UISCE ÉIREANN : IRISH WATER

Water Supply Project

Eastern and Midlands Region

Appendix C

Cost-Benefit Analysis of Water Supply Projects for the Eastern and Midlands Region

Cost-Benefit Analysis of Water Supply Projects for the Eastern and Midlands Region

Submitted to

Irish Water

Prepared by

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***All material subject to change**

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Glossary of Terms and Abbreviations

BC	Benefitting Corridor
BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
EPNR	Economic Project Needs Report
Mld	Mega-litres per day
MTR	Medium Term Review
NPV	Net Present Value
SELL	Sustainable Economic Level of Leakage
WSP	Water Supply Project

Executive Summary

Introduction

The Water Supply Project (WSP) for the Eastern and Midlands region aims to identify a new and sustainable water source to enable the region to grow into the future. As over 40% of Ireland's population lives in the Eastern and Midlands Region, ensuring the security of water supply to the region is a matter of significant importance.

As part of the WSP for the Eastern and Midlands region, Indecon has previously produced a detailed Economic Project Needs Report (EPNR)[1]. This document outlined the economic case for the provision of a new water supply source to the Eastern and Midlands region in light of likely future water demand levels given medium to long-term population projections and economic growth forecasts. Since the publication of the EPNR, Irish Water has published the Preliminary Options Appraisal Report[2]. This report served to narrow down the available options for the provision of a new water supply to the Eastern and Midlands region to two main options in light of the engineering, environmental and hydrodynamic factors underlying each of the potential options.

This report presents the findings of Indecon's cost-benefit appraisal of the investment options to guarantee continued water supply to the Eastern and Midlands region and the defined Benefitting Corridor. Indecon has been tasked with appraising the two main investment options which have been identified by Irish Water. These options are:

- Abstraction of water from the lower Shannon at Parteen Basin; and
- Desalination of water from the Irish Sea in Dublin.

CBA Methodology and Key Parameters

Indecon has undertaken the cost-benefit analysis of the investment options for the provision of a new water supply to the Eastern and Midlands region in line with the latest guidance documents from both the Irish government and the European Commission.

This CBA has followed the key principles outlined in the EU guidance in terms of:

- Undertaking a detailed demand forecast – this was done for the Economic Project Needs Report and the results have been used in this CBA;
- Undertaking a detailed options appraisal process – this has been done as part of the Preliminary Options Appraisal Report published by Irish Water;
- In financial terms the CBA undertaken in this report includes the key costs identified in the guidance including capital and operational costs and environmental costs of the proposed investments;
- The economic benefits of the proposed projects included in this CBA are also in line with those suggested in the latest guidance. This CBA focuses on the benefits of an increased supply of water and increased reliability of this supply in the region.

The analysis undertaken in this report makes use of the key parameter values suggested in the Public Spending Code. The analysis includes a discount rate of 5% and an adjustment for all public expenditure in the project to reflect the shadow price of public funds[3] of 130%. In addition to this, for the purposes of

[1] http://www.watersupplyproject.ie/wp-content/uploads/2015/03/Vol-3_WSP-Economic-Needs-Report.pdf

[2] http://www.watersupplyproject.ie/wp-content/uploads/2016/08/Vol-1_Main-Report_PrelimOptionsAppraisal_V1_Update3.pdf

[3] The Public Spending Code requires the use of a shadow price of public funds of 130%. This is applied to account for the distortionary economic impacts of taxation used to raise funds for public expenditure

valuing the environmental costs associated with the proposed projects, Indecon has utilised the carbon price forecasts suggested in the Public Spending Code.

The 'Do Minimum' Scenario

A key component of any cost-benefit analysis is an accurate definition of the 'Do Minimum' scenario. This is the scenario which is most likely to prevail should the proposed investment or investments not be undertaken. The Do Minimum scenario thus represents the key comparative basis for the investment scenarios.

For the purposes of this analysis, Indecon has judged that a Do Minimum scenario in which mitigating steps are undertaken by Irish Water to attempt to address supply shortfalls is more appropriate than using a 'Do Nothing' scenario as the comparator.

Indecon constructed the Do Minimum scenario for this cost-benefit analysis with the assistance of inputs from both Jacobs Tobin and Irish Water. In the context of this CBA, the Do Minimum scenario outlines:

- The likely steps in terms of additional leakage reduction that Irish Water would be forced to undertake should no new source of water supply be developed;
- The costs associated with this additional leakage reduction over and above the ambitious targets already factored in to the baseline demand projections;
- The likely probability of outage over the appraisal period should no additional water supply be developed;
- The costs of this increased probability of outage to the population and economy of the Eastern and Midlands region.

The below table outlines the additional water supply envisaged under the Do Minimum scenario from additional leakage reduction activities and the anticipated costs of these activities. Irish Water has estimated that realistically additional leakage reduction activities will yield no more than an additional 30 Mld. It is assumed that the additional leakage reduction would be achieved by 2026 at a cost of just over €310 million in net present value terms and adjusted for the shadow price of public funds.

Leakage Reduction in Do Minimum Scenario					
	Unit	2021	2026	2031	2041
Additional Leakage Reduction - Do Min	Mld	15.0	30.0	30.0	30.0
Costs Per MLD	€ Million	7.42	14	14	14
Additional Cost in Do Min	€ Million	111.3	210.0	0	0
Total Additional Cost - Do Min	€ Million	321.3			
Total Additional Cost – NPV and adjusted for the Shadow Price of Public Funds	€ Million	310.5			
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin					

The environmental cost of this additional leakage reduction activity has also been included in the Do Minimum Scenario as illustrated overleaf.

Environmental Costs of Leakage Reduction Activities in Do Minimum Scenario				
	Unit	2017-2021	2021-2026	Total
Emissions from additional leakage reduction activities	Tonnes CO2	127,060	144,120	271,180
Cost based on carbon pricing forecasts	€ 000's	1,084	2,000	3,085
Cost in net present value terms	€ 000's	929	1,343	2,272
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin				

Irish Water has provided Indecon with estimates of the likely costs to the Benefitting Corridor (BC) in the Do Minimum scenario in terms of capital and operation expenditure. Irish Water have also included a cost for the BC in the Do Minimum and Desalination scenario which estimates the costs likely to be borne by Irish Water in providing alternative water sources for the BC beyond the continuing use of the existing water treatment plants. In these scenarios Irish Water would be forced to retain a higher proportion of existing water treatment plants than would be the case under the Shannon option with the associated capital and operational expenditure required to keep these plants operational as well as incurring the expense of developing new sources to address deficits in the BC. The following table outlines these costs. Over the time period of this analysis, in the Do Minimum Scenario Irish Water estimate additional costs of €477 million in absolute terms and €348 million in net present value terms and after accounting for the shadow price of public funds.

Costs to the Benefitting Corridor in the Do Minimum Scenarios						
		2017-2025	2025-2035	2035-2045	2045-2050	Total
Capital Expenditure	€ Millions	157.2	40.8	40.8	20.1	258.9
Operational Expenditure	€ Millions	14.4	22.2	22.2	36.7	95.6
Cost of Provision of Additional Capacity	€ Millions	39.2	50.5	24.3	9.2	123.1
Total Expenditure	**€ Millions**	**210.8**	**113.5**	**87.3**	**66.0**	**477.7**
Total Expenditure - NPV	**€ Millions**	**170.9**	**56.5**	**26.6**	**13.8**	**268.0**
Total Expenditure - Adjusted for Shadow Price of Public Funds	**€ Millions**	**222.2**	**73.4**	**34.6**	**18.0**	**348.4**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin						

As part of the formulation of the Do Minimum scenario Indecon has also forecast the expected property days of water supply disruption over the appraisal period. The calculations of the expected days of outage has been undertaken utilising technical engineering advice and represents the likely impact of water supply deficits on the residential sector in the Eastern and Midlands region. The table overleaf illustrates the forecast path of property days of outage over the appraisal period. In the Do Minimum scenario the number of expected days of water supply restriction are forecast to rise from 0.90 in 2017 to 4.01 by 2050.

Expected Property Days Subject to Restriction in the Do Minimum Scenario							
	2017	2021	2026	2031	2041	2046	2050
Expected average annual number of property days subject to restriction	0.90	0.84	0.90	1.57	2.51	3.46	4.01
Source: Indecon Analysis							

In order to include these costs to the residential sector in the CBA, Indecon has monetised these costs using estimates of the per-capita daily cost of water supply interruptions published in the EPNR and based on a detailed review of international evidence. Indecon has chosen to include a per-capita daily cost of €44 based on the findings of the EPNR international review. We would note that this represents a prudent assumption as it is at the lower end of the range of values suggested by the review of international research. The below table outlines Indecon's estimates of the total cost to the residential sector in the Do Minimum scenario both in absolute and net present value terms. These estimates account for the forecast population growth in the region over the appraisal period.

Total Costs of Expected Property Days Subject to Water Supply Restrictions in the Do Minimum Scenario		
	Unit	Total Costs 2017-2050
Total costs to the residential sector	€ Millions	5,855
Total costs to the residential sector in net present value terms	€ Millions	2,123
Source: Indecon Analysis		

Beyond the costs to residential water users, an increasingly unreliable water supply will also impact on the commercial and industrial sectors of the economy. It may be of particular relevance to the output levels of water intensive firms. Given the uncertainty surrounding the likely impact of water restrictions on individual firms and sectors, for the purposes of this cost-benefit analysis, Indecon has restricted our estimates of the output costs of water supply outages to the main internationally traded sectors which are most water intensive. The combination of these sectors' water intensity means that the output of these sectors may be particularly sensitive to water insecurity given the ability of the firms in these sectors to divert production to other sites.

For the purposes of this analysis, we focus on the most water intensive industries of the internationally traded manufacturing sector. These industries are:

- Chemical manufacturing;
- Pharmaceuticals manufacturing; and
- Computer and electronics manufacturing.

Indecon estimates the likely impact of rising insecurity of the water supply under the Do Minimum scenario by assuming a range of output reductions. For the base case scenario, we assume that these sectors will reduce output by 10% relative to the situation that would have prevailed should these water restrictions not occur. It should be noted that Indecon has also undertaken a range of sensitivities on this assumed impact, the findings of which can be found in the body of this report. The overall findings are not sensitive to changes in this assumption. The following table outlines the likely costs of this output fall in net present value terms over the course of the appraisal period.

Total Output Costs of Water Supply Restrictions in the Do Minimum Scenario in the Internationally Traded Manufacturing Sectors		
	Unit	Output Costs
Assumed reduction in output:		
10%	€ Millions - NPV	989.8
Source: Indecon Analysis		

The table below presents a summary of the total costs in the Do Minimum scenario. This summary represents our baseline scenario in which output in the internationally traded sector falls by 10%. Under these assumptions we find a total cost to the economy of €3.7 billion in net present value terms over the appraisal period.

Summary of Costs in the Do Minimum Scenario	
Cost	**€ Million – NPV**
Leakage Reduction Costs	310.5
Environmental Costs	2.3
Benefitting Corridor Costs	348.4
Residential Outage Costs	2,123.2
Economic Output Costs	989.8
Total Costs	**3,774.2**
Source: Indecon Analysis	

Option 1: Shannon Abstraction (Option C[4])

The first investment option included in this CBA analysis is the option of water abstraction from the Shannon at Parteen Basin and the construction of a pipeline to Dublin. On the cost side, Indecon's analysis includes costs related to:

- Capital costs;
- Operational expenditure;
- Environmental costs;
- Disruption costs of construction works; and
- Benefitting Corridor costs.

Indecon has been provided with detailed costs data by Irish Water and has monetised the environmental and traffic disruption costs in line with the forecasts for the cost of carbon and value of time suggested in the Public Spending Code.

The benefits of the proposed project are directly linked to the costs of additional outage forecast in the Do Minimum scenario. The benefit of the proposed investment projects is the avoidance of the costs of outage envisaged in the Do Minimum scenario.

The following table outlines the expected annual property days of water supply restriction under Option 1. When the proposed investment is operational, property days of outage are expected to fall to 0.23.

[4] Option C: Parteen Basin Reservoir (Direct)

Costs of Expected Property Days Subject to Water Supply Restrictions under Option 1							
	Unit	2017	2021	2031	2041	2046	2050
Expected average number of property days subject to restriction per annum	Property Days	0.9	1.12	0.23	0.23	0.23	0.23
Population of the Dublin Water Supply Area	Millions of People	1,550,602	1,642,391	1,842,060	2,003,156	2,081,225	2,154,252
Estimated cost to the residential sector	€ Millions	61.4	80.7	18.6	20.3	21.1	21.8
Estimated cost to the residential sector in net present value terms	€ Millions	61.4	63.2	9.0	6.0	4.9	4.1
Source: Indecon Analysis							

The following table presents the total costs to the residential sector over the appraisal period under Option 1.

Total Costs of Expected Property Days Subject to Water Supply Restrictions under Option 1		
	Unit	Total Costs 2017-2050
Total costs to the residential sector	€ Millions	1,204
Total costs to the residential sector in net present value terms	€ Millions	752
Source: Indecon Analysis		

The net benefit of Option 1 relative to the Do Minimum scenario is outlined below. Indecon estimates a total benefit from Option 1 of €2,361 million in net present value terms.

Benefit of Option 1-Shannon Abstraction relative to Do Minimum Scenario	
Do Minimum	€ Million - NPV
Costs to the Residential Sector	2,123
Economic Output Costs	990
Option 1 – Shannon Abstraction	
Costs to the Residential Sector	752
Economic Output Costs	-
Benefit of Option 1	
Residential Sector	1,371
Economic Output	990
Total Benefit of Option 1	**2,361**
Source: Indecon Analysis	

The following table outlines the total costs and benefits of the Shannon Abstraction option and illustrates the overall net benefit of the proposed investments at €1,635 million. The Benefit-Cost Ratio (BCR) for the proposed investments is 3.25. This suggests that the proposed investments under Option 1 would bring about considerable benefit to the economy of the Eastern and Midlands region over the course of the assessment period, relative to the Do Minimum scenario.

Option 1-Shannon Abstraction - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	487.1
Operational Expenditure	152.3
Environmental Costs	20.2
Traffic Disruption	0.1
Costs in Benefitting Corridor	66.4*
Total Costs	726.1
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	989.8
Total Benefits	2,361.2
Net Benefit of Option 1	1,635.1
BCR	3.25
Costs to be incurred in supplying water to the BC even in the scenario in which the Shannon project is completed	
Source: Indecon Analysis	

Option 2: Desalination (Option H[5])

The second option identified in Irish Water's options appraisal process is the construction of a desalination plant on the coast to the north of County Dublin. Jacobs Tobin/ Irish Water have provided Indecon with detailed cost data for this proposed investment option for the purposes of this CBA.

On the cost side, Indecon's analysis includes costs related to:

- Capital costs;
- Operational expenditure;
- Environmental costs; and
- Benefitting Corridor costs.

As was the case in the assessment of Option 1, the benefits of Option 2 are directly linked to the costs of additional outage forecast in the Do Minimum scenario. The benefit of the proposed investment projects is the avoidance of the costs of outage envisaged in the Do Minimum scenario.

The table overleaf outlines the total costs and benefits of Option 2 in net present value terms and presents the net benefit and BCR for the investment option. It can be seen that the net benefit of Option 2 is lower than that of Option 1, as is the BCR. This suggests that under the baseline assumptions the Shannon abstraction option represents the investment with the best economic return.

[5] Option H: Desalination

Option 2-Desalination - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	473.8
Operational Expenditure	450.6
Environmental Costs	75.6
Costs in Benefitting Corridor	348.4
Total Costs	1,348.4
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	989.8
Total Benefits	2,361.2
Net Benefit of Option 2	1,012.8
BCR	1.75
Source: Indecon Analysis	

CBA Findings and Sensitivity Analysis

The following table summarises the CBA findings for the two investment options under the base case assumptions. In this scenario, Option 1, abstraction from the Shannon at Parteen Basin appears to be the most economically advantageous investment choice.

CBA Scenario 1: Base Case Summary of Results		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	1,635.1	3.25
Option 2: Desalination	1,012.8	1.75
Source: Indecon Analysis		

Indecon however has undertaken a number of sensitivity tests to ensure the robustness of the CBA findings. These sensitivity tests have flexed the assumptions on the amount of output lost in the water intensive firms in the internationally traded sector. Given the uncertainty around how these firms would respond to water restrictions, Indecon believes that it is prudent that the CBA be run with a range of alternatives in this regard. As such, we present the findings of the CBA analysis for higher and lower impact assumptions. We assume in the higher impact scenario that output falls by 15% and in the lower impact scenario that output falls are limited to 5%.

The table overleaf illustrates the findings of these sensitivity tests. Under each scenario the net benefit of both options remains positive and the BCR remains greater than 1. Under each scenario the net benefit and BCR of the Shannon Abstraction option exceed that of the Desalination option. The Shannon Abstraction investment option thus appears to be the most economically beneficial of the options appraised in this report.

Summary of CBA Findings – Sensitvity Scenarios		
Scenario 2: Low Impact		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	993.5	2.14
Option 2: Desalination	517.9	1.38
Scenario 3: High Impact		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	2,130.0	3.93
Option 2: Desalination	1,507.7	2.12
Source: Indecon Analysis		

Summary and Conclusions

This report has outlined the results of the detailed cost-benefit analysis of the options for investments in new water supply infrastructure for the Eastern and Midlands region undertaken by Indecon. This CBA has been undertaken in line with the latest Irish government guidance in the form of the Public Spending Code and the latest European Commission guidance on cost-benefit analysis of investment projects.

The investment options appraised in this analysis were:

- Abstraction of water from the lower Shannon at Parteen Basin; and
- Desalination of water from the Irish Sea in Dublin.

These investment projects were assessed relative to the Do Minimum scenario. This scenario was formulated by Indecon using data and technical inputs from Irish Water/Jacobs Tobin and represents the most likely outcome for the Eastern and Midlands region should no significant investment in new water supply infrastructure be undertaken.

The CBA has included the key costs and benefits for the proposed investment options. Indecon has been provided with costs for both investment options including:

- Capital costs;
- Operational expenditure;
- Environmental costs;
- Disruption costs of construction works where applicable; and
- Benefitting Corridor costs.

The benefits of the proposed projects are assessed relative to the Do Minimum scenario and are composed of the economic costs of water supply restrictions foregone. Indecon has included estimates of the costs of water supply restrictions to both the residential and commercial sectors. Indecon has used international evidence on the cost of water supply restrictions in the residential sector in its calculation of these costs. In calculating the output costs to the economy Indecon has focused on the water intensive internationally traded sector and assessed the likely cost in economic output in the Do Minimum scenario in which water supply restriction become more common relative to the forecast economic growth in these sectors over the appraisal period.

The base case results for the cost-benefit appraisal of the two investment projects are presented overleaf. The base case represents the model using what Indecon believes to be the most prudent and conservative assumptions. Additional sensitivity analysis can be found in the body of the report. These results indicate that the Shannon abstraction option represents the most cost effective project.

Summary of CBA Findings – Base Case		
Scenario 1: Base Case		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	1,635.1	3.25
Option 2: Desalination	1,012.8	1.75
Source: Indecon Analysis		

Indecon have also undertaken a number of sensitivity analyses on these results. These results alter the net benefit and BCR results for the investment options but the net benefits remain positive and the Shannon abstraction option remains the preferable investment under each of the sensitivity analyses.

The results of Indecon's cost-benefit appraisal of the proposed investment options suggest that Option 1, abstraction of water from the Shannon at Parteen Basin, is the preferable investment choice. This project results in a higher net benefit than the desalination alternative or the net benefit of the Do Minimum scenario. The BCR of the Shannon abstraction option also exceeds that of the desalination option in the base case and all sensitivity analyses. These findings suggest that the Shannon abstraction option represents the most economically advantageous investment option for the provision of new water supply infrastructure to the Eastern and Midlands region.

1 Introduction and Context

1.1 Introduction

The Water Supply Project (WSP) for the Eastern and Midlands region aims to identify a new and sustainable water source to enable the region to grow into the future. As over 40% of Ireland's population lives in the Eastern and Midlands Region, ensuring the security of water supply to the region is a matter of significant importance.

As part of the WSP for the Eastern and Midlands region, Indecon has previously produced a detailed Economic Project Needs Report (EPNR)[6]. This document outlined the economic case for the provision of a new water supply source to the Eastern and Midlands region in light of likely future water demand levels given medium to long-term population projections and economic growth forecasts. Since the publication of the EPNR, Irish Water has published the Preliminary Options Appraisal Report[7]. This report served to narrow down the available options for the provision of a new water supply to the Eastern and Midlands region to two main options in light of the engineering, environmental and hydrodynamic factors underlying each of the potential options.

This report presents the findings of Indecon's cost-benefit appraisal of the investment options to guarantee continued water supply to the Eastern and Midlands region and the defined Benefitting Corridor. Indecon has been tasked with appraising the two main investment options which have been identified by Irish Water. These options are:

- Abstraction of water from the lower Shannon at Parteen Basin; and
- Desalination of water from the Irish Sea in Dublin.

Indecon has undertaken the Cost-Benefit Analysis (CBA) of these investment options in line with the latest guidance from the Public Spending Code[8] published by the Department of Public Expenditure and Reform and the European Commission guidance on CBAs for investment projects[9]. Indecon's CBA has followed the appropriate best-practice methodology as per these guidance documents and has used the most up-to-date recommended parameter values in terms of discount rate, shadow price of public funds, carbon price forecasts etc. This is important in order to ensure that the best use is made of public expenditure. The methodology will be discussed in more detail in forthcoming sections of this document.

The rest of this report discusses in more detail the CBA methodology as well as the nature of the costs and benefits included in the analysis and the assumptions underlying the CBA findings. We begin with a discussion and definition of the 'Do Minimum' scenario, against which the two investment options are to be compared. Following this section on the Do Minimum we then present the findings for the two investment options.

[6] http://www.watersupplyproject.ie/wp-content/uploads/2015/03/Vol-3_WSP-Economic-Needs-Report.pdf

[7] http://www.watersupplyproject.ie/wp-content/uploads/2016/08/Vol-1_Main-Report_PrelimOptionsAppraisal_V1_Update3.pdf

[8] Public Spending Code: Guide to Economic Appraisal: Carrying out a Cost-Benefit Analysis http://publicspendingcode.per.gov.ie/wp-content/uploads/2012/08/D03-Guide-to-economic-appraisal-CBA-16-July.pdf

[9] European Commission: Guide to Cost Benefit Analysis of Investment Projects http://publicspendingcode.per.gov.ie/wp-content/uploads/2012/08/D03-Guide-to-economic-appraisal-CBA-16-July.pdf

1.2 Background and Context

1.2.1 Background to the Project

The need for a new long-term additional secure and sustainable water source for the Eastern and Midlands region was originally identified in 1996, while feasibility studies to assess need and possible options were undertaken between 2004 and 2008. In October 2010, a Plan for the WSP-Eastern and Midlands Region was adopted, which was subsequently published alongside a Strategic Environmental Assessment (SEA) in September 2011 in accordance with the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations 2004.[10] The Plan identified a range of new water supply options to sustainably augment existing sources in the Region from approximately 2022 onwards. It recommended that further and more detailed assessments be carried out to determine the environmental and other criteria which would have to be met for a sustainable new water supply scheme. The next stage in the development of the WSP-Eastern and Midlands Region project involves application to An Bord Pleanála, to seek statutory consent for the Project under the Planning and Development (Strategic Infrastructure) Act 2006.[11] This economic cost-benefit analysis will play a significant role, in tandem with the previously published Economic Project Needs Report, in highlighting the economic need for the proposed project and ensuring that the most economically advantageous project has been chosen.

The completion of a detailed cost-benefit appraisal in line with the latest guidance by both the European Commission and the Department of Public Expenditure and Reform in Ireland is a vital step in the decision making process for major investments. The CBA ensures that the costs and benefits of the project options are appropriately assessed and quantified and that the most cost effective project is identified.

The remainder of this chapter discusses the findings of the Economic Project Needs Report before then providing a brief overview of the two preferred options identified in the Options Appraisal Report.

1.2.2 Economic Project Needs Report

The Economic Project Needs Report (EPNR) was completed by Indecon as part of the process of identifying the water supply requirements for the Eastern and Midlands region. The EPNR provided an independent assessment of the economic need for water in the key parts of the Eastern and Midlands region. This assessment includes new independent estimates of the demand for water over the planning period. The EPNR assessed the economic case for the provision of new water supply sources to the region by analysing the likely future path of water demand in the region in both the residential and commercial sectors.

In forecasting the likely future demand for water in the region, the EPNR made use of a number of inputs to understand the current water supply situation in the region and the likely future path of water demand. Key inputs included:

- Population and demographic forecasts for the Eastern and Midlands region were provided by external demographers;

[10] Dublin City Council, (2011) 'Water Supply Project-Dublin Region – The Plan'

[11] The process will also incorporate an application to An Bord Pleanála for a Water Abstraction Licence under the Water Supplies Act 1942, and for confirmation of Compulsory Purchase Orders and Wayleave Notices served under the Planning and Development Act, 2000.

- Historical water demand data in terms of per-capita consumption rates and demand from different sectors of the economy;
- Information on current levels of leakage and the likely future path of leakage in the region; and
- Sectoral economic growth projections for the region based on the ESRI Medium-Term Review forecasts.

As part of the EPNR Indecon also undertook detailed econometric modelling of the likely future path of water intensity in a number of sectors based on international evidence and data. This ensured that the water demand projections in the EPNR accounted for likely increases in the efficiency of water use in the commercial and manufacturing sector over the coming years.

The EPNR presented a number of scenarios for future water demand in the Eastern and Midlands region based on differing assumptions regarding economic growth population levels, per-capita consumption rates and leakage.

The scenarios for water demand outlined in the EPNR suggest that by 2050 there will be supply deficit in the region of between 108 Mld in the low scenario and 288 Mld in the high scenario. It is appropriate to note here that the EPNR recommended that the high scenario be used for the purposes of long-term strategic planning. The baseline scenario estimates a supply deficit of 197 Mld by 2050.

The EPNR thus clearly outlined the economic case for the investment in new water supply infrastructure for the Eastern and Midlands region.

1.2.3 Shannon Abstraction Option

The Shannon abstraction option was identified as one of the two emerging preferred options in the Preliminary Options Appraisal Report[12] recently published by Irish Water. The Options Appraisal Report identified Option C: Parteen Basin Reservoir (Direct) as a preferred option based on a multi-criteria analysis. Abstraction of water from the Shannon at Parteen Basin was identified as the most favourable of the three Shannon abstraction options considered.

This option involves abstraction and treatment on the shore of Parteen Basin Reservoir, with a distance of 170km for treated water transfer and is capable of supplying communities on route. This option is envisaged to be capable of providing the required water to the Eastern and Midlands region as forecast in the Project Needs Report. The option envisages the construction of a water treatment plant close to the abstraction point capable of supplying 314 Mld of treated water.

The option of abstraction from the Shannon from Parteen Basin was identified based on an analysis of the environmental and technical issues and requirements for each options. A number of investigate studies were undertaken as part of the options appraisal process and the findings of these studies were also taken into account in the identification of the preferred options.

The multi-criteria analysis examined a number of factors around each option including:

- Ecology;
- Aquatic ecology;

[12] http://www.watersupplyproject.ie/wp-content/uploads/2016/08/Vol-1_Main-Report_PrelimOptionsAppraisal_V1_Update3.pdf

- Surface water;
- Air quality;
- Noise;
- Cultural heritage;
- Landscape and visual impacts;
- Tourism;
- Soils, Geology and Hydrogeology;
- Traffic, engineering and design issues.

Based on the comparative analysis of these issues for each potential abstraction point, the Parteen Basin was identified as the preferred option and the option that would have the least impact should it be developed.

1.2.4 Desalination Option

The potential locations for the development of a desalination plant capable of supplying the required water to the Eastern and Midlands region were also subject to a detailed multi-criteria analysis in the Preliminary Options Appraisal Report. Several potential sites were assessed using the same metrics discussed above. The option for construction of a desalination plant at Balbriggan was identified as the most favourable of the options considered.

1.3 Report Structure

The remainder of this report is structured as follows:

- Chapter 2 outlines the CBA methodology and the key parameters included in the analysis;
- Chapter 3 outlines the Do Minimum scenario;
- Chapter 4 outlines the costs and benefits for Option 1: Shannon Abstraction;
- Chapter 5 outlines the costs and benefits for Option 2: Desalination;
- Chapter 6 presents the key CBA findings and the results of a number of sensitivity tests; and
- Chapter 7 summarises the findings of this report and presents our conclusions.

2 CBA Methodology and Key Parameters

2.1 Introduction

Indecon has undertaken the cost-benefit analysis of the investment options for the provision of a new water supply to the Eastern and Midlands region in line with the latest guidance documents from both the Irish government and the European Commission. The key guidance documents are:

- The Public Spending Code published by the Department of Public Expenditure and Reform in Ireland[13]; and
- The Guide to Cost Benefit Analysis of Investment Projects published by the European Commission[14].

These documents provide detailed guidance for the appraisal of investment projects in general and for the analysis of investment in water infrastructure in particular. This chapter will discuss in more detail the methodological points and key parameter taken from these guidance documents and used in this evaluation.

2.2 Methodological Guidance

The European Commission guidelines contain a dedicated section for the appraisal of water infrastructure projects. This section contains a number of recommendations as regards the methodology that should be used when carrying out a CBA of water infrastructure projects. This section outlines these key recommendations and how Indecon's methodology has accounted for these requirements.

2.2.1 Demand Forecasts

The European Commission guidance document suggests that cost-benefit appraisals for water supply infrastructure should include a detailed assessment of the likely path of water demand. The guidance suggests that demographic factors, economic growth, industrial output and average per-capita consumption, amongst other factors should all be accounted for in the demand forecasting exercise.

The EPNR produced by Indecon has already completed a comprehensive demand forecasting exercise which follows the principles set out in the Commission guidance document. The findings of this analysis as regards the likely future path of water demand in Ireland are used in the cost-benefit analysis in this report.

2.2.2 Options Analysis

The European Commission guidance document also highlights the need for a comprehensive options analysis to be undertaken for CBAs of investment projects in water infrastructure. The Commission guidance states that investments project should be justified against a set of feasible alternative options that would achieve the same objective(s). Indecon would note that the

[13] Public Spending Code: Guide to Economic Appraisal: Carrying out a Cost-Benefit Analysis http://publicspendingcode.per.gov.ie/wp-content/uploads/2012/08/D03-Guide-to-economic-appraisal-CBA-16-July.pdf

[14] European Commission: Guide to Cost Benefit Analysis of Investment Projects http://publicspendingcode.per.gov.ie/wp-content/uploads/2012/08/D03-Guide-to-economic-appraisal-CBA-16-July.pdf

detailed options appraisal process undertaken by Irish Water has identified the two options appraised in this report against a variety of alternatives.

2.2.3 Financial Analysis

The Commission guidance suggests that a number of factors should be included on the costs side of any investment project in water infrastructure. The guidance suggests that the following costs should be included in the capital costs of any project:

- Civil works;
- Pipelines; and
- Electrical and mechanical equipment.

The guidance also requires that operational costs are also included in the CBA. These costs are comprised of the costs for energy, materials, services, technical and administrative personnel and maintenance.

Indecon includes all of the above costs in the cost-benefit appraisals carried out for this report. The costs included under each scenario are discussed in more detail in forthcoming chapter.

2.2.4 Economic Analysis

The Commission guidance document outlines a number of potential benefits from water infrastructure projects. Given the main objectives of the proposed projects for the Eastern and Midlands region, Indecon has focused on the benefits of the projects in terms of the increased availability and reliability of water sources and water supply services in our analysis.

A detailed discussion of how these benefits are calculated in our analysis can be found in forthcoming chapters of this report.

2.3 Appraisal Parameters

Both the European Commission guidance and Public Spending Code contain guidance for key parameter values for use in cost-benefit appraisals.

2.3.1 Discount Rate

The discount rate is used in cost-benefit analysis to convert future costs, benefits and income streams into their value today (present value) to allow them to be meaningfully measured and compared for appraisal purposes. The Public Spending Code recommends the use of a discount rate of 5%. Indecon has applied this discount rate in the project appraisals carried out for this report.

2.3.2 Shadow Price of Public Funds

The Public Spending Code recommends that all publicly funded expenditure in cost-benefit analyses should be adjusted by the shadow price of public funds. The motivation for this adjustment is that taxation gives rise to economic distortions by altering the incentives facing economic agents, leading to changes in their behaviour and reduced economic activity. For this reason, the shadow price of public funds is greater than one. The Public Spending Code requires the use of a shadow price of public funds of 130%. Indecon has adjusted all public expenditure in the analysis in this report by this 130% requirement.

2.3.3 Opportunity Cost of Resources

In our analysis we assume that all of the employment in water intensive firms which is lost as a result of any water shortages will be replaced with economic activity in other sectors, albeit at lower levels of productivity. We accept that assuming such high levels of opportunity cost may understate the net economic benefits of the proposed investments in water supply infrastructure but believe that it is important to test the impacts under this assumption.

2.4 Carbon Pricing

Cost Benefit analyses of major investment projects aim to account for the costs of potential externalities from the construction and operational phases of the investments. A key externality from major projects, including those projects considered in this CBA, is the level of harmful environmental emissions produced by the project.

The cost of these emissions to society can be calculated using a carbon price. The Public Spending Code contains detailed guidance on the carbon price that should be used in CBAs of investment projects in Ireland[15].

Table 2.1 outlines the carbon prices recommended in the Public Spending Code and utilised in the analysis outlined in detail later in this report.

Table 2.1: Carbon Pricing Assumptions

	Price - € per Tonne of CO2
Market Spot Price - March 2014	€5.80
Average Futures Price 2014	€6.32
Average Futures Price 2015	€6.58
Average Futures Price 2016	€6.92
Average Futures Price 2017	€7.29
Shadow Price 2018	€7.29
Shadow Price 2019	€7.29
Projected Price - 2020	€10.00
Projected Price - 2025	€14.00
Projected Price - 2030	€35.00
Projected Price - 2035	€57.00
Projected Price - 2040	€78.00
Projected Price - 2045	€90.00
Projected Price - 2050	€100.00

Source: Public Spending Code

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3 The 'Do Minimum' Scenario

3.1 Introduction

A key component of any cost-benefit analysis is an accurate definition of the 'Do Minimum' scenario. This is the scenario which is most likely to prevail should the proposed investment or investments not be undertaken. The Do Minimum scenario thus represents the key comparative basis for the investment scenarios.

For the purposes of this analysis, Indecon has judged that a Do Minimum scenario in which mitigating steps are undertaken by Irish Water to attempt to address supply shortfalls is more appropriate than using a 'Do Nothing' scenario as the comparator.

Indecon constructed the Do Minimum scenario for this cost-benefit analysis with the assistance of inputs from both Jacobs Tobin and Irish Water. In the context of this CBA, the Do Minimum scenario outlines:

- The likely steps in terms of additional leakage reduction that Irish Water would be forced to undertake should no new source of water supply be developed;
- The costs associated with this additional leakage reduction;
- The likely probability of outage over the appraisal period should no additional water supply be developed;
- The costs of this increased probability of outage to the population and economy of the Eastern and Midlands region.

This section outlines the specifics of the Do Minimum Scenario in terms of the leakage reduction activities envisaged, the costs associated with these activities, the impact on the projected supply deficit and the associated increase in the probability of outage and the impact that these factors will have on the residential sector and the economic output of the region over the appraisal period.

3.2 Water Supply and Demand in the Do Minimum Scenario

Under the Do Minimum scenario envisaged for the purposes of this cost-benefit analysis, no major investment is undertaken in a new water supply for the Eastern and Midlands region. Under this scenario, demographic factors and economic growth will continue to put upward pressure water demand in the region.

Table 3.1~~Table 3.1~~ outlines the latest forecasts for water demand in the Eastern and Midlands region under the Most Likely Growth Scenario. These figures are based on the findings of the EPNR but have been updated since the publication of the EPNR to reflect latest data inputs from Irish Water.

Table 3.1: Water Demand Forecasts for the Dublin Region*								
Component		**Element**	**Units**	**2011**	**2021**	**2031**	**2041**	**2050**
Accounted for Water (AFW)	Domestic Demand	Population	Mil.	1.516	1.642	1.842	2.003	2.154
	Household (Customer Side) Losses	Occupancy Rate	No.	2.69	2.48	2.32	2.25	2.20
		No. of Households	000s	592	695	834	935	1,028
		Consumption per connection	l/prop/d	365	360	335	315	305
		Domestic Consumption	Ml/d	216.0	250.3	279.3	294.5	313.6
	Non-Domestic Demand	Non-Domestic Demand	Ml/d	110.1	125.0	145.0	155.0	165.0
		Strategic Allowance for Major Water Using Industry	Ml/d	0	34	75	100	100
	Operational Use	Operation Use Factor	%	1%	1%	1%	1%	1%
		Operational Use Allowance	Ml/d	3.3	3.8	4.2	4.5	4.8
	Accounted for Water (AFW)		Ml/d	329.4	413.1	503.5	554.0	583.4
Unaccounted for Water (UFW) / Distribution Losses		UFW	Ml/d	204.7	165.9	145.0	140.8	140.8
		as % of Average Demand	%	38.3%	28.7%	22.4%	20.3%	19.4%
		cubic metres per km per day	m^3/km/d	22.32	18.09	15.81	15.35	15.35
Average Demand			Ml/d	543.1	579.0	648.5	694.8	724.2
Peak Demand		Peaking Factor	%	15%	15%	15%	15%	15%
		Peaking Allowance	Ml/d	49.4	56.9	64.3	68.1	72.5
Average Day - Peak Week Demand (ADPW)			Ml/d	583.5	635.8	712.8	762.9	796.7
Allowance for Risk and Uncertainty		Headroom & Outage Factor	%	20.0%	20%	20%	20%	20%
		Headroom & Outage Allowance	Ml/d	65.9	75.8	85.7	90.8	96.7
Production Requirement			Ml/d	649.4	711.7	798.5	853.6	893.4

Excludes Benefitting Corridor
Source: EPNR updated with information from Jacobs/Irish Water

Table 3.2 outlines the likely production deficit from the EPNR forecasts of demand, assuming that there is no major investment in new water sources.

Table 3.2: Forecast Supply Deficit from EPNR

	2017	2021	2031	2041	2050
Production Requirement	649.4	711.7	798.5	853.6	893.4
Existing Sources	600	623	650	650	650
Production Deficit	-49.4	-88.7	-148.5	-203.6	-243.4

Source: Indecon Analysis

For the purposes of the formulation of the Do Minimum scenario for the CBA, Indecon has made a number of alterations to the production deficit forecast by the EPNR. These Indecon adjustments have the impact of reducing the net benefits of the proposed investment options but we believe that they are appropriate as they account for the economic response to any potential water shortages.

As will be discussed in more detail in forthcoming sections of this chapter, in the Do Minimum scenario it is assumed that supply levels will increase as additional leakage reduction activities are undertaken in light of the lack of investment in new water sources. In addition to this, Indecon assumes that in the Do Minimum scenario water demand will be somewhat lower than forecast in the EPNR. Indecon believes that it is rational to assume that as the likelihood of water supply outages increases over time households and businesses will take steps to reduce their water usage. Households may install rainwater butts and take other mitigating steps while businesses may switch to less water intensive production processes or invest in alternative water sources. In light of this, for the purposes of the Do Minimum scenario we assume that water demand will be 5% lower than forecast in the EPNR.

Table 3.3 outlines the projected supply deficit in the Do Minimum scenario. The alternative assumptions on leakage reduction and demand levels result in a lower deficit over the appraisal period but there remains a significant gap between supply and demand.

Table 3.3: Forecast Supply Deficit in Do Minimum Scenario

	2017	2021	2031	2041	2050
Production Requirement – Do Min	660	697	769	781	819
Supply Level – Do Min	600	623	650	650	650
Production Deficit	-60.0	-73.7	-118.5	-131.0	-168.7

Source: Indecon Analysis

3.3 Costs

3.3.1 Additional Leakage Reduction

In a scenario in which neither of the proposed investment projects is undertaken, Irish Water would potentially find itself in a situation where demand for water is set to exceed the available water supply in the Eastern and Midlands region with the supply deficit set to continue to increase over time. This is the scenario as outlined in the EPNR. In this scenario, without a new source of supply, Irish Water would be required to maximise the water provided to households and businesses from current water sources.

The means of maximising the current water supplies in a scenario where no new water sources are available will be to undertake additional leakage reduction activities. In the Do Minimum scenario the Sustainable Economic Level of Leakage (SELL) faced by Irish Water is likely to fall as pressure grows on existing water supply sources. While Indecon notes that Irish Water has set ambitious leakage reduction targets which will be pursued in both of the investment scenarios as well as the Do Minimum scenario, should other sources not be available, Irish Water would face little option but to pursue even higher levels of leakage reduction in the Eastern and Midlands region.

Indecon has liaised with both Irish Water and Jacobs Tobin to identify the most realistic level of leakage reduction that could be reached in a Do Minimum scenario and the amount of additional water that might be saved through this leakage reduction. Indecon has also received estimates from Irish Water and Jacobs Tobin as regards the likely cost of these additional leakage reduction activities.

Table 3.4 outlines the water savings from additional leakage reduction in the Do Minimum Scenario. Irish Water and Jacobs Tobin believe that additional water savings in the order of 15Mld by 2021 and 30Mld cumulatively by 2026 are at the upper limits of what is realistically possible for the Eastern and Midlands region. Irish Water believes that the first 15Mld of additional leakage reduction could potentially be achieved at roughly a cost of €7.42 million per Mld while the additional 15Mld to be saved between 2021 and 2026 will likely cost nearly twice as much per Mld at €14 million. The total cost of additional leakage reduction activities in the Do Minimum scenario is likely to be just over €310 million in net present value terms and adjusted for the shadow price of public funds.

Table 3.4: Leakage Reduction in Do Minimum Scenario

	Unit	2021	2026	2031	2041
Additional Leakage Reduction - Do Min	Mld	15.0	30.0	30.0	30.0
Costs Per MLD	€ Million	7.42	14	14	14
Additional Cost in Do Min	€ Million	111.3	210.0	0	0
Total Additional Cost - Do Min	€ Million	321.3			
Total Additional Cost – NPV and adjusted for the Shadow Price of Public Funds	€ Million	310.5			

Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin

Beyond the cost in terms of expenditure by Irish Water on leakage reduction, there is also likely to be an environmental cost of undertaking this additional leakage reduction activity. Indecon has

included in our Do Minimum scenario an estimate of the likely cost to the environment in terms of CO2 emissions from the additional leakage reduction activities envisaged in this scenario.

Irish Water and Jacobs Tobin provided estimates for the CO2 emissions from leakage reduction operations based on the evidence from recent leakage reduction activities. The costs in terms of tonnes of carbon dioxide emitted are outlined in Table 3.5. Indecon has converted these emissions into a monetary cost using the forecasts for carbon prices recommended in the Public Spending Code. The total cost in net present value terms of emissions from additional leakage reduction activities in the Do Minimum scenario is thus estimated at €2.2 million.

Table 3.5: Environmental Costs of Leakage Reduction Activities in Do Minimum Scenario

	Unit	2017-2021	2021-2026	Total
Emissions from additional leakage reduction activities	Tonnes CO2	127,060	144,120	271,180
Cost based on carbon pricing forecasts	€ 000's	1,084	2,000	3,085
Cost in net present value terms	€ 000's	929	1,343	2,272

Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin

3.3.2 Benefitting Corridor

The Benefitting Corridor (BC) is comprised of the areas of Tipperary, Offaly, Laois, Westmeath and parts of Counties Kildare and Meath that potentially stand to benefit from the proposed projects in addition to the Greater Dublin Water Supply Area. Water Supply schemes in Clare, Limerick, Louth and Wicklow are also being examined by Irish Water for consolidation. In the Do Minimum scenario in which no major investment in a new water source is undertaken and in the Desalination scenario, the areas comprising the BC will be required to forego the rationalisation of the existing network of water supply plants in the region which is envisaged should the proposed investments in the Shannon option proceed. This will require additional capital and operational expenditure on these plants that would not take place in either of the investment scenarios.

Irish Water has provided Indecon with estimates of the likely costs to the BC in the Do Minimum and Desalination scenarios in terms of capital and operation expenditure. Irish Water have also included a cost for the BC in these scenarios which estimates the costs likely to be borne by Irish Water in providing alternative water sources for the BC beyond the continuing use of the existing water treatment plants. Table 3.6 outlines these costs. Over the time period of this analysis, in these scenarios Irish Water estimate additional costs of €348 million in net present value terms and adjusted for the shadow price of public funds.

Table 3.6: Costs to the Benefitting Corridor in the Do Minimum Scenarios						
		2017-2025	2025-2035	2035-2045	2045-2050	Total
Capital Expenditure	€ Millions	157.2	40.8	40.8	20.1	258.9
Operational Expenditure	€ Millions	14.4	22.2	22.2	36.7	95.6
Cost of Provision of Additional Capacity	€ Millions	39.2	50.5	24.3	9.2	123.1
Total Expenditure	**€ Millions**	**210.8**	**113.5**	**87.3**	**66.0**	**477.7**
Total Expenditure - NPV	**€ Millions**	**170.9**	**56.5**	**26.6**	**13.8**	**268.0**
Total Expenditure - Adjusted for Shadow Price of Public Funds	**€ Millions**	**222.2**	**73.4**	**34.6**	**18.0**	**348.4**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin						

3.3.3 Expected Property Days of Outage in the Do Minimum Scenario

One of the key benefits of the proposed investments in new water sources for the Eastern and Midlands region is attainment of a sufficient and reliable water supply for the region. As was outlined in the EPNR, without a new water supply for the region, demand will exceed supply as demographic and economic factors in the region put increasing pressure on the supply from existing sources. As demand approaches current supply levels and eventually begins to exceed these levels, it is inevitable that the reliability of the water supply in the region will deteriorate. The number of supply outages experienced in the Do Minimum scenario is thus likely to be significantly greater than the number expected under either of the investment options.

Estimating the costs of these outages to the economy of the Eastern and Midlands region is an important step in the estimation of the likely overall costs of the Do Minimum scenario. However, before estimating the costs of water supply interruptions, it is necessary to forecast the likely levels of water supply disruption in the region under the Do Minimum scenario.

In order to forecast the likely water supply disruption on an annual basis for the Do Minimum scenario Indecon has utilised technical engineering estimates on the average number of property days of restriction faced by the residents of the region.

This methodology assumes that night time water restrictions (between 6pm and 6am) equal half the day time restrictions. Additionally, this methodology assumes that a full day of pressure reduction in an area is equivalent to an outage event effecting 1% of properties for a third of a day.

Using this methodology and based on the outages experienced between 2010 and 2013, the internal Irish water calculations suggest that the prevailing expected average property days per annum in the region is 0.9. Irish Water's internal calculations suggest that following the completion of either of the proposed investment options for a new water supply, the average expected number of property days subject to restriction is anticipated to fall to 0.23. As under both of the investment scenarios supply will meet forecast demand levels with an allowance for

peaking and headroom, this estimate of 0.23 expected property days of restrictions is treated as a lower bound for expected property days of restriction.

Indecon has been advised by Irish Water and Jacobs Tobin that the relationship between expected property days and the differential between water supply and demand is likely to be that for every increase of 25Mld in the deficit between supply and demand, the number of expected property days of outage is likely to double.

The following table outlines Indecon's estimates of the likely path of expected property days of outage over the appraisal period given the above methodology and assumptions.

Table 3.7: Expected Property Days Subject to Restriction in the Do Minimum Scenario

	2017	2021	2026	2031	2041	2046	2050
Expected average annual number of property days subject to restriction	0.90	0.84	0.90	1.57	2.51	3.46	4.01

Source: Indecon Analysis

Indecon is projecting for the purposes of this cost-benefit analysis that in the Do Minimum scenario the average expected property days subject to water restriction will increase to 4.01 by the end of the appraisal period. The expected number of property days subject to restriction will fall as additional leakage reduction activates are undertaken. However, as the amount of water that can realistically be saved by means of these leakage reduction efforts is maximised, the number of property days subject to restriction is expected to increase.

Following the estimation of the likely future level of water supply restriction faced in the Do Minimum scenario, it is then necessary to estimate the monetary cost of these outages to the residential and commercial sectors.

3.3.4 Costs to the residential sector

The costs to the residential sector are estimated using the international evidence on the costs of water supply outages presented in the EPNR. The EPNR presented evidence from a number of studies in countries around the world that have attempted to quantify the costs of water supply interruptions to households. This review of the international evidence suggested a range of costs between €44 and €122 per person, per day of outage. For the purposes of this cost-benefit analysis, Indecon has decided to use the lower value of this range of €44 per person per day in our calculations. We believe that it is prudent to undertake the cost-benefit appraisal using the most conservative estimate of the costs of water supply restrictions in order to ensure that the findings of the analysis do not risk overstating the potential benefits of the proposed investment projects.

The costs of the likely outages are thus a function of the estimate of the per-capita cost and the total population of the region. The population forecasts for the region used in this analysis are the same as those used in the ENPR and are based on the findings of an external demographers' report which forecast the likely future population of the Eastern and Midlands region. Table 3.8 illustrates the likely annual cost at various points in the appraisal period based on the assumption of the costs of a day's outage per person of €44.

Indecon's analysis suggests that by 2050 in the Do Minimum scenario the annual costs of outage to the residential sector will be in the region of €379.8 million in absolute terms or €72.3 million in net present value terms.

Table 3.8: Costs of Expected Property Days Subject to Water Supply Restrictions in the Do Minimum Scenario							
	Unit	2017	2021	2031	2041	2046	2050
Expected average number of property days subject to restriction annually	Property Days	0.90	0.84	1.57	2.51	3.46	4.01
Population of the Dublin Water Supply Area	People	1,550,602	1,642,391	1,842,060	2,003,156	2,081,225	2,154,252
Estimated cost to the residential sector (annual basis)	€ Millions	61.4	60.7	127.3	221.1	316.7	379.8
Estimated cost to the residential sector in net present value terms	€ Millions	61.4	47.5	61.2	65.3	73.7	72.3
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin							

Table 3.9 outlines the total costs to the residential sector of the expected property days of outage under the Do Minimum scenario over the course of the entire appraisal period. In net present value terms, we estimate a total cost to the residential sector of €2,123 million over the appraisal period.

Table 3.9: Total Costs of Expected Property Days Subject to Water Supply Restrictions in the Do Minimum Scenario		
	Unit	Total Costs 2017-2050
Total costs to the residential sector	€ Millions	5,855
Total costs to the residential sector in net present value terms	€ Millions	2,123
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin		

3.3.5 Costs to the internationally traded manufacturing sector

Beyond the costs to residential water users, an increasingly unreliable water supply will also impact on the commercial and industrial sectors of the economy. It may be of particular relevance to the output levels of water intensive firms. Given the uncertainty surrounding the likely impact of water restrictions on individual firms and sectors, for the purposes of this cost-benefit analysis, Indecon has restricted our estimates of the output costs of water supply outages to the main internationally traded sectors which are most water intensive. The combination of these sectors' water intensity means that the output of these sectors may be particularly sensitive to water insecurity given the ability of the firms in these sectors to divert production to other sites.

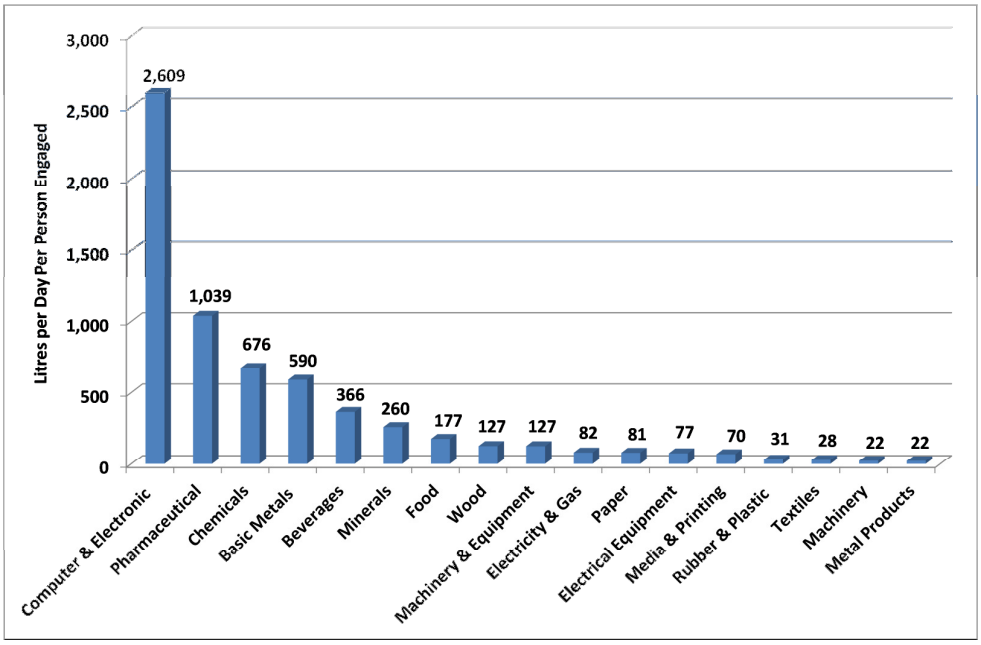
For the purposes of this analysis, we focus on the most water intensive industries of the internationally traded manufacturing sector. These industries are:

- Chemical manufacturing;

- Pharmaceuticals manufacturing; and
- Computer and electronics manufacturing.

Figure 3.1~~Figure 3.1~~ illustrates the water intensive nature of these sectors based on water usage and regional employment data for the Eastern and Midlands region.

Figure 3.1: Water Consumption Per Person Engaged by Sector in Greater Dublin Area



Source: Economic Project Needs Report
* 2011 figures for manufacturing sectors

Exactly to what degree and at what point these water intensive sectors would respond to changes in the security of supply and reliability of water resources in the Midlands and Eastern region is an unknown factor. Given the diverse nature of the firms involved, the differing role of each firm in the global supply chain of the larger multinational corporations and how these supply chains may evolve over the appraisal period of this evaluation, attempting to ascertain the precise elasticity of output of these sectors to the risk of water supply interruptions is not feasible. However, there is no doubt that water shortages and increased risks of outage would impact negatively on the attractiveness of the region to investment by water intensive firms.

For the purposes of this evaluation, Indecon presents a number of scenarios which reflect a potential range of impacts on output in these sectors of increased probabilities of outage in the water supply infrastructure in the Midlands and Eastern region. We present scenarios in which output in these sectors is reduced by 5%, 10% and 15% relative to what would otherwise have been the case.

We impose this output reduction in our model from 2040 onwards. We have chosen to assume this reduction in output from this point onwards as it is at this point in time that the number of expected property days of supply interruption begins to dramatically exceed the prevailing level in 2017. We would note that in a Do Minimum scenario in which it becomes obvious to these firms

that water supply infrastructure is going to continue to deteriorate, they may make production decisions in advance of when the supply problems become chronic and as output may fall at an earlier point and potentially more dramatically than the assumptions we impose here. With this in mind, Indecon believes that the assumptions in our model are a conservative estimate of the likely impact of the Do Minimum scenario on output in these sectors.

The economic forecast against which we benchmark the Do Minimum scenario is an updated version of that presented in the EPNR. Indecon has updated the economic forecasts based on the performance of the economy since the publication of the ENPR and other developments. The EPNR contained a long-term forecast for growth on a sectoral level in the Irish economy based on the ESRI Medium-Term Review (MTR) recovery scenario. However, since the publication of the MTR and the EPNR, the long-term outlook for the Irish economy, and in particular the internationally traded sector, has been negatively impacted by, amongst other factors, the recent decision of the UK to leave the European Union. While the exact nature of the new arrangement between the UK and the EU remains to be seen, there have been a number of studies which have examined the potential impact of the UK leaving the EU on the Irish economy.

The ESRI published one such report titled "*Scoping the possible economic implications of Brexit on Ireland*"[16]. This report highlights the reliance of particular sectors of the Irish economy, including the chemical and pharmaceutical manufacturing sectors, on exports to and imports from the UK. The ESRI report suggests that Brexit could potentially negatively impact merchandise trade between the UK and Ireland by 20%. The baseline economic analysis used in this cost-benefit appraisal accounts for this potential reduction in trade flows for the internationally traded manufacturing sector in Ireland.

The output forecasts for the internationally traded manufacturing sector in our analysis assume a 20% reduction output between 2017 and 2025 relative to the original MTR forecasts as a result of Brexit.

In assessing the likely impact of additional reduction in output in these sectors over the appraisal period, as discussed above, Indecon implements a number of scenarios. In each of these scenarios we assume that the employment lost in these sectors as a result of falling output in the medium term finds employment in other sectors of the economy but at a lower level of output per worker. We assume that those workers displaced by reduced output in the internationally traded manufacturing sector find employment in sectors with an average per-worker output of 90% of that in their previous employment. This assumption of labour market replacement mitigates the negative overall impact on the Irish economy of reduced output in these sectors due to water supply restrictions. While the assumption that 100% of the jobs lost in these sectors will be replaced at output levels as high as 90% of those previously achieved may be somewhat optimistic, we believe that this optimistic assumption is a prudent one as more pessimistic assumptions in this regard may risk overstating the cost of the Do Minimum scenario and thus the benefits of the proposed investments.

Table 3.10 outlines the projected economic output costs to the chemical, pharmaceuticals and computer and electronics manufacturing sectors under the Do Minimum scenario in which the security and reliability of water supply to these sectors deteriorates over the appraisal period. Depending on the scale of the impact on these sectors Indecon estimates a likely reduction in total output of between €500 and €1,500 million in net present value terms.

[16] https://www.esri.ie/pubs/RS48.pdf

Table 3.10: Total Output Costs of Water Supply Restrictions in the Do Minimum Scenario in the Internationally Traded Manufacturing Sectors		
	Unit	Output Costs
Assumed reduction in output:		
5%	€ Millions - NPV	494.9
10%	€ Millions - NPV	989.8
15%	€ Millions - NPV	1484.7
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin		

Indecon would again emphasise the level of uncertainty surrounding the likely impact of water restrictions on output in these sectors and that there is a considerable risk to the downside in these forecasts in so far as the output impact may be considerably higher should firms in these sectors choose to forego major investments in Ireland in light of the potential impact of water restrictions on their production processes.

We would also note that we have focused on these water intensive and internationally traded manufacturing sector as they are likely to be the most responsive to water supply restrictions. It is also likely that other sectors of the economy in the Eastern and Midlands region will be negatively impacted by water restrictions. With this in mind, Indecon's estimate of the impact of water restrictions in the Do Minimum scenario is likely to be underestimating the overall impact on the economy of the region.

3.3.6 Summary of Costs in the Do Minimum Scenario

This chapter has outlined how the water supply situation in the Eastern and Midlands region is likely to develop in the Do Minimum scenario in which no investment is undertaken in a major new water source for the region. Indecon have monetised the costs to the residential sector and economic output in the region using international evidence on the costs of water supply outage to households and estimates of the potential impact of water supply insecurity in water intensive manufacturing sectors.

Table 3.11 presents a summary of the total costs in the Do Minimum scenario. This summary represents our baseline scenario in which output in the internationally traded sector falls by 10%. Under these assumptions we find a total cost to the economy of €3.7 billion in net present value terms over the appraisal period.

Table 3.11: Summary of Costs in the Do Minimum Scenario	
Cost	**€ Million – NPV**
Leakage Reduction	310.5
Environmental Costs	2.3
Benefitting Corridor	348.4
Residential Outage Costs	2,123.2
Economic Output Costs	989.8
Total Costs	**3,774.2**
Source: Indecon Analysis	

4 Option 1: Shannon Abstraction

4.1 Introduction

The first investment option included in this CBA analysis is the option of water abstraction from the Shannon at Parteen basin and the construction of a pipeline to Dublin. This chapter outlines the costs and benefits of this proposed project. On the cost side, Indecon's analysis includes costs related to:

- Capital costs;
- Operational expenditure;
- Environmental costs;
- Disruption costs of construction works; and
- Benefitting Corridor costs.

The benefits of the proposed project are directly linked to the costs of additional outage forecast in the Do Minimum scenario. The benefit of the proposed investment projects is the avoidance of the costs of outage envisaged in the Do Minimum scenario.

This chapter outlines in more detail the costs and benefits of Option 1 and presents an initial benefit-cost ratio (BCR) and net benefit for the proposed project under baseline assumptions.

4.2 Costs

It should be noted that all cost figures presented here are exclusive of VAT. This is in with the latest guidance for the completion of cost-benefit analyses as per the Public Spending Code.

4.2.1 Capital Costs

Indecon has been provided with capital cost data by Jacobs Tobin for the Shannon abstraction investment option. This data includes costs data for each major aspect of the proposed investment and information on when this expenditure is likely to be incurred during the construction of the project. Table 4.1 outlines the costs of the proposed investment over the projected construction period between 2020 and 2024. In absolute terms the capital investments for the project are expected to amount to €514.9 million. After adjusting this figure for the shadow price of public funds and expressing it in net present value terms the capital costs of the project for the purposes of this CBA are €487.1 million.

Table 4.1: Capital Costs for Option 1: Shannon Abstraction (€ Million)						
	2020	2021	2022	2023	2024	Total
Intake	-	-	4.97	-	-	4.97
Raw Water Pumping Station	-	-	10.91	-	-	10.91
Raw Water Pipeline	-	-	5.35	-	-	5.35
Water Treatment Works (WtW)	-	13.06	26.13	34.83	13.06	87.09
Treated Water Pipeline (WtW – TWPS)	-	-	0.07	-	-	0.07
Treated Water Pumping Station (TWPS)	-	1.26	3.12	5.20	1.26	10.84
Treated Water Pipeline: Parteen – Peamount TPR	-	47.14	89.09	89.09	89.09	314.42
Booster Pumping Station Break Pressure Tank	-	-	1.21	-	-	1.21
Peamount Termination Point (TPR) Reservoir and Integration Works	-	-	31.08	24.75	-	55.82
Other capital costs (Power Supply)	-	-	10.39	-	-	10.39
Preliminary Costs	6.95	6.95	-	-	-	13.90
Total	6.95	68.42	182.31	153.87	103.42	514.96
Total - NPV	5.72	53.61	136.04	109.35	70.00	374.71
Total - Adjusted for Shadow Price of Public Funds	7.43	69.69	176.85	142.16	90.99	487.13
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin						

4.2.1 Operational Expenditure

Jacobs Tobin have also provided Indecon with estimates of the operational expenditure required to operate the proposed investment in Option 1. Indecon have been provided with data on labour costs, material input costs, maintenance costs and power costs for the full appraisal period.

Presented in net present value terms and adjusted for the shadow price of public funds the total operational expenditure required to run the proposed investments under Option 1 amount to €152.3 million.

Table 4.2: Operational Costs for Option 1: Shannon Abstraction (€ Million)	
	2025-2050
Labour Fixed Costs (Labour, Insurances, External Auditing, General Consumables)	29.1
Material Inputs (Chemicals)	64.7
Fuel Input Costs Sludge Treatment & Disposal	39.4
Power Costs	168.9
Capital Replacement Allocation	23.1
Total	325.2
Total - NPV	117.1
Total - Adjusted for Shadow Price of Public Funds	**152.3**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin	

4.2.1 Environmental Costs

The proposed investments under Option 1 will involve increased CO2 emissions from the operation of the new water supply infrastructure. Indecon has been provided with estimates of

the emissions of the proposed project over the appraisal period. Indecon has converted these emissions forecasts to a monetary value for inclusion in the CBA using the guidance on carbon pricing from the Public Spending Code. Table 4.3 outlines the total emissions for Option 1 and the value of these emissions over the appraisal period in net present value terms.

Table 4.3: Environmental Costs for Option 1: Shannon Abstraction		
	Units	2021-2050
Emissions during construction	Tonnes CO2	449,999
Emissions from ongoing operation and maintenance	Tonnes CO2	817,391
Total Emissions	Tonnes CO2	1,267,390
Total Cost of Emissions	€ Million	56.6
Total Cost of Emissions - NPV	**€ Million**	20.2
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin		

4.2.2 Costs of Traffic Disruption

Option 1 involves the construction of a major pipeline from the point of abstraction of water from the Shannon to Dublin. The construction of this pipeline is likely to cause a certain amount of disruption to road users along the pipeline route. Jacobs Tobin/ Irish Water have provided Indecon with estimates of the likely delays associated with this sort of infrastructure work based on previous experience. Table 4.4 outlines the expected delays at each point along the proposed pipeline route.

Table 4.4: Vehicle Delays for Option 1: Shannon Abstraction	
Section of Proposed Pipeline Route	**Traffic Delay - Vehicle Minutes**
Parteen to M7 (1st)	27,510
M7(1st) to M7 (2nd)	3,360
M7 (2nd) to N52	19,260
N52 onwards to N62	11,808
N62 to N80 at Killeigh	29,250
N80 to vicinity of Peamount	169,290
Total - Minutes	**260,478**
Total - Hours	**4,341**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin	

Indecon has converted the cost of these delays to monetary values using the latest parameters for the value of time published by the Department of Transport, Tourism and Sport[17]. The parameters presented in this document contain values for time spent working, at leisure and commuting in 2011 prices. The values in the 2011 column in Table 4.5 are taken directly from the Departmental guidance. The figures for the subsequent columns covering the years in which the construction related disruption is envisaged to take place are calculated based on the increase in GNP per

[17] http://www.dttas.ie/sites/default/files/publications/corporate/english/common-appraisal-framework-2016/common-appraisal-framework2016_1.pdf

person employed since 2011 and in line with the forecasts for GNP per person employed between 2017 and 2024.

Table 4.5: Value of Time for Option 1: Shannon Abstraction					
	Factor Cost - € per hour				
Use of Time	2011	2021	2022	2023	2024
Work	€29.02	€40.84	€41.74	€42.66	€43.60
Leisure	€10.78	€15.17	€15.50	€15.85	€16.19
Commuting	€11.86	€16.69	€17.06	€17.43	€17.82
Source: Indecon Analysis of Data from Department of Transport, Tourism and Sport					

For the purposes of this CBA, Indecon assumes that 40% of journeys on these roads will be for work purposes, 40% will be for commuting and the remaining 20% will be for leisure purposes. Under these assumptions the calculation of the overall costs of the project related traffic disruption is displayed in Table 4.6. While the costs of construction related delays are comparatively low relative to the overall capital costs involved in the project, their inclusion in the overall CBA is valid and in line with the latest guidance.

Table 4.6: Cost of Traffic Disruption for Option 1: Shannon Abstraction						
	Unit	2021	2022	2023	2024	Total
Total Hours	Hours	1,085	1,085	1,085	1,085	4,341
Work	€	17,730	18,120	18,519	18,926	73,296
Leisure	€	6,586	6,731	6,879	7,031	27,227
Commuting	€	3,623	3,703	3,784	3,867	14,977
Total Cost	€	27,940	28,554	29,182	29,824	115,501
Total Cost - NPV	**€**	21,891	21,308	20,739	20,186	84,125
Source: Indecon Analysis						

4.2.3 Benefitting Corridor

Jacobs Tobin/ Irish Water have provided Indecon with costs data for the water supply infrastructure in the benefitting corridor under both the Do Minimum and the two investment scenarios. Table 4.7 outlines the projected costs under Option 1. Table 4.7 illustrates that the costs to the benefitting corridor are envisaged to be significantly less under Option 1 than in the Do Minimum scenario.

Table 4.7: Costs to the Benefitting Corridor in Option 1						
		2017-2025	2025-2035	2035-2045	2045-2050	Total
Capital Expenditure	€ Millions	40.80	-	-	-	40.80
Operational Expenditure	€ Millions	22.24	-	-	-	22.24
Cost of Provision of Additional Capacity	€ Millions	-	-	-	-	-
Total Expenditure	**€ Millions**	**63.04**	**-**	**-**	**-**	**63.04**
Total Expenditure - NPV	**€ Millions**	**51.11**	**-**	**-**	**-**	**51.11**
Total Expenditure - Adjusted for Shadow Price of Public Funds	**€ Millions**	**66.44**	**-**	**-**	**-**	**66.44**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin						

4.3 Benefits

The benefits of the proposed investment in new water supply infrastructure for the Eastern and Midlands region are primarily composed of the avoided costs of the increased number of water supply outages and restrictions under the Do Minimum Scenario.

In calculating the benefits of the proposed project it is thus first necessary to estimate the expected number of property days of water supply restrictions and compare the costs of this level of outage to that under the Do Minimum scenario. The difference between these two values will be the benefit of the proposed investment in new water infrastructure.

As outlined previously in the discussion of the calculation expected property days of restrictions under the Do Minimum scenario, Indecon has relied on the methodology used to calculate expected property days of restrictions used by Irish Water in previous internal estimates that have been shared with Indecon. Ongoing internal work by Irish Water suggests that even once the proposed investments are completed there will remain a residual expected level of annual property days of water supply restrictions of 0.23.

Table 4.8 outlines the expected path of property days of outage over the appraisal period under Option 1. While expected property days of water supply restrictions are expected to increase up until 2024, once the proposed investments under Option 1 come online in 2025 the expected number of property days of water supply restrictions are expected to fall to 0.23 and remain at this level for the remainder of the appraisal period.

Table 4.8: Costs of Expected Property Days Subject to Water Supply Restrictions under Option 1							
	Unit	2017	2021	2031	2041	2046	2050
Expected average annual number of property days subject to restriction	Property Days	0.9	1.12	0.23	0.23	0.23	0.23
Population of the region	Millions of People	1,550,602	1,642,391	1,842,060	2,003,156	2,081,225	2,154,252
Estimated cost to the residential sector	€ Millions	61.4	80.7	18.6	20.3	21.1	21.8
Estimated cost to the residential sector in net present value terms	€ Millions	61.4	63.2	9.0	6.0	4.9	4.1
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin							

Table 4.9 outlines the total cost of expected property days of water supply restrictions under Option 1 over the appraisal period. In net present value terms, the expected costs to the residential sector are anticipated to be €752 million. This assumes a value of a single day of outage on a per-capita basis of €44 as was the case in the calculations for the Do Minimum scenario.

Table 4.9: Total Costs of Expected Property Days Subject to Water Supply Restrictions under Option 1		
	Unit	Total Costs 2017-2050
Total costs to the residential sector	€ Millions	1,204
Total costs to the residential sector in net present value terms	€ Millions	752
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin		

Table 4.10 illustrates the total benefit of Option 1 relative to the Do Minimum scenario. All figures in this table are presented in net present value terms. There is a net benefit from Option 1 to the residential sector of €2,123 million and an additional benefit of €990 in avoided output losses. The total benefit of Option 1 is thus estimated at €2,361 million over the appraisal period.

Table 4.10: Benefit of Option 1-Shannon Abstraction relative to Do Minimum Scenario	
Do Minimum	€ Million - NPV
Costs to the Residential Sector	2,123
Economic Output Costs	990
Option 1 – Shannon Abstraction	
Costs to the Residential Sector	752
Economic Output Costs	-
Benefit of Option 1	
Residential Sector	1,371
Economic Output	990
Total Benefit of Option 1	2,361
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin	

4.4 Net Benefit and Benefit Cost Ratio

The previous sections of this chapter have thus outlined the projected costs and benefits of the Shannon abstraction investment option. With these costs and benefits calculated, it is now possible to calculate the overall net benefit of Option 1 and the benefit cost ratio (BCR). The net benefit and BCR reported in this section are for a baseline scenario. The assumptions underlying these findings will be flexed in subsequent sensitivity analysis.

Table 4.11 outlines the total costs and benefits of the Shannon Abstraction option and illustrates the overall net benefit of the proposed investments at €1,635 million. The BCR for the proposed investments is 3.25. This suggests that the proposed investments under Option 1 would bring about considerable benefit to the economy of the Eastern and Midlands region over the course of the assessment period, relative to the Do Minimum scenario.

Table 4.11: Option 1-Shannon Abstraction - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	487.1
Operational Expenditure	152.3
Environmental Costs	20.2
Traffic Disruption	0.1
Costs in Benefitting Corridor	66.4
Total Costs	726.1
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	989.8
Total Benefits	2,361.2
Net Benefit of Option 1	1,635.1
BCR	3.25
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin	

5 Option 2: Desalination

5.1 Introduction

The second option identified in Irish Water's options appraisal process is the construction of a desalination plant on the coast to the north of County Dublin. Jacobs Tobin/ Irish Water have provided Indecon with detailed cost data for this proposed investment option for the purposes of this CBA.

This chapter outlines the costs and benefits of Option 2. On the cost side, Indecon's analysis includes costs related to:

- Capital costs;
- Operational expenditure;
- Environmental costs; and
- Benefitting Corridor costs.

As was the case in the assessment of Option 1, the benefits of Option 2 are directly linked to the costs of additional outage forecast in the Do Minimum scenario. The benefit of the proposed investment projects is the avoidance of the costs of outage envisaged in the Do Minimum scenario.

This chapter outlines in more detail the costs and benefits of Option 2 and presents an initial benefit-cost ratio (BCR) and net benefit for the proposed project under baseline assumptions.

5.2 Costs

It should be noted that all cost figures presented here are exclusive of VAT. This is in with the latest guidance for the completion of cost-benefit analyses as per the Public Spending Code.

5.2.1 Capital Costs

The capital costs for the Desalination option cover the investment costs for the construction of the desolation plant and related infrastructure, the costs of land purchases required and the costs of pipeline construction both from the proposed desalination plant to the Dublin region and to the wider benefitting corridor.

Table 5.1 outlines the costs of the proposed investments in Option 2. The investments are envisaged to be undertaken between 2020 and 2024. In net present value terms, the costs of the investments for the desalination option amount to €473 million.

Table 5.1: Capital Costs for Option 2: Desalination (€ Million)						
	2020	2021	2022	2023	2024	Total
Intake & Brine Disposal	-	-	94.85	-	-	94.85
Desal Plant	-	17.16	68.64	68.64	17.16	171.61
Treated Water Pumping Station (TWPS)	-	10.06	10.06	-	-	20.12
Treated Water Pipeline : PS to Ballycoolin	-	12.61	37.82	37.82	37.82	126.05
Distribution Pipeline - Leixlip to Peamount TPR	-	6.92	1.73	-	-	8.65
Peamount Termination Point (TPR) Reservoir and Integration Works	-	-	31.08	24.75	-	55.82
Other capital costs (Power Supply)	-	-	10.39	-	-	10.39
Preliminary Costs	4.64	4.64	-	-	-	9.28
Total	4.64	51.38	254.56	131.21	54.98	496.77
Total - NPV	**3.82**	**40.26**	**189.96**	**93.25**	**37.21**	**364.49**
Total - Adjusted for Shadow Price of Public Funds	**4.96**	**52.34**	**246.95**	**121.22**	**48.37**	**473.84**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin						

5.2.2 Operational Expenditure

Jacobs Tobin has provided Indecon with estimates of the operational expenditure required to operate the desalination plant and associated infrastructure.

Table 5.2 presents the operational expenditure for Option 2. Presented in net present value terms and adjusted for the shadow price of public funds the total operational expenditure required to run the proposed investments under Option 2 amount to €450.6 million over the appraisal period in net present value terms and adjusted for the shadow price of public funds.

Table 5.2: Operational Costs for Option 2: Desalination (€ Million)	
	2025-2050
Labour Costs	29.12
Power Costs	781.7
Consumables	36.3
Material Inputs (Chemicals)	101.2
Fuel Input Costs Sludge Disposal	5.1
Capital Replacement Allocation	-
Total	953.5
Total - NPV	**346.6**
Total – Adjusted for Shadow Price of Public Funds	**450.6**
Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin	

5.2.3 Environmental Costs

The environmental costs of the proposed investments under Option 2 can be quantified in terms of the tonnes of CO2 that will be emitted over the construction phase and during the operation of the proposed desalination plant over the appraisal period. Using carbon price forecasts as recommended in the Public Spending Code, Indecon has monetised these emissions for inclusion in the CBA.

Table 5.3 illustrates the total emissions from both the construction and operational phases of the proposed project. In net present value terms, the cost of emissions under Option 2 amounts to €75.6 million over the appraisal period.

Table 5.3: Environmental Costs for Option 2: Desalination

	Units	2021-2050
Emissions during construction	Tonnes CO2	260,001
Emissions from ongoing operation and maintenance	Tonnes CO2	3,583,995
Total Emissions	Tonnes CO2	3,843,996
Total Cost of Emissions	€ Million	237.1
Total Cost of Emissions - NPV	**€ Million**	**75.6**

Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin

5.2.4 Benefitting Corridor

Jacobs Tobin/ Irish Water have provided Indecon with costs data for the water supply infrastructure in the benefitting corridor under both the Do Minimum and the two investment scenarios. As it is envisaged that only the Shannon option will provide additional water to the benefitting corridor as a part of its initial capital costs, the costs to the benefitting corridor under this scenario are assumed to be lower than those envisaged under both the Desalination and Do Minimum options. The costs to the benefitting corridor are assumed to be identical in both the Desalination and Do Minimum options.

Table 5.4 outlines the projected costs under Option 2. In net present value terms, the total costs to the benefitting corridor amount to €348.4 million over the appraisal period in net present value terms and adjusted for the shadow price of public funds.

Table 5.4: Costs to the Benefitting Corridor in Option 2

		2017-2025	2025-2035	2035-2045	2045-2050	Total
Capital Expenditure	€ Millions	157.2	40.8	40.8	20.1	258.9
Operational Expenditure	€ Millions	14.4	22.2	22.2	36.7	95.6
Cost of Provision of Additional Capacity	€ Millions	39.2	50.5	24.3	9.2	123.1
Total Expenditure	**€ Millions**	210.8	113.5	87.3	66.0	477.7
Total Expenditure - NPV	**€ Millions**	**170.9**	**56.5**	**26.6**	**13.8**	**268.0**
Total Expenditure - Adjusted for Shadow Price of Public Funds	**€ Millions**	**222.2**	**73.4**	**34.6**	**18.0**	**348.4**

Source: Indecon Analysis of Data from Irish Water/Jacobs Tobin

5.3 Benefits

As was outlined in the previous chapter, the benefits of the proposed investment in new water supply infrastructure for the Eastern and Midlands region are primarily composed of the avoided costs of the increased number of water supply outages and restrictions under the Do Minimum Scenario.

With this in mind, for the purposes of this chapter, we limit the discussion of the benefits from the desalination plant to reporting the benefits in terms of the residential sector and economic output. For a detailed discussion of the methodology used to calculate these benefits the reader should refer to the previous chapter.

Table 5.5 outlines the benefits of Option 2. In net present value terms, Option 2 will bring about benefits of €2,361 million over the appraisal period relative to the Do Minimum scenario.

Table 5.5: Benefit of Option 2-Desalination relative to Do Minimum Scenario

Do Minimum	€ Million - NPV
Costs to the Residential Sector	2,123
Economic Output Costs	990
Option 2 – Desalination	
Costs to the Residential Sector	752
Economic Output Costs	-
Benefit of Option 1	
Residential Sector	1,371
Economic Output	990
Total Benefit of Option 2	**2,361**

Source: Indecon Analysis

5.4 Net Benefit and Benefit Cost Ratio

The preceding sections of the chapter have outlined the costs and benefits of the desalination options. This section outlines the overall net benefit and BCR for this option in light of the benefits and costs discussed previously and under our baseline assumptions.

Table 5.6 outlines the total costs and benefits of Option 2 and presents the overall net benefit and BCR for the investment. In net present value terms, Option 2 has an overall net benefit to the economy of €1,012 million over the appraisal period and a BCR of 1.75.

These figures suggest that while the desalination option would provide a positive return, this return does not exceed the expected return and BCR for the Shannon Abstraction option.

Table 5.6: Option 2-Desalination - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	473.8
Operational Expenditure	450.6
Environmental Costs	75.6
Costs in Benefitting Corridor	348.4
Total Costs	1,348.4
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	989.8
Total Benefits	2,361.2
Net Benefit of Option 2	**1,012.8**
BCR	**1.75**
Source: Indecon Analysis	

6 CBA Findings and Sensitivity Analysis

6.1 Introduction

The previous chapters of this report have outlined in detail the data and assumptions underlying the Do Minimum scenario, the Shannon abstraction option and the desalination option. This chapter summarises the CBA findings under the baseline assumptions before then presenting a number of sensitivity analyses in which the assumptions underlying each scenario are flexed. The inclusion of these sensitivity analyses ensure that the overall CBA findings are robust and not subject to dramatic changes when the underlying assumptions are altered.

6.2 CBA Scenario 1: Base Case

The base case scenario has been outlined in the detailed discussion of the costs and benefits associated with the investment options in the preceding chapters. The key assumptions underlying the findings for the base case are:

- Additional leakage reduction to be undertaken in the Do Minimum scenario will yield an additional 30 Mld in total over the appraisal period;
- The expected number of property days of water supply restrictions will increase significantly as the supply deficit grows. Specifically, the expected number of property days of outage will double with each increase in the supply deficit of 25 Mld;
- The per-capita cost per day of outage in the region is equal to €44;
- The reduced reliability and security of water supply infrastructure in the Eastern and Midlands region will lead to a 10% reduction in output in the most water intensive firms in the internationally traded manufacturing sector compared to what would otherwise have occurred.

Table 6.1 outlines the CBA results for both Options 1 and 2 under the base case assumptions. This table illustrates that while both options have positive net benefit over the project appraisal period, the net benefit from the Shannon abstraction option exceeds that of the desalination option. The BCR of the Shannon option also exceeds that of the desalination option. A detailed breakdown of the calculations for the scenario 1 Base Case findings can be found in the Annex to this report.

Table 6.1: CBA Scenario 1: Base Case Summary of Results

	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	1,635.1	3.25
Option 2: Desalination	1,012.8	1.75

Source: Indecon Analysis

6.1 CBA Scenario 2: Low Impact

Under scenario 2 Indecon have assumed that the impact of increasingly frequent water supply outages on the output of the water intensive internationally traded manufacturing sector is less

significant than was assumed under the base case. Given the uncertainty surrounding the responsiveness of the firms in these sectors to reduced water reliability, Indecon believes that it is prudent to run sensitivities on the assumed output loss from these sectors.

For the purposes of this low impact scenario it is assumed that the output loss from these sectors is limited to 5%. This is relative to the base case assumption of a 10% fall in output in these sectors as the increased unreliability of water supply reaches an unacceptable level for these firms.

6.1.1 Scenario 2: Low Impact – Do Minimum

Table 6.2 outlines the costs in the Do Minimum in the low impact scenario. The low impact assumption gives a lower total cost under the Do Minimum relative to the base case assumptions.

Table 6.2: Summary of Costs in the Do Minimum under Low Impact Scenario

Cost	€ Million – NPV
Leakage Reduction	310.5
Environmental Costs	2.3
Benefitting Corridor	348.4
Residential Outage Costs	2,123.2
Economic Output Costs	494.9
Total Costs	**3,279.3**

Source: Indecon Analysis

6.1.2 Scenario 2: Low Impact – Option 1: Shannon Abstraction

Table 6.3 illustrates the costs and benefits of the Shannon Abstraction option under the low impact assumptions. The low impact assumptions mean that the benefits of the proposed Shannon abstraction investment are lower and thus we get a lower overall net benefit and BCR than under the base case assumptions.

Table 6.3: Option 1-Shannon Abstraction - Net Benefit and BCR

Costs	€ Millions - NPV
Capital Expenditure	536.4
Operational Expenditure	249.7
Environmental Costs	20.2
Traffic Disruption	0.1
Costs in Benefitting Corridor	66.4
Total Costs	872.8
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	494.9
Total Benefits	1,866.3
Net Benefit of Option 1	993.5
BCR	2.14

Source: Indecon Analysis

6.1.1 Scenario 2: Low Impact – Option 2: Desalination

Table 6.3 illustrates the costs and benefits of the desalination option under the low impact assumptions. The low impact assumptions mean that the benefits of the proposed investment in a desalination plant are lower and thus we get a lower overall net benefit and BCR than under the base case assumptions.

Table 6.4: Option 1-Shannon Abstraction - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	473.8
Operational Expenditure	450.6
Environmental Costs	75.6
Costs in Benefitting Corridor	348.4
Total Costs	1,348.4
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	494.9
Total Benefits	1,866.3
Net Benefit of Option 1	517.9
BCR	1.38
Source: Indecon Analysis	

6.1.1 Scenario 2: Low Impact – Overall CBA Finding

Table 6.5 outlines the overall CBA results for the two investment options under the low impact assumptions in terms of net benefit and BCR. While the CBA findings are for a lower net benefit and BCR for both options relative to the base case, both investment options maintain positive net benefit figures and BCRs greater than 1. Option 1: Shannon abstraction remains the more attractive project in terms of net benefit and BCR under the low impact assumptions.

Table 6.5: CBA Scenario 2: Low Impact - Summary of Results		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	993.5	2.14
Option 2: Desalination	517.9	1.38
Source: Indecon Analysis		

6.2 CBA Scenario 3: High Impact

Under scenario 3 Indecon have assumed that the impact of increasingly frequent water supply outages on the output of the water intensive internationally traded manufacturing sector is more significant than was assumed under the base case. As noted previously, given the uncertainty surrounding the responsiveness of the firms in these sectors to reduced water reliability, Indecon believes that it is prudent to run sensitivities on the assumed output loss from these sectors.

For the purposes of this high impact scenario it is assumed that the output loss from these sectors is 15%. This is relative to the base case assumption of a 10% fall in output in these sectors as the increased unreliability of water supply reaches an unacceptable level for these firms.

6.2.1 Scenario 2: High Impact – Do Minimum

Table 6.2 outlines the costs in the Do Minimum in the high impact scenario. The high impact assumption gives a higher total cost under the Do Minimum relative to the base case assumptions.

Table 6.6: Summary of Costs in the Do Minimum under High impact Scenario

Cost	€ Million – NPV
Leakage Reduction	310.5
Environmental Costs	2.3
Benefitting Corridor	348.4
Residential Outage Costs	2,123.2
Economic Output Costs	1,484.7
Total Costs	**4,269.1**

Source: Indecon Analysis

6.2.2 Scenario 2: High Impact – Option 1: Shannon Abstraction

Table 6.3 illustrates the costs and benefits of the Shannon Abstraction option under the high impact assumptions. The high impact assumptions mean that the benefits of the proposed Shannon abstraction investment are higher and thus we find a higher overall net benefit and BCR than under the base case assumptions.

Table 6.7: Option 1-Shannon Abstraction - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	487.1
Operational Expenditure	152.3
Environmental Costs	20.2
Traffic Disruption	0.1
Costs in Benefitting Corridor	66.4
Total Costs	726.1
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	1,484.7
Total Benefits	2,856.1
Net Benefit of Option 1	2,130.0
BCR	3.93
Source: Indecon Analysis	

6.2.3 Scenario 2: High Impact – Option 2: Desalination

Table 6.3 illustrates the costs and benefits of the desalination option under the high impact assumptions. The high impact assumptions mean that the benefits of the proposed investment in a desalination plant are higher and thus we get a higher overall net benefit and BCR than under the base case assumptions.

Table 6.8: Option 1-Shannon Abstraction - Net Benefit and BCR	
Costs	€ Millions - NPV
Capital Expenditure	473.8
Operational Expenditure	450.6
Environmental Costs	75.6
Costs in Benefitting Corridor	348.4
Total Costs	1,348.4
Benefit	
Reduced Outage Costs to Residential Sector	1,371.4
Reduced Economic Output Costs	1,484.7
Total Benefits	2,856.1
Net Benefit of Option 1	1,507.7
BCR	2.12
Source: Indecon Analysis	

6.2.4 Scenario 2: High Impact – Overall CBA Finding

Table 6.5 outlines the overall CBA results for the two investment options under the high impact assumptions in terms of net benefit and BCR. The CBA finds a higher net benefit and BCR for both options relative to the base case. Option 1: Shannon abstraction remains the more attractive project in terms of net benefit and BCR under the high impact assumptions.

Table 6.9: CBA Scenario 2: High impact - Summary of Results		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	2,130.0	3.93
Option 2: Desalination	1,507.7	2.12
Source: Indecon Analysis		

6.3 Summary of CBA Findings

This chapter has outlined the findings of the cost-benefit analysis for the proposed investment projects under a number of differing scenarios. Table 6.10 outlines the main CBA findings under each of the scenarios discussed in this chapter.

Table 6.10: Summary of CBA Findings – All Scenarios		
Scenario 1: Base Case		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	1,635.1	3.25
Option 2: Desalination	1,012.8	1.75
Scenario 2: Low Impact		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	993.5	2.14
Option 2: Desalination	517.9	1.38
Scenario 3: High Impact		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	2,130.0	3.93
Option 2: Desalination	1,507.7	2.12
Source: Indecon Analysis		

Under each scenario the net benefit of both options remains positive and the BCR remains greater than 1. Under each scenario the net benefit and BCR of the Shannon Abstraction option exceed that of the Desalination option. The Shannon Abstraction investment option thus appears to be the most economically beneficial of the options appraised in this report.

7 Summary and Conclusions

This report has outlined the results of the detailed cost-benefit analysis of the options for investments in new water supply infrastructure for the Eastern and Midlands region undertaken by Indecon. This CBA has been undertaken in line with the latest Irish government guidance in the form of the Public Spending Code and the latest European Commission guidance on cost-benefit analysis of investment projects.

The investment options appraised in this analysis were:

- Abstraction of water from the lower Shannon at Parteen Basin; and
- Desalination of water from the Irish Sea in Dublin.

These investment projects were assessed relative to the Do Minimum scenario. This scenario was formulated by Indecon using data and technical inputs from Irish Water/Jacobs Tobin and represents the most likely outcome for the Eastern and Midlands region should no significant investment in new water supply infrastructure be undertaken.

The CBA has included the key costs and benefits for the proposed investment options. Indecon has been provided with costs for both investment options including:

- Capital costs;
- Operational expenditure;
- Environmental costs;
- Disruption costs of construction works where applicable; and
- Benefitting Corridor costs.

The benefits of the proposed projects are assessed relative to the Do Minimum scenario and are composed of the economic costs of water supply restrictions foregone. Indecon has included estimates of the costs of water supply restrictions to both the residential and commercial sectors. Indecon has used international evidence on the cost of water supply restrictions in the residential sector in its calculation of these costs. In calculating the output costs to the economy Indecon has focused on the water intensive internationally traded sector and assessed the likely cost in economic output in the Do Minimum scenario in which water supply restriction become more common relative to the forecast economic growth in these sectors over the appraisal period.

The baseline results for the cost-benefit appraisal of the two investment projects are presented below. These results indicate that the Shannon abstraction option represents the most cost effective project.

Table 7.1: Summary of CBA Findings – Base Case

Scenario 1: Base Case		
	Net Benefit (€ Million)	BCR
Option 1: Shannon Abstraction	1,635.1	3.25
Option 2: Desalination	1,012.8	1.75

Source: Indecon Analysis

Indecon have also undertaken a number of sensitivity analyses on these results. These results alter the net benefit and BCR results for the investment options but the net benefits remain positive and the Shannon abstraction option remains the preferable investment under each of the sensitivity analyses.

The results of Indecon's cost-benefit appraisal of the proposed investment options suggest that Option 1, abstraction of water from the Shannon at Parteen Basin, is the preferable investment choice. This project results in a higher net benefit than the desalination alternative or the net benefit of the Do Minimum scenario. The BCR of the Shannon abstraction option also exceeds that of the desalination option in the base case and all sensitivity analyses. These findings suggest that the Shannon abstraction option represents the most economically advantageous investment option for the provision of new water supply infrastructure to the Eastern and Midlands region.

Annex 1 Detailed CBA Tables – Base Case

Table A.1: CBA Scenario 1: Base Case - Do Minimum Option																			
Costs																			
	Unit	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Leakage Reduction	€ Million - NPV	-	27.6	26.2	25.0	23.8	22.7	40.7	38.8	37.0	35.2	33.5	-	-	-	-	-	-	-
Environmental Costs	€ Million - NPV	-	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	-	-	-	-	-	-	-
Benefitting Corridor	€ Million - NPV	27.41	26.10	24.86	23.67	22.55	21.47	20.45	19.48	18.55	17.67	9.06	8.63	8.22	7.83	7.45	7.10	6.76	6.44
Residential Outage Costs	€ Million - NPV	61.40	58.37	55.47	52.70	50.05	47.51	46.41	45.32	44.24	43.18	42.12	46.75	50.97	54.80	58.28	61.22	62.55	63.49
Economic Output Costs	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Costs	**€ Million - NPV**	**88.8**	**112.2**	**106.7**	**101.5**	**96.6**	**91.9**	**107.9**	**103.9**	**100.0**	**96.3**	**85.0**	**55.4**	**59.2**	**62.6**	**65.7**	**68.3**	**69.3**	**69.9**
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Total**
Leakage Reduction	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	310.5
Environmental Costs	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3
Benefitting Corridor	€ Million - NPV	6.13	5.84	4.28	4.07	3.88	3.70	3.52	3.35	3.19	3.04	2.90	2.76	3.97	3.78	3.60	3.43	3.27	348.4
Residential Outage Costs	€ Million - NPV	64.25	64.85	65.30	65.61	65.79	65.84	65.78	65.31	67.76	69.62	79.58	72.57	73.69	73.60	73.41	73.11	72.30	2,123.2
Economic Output Costs	€ Million - NPV	-	-	-	-	-	-	104.8	101.5	98.4	95.4	92.4	89.5	86.8	84.1	81.5	79.0	76.5	989.8
Total Costs	**€ Million - NPV**	70.4	70.7	69.6	69.7	69.7	69.5	174.1	170.2	169.3	168.0	174.9	164.9	164.4	161.5	158.5	155.5	152.1	3,774.2
Net benefit	**-3,774.2**																		
BCR	**NA**																		

Source: Indecon Analysis

Table A.2: CBA Scenario 1: Base Case - Option 1: Shannon Abstraction																			
Costs																			
	Unit	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Capital Expenditure	€ Million - NPV	-	-	-	-	7.4	69.7	176.9	142.2	91.0	-	-	-	-	-	-	-	-	-
Operational Expenditure	€ Million - NPV	-	-	-	-	-	-	-	-	-	3.1	5.9	9.2	8.8	8.4	8.7	8.3	7.9	7.5
Environmental Costs	€ Million - NPV	-	-	-	-	-	0.5	1.4	1.2	0.9	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.7
Traffic Disruption	€ Million - NPV	-	-	-	-	-	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
Benefitting Corridor Costs	€ Million - NPV	8.2	7.8	7.4	7.1	6.7	6.4	6.1	5.8	5.5	5.3	-	-	-	-	-	-	-	-
Total Costs	**€ Million - NPV**	**8.2**	**7.8**	**7.4**	**7.1**	**14.2**	**76.6**	**184.4**	**149.2**	**97.5**	**8.7**	**6.3**	**9.6**	**9.2**	**8.9**	**9.2**	**8.9**	**8.5**	**8.2**
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Total**
Capital Expenditure	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	487.1
Operational Expenditure	€ Million - NPV	7.1	6.8	6.5	6.2	5.9	5.6	5.3	5.1	4.8	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.3	152.3
Environmental Costs	€ Million - NPV	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	20.2
Traffic Disruption	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
Benefitting Corridor Costs	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	66.4
Total Costs	**€ Million - NPV**	**7.8**	**7.5**	**7.2**	**6.9**	**6.6**	**6.3**	**6.1**	**5.8**	**5.6**	**5.3**	**5.1**	**4.9**	**4.6**	**4.4**	**4.2**	**4.0**	**3.9**	**726.1**
Source: Indecon Analysis																			

Table A.3: CBA Scenario 1: Base Case - Option 1: Shannon Abstraction (Cont.)																			
Benefits																			
	Unit	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Reduced Outage Costs Compared to Do-Min:																			
Residential	€ Million - NPV	-	-3.6	-7.0	-10.2	-13.0	-15.7	-16.9	-18.0	-18.9	31.94	31.30	36.32	40.92	45.13	48.97	52.26	53.93	55.21
Industrial Output	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	**€ Million - NPV**	-	-3.6	-7.0	-10.2	-13.0	-15.7	-16.9	-18.0	-18.9	31.9	31.3	36.3	40.9	45.1	49.0	52.3	53.9	55.2
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Total**
Reduced Outage Costs Compared to Do-Min:																			
Residential	€ Million - NPV	56.30	57.22	57.97	58.57	59.02	59.35	59.55	59.32	62.01	64.11	74.29	67.49	68.81	68.92	68.91	68.79	68.15	1,371.4
Industrial Output	€ Million - NPV	-	-	-	-	-	-	104.78	101.54	98.40	95.35	92.40	89.54	86.77	84.09	81.48	78.96	76.52	989.8
Total Benefits	**€ Million - NPV**	56.3	57.2	58.0	58.6	59.0	59.3	164.3	160.9	160.4	159.5	166.7	157.0	155.6	153.0	150.4	147.8	144.7	2,361.2
Net benefit	**1,635.10**																		
BCR	**3.25**																		

Source: Indecon Analysis

Table A.4: CBA Scenario 1: Base Case - Option 2: Desalination																			
Costs																			
	Unit	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Capital Expenditure	€ Million - NPV	-	-	-	-	5.0	52.3	246.9	121.2	48.4	-	-	-	-	-	-	-	-	-
Operational Expenditure	€ Million - NPV	-	-	-	-	-	-	-	-	-	10.2	19.7	28.9	27.5	26.2	24.9	23.7	22.6	21.5
Environmental Costs	€ Million - NPV	-	-	-	-	-	-	0.3	1.1	0.6	0.6	1.0	1.9	2.1	2.3	2.5	2.7	2.9	3.0
Benefitting Corridor Costs	€ Million - NPV	27.4	26.1	24.9	23.7	22.5	21.5	20.5	19.5	18.5	17.7	9.1	8.6	8.2	7.8	7.5	7.1	6.8	6.4
Total Costs	**€ Million - NPV**	27.4	26.1	24.9	23.7	27.5	73.8	267.7	141.8	67.6	28.5	29.7	39.4	37.8	36.3	34.9	33.6	32.3	31.0
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Total**
Capital Expenditure	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	473.8
Operational Expenditure	€ Million - NPV	21.0	20.0	19.1	18.1	17.3	16.5	15.3	14.6	13.9	13.2	12.6	12.0	11.4	10.9	10.4	9.9	9.4	450.6
Environmental Costs	€ Million - NPV	3.1	3.2	3.3	3.4	3.4	3.5	3.5	3.4	3.3	3.3	3.2	3.1	3.1	3.0	2.9	2.8	2.7	75.6
Benefitting Corridor Costs	€ Million - NPV	6.1	5.8	4.3	4.1	3.9	3.7	3.5	3.4	3.2	3.0	2.9	2.8	4.0	3.8	3.6	3.4	3.3	348.4
Total Costs	**€ Million - NPV**	30.3	29.1	26.6	25.6	24.6	23.6	22.3	21.3	20.4	19.5	18.7	17.9	18.5	17.6	16.9	16.1	15.4	1,348.4
Source: Indecon Analysis																			

Table A.5: CBA Scenario 1: Base Case - Option 2: Desalination (Cont.)																			
Benefits																			
	Unit	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Reduced Outage Costs Compared to Do-Min:																			
Residential	€ Million - NPV	-	-3.65	-7.03	-10.1	-13.1	-15.7	- 16.8	-17.9	-18.9	31.94	31.30	36.32	40.92	45.13	48.97	52.26	53.93	55.21
Industrial Output	€ Million - NPV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	**€ Million - NPV**	-	-3.65	-7.03	-10.2	-13.1	-15.7	-16.8	-17.9	-18.9	31.94	31.30	36.32	40.92	45.13	48.97	52.26	53.93	55.21
		2034	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**	**Total**
Reduced Outage Costs Compared to Do-Min:																			
Residential	€ Million - NPV	56.30	57.22	57.97	58.57	59.02	59.35	59.55	59.32	62.01	64.11	74.29	67.49	68.81	68.92	68.91	68.79	68.15	1,371.4
Industrial Output	€ Million - NPV	-	-	-	-	-	-	104.78	101.54	98.40	95.35	92.40	89.54	86.77	84.09	81.48	78.96	76.52	989.8
Total Benefits	**€ Million - NPV**	56.3	57.2	58.0	58.6	59.0	59.3	164.3	160.9	160.4	159.5	166.7	157.0	155.6	153.0	150.4	147.8	144.7	2,361.2
Net benefit	**1,012.81**																		
BCR	**1.75**																		

Source: Indecon Analysis