** | Environmental Protection Agency |
| **ERC** | Environmental Research Centre |
| **ERDTI** | Environmental Research, Technological Development and Innovation |
| **EU** | European Union |
| **FP7** | Seventh EU Framework Programme for Research and Technological Development |
| **GIS** | Geographical Information System |
| **H2020 CEE** | Horizon 2020 Catalogue of Environmental Expertise in Ireland |
| **ICT** | Information and communications technologies |
| **INSPIRE** | Infrastructure for Spatial Information in the European Community |
| **IPR** | Implementing Provisions on Reporting |
| **ISDE** | Irish Spatial Data Exchange |
| **IT** | Information technology |
| **JPI** | Joint Programming Initiative |
| **JSON** | JavaScript object notation |
| **NCPs** | National contact points |
| **NGO** | Non-governmental organisation |
| **PDS** | Person-days saved |
| **PHS** | Person-hours saved |
| **SAFER** | Secure Archive for Environmental Research Data |
| **SME** | Small and medium-sized enterprise |
| **STRIVE** | Science, Research, Technology and Innovation for the Environment |
| **TPT** | Time per task |
| **UGEE** | Unconventional Gas Exploration and Extraction |
| **XML** | eXtensible Markup Language |

# Appendix 1 List of Website Links

A list of links to various websites and web applications that were referenced in the text is provided in this appendix. As is the nature of websites and Internet links, these website links may change in the future. Every effort has been made to provide a set of links with a low possibility of changing in the short to medium term.

- SAFER: the Secure Archive for Environmental Research Data. The publicly accessible open pages of SAFER can be browsed without the need for registration. However, if one wishes to upload data and information to SAFER, you will need to register for a username and password. http://erc.epa.ie/safer
- SAFER Reports: a special area on SAFER where all EPA Research Reports (including larger technical reports and manuals) are made available for public access and download. http://erc.epa.ie/safer/reports
- H2020Catalogue: the Horizon 2020 Catalogue of Environmental Research Expertise in Ireland http://erc.epa.ie/h2020catalogue
- JSON access to Air Quality Index for Health data. http://www.epa.ie/air/quality/dev/
- Metadata and data resources for EPA water data. http://erc.epa.ie/safer/resourcelisting.jsp?oID=10206&username=EPA\%20Drinking\%20Water
- Metadata and data resources for the air quality network data. http://erc.epa.ie/safer/resourcelisting.jsp?oID=10136&username=EPA\%20Air\%20Quality
- Ireland's National Greenhouse Gas Inventory. http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=21
- Metadata and data resources for mines. http://erc.epa.ie/safer/resourcelisting.jsp?oID=10170&username=EPA\%20Historical\%20Mines
- Tool for estimation of pollutant release and transfer register (PRTR). http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=288
- DROPLET: Database of Research Outputs Publications and Environmental Technologies. http://erc.epa.ie/droplet
- National Soils Database Resource on SAFER. http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=7

**AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL**

Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol 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 comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

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

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

## Ár bhFreagrachtaí

### Ceadúnú

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

- 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 ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

### Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; 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 gComhshaol

- 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 Chomhshaol na hÉireann agus Tuarascálacha ar Thascairí)*.

### 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 shainaithint, 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 gcomhshaol in Éirinn *(m.sh. mórphleananna 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 gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol (*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 chosc 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
- An Oifig um Cosaint Raideolaíoch
- 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 imní agus le comhairle a chur ar an mBord.

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# Connecting Data and Environmental Research at the Environmental Protection Agency

Author: Peter Mooney

## Informing Policy

Access to timely and good quality environmental research data and information is essential for environmental management and policy development. The technological solutions outlined in this report have supported Ireland's efforts in relation to INSPIRE-compliant reporting on Air Quality Directive and provided support for Open Access and Open Data in the area of environmental research.

## Developing Solutions

This Fellowship has developed a number of technological solutions to support, encourage and facilitate the management, curation, sharing and access to environmental research data and information. The most prominent solution is SAFER (Secure Archive for Environmental Research Data), which provides an environmental research data management system for researchers and the EPA. There are over 3,000 dataset files available from environmental research projects and from EPA activities such as Air Quality monitoring and Water Quality testing. In addition to SAFER, solutions such as DROPLET and the Horizon 2020 Catalogue of Environmental Expertise in Ireland provides ways to consolidate research outputs, build research networks and collaborations, and reduce duplication of research effort.

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