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Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication (REMARC)

Authors: Linda Fox-Rogers, Paul Hynds, Simon Mooney, Rabia Asghar and Jean O'Dwyer

Lead organisations: University College Dublin, Technical University Dublin and University College Cork

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Government of Ireland

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3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

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What did the research aim to address?

Domestic waste water treatment systems (DWWTSs) (e.g. septic tanks) constitute the sole means of waste water disposal for approximately 500,000 households in Ireland. While well designed, located and maintained systems can treat waste water effectively, malfunctioning or poorly designed systems can result in the discharge of untreated effluent to adjacent surface water and groundwater bodies, causing significant environmental and public health risks. This is problematic, as the EPA's annual DWWTS inspection data show that approximately half of inspected households routinely fail their inspection. Moreover, there is growing concern over the high number (500+) of unresolved advisory notices nationally, where households that failed their inspection 2 or more years ago have yet to undertake the remediation works required.

The Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication (REMARC) project investigates the barriers to DWWTS remediation through a national household survey of DWWTS users and eliciting the views of local authority officials (i.e. DWWTS inspectors and planners). This unique approach brings together both lay and expert views in the development of new policy solutions to effect the behavioural change required to foster better environmental and public health outcomes.

What did the research find?

Project findings illuminate a range of policy gaps and top-down management challenges (which remain largely underexplored to date), as well as key determinants of householder system management. At the policy/regulatory level, a lack of regulatory oversight for onsite system installation and the absence of licensing/monitoring regimes for system installers emerged as key concerns. At the local authority (i.e. top-down) level, interviews identified staff capacity issues, inspection enforcement challenges, grant restrictions and deficiencies in public engagement as key challenges to DWWTS remediation.

At the household (bottom-up) level, the survey identified that appropriate levels of system desludging were more common among system owners reporting high confidence in undertaking system maintenance actions and prior exposure to system maintenance information. Financial cost emerged as a central barrier to both routine and remedial system maintenance. Agent-based modelling (simulating future system maintenance behaviours) identified that intensified risk communication interventions and financial incentives represented the most impactful future strategies. Based on the results, the project offers an evidence-based risk communication framework that systematically outlines recommended policy measures, engagement strategies and information items.

How can the research findings be used?

The project team will now concentrate on disseminating research findings through various channels, including peer-reviewed journals and international conferences. To date, findings have been published in *Science of the Total Environment*, with several more papers in preparation. We have also engaged with the public by accepting invitations to speak on the radio and through other media channels (e.g. EPA videos/events), which will continue post project.

Plans are also under way to host an in-person knowledge-transfer event in conjunction with the UCD Earth Institute to engage with key stakeholders and relevant policymakers to communicate key recommendations and maximise impact. The project findings can be employed in a variety of policy spheres, and the team will scope and respond to public consultations and information events in relevant policy spaces as they arise (e.g. the government's review of the sustainable rural housing guidelines, the EPA's consultation on the National Inspection Plan). This can be a highly effective route to knowledge transfer and the take-up of evidence-based recommendations generated by the REMARC project to bring about environmental and health benefits.

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EPA RESEARCH PROGRAMME 2021–2030

Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication (REMARC)

(2023-HE-1198)

EPA Research Report

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DISCLAIMER

This report is based on research carried out/data from March 2024 to June 2025. More recent data may have become available since the research was completed.

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

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Executive Summary

Continual maintenance of domestic waste water treatment systems (DWWTSs) underpins safe, sustainable waste water conveyance in unsewered rural areas. National oversight for household DWWTS maintenance is administered via the National Inspection Plan (NIP), which comprises a risk-based allocation of local authority-implemented system inspections and a public engagement strand. However, inspection data, which are published annually by the EPA, highlight potential issues surrounding the inspection regime, with roughly half of selected households failing inspection. Moreover, there has been growing concern over the increasing number of unresolved advisory notices nationally, where over 500 households that failed inspection 2 or more years ago have yet to undergo the remediation works required. To progress the plan's performance objectives to safeguard rural public and environmental health, efficient resolution of low system maintenance rates and challenges to inspection execution is of optimal importance. The present study report, *Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication (REMARC)*, details key insights and prescriptive recommendations gathered through a structured suite of multimodal enquiries spanning top-down and bottom-up DWWTS management perspectives.

Following a brief account of the current risk landscape regarding watercourses and drinking water supplies (**Chapter 1**), an extensive review of national policies and regulatory stipulations for DWWTS management is undertaken (**Chapter 2**). **Chapter 3** summarises key review observations, which variously note historical planning discrepancies, lack of oversight mechanisms for DWWTS installation, absence of licensing regimes for site assessors/system installers, prohibitive system grant conditions and strategic deficits in public engagement. **Chapter 4** reports the results of a novel online household survey considering general system maintenance, and actual and hypothetical responses to NIP system inspections. Exposure to system maintenance information and high self-perceived ability to undertake maintenance demonstrated significant associations with appropriate desludging actions, while financial cost emerged as a central barrier to system maintenance. Novel application of agent-based modelling to simulate behaviour adoption in hypothetical future policy environments distinguished incentivised desludging regimes and high-intensity risk communication interventions as optimal strategies. **Chapter 5** outlines findings from a series of semi-structured interviews with local authority DWWTS inspectors and planning officers. NIP inspectors and planners alike observed limited local authority resourcing as principal barriers to execution of formal duties. Considering factors contributing to existing system fail rates and enforcement difficulties, inspectors highlighted lack of national- and local-level communication, grant restrictions, financial issues, legacy system issues and judicial disadvantages as key concerns. Broaching broad planning policy as well as functional duties, planners foregrounded lack of follow-up mechanisms for system installation and legacy system issues, financial concerns, potential misinformation via planning agents and expedient system installation. Employment of sentiment analysis through natural language processing supported these observations and largely validated categorised themes concerning planning and inspection challenges and recommendations (e.g. staff turnover issues, suggested improvements in public communication). **Chapter 6** synthesises study findings into a condensed framework, emphasising key behavioural variables and information components/strategies of note. Provided schematics outline significant determinants of DWWTS maintenance across frames of reference and list core information materials, presentation techniques, dissemination strategies and policy supports of consequence. The combined framework emphasises the importance of engagement with DWWTS users across all stages of a system's functional life cycle and accounts for potential system legacy issues or design considerations upon system installation or inheritance through a property transaction. Suggested key messages are intended to impart (1) the primacy of household health protection and property integrity as pretexts for due diligence, (2) the importance of regular system maintenance towards personal and environmental risk mitigation, and (3) the attainment of peace of mind and potential financial incentives by

acting in the short term to prevent long-term system malfunctions. **Chapter 7** contextualises project findings within the wider thematic literature and national policy environment and provides a series of recommendations for future iterations of the NIP and broader apparatus for public engagement. Suggested communication measures include increased direct dissemination of maintenance guidance to households; centralisation of online information repositories and materials specifying recommended and unauthorised management practices; and multi-channel adoption of key messages stressing acquisition of peace of mind regarding health/environmental risk and potential future material benefits.

1 Introduction

Domestic waste water treatment systems (DWWTSs) constitute the sole means of waste water disposal for approximately 526,000 households in Ireland (CSO, 2023). In rural areas, where connections to municipal sewerage schemes are irregular due to dispersed patterns of residential development, close to 80% of households avail of (predominantly septic tank-based) DWWTSs (CSO, 2023). While DWWTSs that are well designed, located and maintained can provide effective treatment of waste water, findings from the EPA (2022a) suggest that this is often not the case. Malfunctioning DWWTSs can result in the discharge of insufficiently treated effluent, leading to contamination of adjacent surface water and groundwater bodies. This is problematic not only from an environmental risk perspective, but also with respect to public health, particularly in instances where natural and anthropogenic phenomena facilitate entry of untreated waste water into private domestic drinking water supplies (most notably private wells) (Hynds *et al*., 2014). Rural households are particularly vulnerable in this regard, as it is generally unfeasible to connect single or "one-off" rural homes to municipal sewerage schemes or treated water supply networks; these households typically rely on both private wells and septic tanks (176,000 in total) for their domestic needs. Accordingly, rural inhabitants in Ireland may represent both sources *and* receptors of groundwater contamination (Naughton and Hynds, 2014) and are a population at disproportionate risk of waterborne disease acquisition (Óhaiseadha *et al*., 2017). While the potential risks posed to human health are difficult to quantify, current surveillance statistics highlight that Ireland has one of the highest crude incidence rates of Shiga toxin-producing *Escherichia* coli (STEC) infection in Europe and indicate a strong link between waterborne illness and private well water exposure (HPSC, 2019). At least 40% of annual national (reported) STEC cases can be attributed to private groundwater consumption (HPSC, 2019), with multiple studies highlighting DWWTSs as a key point source of supply contamination (Hynds *et al*., 2012; O'Dwyer *et al*., 2018) in addition to agriculture (Óhaiseadha *et al*., 2017). The susceptibility of private well users to DWWTS-derived contamination may be further exacerbated by the effects of climate change (Óhaiseadha *et al*., 2017), with experts projecting increases in winter precipitation nationally of up to 7% by the end of the century (Fealy *et al*., 2018). Recent occurrences of heavy rainfall and flood events have been found to significantly correlate with STEC outbreaks originating from private water supplies via expedited transport of untreated waste water to private wells through preferential subsurface flow and surface run-off (Hynds *et al*., 2012; O'Dwyer *et al*., 2016). Therefore, the risk posed by DWWTSs to rural public health is palpable and necessitates concerted, interdisciplinary solutions.

1.1 Ireland's National Inspection Plan

In response to the mounting environmental health pressures posed by defective DWWTSs, and within the wider context of the country's obligations vis-à-vis the EU's Waste Framework Directive and Water Framework Directive (EU, 2000, 2008), Ireland (under the auspices of the EPA, as set out in the Water Services (Amendment) Act 2012 (Government of Ireland, 2022)) established the National Inspection Plan (NIP) in 2013 (EPA, 2013). The NIP constitutes a two-pronged approach to DWWTS risk management, comprising a nationally allocated, local authority (LA)-delivered DWWTS inspection regime (strand 1) and a multi-tier public engagement strategy (strand 2). The inspection regime is underpinned by a risk-based approach targeting an annual minimum of 1200 registered DWWTSs in priority areas characterised by high relative risk to surface waters and private wells (based on Department of Housing, Local Government and Heritage and Geological Survey Ireland (GSI) classifications) (EPA, 2022b). The public engagement strand aims to educate, advise and assist DWWTS owners in relation to risks, maintenance and individual responsibilities under the Water Services (Amendment) Act 2012 (i.e. to register their DWWTS and cooperate with inspections).

While the NIP has been in existence for over a decade, concerns surrounding its efficacy are being raised. Specifically, the EPA's most recent DWWTS

inspection data demonstrate persistently high failure rates among inspected households, with annual failure rates ranging from 44% to 56% since the NIP started in 2013 (EPA, 2024). The fact that approximately half of all DWWTSs have consistently failed inspection (with little discernible progress in this regard over a 10-year period) suggests that the NIP's engagement and communication strategies (strand 2) have not yielded the anticipated behavioural changes required. The report further highlights serious issues in relation to the inspection regime itself (strand 1). The number of unresolved advisory notices has been a growing problem, as over 500 DWWTSs that failed inspection 2 or more years ago have yet to undergo the remediation works required (EPA, 2022a). However, the most recent figures reveal that the number of unresolved advisory notices has decreased for the first time (from 576 at the end of 2023 to 523 at the end of 2024), which has more than likely been aided by the increase in grants for DWWTS remediation, from €5000 to €12,000, from the start of 2024 (EPA, 2024). Notably, these reports (EPA, 2022a, 2024) also indicate variations in the performance of individual LAs in closing off advisory notices, with authorities ranked by the EPA on a spectrum of high to low performance (EPA, 2024). The factors underpinning these trends remain unclear and need to be urgently investigated and addressed to reduce the ongoing risks to public health and the environment.

1.2 Existing State of the Art

Rather than understanding the social dimensions associated with managing the environmental and public health risks deriving from malfunctioning DWWTSs, existing enquiries have tended to centre on developing technical solutions within the context of environmental and/or geotechnical engineering, hydrogeology and environmental chemistry (Gill *et al*., 2007, 2009; O'Luanaigh *et al*., 2010). There are some notable exceptions, however. For instance, Naughton and Hynds (2014) initiated a nationwide cross-sectional survey of Irish households ($n = 1106$) in 2012 (funded by the EPA Science, Technology, Research and Innovation for the Environment (STRIVE) programme) to quantify levels of awareness and examine attitudes and behaviours among Irish DWWTS users. Study findings revealed that householders often maintained or upgraded their systems in response to an obvious breakdown rather than proactively engaging in preventive maintenance practices, suggesting that a greater understanding of the risks posed by DWWTSs to drinking water is necessary. The study suggests that highlighting the fiscal benefits of appropriate DWWTS maintenance to householders may increase public engagement with (and adherence to) the NIP. A follow-up study conducted by Hynds *et al*. (2018), which sought to explore the extent to which householder attitudes and behaviours changed a year after the NIP's introduction, indicated a significant awareness–behaviour gap. Study results suggested that the NIP's inaugural year was successful from an information dissemination standpoint but it did not initiate significant rates of behaviour change. Elsewhere, Devitt *et al*. (2016) adopted a qualitative approach to elicit the attitudes of 28 households towards DWWTS management through a series of focus groups and semi-structured interviews. They found that no participating householders had a regular DWWTS maintenance regime in place, despite most participants agreeing that poorly maintained septic tanks posed a threat to public health and the environment. Interestingly, the study noted that "more concern was attributed to the risk of having one's system inspected than the health and environmental implications of a malfunctioning system" (Devitt *et al*., 2016, p. 540). This finding highlights the need for acknowledgement of key risk perceptions, attitudes and motivations determining behaviour adoption when engaging with the public and fostering shifts towards more purposive, routine DWWTS maintenance. More recently, an Economic & Social Research Institute study (see Curtis, 2024) carried out an extensive survey of 1822 registered DWWTS users in Ireland to gain their views and experiences related to both drinking water and DWWTSs. The study revealed that almost one in five DWWTSs had not been desludged in the past 5 years and the primary reason for this was a belief that it is unnecessary. Interestingly, cost was not indicated as a significant reason for lack of regular maintenance behaviour, nor was awareness of environmental pollution risks (Curtis, 2024).

While these studies offer a valuable baseline of householder perceptions and behaviours, there remain notable limitations and gaps within the existing state of knowledge. First, the focus of existing empirical enquiries has largely centred on capturing the perceived barriers to and drivers of system

maintenance and remediation from the perspective of individual households through either quantitative surveys (Naughton and Hynds, 2014; Hynds *et al*., 2018; Curtis, 2024) or qualitative focus groups (Devitt *et al*., 2016). Accordingly, there remains a dearth of empirical enquiry exploring the barriers to and drivers of DWWTS remediation from other perspectives – most notably the views of LA officials responsible for implementing inspection regimes and communication activities. This is a curious and notable gap given that many of these officials now have over a decade of experience in carrying out DWWTS inspections and can offer unique insights about the barriers to remediation and engagement based on their experiences in dealing with a diverse range of households. Moreover, they may be able to shed light on factors accounting for variation in remediation rates nationally (e.g. LA procedural protocols, staffing and skill sets) and offer opportunities to learn from first-hand contextual knowledge. Second, existing studies have generally failed to explore the potential role that the planning system can play in terms of promoting DWWTS remediation (e.g. planning enforcement, development management) or more broadly by initiating policies or regulations that can help reduce the risks posed by malfunctioning DWWTSs. Third, the empirical enquiries that have explored householder attitudes and behaviours are now somewhat outdated, having been conducted shortly before and after the NIP's initial roll-out (Hynds *et al*., 2018). While the Economic & Social Research Institute study (Curtis, 2024) is more recent, it is nevertheless already somewhat outdated, as there has since been an increase in the remediation grant available. There is now a unique opportunity to reflect on potential changes in householder perceptions and behaviour, and perceived challenges, in order to chart more effective pathways to behavioural change.

The aims and objectives underpinning the "Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication" (REMARC) project have been carefully designed to address the gaps identified above.

1.3 Research Aims and Objectives

The overarching aim of the REMARC project is to advance Ireland's NIP by identifying top-down (governance) and bottom-up (engagement) pathways towards higher levels of septic tank remediation nationally to generate positive outcomes for water quality, the environment and ultimately public health. Specific project objectives are to:

- provide a state-of-knowledge review and policy audit of existing approaches to septic tank remediation and risk communication;
- identify principal "hard" (e.g. financial, geographical) and "soft" (e.g. cognitive, normative) barriers to DWWTS maintenance and remediation via a cross-sectional survey of individual households and expert interviews;
- examine the factors accounting for divergence in DWWTS remediation rates (and unresolved advisory notes) across LAs through expert qualitative interviews;
- explore the role that the planning system can play in bolstering DWWTS management nationally;
- synthesise key research findings to generate agent-based models (ABMs) and develop a modular, transferable public communication framework;
- develop a series of evidence-based recommendations that combine empirically informed and transferable top-down and bottom-up approaches to both governance and engagement.

2 Methods

The project employs a mixed methods approach, including a desktop policy audit, a national household survey and qualitative interviews with LA officials. The detailed methodological approach associated with each of these components is presented below. The results associated with the policy audit, survey and interviews are presented in Chapters 3, 4 and 5, respectively.

2.1 Policy and Practice Audit

To firmly establish the current regulatory and practical context of DWWTS management across government levels, a review of national guidelines/regulations, including building controls, planning procedure and DWWTS maintenance, was undertaken. Particular consideration was given to the historical evolution of national DWWTS regulations and the performance of the NIP.

2.2 Household Survey

An anonymised survey was developed to analyse key DWWTS maintenance and remediation behaviours and associated predictive factors. The survey adopted the Knowledge, Attitude and Practice model and contained five distinct sections spanning socio-demographic, experiential, cognitive, attitudinal and behavioural variables. To ensure a comprehensive measure of supply knowledge and substantive basis for testing hypothetical behavioural intervention scenarios, an awareness scoring protocol and intervention strategy weights (derived from qualitative interviews and a rapid literature review) were formulated. After a small-scale pilot study, the finalised survey was hosted on SurveyMonkey from 27 September 2024 to 2 March 2025 and disseminated electronically through county councils, non-governmental organisations, rural interest groups and media outlets (e.g. Agriland, *Irish Farmers Journal*).[1] The survey yielded a high response rate and was attempted by 1057 eligible respondents, with 974 responses across all 26 Irish counties retained for analysis. A total of 858 respondents answered the survey in full, resulting in a completion rate of 81.2%.

2.2.1 Statistical analysis

Survey data were imported to IBM SPSS Statistics 29 software for initial analysis. Chi-square tests identified significant associations between categorical/ordinal variables and system maintenance actions, with binary logistic regression adopted to distinguish factors with the greatest predictive power. To account for the mediating impact of the NIP on behavioural history, bivariate statistical tests prioritised respondents who did not report being inspected as part of the plan. Stepwise regression was used to reduce model saturation and identify key explanatory variables. Statistically significant bivariate associations and intervention scenario weights were used to inform the development of ABMs.

2.2.2 Agent-based model development

The ABM framework (executed in Python Mesa Library) utilised a Deep Q-Network (DQN) (reinforcement learning) approach. The dataset used for agent-based modelling comprised 873 Irish agents (out of 974 eligible survey attempts) characterised by 50 attributes (variables). The following four steps outline the phases of ABM development:

1. **Feature selection:** Recursive Feature Elimination was adopted to gauge model efficiency and key features. Shapley Additive Explanations interpretation was used to validate each contribution.
2. **DQN architecture:** A DQN was developed to allow agents to make desludging decisions based on their states. The DQN architecture consisted of an input layer (selected features) and output layer, producing Q-values for two actions (1 = desludging, 0 = no desludging).

1 Survey dissemination through the Protect Our Water database of registered DWWTS users was not facilitated by the vast majority of LAs for reasons relating to General Data Protection Regulation compliance and potential conflicts of interest.

3. **Agent-based modelling:** Models were developed via the Mesa framework. Agents were characterised by several states, including system age, environment and a penalty/reward based on frequency of desludging. The agent–environment interaction followed a Markov decision process.
4. **Reward design and free desludging scenario:** A reward mechanism was developed to encourage appropriate desludging behaviour. New systems were given moderate rewards for desludging, receiving +0.25, and a penalty of –0.25 for not desludging. Moderate-aged systems received higher rewards for desludging, receiving +0.4, and a penalty of –0.4 for not desludging. Old systems received the highest rewards for desludging, receiving +0.5, and a penalty of –0.5 for not desludging. Moreover, a free desludging scenario was implemented to simulate introduction of external incentives. Under this scenario, agents performing desludging received an additional bonus reward of +0.8, representing a real-world intervention where desludging services were offered at no cost to households.

2.3 Qualitative Interviews

2.3.1 Interview design and sampling

To understand LA officials' perceptions and experiences of the challenges to remediation that are experienced in practice and the potential role the planning system can play in reducing the risks posed by malfunctioning DWWTSs, a series of qualitative interviews were carried out nationally with DWWTS inspectors, planning officers and LA awareness officers. In order to capture potential variations in terms of challenges and practices locally, which might account for variations in the remediation rates across LAs nationally, analysis of EPA enforcement data over a 10-year period was carried out to identify LAs with high, moderate and poor levels of DWWTS performance nationally (as measured by average rates of inspection, failures and advisory notice closure rates) (Figure 2.1). Four LAs from each of the performance bands were selected with the aim of interviewing one inspector, planner and awareness officer from each LA.

COUNTY COUNCIL	SYSTEM INSPECTION RATE	SYSTEM FAIL RATE	ADVISORY NOTICE CLOSURE RATE	OVERALL PERFORMANCE
Carlow	103%	25%	95%	HIGH
Cork County	102%	53%	90%	HIGH
Cork City	102%	17%	50%	POOR
Kilkenny	97%	54%	57%	POOR
Laois	99%	42%	75%	MODERATE
Louth	102%	29%	98%	HIGH
Mayo	118%	71%	73%	MODERATE
Monaghan	97%	39%	71%	MODERATE
Roscommon	103%	70%	57%	POOR
Tipperary	94%	44%	72%	MODERATE
Waterford	89%	27%	45%	POOR
Wexford	161%	63%	88%	HIGH

Figure 2.1. Targeted LAs by inspection regime performance bracket (2013–2023).

Purposive snowball sampling (with selection criteria to reduce potential bias) was employed to recruit interview participants. In the case of DWWTS inspectors, participants were recruited through the EPA's Septic Tank Inspectors Network. This target group was then used to snowball the recruitment of planners and awareness officers from their respective administrative areas, as well as using publicly available contact information from LA websites. All participants were provided with information sheets about the nature of the project, and consent was obtained prior to the commencement of interviews.

The response rate from DWWTS inspectors across all 12 targeted LAs was very positive, probably due to the close alignment between the role of inspectors and the project's aims and objectives. It proved more difficult to recruit planners, generally due to time and resourcing constraints. Eventually, 10 planners were secured for interview. However, in the case of LA awareness officers, only four participants took part, due partly to staff turnover and vacant positions. Interestingly, however, several awareness officers declined to participate in the study as they felt that they did not have sufficient knowledge of DWWTS management or the NIP. This was unanticipated, given that the NIP identifies awareness officers as playing a key role in terms of the delivery of the engagement strand. In total, 26 interviews were carried out across the 12 targeted LAs. The duration of the interviews ranged from 30 to 90 minutes. The interviews were subsequently transcribed verbatim and fully anonymised before analysis commenced.

2.3.2 Analytical approaches

Thematic analysis

The interview transcripts were also subjected to more traditional qualitative thematic analysis using NVivo software to identify dominant themes to shed light on the views of LA officials in terms of general views on the NIP, explanatory factors relating to national variations in failure and remediation rates, and potential interventions. In doing so, the planning system's existing and potential role in the regulation and control of DWWTSs nationally were also explored. Before the coding commenced, data familiarisation took place followed by the drafting of an initial coding scheme. Adoption of NVivo software also facilitated delineation of thematic insights across LA stakeholder roles (inspectors and planners), as well as historical NIP performance bands. Broad themes and constituent codes were developed inductively and employed for all five sections in each interview guide.

Natural language processing and sentiment analysis

To enhance analysis of the qualitative outputs, natural language processing and sentiment analysis were also employed to explore and interpret the interview data. Large language models are increasingly being recognised as a novel approach that can assist with tasks like transcription, coding and theme identification. For the purposes of this study, large language models are used to carry out content analysis (to identify the frequency and distribution of dominant themes), as well as sentiment analysis (to gain insights into the sentiment or emotional tone of textual data), to explore how participants feel or express themselves.

3 Policy and Practice Audit: Key Findings

A comprehensive review of historical national policies and regulations was undertaken to contextualise the current landscape of top-down DWWTS management apparatus in Ireland. The review examined extant and contemporary legislative instruments and guidance documents as well as information repositories and empirical enquiries of relevance. The review identified a range of historical and existing oversights. The principal observations are outlined below and were used to inform the policy recommendations presented in Chapter 7:

- absence of a clear national communication framework or protocol for communication of DWWTS management requirements;
- lack of DWWTS compliance with planning and building regulations at installation stage (i.e. post-planning permission);
- absence of a licensing regime for DWWTS installers/site assessors and a legally required training course;
- historical deficiencies in DWWTS regulations that precede the establishment of Ireland's formal planning system;
- lack of publicly available inventories of DWWTS contractors;
- lack of clarity surrounding planning requirements for/desirability of shared DWWTS arrangements (i.e. up to 50 population equivalent) in national policy;
- lack of national guidance and regulatory thresholds for system decommissioning/ replacement works and management requirements during property transactions;
- over-reliance on householders seeking DWWTS maintenance and risk information themselves, rather than it being provided to them;
- persistence of prohibitive eligibility criteria for the existing DWWTS grant;
- uncertainty about the rigour of oversight mechanisms concerning application of DWWTS sludge for agricultural purposes.

4 Survey Results

4.1 Respondent Demographics and DWWTS Characteristics

The survey was attempted by 1057 eligible respondents, with 974 responses retained for analysis. A total of 858 respondents answered the survey in full, resulting in a completion rate of 81.2%. The majority of survey respondents (80.6%, *n* = 785) reported using a septic tank system for domestic waste water treatment and disposal, with 19.4% (*n* = 189) availing of a packaged treatment system. Of respondents able to recall discrete system details, over two-thirds (69.9%, *n* = 664) stated that their household arranged the installation of their current system while over half (52.7%, *n* = 495) reported that their system exceeded 20 years in age. Almost one-third of respondents (32.6%, *n* = 318) observed a previous system issue relating to effluent blockage, odour and/or ponding, while 8.1% (*n* = 73) noted a current system operation issue.

4.2 System Registration and Inspection

A total of 665 respondents were able to recall their DWWTS registration status, with 79.2% (*n* = 527) claiming that their household had registered their system (Table 4.1). Of the respondents who were aware of their system inspection history, 12.5% (*n* = 92) stated that their household system was previously subject to an NIP inspection. A fail result was reported by 12.4% (*n* = 11) of such respondents – all of whom subsequently claimed to have successfully addressed inspector recommendations. Appraisals of hypothetical results among respondents yet to undergo an NIP inspection were generally positive, with 80.2% (*n* = 519) contending that their system would pass an official inspection. Among respondents who believed that their system would pass and subsequently stated how they would respond to a hypothetical inspection fail, 94.2% (*n* = 409) indicated that they would take responsive measures. Among respondents who believed that their system would fail and stated their hypothetical response, 87.6% (*n* = 85) indicated likewise.

When evaluating why their household system would fail a hypothetical inspection, over 50% (*n* = 68) of respondents referenced multiple issues (outlined in Figure 4.1). Respondents most frequently flagged incorrect system design (32.8%, *n* = 40) and ingress of rain/surface water into the system (30.3%, *n* = 37).

Table 4.1. System registration and inspection history

Variable	Total answered, *n*	Variable category	Frequency, *n* (%)
System registration	665	Registered	527 (79.2)
		Unregistered	138 (20.8)
NIP system inspection	735	Previous inspection	92 (12.5)
		No previous inspection	643 (87.5)
NIP system inspection result[a]	89	Pass	78 (87.6)
		Fail	11 (12.4)
Adoption of inspector recommendations[b]	11	Adopted recommended measures	11 (100.0)
		Did not adopt recommended measures	–
Belief system would pass NIP inspection[c]	647	Believed system would pass	519 (80.2)
		Believed system would fail	128 (19.8)
Response to hypothetical inspection fail[c]	531	Would adopt inspector recommendations	494 (93.0)
		Would not adopt inspector recommendations	37 (7.0)

[a]**Households that were inspected under the NIP.**

[b]**Households that failed an NIP inspection.**

[c]**Households that have not undergone an NIP inspection.**

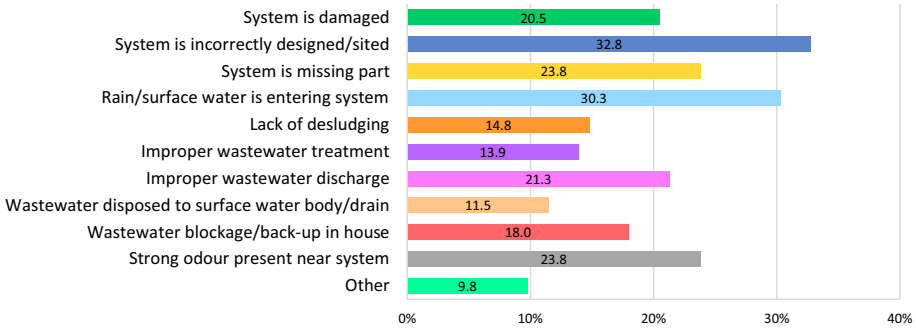

Figure 4.1. Reasons why respondents believed their system would fail a hypothetical inspection.

Lack of desludging (14.8%, $n=18$) was one of the less frequently cited reasons.

Key factors encouraging adoption of post-inspection measures following a hypothetical inspection fail are listed in Figure 4.2. Respondents who indicated that they would address a hypothetical fail principally cited protection of local environment (71.9%, $n=454$), proper system performance (68.1%, $n=430$) and protection of household health (62.6%, $n=395$) as motivating factors. Regulatory compliance was cited as an impetus to action by 36.8% ($n=232$) of respondents. Confidence in system performance (48.8%, $n=21$) and financial cost of remedial measures (69.8%, $n=30$) were the most frequently cited disincentives to action among respondents who claimed that they would not address a failed system inspection.

4.3 System Management Awareness

The mean overall system management awareness score attained by all survey respondents was 5.5 out of 7 (standard deviation (SD) ± 1.224) or 78.7 out of 100. Inspected system users registered an overall awareness score of 6.152 (SD ± 0.913) compared with 5.722 (SD ± 1.093) among non-inspected system users. Where scores were segmented into awareness tiers, high awareness was exhibited by a total of 51.0% ($n=497$) of respondents, while moderate and low awareness were demonstrated by 44.3% ($n=431$) and 4.7% ($n=26$) of respondents, respectively. Respondents who reported undergoing an NIP system inspection previously demonstrated significantly higher levels of system management awareness ($\chi^2=10.081$, $p=0.006$), with 73.9% ($n=68$) of inspected respondents demonstrating high awareness compared with 57.2% ($n=368$) of non-inspected respondents.

4.4 System Maintenance Behaviour

Among respondents who did not report having undergone a DWWTS inspection before, a large majority (89.1%, $n=738$) reported adoption of one or more system maintenance measures. Previous system desludging and operational/structural examination was cited by 73.4% ($n=578$) and 24.2% ($n=191$) of non-inspected respondents, respectively. With respect to remedial measures, 25.1% ($n=198$) reported arranging system repair works while 11.5% ($n=91$) reported organising a previous system replacement or upgrade. Over one-third of non-inspected respondents (37.5%, $n=282$) stated that their household previously sought system maintenance information.

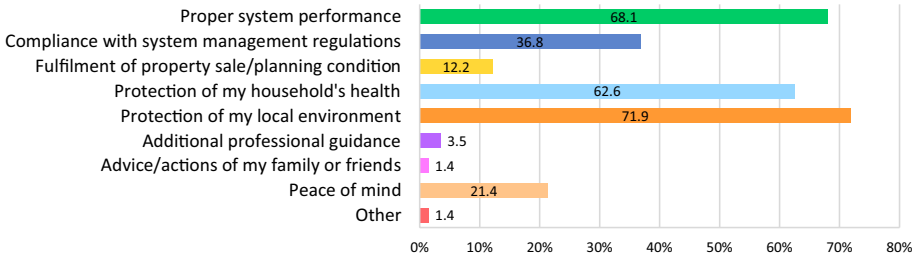

Figure 4.2. Factors encouraging adoption of recommended measures following a hypothetical inspection fail.

Among non-inspected households reporting previous system maintenance, almost 80% ($n = 523$) stated that they had consistently maintained their system historically. The most regularly cited rate of system maintenance was once every 2–5 years (54.5%, $n = 372$), with one-quarter of respondents reporting implementation of one or more annual system maintenance measures (25.0%, $n = 171$). Of the respondents who stated that their household had desludged their system before, 79.6% ($n = 442$) did so in accordance with recommended desludging rates. Rates of adherence to recommended desludging rates were significantly higher among respondents reporting a prior NIP system inspection ($\chi^2 = 4.856$, $p = 0.028$), with 91.8% ($n = 56$) of inspected respondents indicating historical adherence and 80.1% ($n = 359$) of non-inspected respondents indicating the same.

In terms of motivations for system maintenance, respondents most frequently cited proper system performance as a driving factor (72.8%, $n = 586$). Protection of local environment (43.3%, $n = 344$), protection of household health (42.1%, $n = 334$) and indication of system malfunction (40.9%, $n = 325$) represented the second, third and fourth most regularly referenced motivating factors, respectively. When considering the reasons for lack of maintenance, over 60% ($n = 56$) of respondents who had yet to undertake system maintenance cited proper system performance as the principal discouraging factor. Financial cost (30.8%, $n = 28$) emerged as the third most frequently cited reason after absence of perceived danger to household health (33.0%, $n = 30$).

4.5 DWWTS Management Perspectives

A total of 885 respondents appraised their perceived level of confidence in undertaking system maintenance, with 53.4% considering themselves confident in their ability to do so. Of the 814 respondents who considered the presence of barriers to current system maintenance action(s), 68.6% ($n = 558$) cited one or more impediments (Figure 4.3). Financial cost (49.0%, $n = 399$) emerged as the most frequently selected maintenance barrier, cited by almost half of system users. Lack of knowledge (28.6%, $n = 233$) and lack of available/clear guidance (25.4%, $n = 207$) constituted the second and third most frequently cited barriers, respectively. Almost one-quarter of responses (23.0%, $n = 187$) referenced lack of time and/or lack of accessible services/solutions.

Respondents preferred changes in policy principally centred around financial endowments (Figure 4.4), with them favouring the introduction of a financial incentive for desludging (58.1%, $n = 495$) and widened eligibility criteria for DWWTS remediation grant access (48.9%, $n = 417$). Over one-third of respondents desired enhanced availability of guidance information (37.8%, $n = 322$) while over one-quarter desired enhanced quality of guidance information (27.5%, $n = 234$).

4.6 Bivariate Associations

Reported desludging behaviour was associated with several experiential, cognitive and environmental factors. Respondents who had previously observed indicators of system malfunction ($\chi^2 = 9.553$, $p = 0.002$) and cited an absence of barriers to system maintenance ($\chi^2 = 11.804$, $p < 0.001$) were significantly more likely to have had their system desludged before. In terms of cognitive factors, likelihood of desludging was significantly higher where respondents demonstrated awareness of the NIP ($\chi^2 = 8.089$, $p = 0.004$) and

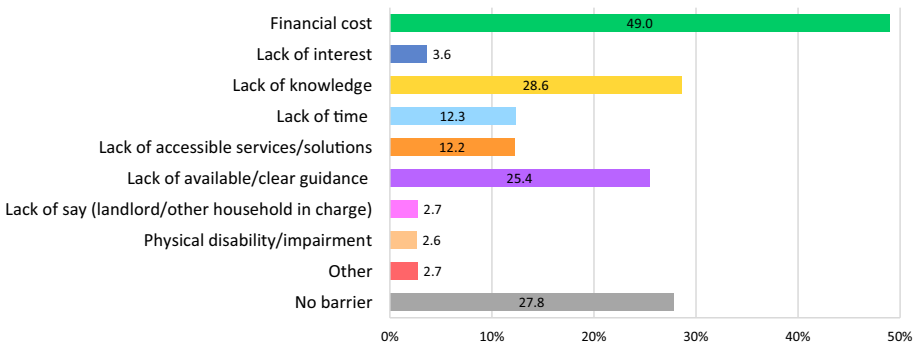

Figure 4.3. Cited household barriers to DWWTS maintenance.

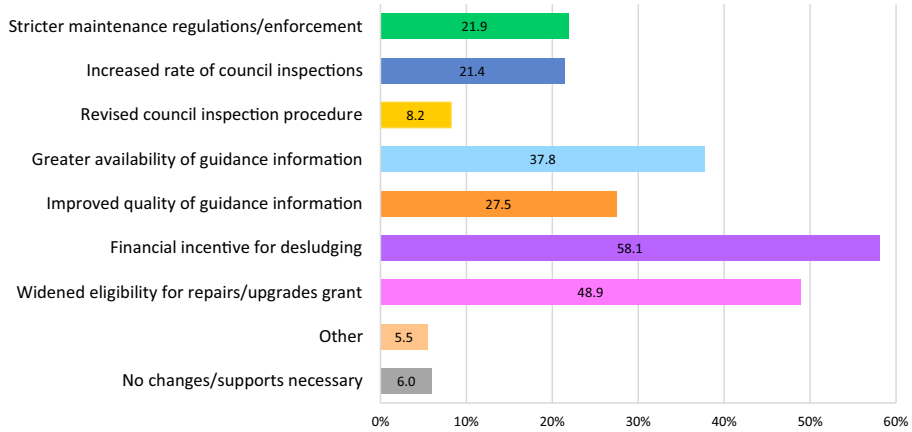

Figure 4.4. Cited policy changes/supports motivating future system maintenance.

confidence in undertaking system maintenance ($\chi^2 = 23.687$, $p < 0.001$).

Adherence to recommended rate of desludging was significantly associated with DWWTS type, receipt of maintenance information and confidence in undertaking system maintenance. Respondents who claimed to avail of a packaged treatment system were five times more likely (odds ratio (OR) = 5.147) to adhere to recommended desludging rates ($\chi^2 = 17.132$, $p < 0.001$). Households that reported receiving system maintenance information ($\chi^2 = 7.264$, $p = 0.007$) and having confidence in maintaining their system ($\chi^2 = 11.858$, $p = 0.003$) were likewise significantly more likely to follow guidelines for desludging frequency (OR = 1.832 and OR = 2.879, respectively).

Previous undertaking of a DWWTS examination (distinct from an NIP inspection) was associated with socio-demographic as well as experiential and cognitive variables. DWWTS examination demonstrated a significant association with DWWTS type ($\chi^2 = 75.071$, $p < 0.001$) and household income ($\chi^2 = 13.339$, $p = 0.001$), with respondents using a packaged treatment system and those recording high annual household income both more likely to have previously self-inspected their system. System examination was significantly linked with experiential/ behavioural factors in the form of the householder seeking and receiving system maintenance information ($\chi^2 = 28.133$, $p < 0.001$ and $\chi^2 = 13.267$, $p < 0.001$, respectively). Respondents who previously sought and those who acquired system maintenance information were both over twice as likely to report previous household system examination (OR = 2.514 and OR = 2.010, respectively). Perceived confidence in maintaining their system ($\chi^2 = 12.801$, $p = 0.002$) and presence of maintenance barriers ($\chi^2 = 7.681$, $p = 0.006$) also exerted a significant influence, with higher confidence and absence of barriers typically corresponding with reported system examination.

4.7 Agent-based Modelling

Agent-based modelling identified incentive- and information-based interventions as optimal strategies for promotion of desludging (Table 4.2). Free desludging and subsidised desludging (scenario 6) demonstrated high levels of learning efficiency and predictive accuracy (85.68 and 80.18, respectively). Implementation of a high-intensity information campaign (scenario 5) emerged as the third most successful hypothetical scenario and engendered a similar rate of behavioural adoption to introduction of incentivised desludging. Scenarios 1 (mandatory maintenance contracts), 2 (increased fines for illicit discharge), 3 (low-intensity information campaign) and 4 (medium-intensity information campaign) generated positive albeit lower rates of behavioural change.

Table 4.2. Efficacy of simulated intervention scenarios to promote desludging behaviour

Scenario[a]	Parameter	Probability value (weight)	No. of agents arranging desludging	Learning efficiency (episodes)	Accuracy (%)	Mean squared error
1	Mandatory maintenance contract for new-build home/extension	0.25	644/873	1000	73.75	1.0899
2	Increase in fine for illicit waste water discharges	0.25	637/873	1000	72.96	0.0936
3	Information campaign (low intensity)	0.15	629/873	1000	72.03	0.0074
4	Information campaign (medium intensity)	0.30	650/873	1000	74.45	0.0645
5	**Information campaign (high intensity)**	**0.45**	**698/873**	**500**	**79.75**	**0.6464**
6	**Incentivised desludging (e.g. discount)**	**0.45**	**700/873**	**500**	**80.18**	**0.3770**
6	**Free desludging (i.e. one free service permitted by LA)**	**0.90**	**748/873**	**500**	**85.68**	**0.0231**

[a]**Text rendered in bold indicates the most successful intervention scenarios.**

5 Interview Findings

This chapter offers an overview of the key findings emerging from the thematic analysis and large language processing of interview data collected from LA inspectors, planners and awareness officers. As only four awareness officers partook in the interviews, respondent saturation was deemed insufficient to merit the inclusion of awareness officers' observations. Therefore, this chapter considers broad observations regarding the performance of the NIP and the planning system in the regulation of DWWTSs, as well as key determinants of performance within and across LAs. Key findings in relation to observed barriers to DWWTS maintenance and remediation as well as potential interventions are also provided.

5.1 Thematic Qualitative Analysis

5.1.1 National Inspection Plan performance appraisal

LA inspectors were asked to assign scores (out of 10) for both the engagement and inspection strand of the NIP, and an amalgamation of assigned scores resulted in a mean overall NIP performance score of 6.7 (Table 5.1). Over half of interviewed inspectors (7/12) deemed the inspection regime to constitute the most effective NIP strand. Mean assigned performance scores for the inspection regime and public engagement programme were 7.4 and 5.8, respectively. Two of four interviewed inspectors representing high-performing LAs referenced the historical presence of an inspection team and attendant administrative staff in their respective departments. Three of four interviewed inspectors representing low-performing LAs mentioned regular or recent instances of inspection staff turnover.

Table 5.1. Mean NIP performance scores (/10) assigned by LA DWWTS inspectors

	LA NIP performance bracket			
NIP strand	High	Moderate	Low	All
Inspection regime score	8.1	7.6	6.0	7.4
Public engagement programme score	5.1	6.3	6.0	5.8
Overall score	6.6	6.9	6.0	6.7

5.1.2 Engagement

Mixed assertions concerning the adoption of public engagement activities were expressed by inspectors. Half of interviewed inspectors (6/12) articulated a distinctly negative view of DWWTS-oriented public engagement, with some contending that the existing volume and visibility of national- and subnational-level engagement mechanisms targeting DWWTS users was inadequate. However, some inspectors held divergent views. For instance, three of four inspectors who positively evaluated national-level modes of DWWTS management communication suggested that such channels compensated for the absence of more local, county-wide householder engagement. Dominant themes in this regard are outlined in Table 5.2.

5.1.3 Inspections and enforcement

Analysis of interview data in relation to inspectors' views on the implementation of the NIP inspection strand revealed a number of dominant themes, particularly in relation to resourcing and staffing issues. Inspectors universally contended that staff resourcing constituted the primary determinant of LA adherence to allocated inspection numbers and closure of advisory notices, with some making specific references to competing demands within LAs detracting from DWWTS inspections and subsequent enforcement. Indeed, most obstacles to advisory notice closures referenced by inspectors were administrative in nature and help explain variation in the performance of individual LAs. However, apathy among LAs to pursue legal proceedings and the difficult personal circumstances of individual households with unresolved advisory notices were also highlighted as prominent explanatory factors. More details are provided in Table 5.3.

Table 5.2. Inspectors' views on engagement

Theme	Supporting statement
Absent overarching communication framework: Inspectors' principal concerns about the NIP most frequently related to public communication and information conveyance, with 11 of 12 inspectors indicating a strategic deficiency related to DWWTS user engagement. While half of inspectors referred to pre-inspection or neighbourhood-based household visits as an effective engagement mechanism, most, nevertheless, flagged a general lack of effective communication measures and/or overarching communication framework.	LAI09: On the information and engagement side, we probably need to do more locally and nationally because there's not a great knowledge of the inspection regime and what it's about and what needs to be done. From the time that the first notice is issued, you're possibly entered into a legal process if your system isn't compliant with the standards. So, there's probably a need for more work to be carried out there.
Insufficient DWWTS maintenance information: Half of interviewed inspectors (6/12) contended that the existing volume and visibility of both national- and local-level engagement mechanisms targeting DWWTS users was inadequate.	LAI01: I can't remember the last time I read anything about the National Inspection Plan for septic tanks. We go to the seminars and the meetings once or twice a year. That's it. I can't remember seeing anything on the national news or newspapers or any mention of it at all.

Table 5.3. Inspection and enforcement strand: key findings

Theme	Supporting statement
Staff resourcing: Inspectors universally contended that staff resourcing constituted the primary determinant of LA adherence to allocated inspection capabilities. The number of personnel was a salient concern in this respect, as the rate of assigned inspections relative to county size was regarded as the greatest gauge for quota adherence and advisory notice closures.	LAI06: I think the environment sections of councils always struggle for resources compared to other sections. I know the number of inspections obviously increased in the last couple of years. I suppose we were lucky that our numbers actually went down … but a lot of other councils … obviously their numbers kind of jumped considerably. So, yeah. Staff resources is the main thing.
Low inspection rates: The majority of LA inspectors (10/12) demonstrated an ambivalent attitude towards the NIP, with recognised benefits often deemed to be counterbalanced by strategic weaknesses or limitations, most notably the low number of system inspections overall.	LAI02: The risk zones and all has worked … and it does identify and bring you into an area … but it's still like we're only one snowflake in a snowstorm. So, it's there to do for a purpose and we just have to take it for what it is.
Reluctance to initiate legal proceedings: The most frequently quoted impediment to closure of advisory notices derived from enforcement action for expired notices was the reluctance to initiate legal proceedings. Nine of 12 inspectors cited this (and/or duration of court hearings) as a pertinent reason for regional variance or shortfalls in advisory notice closures.	LAI01: The legal system is so adversarial towards bringing a successful case. You'll do anything you can to avoid going to court … and I've been in the High Court, 26 or 27 times. So, I'm well used to it … but there is very, very little drive in the management in local authorities to go to court because of the difficulty of bringing forward a case and winning it. Then what happens? You just get adjourned and more time is given to the defendant to resolve the problem anyway.
Increased resource demands for other environmental inspection domains: Local government restructuring (2/12 inspectors), reduced focus on DWWTS inspections (4/12 inspectors) and staff turnover (4/12 inspectors) emerged as key concomitant topics. Four inspectors posited that increased resource demands for other environmental inspection domains (e.g. agricultural inspections) had, in some cases, inadvertently resulted in de-prioritisation of DWWTS inspections in certain LAs.	LAI03: You may be aware that there's a National Agricultural Inspection Plan [that] has been rolled out in the last year. We're kind of robbing Peter to pay Paul at the moment in that we're ring-fencing money for each local authority to take on staff in those areas … and only to do that kind of work – that farm inspection work.
Individual householder circumstances: While householder evasiveness/stonewalling was highlighted as a challenge on multiple occasions (4/12 inspectors), six inspectors referred to cases where system remediation was delayed by legitimate (often personal) householder circumstances, which resulted in exceptionally long delays and necessitated additional resource allocation.	LAI04: We've sent out letters chasing up on the older inspections [that remain] open – follow-up letters … Some of them might say "My husband has died and he was always looking after it. I believe he told me it was closed out but you'd have to …". So, it's making us go out and nearly do another follow-up inspection to see if the work issue is still there.

Table 5.3. Continued

Theme	Supporting statement
Miscommunication of the DWWTS grant scheme: In relation to information content, miscommunication of the DWWTS grant scheme by politicians and public servants was cited overwhelmingly. Six of 12 inspectors asserted that the eligibility criteria of the (recently increased) financial endowment was widely misinterpreted due, in part, to the expedient co-option of the grant for political leverage.	LAI11: The government caused uproar in regard to the septic tank grant. They gave the impression to the country that the grant was available to everybody. So, we've had phone calls on a daily basis asking for inspections … That has put us into a kind of quandary because there are some people out there and their tanks are really, really bad. So, what do you do?
Positive impact of the grant scheme: Inspectors deemed the recent increase in the DWWTS remediation grant subsidy to represent the most positive measure influencing resolution of advisory notices. Five of 12 inspectors believed that this modification would help abate existing financial household pressures and reduce current advisory notice backlogs.	LAI10: Definitely, the engagement has improved since the grant has gone up to a maximum of €12,000 … The grant is very good for those who can access it … and the increased money has increased engagement for the people that we needed increased engagement from.
Grant eligibility: While 3 of 12 inspectors considered the DWWTS grant policy to represent a major strength of the NIP, 3 inspectors stated that the grant eligibility constituted a strategic flaw and counterintuitive restriction.	LAI08: If the whole thing is adamant or is very focused on preventing septic tank pollution, I think the existing scheme or a different scheme, even, should be widened so that members of the public could avail of some type of a grant system and have their septic tank inspected without having to be picked at random.

5.1.4 Inspectors' views on high failure rates

The interview guide also requested inspectors to account for high failure rates nationally. The most prominent issues cited related to lack of system management awareness (particularly in relation to packaged DWWTSs), non-compliance with the planning permission/conditions stipulated at the application stage, as well as physical/environmental site characteristics, which were commonly cited in relation to variations in the failure rates among LAs (Table 5.4).

Table 5.4. Views concerning DWWTS inspection fails

Theme	Supporting statement
Deficit of operational knowledge: The most prominent themes underlying current national DWWTS inspection fail rates related to lack of system maintenance (12/12), limited system management awareness (9/12) and lack of interest (8/12). While infrequent or absent desludging was noted across DWWTS modalities, five inspectors notably highlighted a deficit of operational knowledge regarding packaged (typically mechanised) systems.	LAI11: There was one system, would you believe, where an inspection had been done by some engineer when the house was bought about 12 years ago. This was an actual [inspection] that we picked out of the hat. We walked in, went over the side of the garden and [the householder] said "The mechanical system is over there. It's working away grand. We were told it's one of the best systems in the world". The system wasn't even turned on and hadn't worked for 12 years.
Non-compliance with planning conditions: Incorrect installation/arrangement of DWWTS (post-planning or construction) also emerged as a recurring reason for DWWTS inspection fails. Ten inspectors acknowledged this concern, often linking the issue to non-compliance with planning stipulations (for financial reasons).	LAI10: So, the two mains fails would be poorly designed percolation areas and just lack of maintenance … but while soil can often be [an issue], it's [also] at planning. Planning may not have stipulated it or maybe somebody said "Do you know what? I'm not going to build a tertiary system because I can't afford it".
Physical/environmental characteristics: Eight of 12 inspectors regularly observed physical and environmental characteristics (particularly hydrogeological and soil conditions) as contributing factors to discrepancies in regional DWWTS fail rates, underscoring the need for comprehensive system inspection methodologies. Several inspectors noted that favourable subsoil characteristics may accelerate subsurface waste water attenuation and therefore reduce the likelihood of waste water backup or effluent ponding from deficient systems.	LAI01: My county has very good ground conditions. It's a very strong agricultural county with a very strong tillage base. So, my inspection pass rate is higher than the average. My pass rate might be 65% maybe … and that's because of the good ground conditions. You can't equate my county's failure or pass rate to [other counties with poorer] groundwater conditions and soil and vulnerability zones.

5.1.5 Observed barriers to householder DWWTS maintenance

Looking towards the key barriers to DWWTS maintenance based on the experience of the inspectors, a number of dominant themes emerged, including lack of system maintenance knowledge, intangibility of DWWTS malfunction, as well as financial concerns and contractor availability (Table 5.5).

5.1.6 The role of the planning system

While approaching the issue of DWWTS regulation and management from a planning perspective (rather than NIP implementation more specifically), the interviews with local authority planners (LAPs) demonstrated close alignment with those with inspectors, particularly in relation to issues of LA resourcing, as well as post-planning compliance and enforcement issues. Table 5.6 offers additional details and supporting statements of the planning-specific issues raised.

Looking more specifically at the difficulties stymying efficient processing of and adherence to planning applications and permissions involving DWWTSs, planners citied various issues, including lack of post-planning regulatory follow-through and concerns relating to the quality and integrity of planning agents. These themes are more fully explained and contextualised in Table 5.7.

5.1.7 Planning-related barriers to effective DWWTS management

Material and knowledge hindrances flagged by LA DWWTS inspectors as especially inimical to system maintenance were accorded similar prominence by planners in the context of system planning compliance. Views concerning barriers to householder planning compliance are listed in Table 5.8.

Table 5.5. Observed barriers to DWWTS maintenance

Theme	Supporting statement
Lack of system maintenance knowledge: Cognitive and attitudinal factors emerged as the most frequently cited barriers to DWWTS maintenance and remediation. Nine inspectors collectively flagged lack of system maintenance knowledge, imperceptibility of system risks and wilful neglect as common behavioural deterrents.	LAI09: The general way of affairs is "I've installed a septic tank. It isn't causing any trouble. I haven't had to do anything with it in years". It's a hassle-free system for them. They don't want to go looking for problems if they perceive that there's none there … until, by chance, their system is inspected, fails and requires a system upgrade … and you're coming up against difficulty there because they're not informed or aware and they don't see the need to get the works done.
Intangibility of system malfunction: A salient issue, irrespective of property/household characteristics or DWWTS type, was the intangibility of system malfunction. Recounting prior field observations, three inspectors implied that perceptual barriers to system intervention may be effectively addressed by highlighting the subsurface intricacies of domestic waste water treatment.	LAI08: A lot of the time, you'll land in the house… You'll go in, you'll have a problem; they're not aware of it… and they're very glad that you've informed them that there is a problem … because nobody wants raw sewage … They'd be quicker to rectify those sorts of problems. It's once they see ponding in the back garden, manholes overflowing everywhere.
Financial concerns: While inspectors acknowledged the utility of the system remediation grant as a means of encouraging DWWTS remediation, financial concerns (pertaining to both general system maintenance and post-inspection requirements) were raised by eight inspectors.	LAI06: If they made the grant more freely available rather than making it restrictive … I suppose there could be a better public awareness campaign for desludging septic tanks and not letting roof water into a septic tank system … but, I suppose, the bottom line is money. Even a nominal amount of money … Let's say it's €200–300. Some people will say "Well, I can put that off till some other time".
Contractor availability: Absence of available contractors was highlighted as a significant impediment to completion of DWWTS works in three counties. Inspectors noted that certain householders arranging system maintenance were dependent on a dwindling number of contractors.	LAI07: Tradesmen would be a key issue … and I've found that in certain areas there might be two or three that are doing jobs and leave good work behind them and people will wait for those people … but if they let me know that those contractors are engaged, I'm quite happy to go over the time of the advisory notice – that I know that it's going be done properly. It's just a matter of them getting around to it. So, quality workmen is an issue for homeowners.

Table 5.6. The role of planning in regulating and managing DWWTSs

Theme	Supporting statement
Lack of resources and staff: Most planners cited administrative constraints as a key issue impacting the proper regulation and control of DWWTSs in a general sense. Specifically, planners cited lack of resources (8/10 planners) and lack of staff (7/10 planners) as the most common issues raised.	LAP01: It's one hundred per cent staffing and resources. I think, at the moment, there's a real problem with recruitment. There aren't people out there; big shortages. I know the government is doing their new plan to address that but most local authorities would feel they're severely understaffed to manage the workloads that come … and different new provisions.
Lack of planning enforcement: Departmental under-resourcing materialised as a barrier to implementation of post-installation enforcement actions on five occasions. Several planners also explained key procedural challenges (encompassing inspection duration, burden of proof and judicial disinclination towards defendant sentencing) that can exacerbate demands on enforcement officers.	LAP04: Planning enforcement is generally cumbersome, long-winded and doesn't have any great teeth. If you go for the indictable offence, you have to prove it beyond reasonable doubt. So, you could imagine, in the case of a septic tank or water, all the variables that might be involved. It would be a waste of time and effort to try and do something the way the planning enforcement regime is set up at the moment.

Table 5.7. Key planning issues at the application and post-planning stages

Theme	Supporting statement
Absence of regulations at the installation phase: Views expressed by LAPs regarding the planning system's effectiveness in managing DWWTS installation were largely mixed and attitudinally comparable to inspectors' appraisals of the NIP. While planners contended that planning provisions for DWWTS screening largely accounted for system design and site suitability, nine planners flagged an absence of regulations addressing follow-through at the installation stage.	LAP02: It's only at the start that the planning system is relevant. By the time a house is built and the septic tank is put in … We don't inspect it when it's put in and there's no building inspectors going to see how it's put in. It's signed off by a private consultant. Once the planning application is submitted and decided upon, the planning system is finished, really, with systems.
Quality and integrity of planning agents: Six planners raised quality and integrity of planning agents as an issue in relation to applications as well as post-planning compliance. An associated concern was agent misconceptions regarding DWWTS operational efficiency. Three of six planners raising the subject of planning agents claimed that some consultants misguidedly urge applicants to commission installation of packaged treatment systems to enhance the likelihood of granting of permission.	LAP01: I'm always surprised at agents. They come in with a lot of stuff half-baked. They come in with an extension that clearly has additional bedrooms and won't have looked at the treatment system. LAP07: There are certain applications that come in and you see a perfectly good site … yet they're still proposing to put in an extremely technical and extremely expensive piece of apparatus … I blame it a lot on the agents that submit planning applications. They've got this idea that "Oh, listen – they won't take septic tanks off you anymore", which is totally untrue.
Potential for inappropriate or manipulated site assessments: Five of 10 planners highlighted the potential for inappropriate or manipulated site assessments at the pre-construction stage. LAP12 disclosed an awareness of instances in which site assessors were found to falsify or deleteriously alter site characteristics.	LAP12: The interpretation and the enforcement of guidelines is maybe where things falls down in that it's very much self-certified. There are checks from local authorities but you are very much reliant on those submitting the site characterisation – that they are not doctoring ground conditions … and that can happen … but luckily our environment section is fairly on top of that.
Overdependence on self-regulation at installation stage: Despite 5 of 10 planners referencing a parent LA condition stipulating certification of compliance with the EPA code of practice, existing post-permission measures were generally deemed inadequate. Therefore, overdependence on self-regulation at the installation stage (considered a function of scarce DWWTS building control and LA staff shortages) emerged as the perceived regulatory shortcoming. Disputing the veracity of certification provided to LAs, one planner stated that elicitation of independent system surveyors was necessary to provide a failsafe.	LAP05: If you talk to every county, they will tell you that there's people who will sign off on stuff that don't give it full examination. Probably not as much as there used to be but certainly it still goes on. So, I think, realistically, the only way is if it's checked by an independent person. Somebody not involved in the build. We can condition all day but we're only going to get the piece of paper that says everything is okay.

Table 5.7. Continued

Theme	Supporting statement
Financial cost of DWWTSs: Five planners referred to the financial cost of DWWTSs, which they invariably believed posed a deterrent to applicant fulfilment of prescribed system arrangements.	LAP06: Applicants will promise the sun, moon and stars … but after they get that permission, suddenly we have the valuation end coming into it where the cost of the overall project is only then being considered … I would say, anecdotally, a lot of people do not actually pay registered installers of systems … I think it comes down to cost.
Legacy issues: Four planners observed planning complications arising from legacy system issues. Several described cases in which historically inherited or self-induced instances of DWWTS regulatory non-compliance posed obstacles for future property modifications/transactions or may dissuade prospective applicants from pursuing obligatory planning permission.	LAP01: Let's say the house is located 2 metres back from where it was approved … It usually comes back to bite people. We've had so many cases over the years where people are in the process of trying to sell a property and the buyer's solicitor is looking for compliance … and there might have been different particulars like the certificate of compliance not submitted … and it stalls the sale.

Table 5.8. Views concerning material and knowledge barriers to householder planning compliance

Theme	Supporting statement
Limited knowledge of system management cost requirements: Financial cost (7/10 planners) and dearth of knowledge regarding system management requirements (5/10 planners) constituted the main cited barriers to performance of due diligence by applicants. Several planners elucidated the thematic relationship between both matters and appealed for greater provision of system management information to householders.	LAP06: Householders need someone to explain to them that these things have to be maintained right … and there is going to be X associated costs on an ongoing basis associated with that … Not when they get to the point where whoever installs their system charges X and they say "Jesus, I'm not paying that. That's too dear. Go away". There needs to be more knowledge of that at the outset.
Limited awareness of DWWTS planning regulations: Another recurring householder knowledge gap concerned the apparent dearth of awareness or recall of system regulations across planning stages. Regulatory unfamiliarity was recognised by three inspectors.	LAP05: You could probably argue that people need to be told and keep being told … whether that's registering systems or a reminder that you have to get your tank desludged. We put in conditions years ago requiring people to submit their maintenance contracts on an annual basis but people didn't do it. Once they get permission, they just forget about it.
Over-reliance on and inconsistencies among planning agents/contractors: Disquiet about existing levels of DWWTS knowledge was often manifest in the perceived over-reliance of householders on the direction of planning agents and contractors. Six planners voiced reservations about the quality of third-party system works and advice, underscoring the current absence of licensing regimes for site engineers and system installers.	LAP04: I know one guy who used to do planning applications as nixers on the side … but when it became more lucrative he started doing planning full-time. So, he sets himself up as a house designer, a site supervision guy and he does the site assessment form as well. I know he has an engineering background and all that but he's not trained in any of those areas. He's just self-trained … and I know a couple of people like that around the county.
Financial cost and expedience: Contemplating householder motivations influencing consultant procurement, three planners identified financial cost and expedience as priority criteria.	LAP01: Cost is a thing for people too, and local agents might be less costly, but then maybe sometimes local agents don't hit all the requirements and submit all the necessary detail … and people may have been better to get a more qualified consultant or architect because they would have avoided a further information request on the layout and design of a drainage system.

5.1.8 Optimal approaches

A series of recommendations were brought forward by both the inspectors and the planners in terms of devising optimal approaches towards DWWTS management, implementation of the NIP and the role of the planning system more generally. The key themes that emerged are presented for inspectors and planners in Tables 5.9 and 5.10, respectively.

Recommendations put forward by planners frequently overlapped with inspectors' proposals – particularly in relation to public engagement and LA resourcing (albeit with more emphasis from a planning-compliance perspective).

5.2 Natural Language Processing and Machine Learning

5.2.1 Key themes

Drawing on natural language processing techniques with advanced machine learning approaches, the qualitative interview data were analysed to identify key themes and to examine the sentiment and tone of the inspectors' and planners' responses within each thematic area. Principal component analysis clustered interview responses into three key categories: (1) challenges, (2) achievements and (3) recommendations. Table 5.11 reflects the thematic

Table 5.9. Inspectors' recommendations

Theme	Supporting statement
Intensified public engagement programme: Over half of inspectors (7/12) advocated for an intensified public engagement programme, collectively desiring greater information visibility and stakeholder coordination in message formulation/dissemination.	LAI03: I think it needs to be something that's nationally out there … I think it needs to be something readily available to people in their day-to-day lives … because it needs to be something that gets drilled home. A one-off meeting with someone … you might get 10% of people that decide "Yeah. I'm going to take that on board and run with it".
Enhanced provision and quality of information addressing DWWTS misconceptions: Accounting for false beliefs regarding system functionality/safety was considered a crucial objective for future behaviour promotion initiatives by four inspectors.	LAI07: If you had a community group, you could do workshops with them on awareness … but you're still depending on people to inform themselves and actually do something with their systems … and what support is there for them? Awareness is key … and people usually don't realise the problem until it's bad, whereas a small bit of maintenance would have avoided it getting bad.
Widening of existing DWWTS grant parameters: Notwithstanding the recognised significance of augmented staff resources, half of inspectors (6/12) proposed grant modifications when presenting solutions to unresolved advisory notices and routine maintenance costs. Inspectors posited that raising the grant's financial ceiling and loosening existing eligibility/ maintenance criteria would furnish an added incentive for householders.	LAI08: The introduction of a subsidy, a €100 subsidy, to have your tank desludged … I think it would be enticing to people … and it is about €300 or €400. You could have a young couple with kids and they have to get it desludged in 20 days and they can't afford it … The cost of desludging comes up a lot. People think it's quite expensive to get it desludged … and they always have the temptation of the local farmer down the road that will come in and do it for a quarter of the price.
Increase and refinement of DWWTS inspections: Four inspectors proposed an increase in the number of annual inspections – a suggestion that coincided with other associated recommendations (i.e. improved risk mapping, and encouragement of neighbourhood-based inspections).	LAI09: I think we should be doing more inspections in a more targeted way … You're kind of limited in the septic tanks to proximity to drains, watercourses, groundwater vulnerability. The risk assessment metrics are a bit static. I think there might be some sort of way to use some of the GSI data [informing] agricultural inspections … Maybe as a sort of a tool to assist local authorities in site selection because, as I said before, it's not always obvious where the problems are.
Strengthened staff resources and alleviation of paperwork requirements: In addition to reasoning for additional staff resources (3/12 inspectors), several inspectors also highlighted the functional benefits that may accrue from reduced inspection paperwork. Several inspectors believed that the typical duration of document completion and processing was excessive (particularly in the case of minor DWWTS management infractions).	LAI08: There's a huge amount of paperwork … The inspection itself is the easy part of it. There's a lot of admin … You have to a get a director's order and file notices … Then you get the director's order for the grant payment. Too much work for a small number of tanks … They could simplify it a wee bit that way.

Table 5.10. Planners' recommendations

Theme	Supporting statement
Increased staff capacity and knowledge translation: Recommendations centring on administrative supports hinged the most on increased staff resources and training programmes, with 7 of 10 planners advocating for greater staff capacity to supplement desired policy changes.	LAP03: There has been a push in the last 12 to 18 months in terms of upskilling and increasing resources in planning departments. I'd question if we have sufficient expertise at the moment to fully check the veracity of the site suitability assessors' findings. It's a complex issue – new systems, new technologies. As a follow-on from that, then, there's probably a need for inspection teams and promoting the fact that this will be happening.
Introduction of a register for DWWTS site assessors and re-evaluation of qualification thresholds: A number of planners attributed prominence to site assessors and contractors, recommending that renewed attention be given to existing registers and qualification thresholds for planning consultants and commercial engineers.	LAP03: There are certain agents who have a bad name for not having either the professional capacity or the moral capacity … but I don't always know who the best person is. Is it an engineering qualification? Is it a scientific or environmental qualification? There should be a high bar and a register of assessors in the first instance.
Enhanced awareness-raising initiatives explaining DWWTS planning requirements: Three planners suggested that there should be an enhanced focus on elucidating existing DWWTS planning and maintenance policy to the general public.	LAP06: I think the planning policy and system could be more proactive in raising awareness around this issue. I would feel education is key. Where I would feel it is probably more effective is school kids – that they're educated at that young stage. They can bring that with them as they go through their life stages rather than the other end, where it's "what's the benefit?".

Table 5.11. Cluster-wise topic terms

Cluster (category)	Top keywords
Challenges	barrier, inspection, issue, system, problem, compliance, constraints
Achievements	improved, grant, introduced, policy, maintenance, success, progress
Recommendations	strategy, recommendation, engagement, support, planning, public, improvement

focus of each category. For instance, the challenges cluster includes common obstacles discussed by inspectors, while the achievements cluster captures improvements and initiatives. The recommendations cluster contains forward-looking suggestions and strategies. The distribution of paragraph themes in the 30% test dataset (762 paragraphs) shows that challenges is the most frequent category (388 paragraphs), followed by achievements and recommendations (Figure 5.1).

5.2.2 Sentiment analysis results

Sentiment analysis was applied to 20 interview transcripts to examine the perspectives of environmental inspectors further. Each response was systematically categorised under three overarching themes: challenges, achievements and recommendations. In addition to thematic classification, each response was analysed for

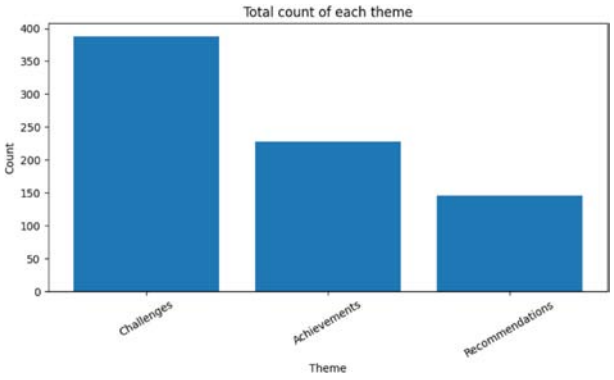

Figure 5.1. Total paragraph count of each theme.

emotional tone using a pre-trained transformer-based sentiment analysis model. Sentiment was classified into three categories – positive, neutral and negative – with a sentiment score. This dual-layered annotation allowed for a more nuanced understanding of what the inspectors communicated and how it was expressed in terms of emotional tone or attitude.

As illustrated in Figure 5.2, the challenges theme received the largest number of responses, totalling 1268 paragraphs. Of these, the majority (53.4%, $n = 677$) were labelled as neutral, suggesting that inspectors often provided factual, objective descriptions when discussing their difficulties in the field. However, a significant portion (39.1%, $n = 496$) were classified as negative, indicating that concerns such as limited resources, administrative constraints

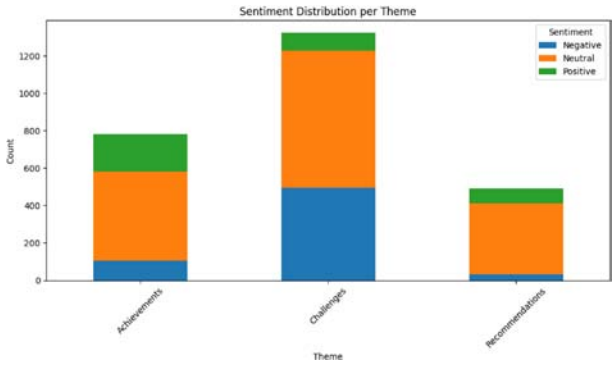

Figure 5.2. Distribution of sentiment across themes.

and public resistance were conveyed with a tone of dissatisfaction, frustration or criticism. Positive sentiment regarding this theme was relatively low (7.5%, *n* = 95) but still reflected instances where inspectors found specific processes manageable or improving despite the broader difficulties. In contrast, the achievements theme included 780 responses and, as might be expected, demonstrated a more optimistic tone overall. While neutral sentiment still comprised the majority (60.9%, *n* = 475), a markedly higher count of positive sentiment (25.5%, *n* = 199) suggested that inspectors could identify and articulate successful aspects of their work, including improved inspection protocols, increased public awareness and effective collaboration with other agencies (e.g. EPA). A smaller portion (13.6%, *n* = 106) conveyed negative sentiment, which may have reflected critical reflections or challenges even within positive developments.

Table 5.12. Sentiment classification of paragraphs (*n* = 2539)

	Sentiment		
Theme	**Negative**	**Neutral**	**Positive**
Achievements	106	475	199
Challenges	496	677	95
Recommendations	33	377	81

The recommendations category encompassed 491 responses and was primarily neutral in tone, with 377 responses reflecting objective, fact-based suggestions and proposals. This pattern suggests that inspectors framed their recommendations constructively and professionally, focusing on areas for policy improvement or procedural refinement without strong emotional framing. The remaining responses included 81 positive and 33 negative sentiments, respectively illustrating optimistic expectations for change or criticisms of existing systems. These findings, summarised in Table 5.12, show that sentiment varies notably across themes. Challenges are expressed mainly in neutral or negative tones, while achievements show a higher positive sentiment. Recommendations are mostly neutral, with some positive and negative inputs. This sentiment-layered qualitative data analysis clarifies inspectors' perspectives, supporting more informed and responsive policy development.

6 Risk Communication Framework

To provide a basis for future initiatives encouraging household DWWTS maintenance and risk mitigation, a national risk communication and behaviour promotion framework was developed for the current project. The framework amalgamates empirical findings gathered across REMARC work packages and established public communications paradigms, integrating key results and recommendations into strategic action points. The two central components of the framework are represented in the form of two figures: (1) a conceptual and empirical model of factors influencing DWWTS maintenance and (2) a model of strategic requirements and components of communication campaign development.

Figure 6.1 helps orientate a prospective campaign designer through key contextual determinants of DWWTS management in a structured format. The schematic variously considers the role of existing service provision, sociocultural context and environmental factors as well as behaviour-specific parameters of consequence for different household- and individual-level frames of reference. The construct of social amplification of risk (explained in detail by Kasperson *et al*., 2022) accounts for the various ways in which risks are processed, interpreted and discursively transferred across relevant societal actors. Listed behaviour considerations draw from several studies, including Chatterton and Wilson (2014) and Atkins *et al*. (2017), and collectively provide a wide-frame view of the multiple facets of behavioural adoption (or change) of relevance to DWWTS maintenance.

Figure 6.2 serves as a blueprint for organising principal information content and materials under a strategic rubric. Outlining all DWWTS management requirements visibly and in a manner conducive to the needs and sensitivities of target audiences will help ensure that DWWTS users are not reliant on multiple information repositories or vulnerable to misdirection. Employment of key messages and elicitation of trusted communicators may meanwhile impart a sense of immediacy and resonance that positively draws the attention of sceptical and information-saturated audiences. Tactful adoption of behaviour-change strategies such as associative learning at opportune moments or control points will increase the likelihood of information absorption at the incipient phase of system maintenance (a key phase of system

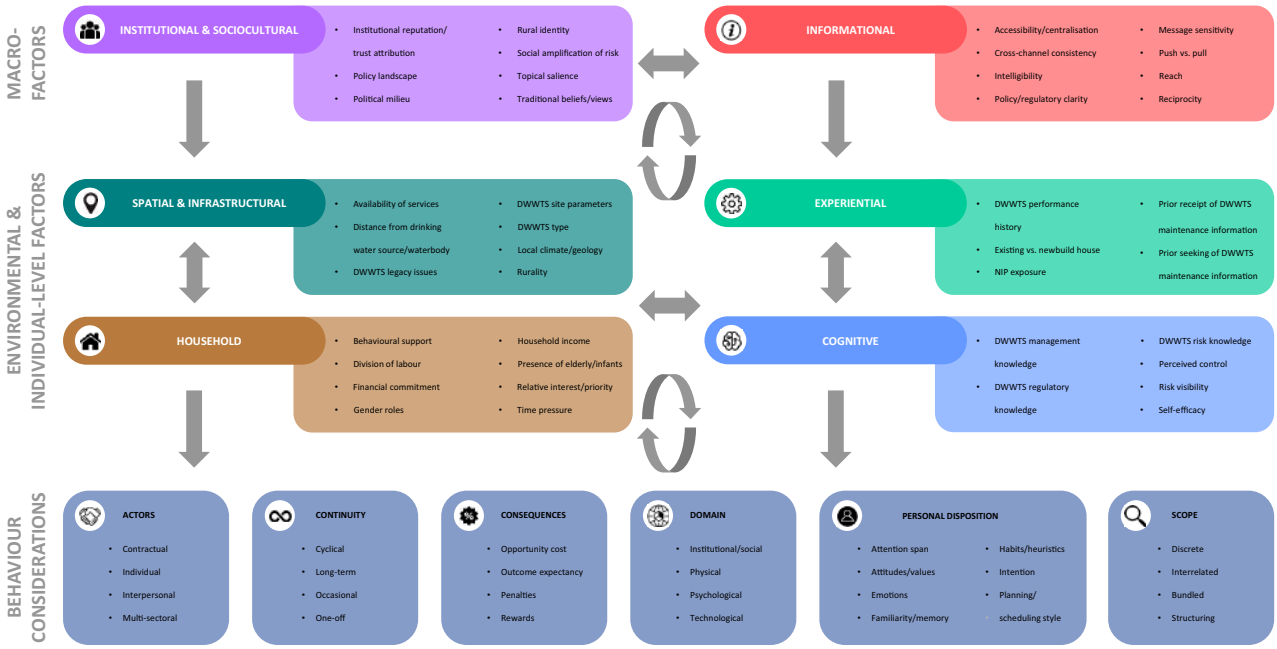

Figure 6.1. A conceptual and empirical model of factors influencing DWWTS maintenance.

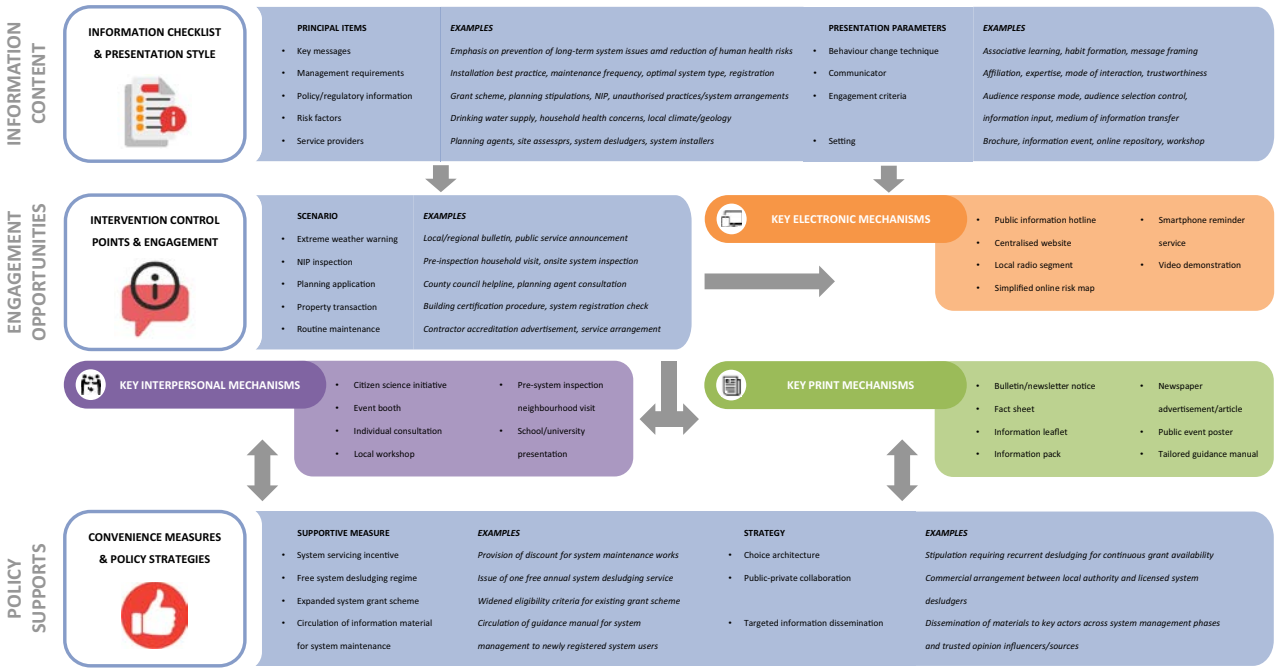

Figure 6.2. Requirements and components of communication campaign development.

management concerning legacy issues or household unfamiliarity with DWWTSs). Listed engagement criteria reflect guidelines for engagement mechanism adoption set out in Rowe and Frewer's (2005) typology of public engagement mechanisms, while strategy selection is informed by intervention selection guidelines outlined by Bujold *et al*. (2020) and Miller and Prentice (2013).

7 Discussion and Recommendations

7.1 Key Findings and Future Implications

The REMARC project was developed to investigate current barriers to multiscalar management of DWWTSs and provide a suite of policy recommendations to (1) promote sustained adoption of household DWWTS maintenance, (2) prevent environmental externalities derived from defective systems and (3) better comprehend factors underpinning high system fail rates and high rates of unresolved inspection advisory notices. To formulate an empirical basis for future policy strategies, the project employed a multimodal suite of investigative measures encompassing a national policy and regulatory review, interviews with LA public servants, a survey of DWWTS users and synthesis of research in risk communication and behaviour promotion domains. Consolidation of project findings evinces a broad requirement for greater policy funding to support the roles of both LAs and households in managing DWWTSs and a renewed approach to communication of system hazards and risk mitigation requirements.

Insights gathered via policy and regulatory analysis reveal several oversights regarding prevention of improper system installation and unauthorised maintenance measures. The absence of a licensing regime for DWWTS installers and limited post-installation verification mechanisms places an arguably inordinate onus of responsibility on householders to ensure commissioning of appropriate system works and acquire information voluntarily. Selection of DWWTS type and initiation of system installation has inexorable repercussions for future maintenance procedures in operational rigour and cost (Capodaglio, 2017). Therefore, the lack of direct targeting of guidance materials towards DWWTS owners (particularly at installation stage) may engender not only subsequent maintenance knowledge gaps, but also path dependence where remedial action is necessary. Similar observations have been made internationally and indicate that paucity of concerted guidance for system management constitutes a broad concern in the domain of onsite domestic waste water management (Nunn and Ross, 2006; Brownlie *et al*., 2015). There is currently no nationally coordinated programme in place for DWWTS user engagement. While the inspection strand of the NIP is underpinned by a legal framework, there is no equivalent in relation to LAs' requirements to undertake engagement, which may be worthy of further investigation. Moreover, the conditions for grant eligibility for system upgrades/repairs remain highly restrictive, which suggests that an audit of current information repositories and market prices for DWWTS works may represent an advisable course of action.

Financial concerns emerged as a recurring theme among LA DWWTS inspectors and planners with respect to execution of both LA and household obligations for system management. Limited resourcing and staff capacity for LAs (a key corollary of underfunding) was deemed a critical impediment to adherence to NIP system inspection and planning protocols. Cited human resource constraints, most notably concerning environmental departments, would appear to have a substantive basis in existing statistics regarding LA staffing nationally. Notwithstanding putative impacts of LA restructuring, statistics from the Department of Public Expenditure & Reform – Databank (2025) demonstrate that the collective national complement of LA staff has yet to return to numbers predating the last global recession. Such staff shortfalls represent a feasible pretext underlying other cited LA barriers, such as lack of internal expertise and enforcement difficulties. As only four LA environmental awareness officers felt suitably qualified to partake in the interview study, it would appear that the role of awareness officers is not being capitalised on to support the work of LAs in delivering the engagement strand of the NIP at the local level. A wider reflection on the existing proficiency (and solutions for) subnational government in addressing DWWTSs may be necessary, as several studies in the USA have reported comparable problems (Naman and MacDonald Gibson, 2015; Vorhees *et al*., 2022).

In addition to flagging resource concerns, LA DWWTS inspectors and planners alike noted several challenges deriving from perceived miscommunication and misinterpretation of policy. Inaccurate representations

surrounding NIP grant eligibility among political actors and misconceptions about preferred DWWTSs among planning agents emerged as barriers to accurate information conveyance. These observations mirror some of the issues raised in the policy audit summarised in Chapter 3. Accordingly, greater inter- and intra-organisational alignment among stakeholders with a defined role across DWWTS management phases will be essential to improve subsequent public outreach initiatives for risk communication and behaviour promotion.

Results from the online householder survey often emphatically corresponded with phenomena referenced by LA interviewees. Financial cost constituted the most frequently cited barrier and was found to significantly increase the likelihood of prior household examination of system operational/ structural integrity. System maintenance costs have been repeatedly identified as a key consideration in behaviour analysis and cost evaluation studies of DWWTS maintenance, and merit attention for future strategy development (Moelants *et al*., 2008; Fizer *et al*., 2018; Vale *et al*., 2023). This assertion is strengthened by ABM results that identified the hypothetical intervention scenarios of incentivised and free-of-charge system maintenance programmes as the most propitious for future behaviour adoption. While pilot studies and cost–benefit analyses will be required in the future to estimate the viability of such policy measures, prior international and national precedents may serve as efficacious points of reference (NFGWS, 2016; Vale *et al*., 2023).

Other principal survey results relate to the primacy of information exposure and self-efficacy in determining both adoption and continuity of DWWTS maintenance. Survey respondents who reported previous seeking and receipt of system maintenance information and high confidence in implementing maintenance measures were significantly more likely to arrange system desludging in accordance with recommended frequencies (i.e. at least once every 5 years). Of further note, survey participants who indicated that their system was previously inspected under the NIP demonstrated significantly higher rates of system management awareness and appropriate desludging intervals. It would hence appear that NIP inspections have, to some extent, exerted a positive effect on inspected householders and improved upon previously established levels of system awareness and maintenance (however marginal) indicated by Devitt *et al*. (2016) and Hynds *et al*. (2018). The significant discrepancy in reported desludging rates between septic tank and packaged treatment system users may be attributable to the common proviso of a maintenance agreement between proprietary system installers and householders, further indicating the importance of system type in determining potential maintenance behaviours.

7.2 Recommendations

The presented risk communication and behaviour promotion framework synthesises project findings with established best practice guidelines in information campaign development, serving as a toolkit for subsequent communication and policy interventions. Key project and framework recommendations are summarised below.

Education and training:

- Increase the provision of educational programmes for LAPs elucidating DWWTS site suitability procedures.
- Explore widened engagement duties for LA environmental awareness officers.

Local authority resourcing:

- Increase provision of funding to support staffing levels and the strategic direction for DWWTS inspectors, LAPs and awareness officers in executing functional duties relating to system management.

Fiscal measures/incentives:

- Explore a financial discount for or a free-of-charge system desludging service for householders.
- Examine potential avenues for widening of the existing system remediation grant on a pro-rata basis (e.g. according to severity of system malfunction).

Regulation and enforcement:

- Explore novel regulatory instruments accounting for system site assessment, installation and post-installation adherence to planning stipulations.

- Explore a licensing regime for system site assessors and installers and a request for information regarding the status of the recent DWWTS market surveillance programme.

Communication/public awareness:

- Build upon and further develop EPA's existing suite of information resources, including the development of a new public campaign predicated on multisector stakeholder collaboration and incorporating targeted, multi-channel forms of DWWTS user engagement.
- Adopt key communication messages stressing the importance of system maintenance as (1) a means of safeguarding household health and environmental protection, (2) an integral action towards avoiding future/long-term system malfunctions and environmental degradation arising from inaction and (3) a cyclical measure that may confer further benefits in the context of a financial incentive scheme.
- Increase the circulation and standardisation of system maintenance information across all stages of a DWWTS's life cycle.
- Modernise and streamline existing online information repositories to set out system management requirements and services in a concise and user-friendly manner.

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Abbreviations

ABM	Agent-based model
DQN	Deep Q-Network
DWWTS	Domestic waste water treatment system
GSI	Geological Survey Ireland
LA	Local authority
LAP	Local authority planner
NIP	National Inspection Plan
OR	Odds ratio
REMARC	Remediation of Faulty Septic Tanks: A Mixed Methods Approach to Environmental Risk Communication
SD	Standard deviation
STEC	Shiga toxin-producing *Escherichia* coli

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- 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 um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

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

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht 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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