Spring 2021

National Water Resources Plan - Framework Plan
Technical Appendices

Appendix K
Residuals

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Data Disclaimer:

This document uses best available data at time of writing. Some sources may have been updated in the interim period. As data relating to population forecasts and trends are based on information gathered before the Covid 19 Pandemic, monitoring and feedback will be used to capture any updates. The National Water Resources Plan will also align to relevant updates in applicable policy.

1.1 Introduction

Before drinking water is supplied to our customers, abstracted raw water is subjected to site specific sequential treatment process elements to remove organic and inorganic contaminants and disinfection processes, in order to meet the microbiological and chemical parametric limit values that are set out in the European Union Drinking Water Regulations 2014.

Irish Water's Water Treatment Plant (WTP) Residual Strategy sets out how it is planned to manage the residuals that are generated from these water treatment processes in an economical, environmentally acceptable and sustainable manner.

Irish Water's WTP Residual Strategy is based on the circular economy model to promote the recovery or reuse of WTP residuals as products in the wider economy. This is a move away from the traditional linear model of 'take-make-consume-waste/dispose' towards a sustainable approach, which focusses on productive reuse and recycling of residuals. See Figure 1-1 below.

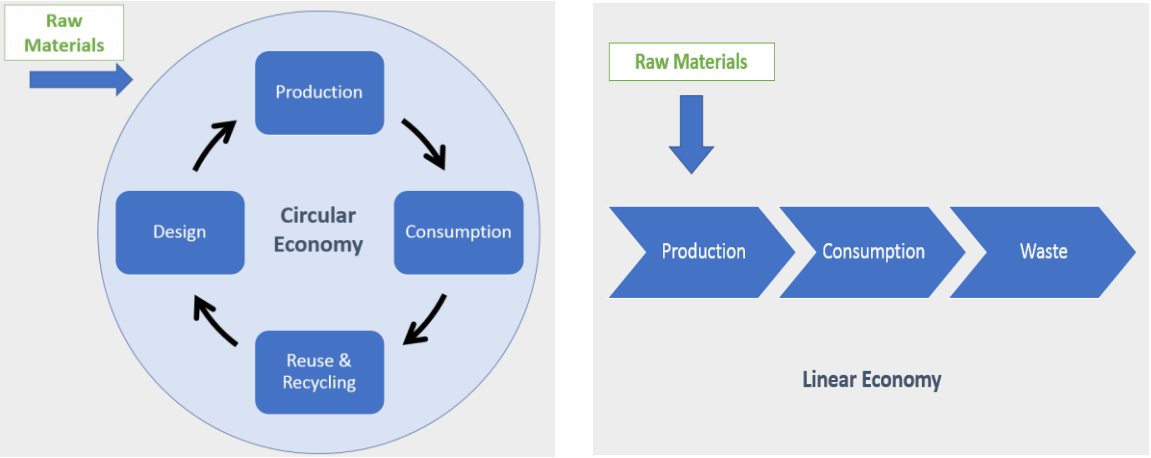

Figure Error! No text of specified style in document.**-1 Comparison between Circular and Linear Economy Models; adapted from: EU circular economy – a new ambition in European sustainable development Engineers Journal, Engineers Ireland, 9th February 2016**

Irish Water's WTP Residual Strategy, set out in Section 1.4 and 1.5 of this Appendix, will be considered, when determining options or approaches, using the NWRP Options Assessment Methodology (see Chapter 8 of the Framework Plan), particularly where new WTPs or upgrades to existing WTPs are proposed.

1.2 What are Water Treatment Plant residuals?

WTP Residuals is the term given to the waste products generated from the chemical and physical processes involved in water treatment. These processes produce two main residual waste types:

- **Solid Residuals** which are water sludge wastes as either a liquid with a considerable solid make up or a 'dried cake' with a range of dried solids, depending on the level of treatment provided.
- **Water Residuals** which are a clear liquid waste type, following treatment of various process tank supernatants, which is generally either discharged to a receiving water or recirculated to the head of the WTP.

The solid residual waste fraction comprises:

- Settleable solids of natural origin in the raw water such as silt, clay and sand particles and
- Chemical compounds which are flocculated sludges, formed of dosed coagulant and organic/inorganic contaminants from the raw water, precipitate principally through Coagulation, Flocculation and Clarification (CFC) process.

Figure 1-2 illustrates the CFC treatment process and associated residuals.

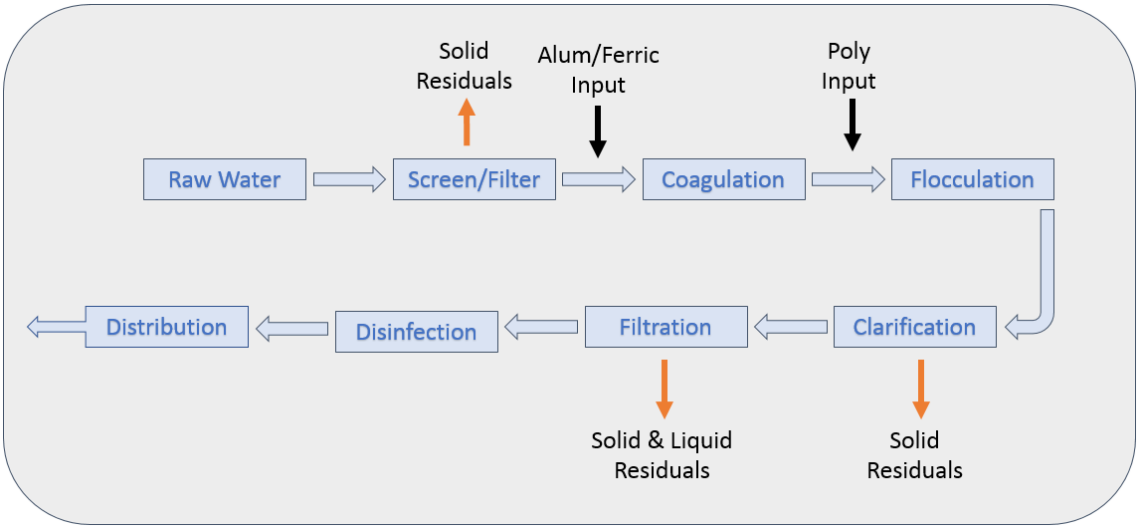

Figure Error! No text of specified style in document.**-2 Coagulation, Flocculation and Clarification Process and its process residuals**

The solid residuals generated at each WTP are usually treated to reduce the liquid component of the removed chemical sludges. In general, there are two stages of treatment.

- The first is a thickening process which produces a thickened liquid with a dry solids (DS) content of between 1% and 6%; and
- The second stage is a dewatering process which produces a dried cake, ranging between 10% and 25% dry solids.

WTP solid residuals are currently classified as a waste (List of Waste Code 19 09 02) under the *Waste Management Act, 1996*. This means that the management and disposal arrangements are covered under licensing or permitting (subject to the nature and scale of the activities). WTP solid residuals are listed on the Second Schedule of the Act under Category 2 wastes but do not appear on the hazardous waste list. The Act requires that the waste be managed in accordance with its provisions and in particular that it is collected, transported and recovered or disposed of in accordance with appropriate permit or license.

1.3 Overview of existing WTP residual management

Prior to the set-up of Irish Water in 2014, the evolution and management of WTP residual infrastructure to date was undertaken at a local water service provider level, resulting in a varied approach nationally. The standard of inherited infrastructural facilities varies from WTPs having full on-site management/treatment of all residual wastes to limited treatment of the residuals stream.

There have been varied approaches to the disposal of solid residuals nationally, including:

- Solid WTP residuals are stockpiled on site via sludge drying beds and lagoons
- Solid residual sludges are co-disposed to the wastewater collection stream for subsequent treatment, thickening dewatering and disposal, in conjunction with generated wastewater sludges

Most larger residual facilities are well managed with periodic removal of settled solids for licensed disposal or recycling. However, where WTP residual facilities are not managed correctly; there is a risk of solids being released to watercourses.

Generally, the larger WTPs tend to have better management of residuals, which often involves the removal of the solid residual from site to landfill or for reuse in industry. Smaller WTPs tend to have a greater need for investment and improvement of residual management processes.

Within the Framework Plan Irish Water identifies the WTPs where treatment is provided by way of coagulation, flocculation, clarification and filtration (CFC) and pressure filtration processes, which produce residuals. The Framework Plan also provides a methodology to identify need across all of these facilities (the barrier scores) in terms of current treatment of residuals.

As all of the Preferred Approaches developed as part of the NWRP must meet the appropriate standards for treatment and disposal of residuals, as set out in this appendix, the Whole Life Costs are included within the NWRP.

In many WRZs, the identified need when subjected to the Option Assessment Methodology in the Framework Plan, would be expected to identify robust full CFC plants as part of the Preferred Approach. The new CFC plants will likely give rise to an increase in the national volume of residuals, while reducing the environmental impact of liquid residuals by improving their quality. Accordingly, the Framework Plan methodology also needs to take account of the impact of the increase in residuals and change in their quality in its options evaluation methodology. This WTP Residual Strategy sets out how that will be done.

1.4 Key objectives of this WTP Residual Strategy

The key objectives of the Irish Water WTP Residual Strategy are to:

1. Provide a standard national approach to on-site treatment and management of WTP residuals. This standard approach is applied to all of the Framework Plan level treatment options considered within the Framework Plan.
2. Provide a standard national approach to the management of residuals to final destination outlets. This is included in the Whole life costs for treatment options included within the Regional Water Resources Plans.
3. Provide guidance around the preferred outlet options that Irish Water could pursue. This is considered as Plan options are progressed as Projects and is included within the detailed design. It is also considered at within the Environmental Impact Assessment for a project, where required.
4. Ensure that any investment in “On-Site Treatment and Residual Management” will deliver a solid residual product that will be accepted at the outlet destinations identified by Irish Water. This is included within the scope of detailed design at project level.
5. Ensure that the quality of the discharge from the WTPs with chemical and filtration processes is compatible with the Water Framework Directive to prevent further deterioration and to enhance the status of all waterbodies with the aim of achieving at least “Good” status. At a plan level no option is allowed to result in a deterioration of waterbody status. Therefore, on a conservative basis, the whole life cost for a treatment plant option with chemical and filtration processes is based on the most onerous costs for residuals treatment. As a result, options that do not involve residuals (e.g protected groundwater) will fare more favourably in a Least Cost assessment, if they are feasible and can be found.
6. Investment in WTP liquid and solid management infrastructure and incorporate into the overall Irish Water investment plan. The NWRP identifies need across the entire asset base. Therefore, deficiencies in the treatment of residuals are included in the strategic NWRP, which informs the Capital Investment Plans.
7. Ensure that investment in new infrastructure provides best whole life cost. All Plan level treatment options include the whole life costs for residuals.

8. Investigate and develop new sustainable, economic and circular economy model options for the recovery/reuse of solid residuals. This will be fed back into the NWRP in the form of changes to Whole Life Cost.
9. Develop and roll out a data capture system for tracking movement and disposal of existing solid residuals and to cater for the improvement of WTP assets. As part of the data requirements identified in the Framework Plan, when this information is available it will inform the assessment of need, and whole life costs for certain treatment types.

1.5 Residual Management

Irish Water's preferred approach for residuals management is shown in Figure 1-3 below.

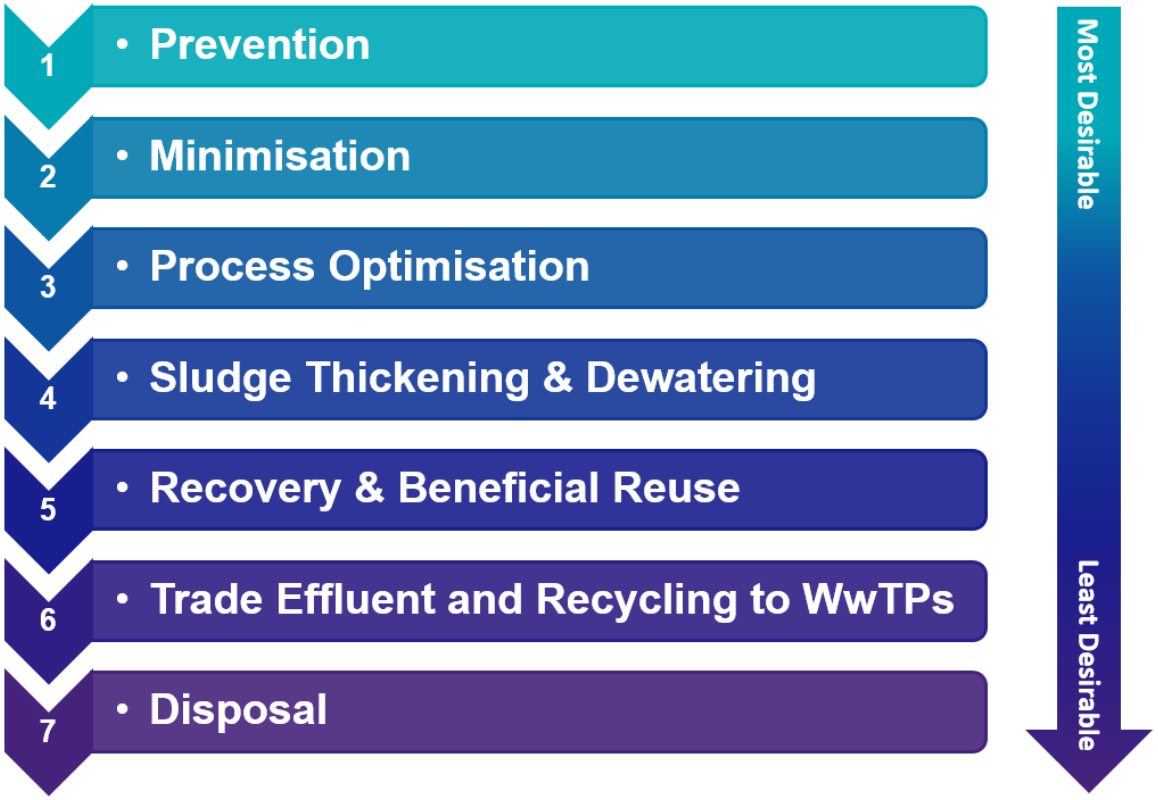

Figure Error! No text of specified style in document.**-3 Waste hierarchy for residuals.**

We have adopted the Waste Hierarchy as set out in the European Waste Framework Directive 2008.

- **Prevention** is the preferred approach to managing WTP residuals through improved raw water quality and or the provision of alternative sources (e.g. groundwater sources) with no or minimal requirement for chemical treatment. As the Framework Plan level options take a conservative approach to the Whole Life Cost of a project (including treatment of residuals), options that involve ewer residuals have an automatic cost advantage.
- Where WTP residuals are produced these volumes should be **minimised,** firstly through Process Optimisation and secondly through **Sludge Thickening and/or Dewatering**. Where there are no Plan level alternatives to full treatment options, minimizing residuals is included in the scope at Project level.
- For WTP residuals arising following **Sludge Thickening and/or Dewatering,** the preferred management approach is **Recovery and Beneficial reuse** of these residuals in line with a circular economy model. This is assessed at Project level.
- Disposal is the least desirable solution and should only be implemented where **Recovery and Beneficial reuse** or **Recycling** cannot be achieved. This is assessed at Project level.

1.5.1 Prevention, Minimisation and Process Optimisation

Irish Water will construct new WTPs in coming years to remove high risk plants and in doing so may produce additional residuals. This however will be offset by Irish Water's objective to reduce overall consumption nationally. The Framework Plan methodology will ensure that the change in volume and quality of residuals is a key consideration when evaluating options and will that the Whole Life Cost considerations drive prevention, minimization and appropriate handling of residuals.

Groundwater or surface water sources of good quality raw water require less chemical treatment, which reduces the volume of residuals produced. As the raw water quality risks will be assessed as part of the Drinking Water Safety Plans that feed into the Framework Plan, need will be driven by raw water quality and Preferred Approaches for establishing any new sources will automatically favour high quality water sources (resulting in low treatment requirements) as part of the Least Cost approach (see Chapter 8 of the Framework Plan).

Where prevention of the production of residuals cannot be achieved, the WTP Residual Strategy approach will be to refine the treatment process to minimise the volume of residuals produced for a given volume of treated water. This will be based on delivering an optimum balance between

- The necessary capital investment in treatment facilities,
- WTP operating costs,
- Transport and end use costs associated with the residuals.

Irish Water is also embarking on a programme to upgrade its existing WTPs nationally, as part of the risk reduction efforts to enhance security of water supplies across the country. This programme will include the provision and/or augmentation of pre-treatment process elements, the resultant optimisation of chemical dosing and the improved operation of the sedimentation and filtration process elements of CFC plants. These Water Treatment Plant upgrades are assessed through the Regional Water Resources Plans.

When complete, this programme will result in enhanced removal of contaminants and better sludge formation at these optimised plants, leading to reduced solid residual volumes.

1.5.2 Sludge thickening and dewatering

A combination of thickening and dewatering are the main methods for reducing the volume of residuals produced.

Thickening is used to increase the proportion of the solid content of residuals and remove some of the liquid portion. Gravity thickening is commonly used to settle and thicken the residuals. This process results in the residual being thickened from 0.1% DS (Dry Solids) to 1-6% DS.

Dewatering achieves the greatest volume reduction for residuals, typically from 1-6% DS to 10-25% DS. The principle technologies used for dewatering thickened WTP sludges, in descending order of DS achieved, are plate presses, centrifuges and belt presses.

All thickened WTP solid residuals will require de-watering. There are several options available for this process:

- Dewatering facility located at the existing WTP (Fixed or mobile).
- Dewatering facility located at another existing WTP.
- Dewatering facility located at a Wastewater Treatment Plant (WwTP - transfer either by connection to a sewer pipe or by a road tanker).
- For interim solutions on smaller plants on site containment and decanting with natural or assisted drying (for example: reed beds, lagoons, geo-bags).

In general, larger plants will have on-site thickening and de-watering, where this option proves to be the most cost-effective solution.

For smaller WTPs thickening will be provided at all these plants while de-watering will not generally be provided, unless a favourable cost: benefit analysis can be demonstrated for the provision of dewatering facilities.

For these smaller plants, the preferred dewatering method will be to

- transfer the thickened sludge to other WTPs for dewatering, where it is more cost effective to dewater the residuals or
- transfer blend and dewater WTP sludges in WwTPs, in conjunction with wastewater sludges.

It should be noted however that as Irish Water moves away from the traditional disposal "end of life" solution for WTP residuals towards a Circular Economy model, there will be an increasing need to dewater residuals in line with the requirements of the preferred recovery method or beneficial reuse. The percentage dry solids required will be determined by the proposed reuse to ensure the residuals are a useable product. Site specific dewatering requirements are addressed at project level.

Further details on the potential reuse or recovery of WTP residuals within this Circular Economy Model are outlined in Section 1.5.3 below.

1.5.3 Circular Economy & Sustainable Development – Residual Outlets

Irish Water is moving towards a circular economy model for the management of the WTP residuals. This is a significant change from the traditional linear model of 'take-make-consume-waste-dispose', with landfill being the primary end point, towards a sustainable approach, which focusses on productive reuse and recycling of WTP residuals as a product.

The recovery or reuse of residuals in line with this model is the preferred long-term sustainable option for Irish Water. This follows the EU Waste Framework Directive waste hierarchy, after prevention and minimisation measures.

Irish Water's Residual Strategy proposes the long-term maintenance of sustainable development, due to its social benefits, economic viability and environmental sustainability.

The UN Sustainable Development Goals (SDG's) have set an ambitious framework. Water has an individual goal within the SDG's to: "*ensure availability and sustainable management of water and sanitation for all"*. Its achievement is interdependent on other SDG's, and particularly SDG 12, "*responsible consumption and production"*, where the goal is to create a circular economy.

This interdependency highlights the need for collaboration amongst businesses and society. Existing environmental legislation was developed for linear production and consumption patterns. The European Commission put forward the Circular Economy Package in 2015 to facilitate a move towards a more circular economy. Collaboration is required to ensure compatibility across legislation and regulation to drive a circular economy and achieve sustainable development.

This Strategy supports the identification of potential opportunities in the context of the circular economy for the management of WTP solid residuals and their recovery/reuse. It can also be the basis for initiating a national and/or regional dialogue around the circular economy approach, taking into consideration local conditions and requirements.

Irish Water is seeking to scale up scientific studies and trials into field operations, which demonstrate sustainable reuse or recovery of WTP residuals to useable products. There are numerous constraints

that hinder these trials, including the regulatory environment and market conditions. However, Irish Water is taking a proactive approach to addressing these constraints through collaboration with the relevant parties.

WTP residuals are currently classified as a waste and as such, must be stored, collected, transported and disposed of in compliance with the Waste Management Act. Irish Water however views alum sludge, which is a solid residual produced in water treatment, as a valuable resource, and potential product in a circular economy model.

There is unlikely to be one single option to best reuse/recover sludge sustainably. Instead, it is likely to involve a suite of options, many of which are currently dependent on local factors and regulatory constraints.

Irish Water is progressing several potential sustainable options. Recovery/reuse of the solids is the preferred long-term sustainable option for Irish Water aligned with the EU Waste Framework Directive waste hierarchy, after/in tandem with prevention and minimisation measures.

Circular Economy Options	Potential Residual Products/Use
Integrated Constructed Wetland (ICW) Reed Bed Systems	Integrated Constructed Wetlands (ICWs) are a sustainable means of treating wastewater, with sustainability aspects such as biodiversity enhancement, landscape aesthetics, amenity value, low carbon (energy) usage and carbon sequestration. Studies have demonstrated the capacity of residuals (alum sludge) in ICWs, as a beneficial product for nutrient removal, including phosphorous and nitrogen. ICW's could provide a sustainable means of treating wastewater for small communities with low volume and strength wastewater loads.  **ICW at Clonaslee** Reed bed systems are being successfully used to dewater and treat WTP residuals. Reed bed systems have similar sustainability aspects to ICW's.  **Reed Bed at Hanningfield** **(Source: Irish Water)**
Cement Manufacturing	The cement industry provides a sustainable option for the use of WTP solid residuals as a product, displacing aluminium containing raw materials such as bauxite. The alum content of WTP residuals make it a suitable product as an alternative to the raw materials used in cement manufacture due to the high aluminium content.

Circular Economy Options	Potential Residual Products/Use
Brick Manufacturing	As with cement manufacturing, WTP residual can also be used as a product as an alternative to the raw materials currently used in brick manufacture. The brick industry provides an opportunity (like the cement industry) to develop a 'product' management approach to WTP residual, delivering sustainability benefits to both Irish Water and the brick industry.  **Photograph of an Alum Brick** **(Source: Irish Water)**
Landfill cover/remediation	Residual can be used as a product by being incorporated into the material used to cover and remediate landfill sites that are being closed.
Discharge to Wastewater Treatment Plant (WwTP)	WTP residuals can be utilised in WwTP's, as a product to improve nutrient removal and dewaterability of the WwTP biosolids, displacing coagulant chemical usage for this purpose. This option does not require the residuals to be dewatered and provides a sustainable circular economy outlet for the residuals.
Long term storage	Future technological advances could make alum recovery a feasible option, whereby a stockpile of WTP residuals could be a valuable asset. Storage of the WTP residuals could provide a stockpile for future use as products in industry and a buffer to industrial production patterns. This would allow Irish Water to meet supply and demand with sufficient quantities of WTP residuals to be used as raw material in production.
Export	A small amount of residual is currently exported to facilities in Northern Ireland and other European countries. It is possible that this may increase while outlets are being developed in Ireland.

1.5.4 Emerging Treatment Options (Recovery of Alum)

The recovery of aluminium from the WTP solid residual provides a sustainable and circular economy solution. There have been several reported processes for the recovery of alum.

Many of these processes involve either acidification or alkalisation of the WTP residual. These processes make use of the solubility of aluminium in very acidic or very alkaline environments. The pH of the residual is changed, dissolving the aluminium and making it available for recovery.

There have also been a few case studies, using ion exchange and membrane filtration to recover alum chemicals. The efficiency of recovery varies greatly with recovery process. At this stage, it is considered that the progress of these technologies for recovery is not feasible, due to the infrastructure required, the intensive processing involved, and significant capital costs. However, it may become a feasible sustainable solution in the future as recovery processes advance.

1.6 Challenges and Next Steps

In parallel with the implementation of the Circular Economy approach and following the waste hierarchy for new or proposed upgrades to existing WTPs, there is a need to upgrade the management of residuals at existing plants. To do this, there are several issues which need to be addressed such as:

- Investment prioritisation
- The existing classification of the residuals.
- Transport costs and carbon emissions.
- Quality control; and
- Research into further use of the residual solids.

The following sections outline the proposed plans to resolve these issues.

1.6.1 Investment Prioritisation

There are currently approximately 180 CFC WTPs producing sludge residuals nationally. The Framework Plan and Regional Water Resources Plans will identify water resources zones that require new WTPs and water resource zones where existing WTPs can be rationalized. Therefore, the WTP number will change over time. Irish Water will prioritise investment in WTPs in accordance with its regulated capital programme approved by the CRU. The Preferred Approaches identified in the Regional Water Resources Plans will inform the priorities in future approved capital programmes. Actions are underway to facilitate this prioritization and investment roll out.

1.6.2 Solids Residuals Classification

WTP solid residuals are currently classified as a waste under the *Waste Management Act, 1996 (as amended)*, which poses a constraint to establishing a circular economy approach. Irish Water is collaborating with relevant parties to comply with the requirements of the Act and to enable sustainable solutions.

1.6.3 Quality Assurance

Standard Operating Procedures (SOPs) have been developed by Irish Water and are being introduced at various plants nationally. These are aimed at ensuring quality requirements are met consistently across all outlets.

There are statutory requirements for reporting on WTP residuals. Irish Water are currently rolling out a template to capture information including, but not limited to, volumes, movements and the end destination of residuals. Alongside this, an online system is being developed to allow for ease of reporting and auditing.

1.6.4 Areas for further Research

Areas where research is required include:

- Ways to recover and reuse the metals from the WTP residual sludge,
- Alternative uses of WTP residual sludge in building, engineering and other materials,
- Use of sludge as a means of nutrient removal in WwTPs,
- Developing markets for water sludge,
- Use of Reed beds to dewater WTP alum sludge.

1.7 Summary

The purpose of this Strategy is to provide a plan to manage residuals from the water treatment process in an economical, environmentally acceptable and sustainable manner in the short, medium and long

term, and how this strategy is an intrinsic part of the resource planning process set out in the Framework Plan and Regional Water Resources Plans. Implementation will initially focus on addressing significant historic deficiencies in the existing WTP residual infrastructural assets and their management.

A data gathering exercise was conducted to inform this strategy on a site by site basis through the barrier assessment process as set out in Chapter 5 of the Framework Plan. The data collected also allowed a high-level assessment of the condition of the residual treatment assets and residuals, allowing a first ever national picture to emerge.

An Irish Water Design Specification has been developed and is now in use in the design and construction of new and upgraded WTP Residual plants. Conformance with this specification is included in the Framework Plan level within the Whole Life Costs for Preferred Solutions, and at Project level for any Preferred approach that is progressed through the regulated capital investment plans. Design guidance and additional specifications will be produced for any emerging treatment and management systems as they are developed. This will allow for the adoption of a standard approach to the design, construction and operation of the residual management process elements of Irish Water WTPs. This strategy sets out guidance regarding the level of infrastructure to be provided at different size plants. On site treatment will focus on developing and implementing a standard and uniform approach to the treatment and operational management of residuals.

However, recognising that implementation will be subject to financial constraints, lower cost interim measures will be considered where appropriate, for instance where it is planned to decommission a plant in the short to medium term.

Irish Water's WTP Residual Strategy is based on the circular economy model to promote the recovery or reuse of WTP residuals as products in the wider economy. This is a move away from the traditional linear model of 'take-make-consume-waste/dispose' towards a sustainable approach, which focusses on productive reuse and recycling of residuals.

This Appendix has presented key sections from the WTP Residual Strategy. Its recommendations have been incorporated in the methodology for options identification and appraisal in the NWRP - Framework Plan and will be carried through to Project Level for any Preferred Approaches identified as part of the RWRPs.