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Valuation Case Study:

The Economic Evaluation of Gwen Finch Wetland Reserve

2011

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November 2011

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Suggested Citation:
Hölzinger, O., and Dench, D. (2011): *The Economic Evaluation of Gwen Finch Wetland Reserve.* Case Study for the Worcestershire Wildlife Trust. Worcester. November 2011.

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I. Abstract

The present valuation case study evaluates the value of ecosystem services provided by Gwen Finch Wetland Reserve in Worcestershire. Stating the best guess, services the habitat provides such as flood control, water quality improvement, recreation and biodiversity can be valued at more than £60,000 annually or £3,150,000 capitalised. Comparing the costs of less than £500,000 for site creation and £3,400 annual management costs a cost-benefit analysis results in a positive assessment of the project. The capitalised net benefits provided by Gwen Finch Wetland Reserve add up to £2,398,587; considering all costs and benefits. In 2016 the initial one-off investment will have been paid back. In other words: In 2016 the investment in Gwen Finch Wetland Reserve will turn cost-effective and will have an annual net return on investment what means that the investment is rewarding.

II. Acknowledgements

In particular, the authors would like to thank Rob Allen and Helen Woodman from Worcestershire Wildlife Trust for the extensive support and data input. We would also like to thank the six West Midlands Wildlife Trusts, Birmingham and the Black Country, Hereford, Shropshire, Staffordshire, Warwickshire and Worcestershire whose funding made this project possible.

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V. List of Abbreviations

BAP	Biodiversity Action Plan
BCA	Benefit-Cost Analysis
BG	Best Guess
CBA	Cost-Benefit Analysis
Defra	Department for Environment, Food and Rural Affairs
GI	Green Infrastructure
PBP	Payback Period
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UHIE	Urban Heat Island Effect
WTP	Willingness-To-Pay

1. Gwen Finch Wetland Reserve

Gwen Finch Wetland Reserve is located in Worcestershire and is situated in the floodplain of the River Avon. The nearest town is Pershore. The wetland site is 20ha in size and was created between 1999 and 2001 by the Worcestershire Wildlife Trust. A map can be found below.

> *"While an inclusive definition of wetlands is difficult to state, they are generally characterised as being moist during an extended period each year with soils, plants and animals that are distinct from their aquatic and terrestrial neighbours."*[1]

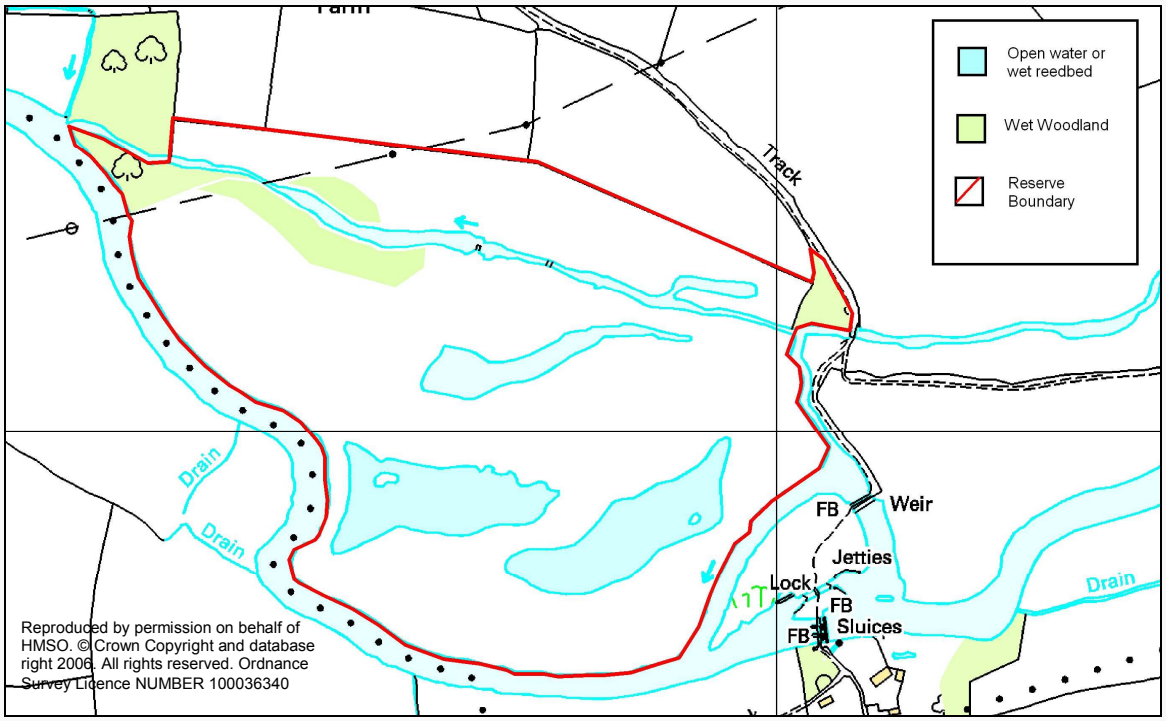
Prior to restoration, the land was managed as intensive agricultural grassland for gazing which was difficult to manage due to regular flooding of the site.

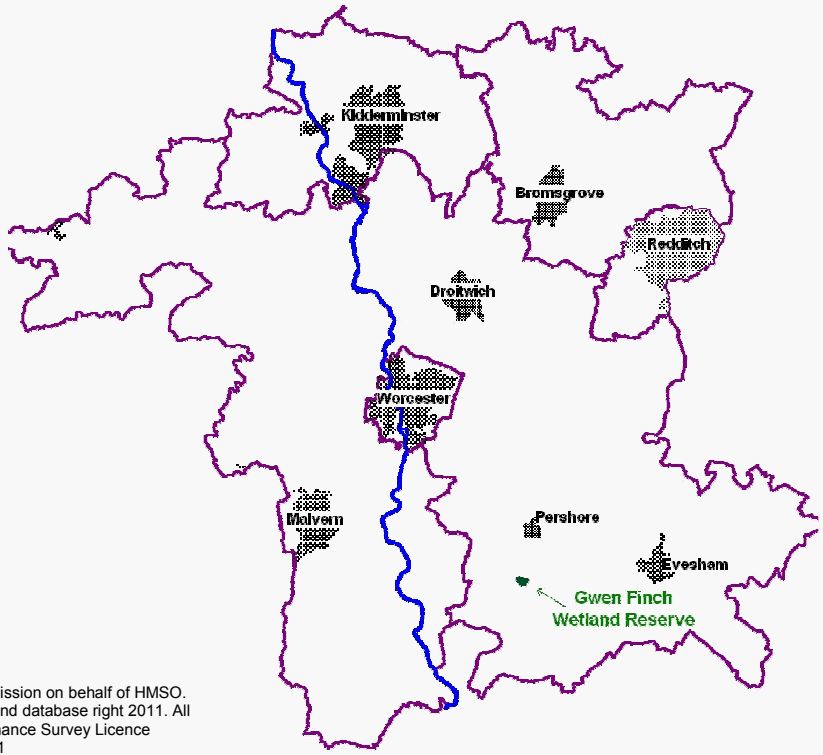
Main aim for the wetland creation was to provide a habitat for a range of species including; breeding waders and otters. The creation of the reedbeds contributed 10 % of the Local Biodiversity Action Plan (LBAP) target for this habitat. The area contains about 1 ha (300m) of ditches, 6 ha of reedbeds, 11 ha of wet grassland and 2 ha of wet woodland. Two wind pumps were installed to pump water from the adjoining River Avon into the ditches.[2] The flora includes species such as purple loosestrife, marsh speedwell, soft rush, water plantain and brooklime. Furthermore the site provides habitat for birds including redshanks, water rails, reed warblers and swallows. Additionally it provides a haunt for otters, and a wide range of dragonflies and damselflies.

Due to its sensitive nature the access to the site is restricted to 2-3 organised open days a year. However, the site can be viewed from the adjoining road at Eckington and local footpaths. It is also viewable from the River Avon which during the summer is frequently used for boat trips.

[1] Woodward and Wui 2001, 258.
[2] Worcestershire Wildlife Trust undated, 1.

Map 1.1 Gwen Finch Wetland Reserve





Source: Worcestershire Wildlife Trust

2. Objectives of this Case Study

In the UK, natural habitats are under pressure. Economic austerity in the course of profound changes in public administration is not expected to mitigate the pressure on the natural environment. This study values the benefits to human wellbeing provided by the Gwen Finch Wetland Reserve in Worcestershire. More exactly it values a range of the ecosystem services the site provides. An ecosystem service describes a way that human wellbeing is influenced by the natural environment. Wetland for example mitigates the risk of flood events and improves the water quality. It also provides a habitat for species and biodiversity or space for recreation. These are only some examples. The ecosystem provides a manifold range of services and is in fact the basis for our existence. This is often underestimated or simple ignored and accepted as self-evident. Valuing these services makes the benefits visible and comparable. The Department for Environment, Food and Rural Affairs (Defra), subscribes to the opinion that

> *"…the benefits the natural environment provides are not yet valued properly in policy and project appraisal across government."*[3]

This can lead to decisions detrimental to the natural environment and finally to a decline of net human wellbeing. The economic valuation can mitigate this circumstance.

On the other hand the restoration costs as well as the annual management costs of the wetland site can be opposed. This cost-benefit analysis allows a statement about the meaningfulness of the site restoration as well as the additional benefits provided to human wellbeing. The different ecosystem services and the respective effects are explained in chapter 5.

[3] Defra 2007, 2.

3. Methodical Approach and Limitations

The economic valuation of ecosystem services always concentrates on human welfare or wellbeing. This is the only practicable approach because *"non-anthropocentric value is, by definition, beyond any human knowledge."*[4] However, that does not mean that wildlife and biodiversity has no intrinsic value. The approach can involve for example existence values (non-use values)[5], option values[6] or bequest values[7] as a matter of course.

Many people have difficulty with a monetary value for environmental goods in general. The criticism is that you can not or should not sell the environment. However, to make social, environmental and economical issues comparable, you need a common denominator. A sacrifice of monetary valuation usually leads to a neglect of environmental protection.

To value Gwen Finch Wetland Reserve the benefit or value transfer approach has been applied. That means that findings from other primary valuation studies were transferred to our specific context. Primary valuation studies are very time and cost intensive and therefore not applicable for a wider range of ecosystem services and habitats. The value transfer approach is widely accepted for this kind of valuation.

To value the benefits provided by Gwen Finch Wetland Reserve a value transfer function based on findings from Brander et al. (2008) has been applied. The meta-analysis involves more than 260 studies.

> *"From the perspective of the policy good, Brander et al. (2008) provides the most appropriate match, being limited to temperate European wetlands."*[8]

The calculation is based on a per hectare basis. The function and the involved primary valuation studies respectively include a wide range of valuation techniques. Replacement costs for example reflect the costs that would be necessary to invest in

[4] Ibid., 12.
[5] You might never be able to see a whale in nature, but you can nevertheless benefit from the pure existence of whales.
[6] You might never see a whale in nature, but you can benefit from the ability to see whales in the future.
[7] You might never see a whale in nature, but you can benefit from the ability of coming generations to see whales in the future.
[8] EFTEC 2010b, 7.

engineering flood protection instead of natural alternatives. Contingent valuation techniques on the other hand ask people their willingness-to-pay (WTP) for a specific feature. This can be a hypothetical entrance fee to a site or a theoretical funding fee to protect specific species.

Whilst valuing the site, thought has been given to the "Introductory Guide to Valuing Ecosystem Services", published by the Department of Environment, Food and Rural Affairs as well as the "Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal" provided by the Economics for the Environment Consultancy.[9] Using these guidelines it has been ensured that the outcomes of this case study matches the state of the art techniques as well as transparency and comparability with other studies.

It has to be noted that all valuation studies implicate some limitations. Related willingness-to-pay techniques for example have their own imperfections such as the social desirability bias (the interviewees may like to make out that they value an ecosystem service more than they actually do) or a lack of imagination of hypothetical markets and goods. However, questioning techniques are advanced enough to gather resilient outcomes.[10]

Another limitation may occur by applying the value transfer approach. Usually, the study sites (primary valuation studies) and the policy site (in this case Gwen Finch Wetland Reserve) are not similar. Even if some socio-economic influencing variables such as income or population density and the availability of substitutes have been adjusted, a benefit transfer error can never be ruled out. Some adjustments such as for cultural distinctions are hardly possible. Further limitations are linked to general scientific uncertainties such as for future impacts of climate change. To take these circumstances into account within this research, a sensitivity analysis has been applied.

[9] Defra 2007; EFTEC 2010a.
[10] For more information see EFTEC and EFL 2006.

> *"Sensitivity analysis is core to any appraisal exercise and should be employed to compensate for the limitations and uncertainty concerning the data informing the assessment."*[11]

Therefore, every value is stated as "best guess" with a range, following best practice recommendations. If not noted otherwise stated values in the different sections are best guesses for annual values.

The valuable ecosystem services are not only stated as an annual value; they are also stated as capitalised value over 100 years. To value an annual ecosystem benefit over time it is usual and reasonable to apply a discount rate. This discount rate is used to convert the benefits to present values. UK government recommends a discount rate of 3.5 percent for periods up to 30 years. After 30 years this rate is declining to 3.0 percent and after 75 years to 2.5 percent.[12] The derivation for this rate, however, seems out-dated and very high. Within this case study the discount rate recommended by HM Treasury is only applied for the low boundary of the sensitivity analysis. For the best guess a discount rate of 1.5 percent has been applied. The rate has been set to zero for the high boundary of the sensitivity analysis. Both are recommendations of the German Federal Environmental Agency.[13] For a more extensive discussion of discounting as well as more in-depth information about ecosystem services and its valuation see Hölzinger (2011).[14]

[11] EFTEC 2010a, 35.
[12] HM Treasury 2003, 97.
[13] German Federal Environment Agency 2008.
[14] Hölzinger 2011.

4. Costs

As mentioned before Gwen Finch Wetland Reserve was created between 1999 and 2001. The total one-off creation costs were £490,000.[15] From an economical perspective we can term this an investment. The assets can be seen in table 4.1 below.

Tab. 4.1 One-off creation costs for Gwen Finch Wetland Reserve (nominal values)

Asset	*Costs*
Land purchase costs	*£249,000*
Earth works, associated structures, sluices	*£144,000*
Wind pump purchase	*£18,000*
Reeds and willows	*£36,000*
Fencing	*£8,000*
Tools & machinery	*£4,000*
Staff costs	*£31,000*
Total	***£490,000***

Source: Worchestershire Wildlife Trust

To compare costs and benefits an adjustment for inflation is necessary. The £490,000 is a nominal value. However, with the same nominal amount in 2000 you are not able to by goods today worth the same value. Using the ONS figures to calculate the 2010 value of the investment this would come to £602,632.

Beneath the one-off investment additional running costs are occurring. These costs are listed in table 4.2 below.

Tab. 4.2 Annual average running costs for Gwen Finch Wetland Reserve

Asset	*Costs*
Pump servicing	*£1,400*
Infrastructure repairs and improvements	*£800*
Staff costs	*£1,200*
Total	***£3,400***

Source: Worchestershire Wildlife Trust

[15] Worcestershire Wildlife Trust undated, 1.

The real costs are estimated to be constant over time in prices 2010; therefore an inflation adjustment is not necessary. Only the technical progress has been taken into account by applying a discount rate (1.5% for the best guess). Therefore the capitalised running costs add up to £178,157 over a time period of 100 years. Because it is a forecast which always includes uncertainties a range for annual costs from £3,200 to £3,600 has been applied for the sensitivity analysis.

5. Benefits

5.1 Valuation of Ecosystem Services

As mentioned before, a value transfer function has been applied to calculate the values for different ecosystem services. Brander et al. (2008) provides a value function which can be viewed in figure 5.1 below. This function allows adjusting the average value of wetland by a range of site-specific variables.

Fig. 5.1 Meta-analysis value function for wetland

The used per-hectre function for the value transfer can be expressed as:

$$y_i = a + b_S X_{Si} + b_E X_{Ei} + b_C X_{Ci}$$

- y_i measures the value of ecosystem site *i*, based on three vectors of explanatory variables:
  - the valuation study X_S
  - the valued ecosystem X_E
  - the socio-economic and geographical context X_C.
- The coefficients b_s, b_E and b_C are the vectors containing the coefficients of the explanatory variables, and
- *a* is a constant.

Source: Brander et al. (2008), p. 16

The application for valuing the Gwen Finch Wetland Reserve addresses the need of some assumptions. Additionally a range of statistical data has to be collected. Table 5.1 below shows the calculation as well as the underlying assumptions. Note that this

is the calculation for the best guess. Assumptions for the sensitivity analysis stated as well. The calculation has been repeated simultaneous.

Tab. 5.1 Value function for Gwen Finch Wetland Reserve (best guesss)

Variable	Coefficient value	Value of explanatory variable	
Constant a	-3.078	1	
Wetland Type: Inland marsh	0.114	1	
Wetland size:	-0.297	*ln* 20.19	
Flood control:	1.102	1	See section 5.3
Water quality improvement:	0.893	1	See section 5.4
Surface and ground water supply:	0.009	1	The supply and surface of groundwater is expected to play a role on Gwen Finch Wetland Reserve. Because of the comparatively small influence on the result we are not providing a detailed explanaition.
Biodiversity:	0.917	1	See section 5.5
Non-consumptive recreation:	0.340	1	Pooled in section 5.6
Amenity and aesthetic services:	0.452	1	
GDP per capita (2003 US$):	0.468	*ln* 30,206	GDP is approximated from the West Midlands Unitaries level with €26,400 (Pricelevel 2003; Source Eurostat NUTS 2). Converted to 2003 US$ using OECD purchasing power parity (PPP) exchange rates (factor 0.87) this results in US$30,206.
Population density per km^2 within 50 km:	0.579	*ln* 405	The population density within 50 km has been approximated from the average population density within West Midlands Region of 405 people per km^2,referring to the Office of National Statistics (ONS).
Wetland area within 50 km:	-0.023	*ln* 3,000	Considering the marginal influence on the result we calculate with a generous wetland area of 3,000 ha within 50 km radius of each wetland site.

Source: Adopting the calculation in table 4 in EFTEC (2010d), p. 10-12 referring to Brander et al. (2008)

To calculate the annual benefit per hectare for this setting we use the formula from figure 5.1 applying the parameters from table 5.1 above. This results in the following natural logarithm term:

$$\$/ha/yr = -3.078 + 0.114 - (0.297 \times ln(20.19)) + 1.102 + 0.009 + 0.893 + 0.340 + 0.752 + 0.917 + (0.468 \times ln(30{,}206)) + (0.579 \times ln(405)) - (0.023 \times ln(3000))$$

$$\$/ha/yr = ln\ 8.276$$

To transform this natural log term we raise the exponential to the power of 8.276:

$$e^{8.276} = \text{US\$3,930 (price level 2003)}$$

Applying PPP exchange rate again and conversion to GB£ (2010 prices) we gather an annual value per ha of £2,983. Multiplied with the attributable area of 20.19 ha this results in an annual value of **£60,234** for the valued ecosystem services provided by Gwen Finch Wetland Reserve. Applying the discount rate of 1.5 percent this results in **£3,156,197** capitalised over the next 100 years.

Not included in this sum is the value of the space for the cattle that are grazing on the site. The Wildlife Trust does not charge the grazier for using the site. Figures about the costs the owner would have had to pay to rent a similar site could not have been made available. However, it can be estimated that this benefit has a slight value compared to others.

In a next step the attributable value for each ecosystem service can be approximated. When setting every variable standing for an ecosystem service equal to zero and viewing the difference in the sum, an estimation can be made about the attributable value for each benefit. Following this approach amounts of about 24.9% for flood protection, 0.3% for surface and ground water supply, 22.0% for water quality improvement, 10.7% for recreation, 19.7% for amenity and aesthetical services as well as 22.7% for biodiversity or habitat for species, are produced. A summary of the findings can be found in table 5.2. Following, the different ecosystem services are explained.

5.2 Climate Change Mitigation

The benefits of wetland concerning climate change mitigation still remain uncertain.[16] On the one hand, wetland acts as a carbon sink. However, on the other, wetland micro organisms emit other greenhouse gases, especially methane.

Within a comparatively short time horizon of 20 years wetlands in northern latitudes are estimated to have net negative effects on climate change. This effect decreases over time and may lead to a balanced greenhouse gas effect over 100 years. After 500 years northern wetlands are estimated to reduce the net greenhouse gas warming potential.[17] In respect of the poor scientific evidence, valuation of this ecosystem service from wetland is extremely difficult. Further research is necessary.

5.3 Flood Risk Reduction

The reduction of damage and other costs caused by flooding is certainly one of the main services provided by wetland. The formula provided by Brander et al. (2008) includes flooding related to storm events as well.

> *"Many wetlands diminish the destructive nature of flooding, and the loss of these wetlands increases the risks of floods occurring."*[18]

To value this benefit we can approximate from the calculations in section 5.1. Therefore wetland services assigning flood and storm protection provided by Gwen Finch Wetland Reserve can be monetized as **£14,984** annually. These values are based on replacement costs.[19] This reflects the costs which would occur if alternative engineering flood alleviation would have to be installed instead of the wetland. However, it should be noted that flood risk reduction services caused by wetland are very site specific and should be valued case-by-case.[20] A more precise valuation is an assignment worthy of future policy appraisals. This could help to apply the best flood risk reduction management options.

[16] EFTEC 2007, 12.
[17] Whiting and Chanton 2001, 521; O'Gorman and Bann 2008, 61.
[18] McInnes 2007, 13.
[19] Brander et al. 2008, 33.
[20] Land Use Consultants and GHK Consulting 2009, 132.

The capitalised value of **£785,157** can be interpreted as an underestimation. In the future, the quality and quantity of extreme weather events are estimated to rise. This effect is not included in this forecast.

5.4 Water Quality Improvement

Another significant benefit from wetlands is the improvement of freshwater quality, in particular retention, removal and transformation of nutrients. Furthermore they can capture heavy metals such as TBT (tributyl tin) and complex organic pollutants.[21]

> *"Nitrate concentration has grown rapidly in the last 30 years. The capacity of ecosystems to purify such wastes is limited […] Loss of wetlands has further decreased the ability of ecosystems to filter and decompose wastes."*[22]

Some fens and other wetlands fill rapidly during floods. The floodwater filters back out through the plants and soils.[23] .These services lead to lower costs for technical percolation and/or a better health (lower healthcare costs). Annually, Gwen Finch Wetland Reserve is estimated to improve water quality worth **£13,469**.

5.5 Habitats for Species (Biodiversity)

The provision of a habitat for target species was the main aim of the creation of Gwen Finch Wetland reserve. As discussed before the habitat attracts a wide range of species and has high biodiversity values different from the former land management option.

> *"The degradation and loss of wetlands is more rapid than that for other ecosystems. Similarly, the status of both freshwater and, to a lesser extent, coastal species is deteriorating faster than that of species in other ecosystems. Wetland-dependent biodiversity in many parts of the world is in continuing and accelerating decline."*[24]

[21] EFTEC 2010a, 12.
[22] Millennium Ecosystem Assessment 2005, 43.
[23] Scottish Natural Heritage 4.
[24] McInnes 2007, 8.

Providing a habitat for species, Gwen Finch Wetland Reserve can be valued at **£13,469** per year or **£705,782** capitalised. However, non-use values are explicitly excluded from the valuation function. Such primary valuation studies are not available at the moment.[25] Therefore we have to imply that the accessibility of the habitat is necessary to profit from this benefit. As noted before the physical accessibility is restricted to 2-3 days a year because of protection issues. However, "access" in this context does stringently mean physical accessibility. Experiencing access or views on the site from other open spaces might be adequate. Taking the good viewable location of the site, the frequently used adjoining River Avon for boat trips as well as the organised visitor into account allows the assumption that the site can be experienced regularly.

Because especially the maximisation of non-use values of the habitat was the main reason of creation and access restriction, these values can be estimated very high. Because the scientific evidence does not allow to take this value into account the biodiversity values are still likely to be strongly undervalued.

5.6 Recreation & Aesthetical Appreciation

The calculation from Brander et al. (2008) involves consumptive services like recreational hunting and fishing as well as non-consumptive recreation, amenity and aesthetic services being separated. Recreational fishing or hunting does not occur on the site. As discussed before non-consumptive recreation as well as aesthetical services can also occur from adjoining open spaces. Therefore the assumption has been made that these services also occur regularly, even if there remain some uncertainties. These uncertainties have been recognised by excluding these services within the low estimate of the sensitivity analysis. For the best guess recreation and aesthetical appreciation can be valued at **£18,328** annually or **£960,358** capitalised.

5.7 Sensitivity Analysis and Summary

For the sensitivity analysis, uncertainties regarding the estimations taken, as well as the scientific evidence, are considered. Additionally to the restrictions above a 50 percent range has been applied to take account of the scientific uncertainties as well

[25] Brander et al. 2008, 33.

as possible transfer errors. A summary can be seen in the table below. Note that capitalised values are calculated with different discount rates. According to chapter 3 the discount rate has been set to zero for the high estimate. For the low estimate the recommendation of HM Treasury (3.5 – 2.5 percent) has been adopted. For the best guess a discount rate of 1.5 percent has been applied.

Tab. 5.2 Valued ecosystem services provided by Gwen Finch Wetland Reserve

	Low	**Best Guess**	*High*
Annual value of the wetland site	*£9,043*	**£60,234**	*£89,295*
Flood control	*£3,233*	**£14,984**	*£22,214*
Surface and ground water supply	*£43*	**£201**	*£298*
Water quality improvement	*£2,859*	**£13,251**	*£19,645*
Non-consumptive recreation	*£0*	**£6,467**	*£9,588*
Amenity and aesthetic services	*£0*	**£11,860**	*£17,583*
Biodiversity	*£2,906*	**£13,469**	*£19,968*
Capitalised value of the site over 100 years	*£269,587*	**£3,156,197**	*£8,929,543*
Flood control	*£96,395*	**£785,157**	*£2,221,373*
Surface and ground water supply	*£1,293*	**£10,534**	*£29,804*
Water quality improvement	*£85,249*	**£694,366**	*£1,964,507*
Non-consumptive recreation	*£0*	**£338,885**	*£958,777*
Amenity and aesthetic services	*£0*	**£621,473**	*£1,758,278*
Biodiversity	*£86,650*	**£705,782**	*£1,996,804*

Source: Own calculations

If broken down, Gwen Finch Wetland Reserve provides ecosystem services valued at about £3,000 per hectare annually or £156,000 capitalised. As mentioned previously for biodiversity the scientific basis is incomplete which leads to a more or less undervaluation in the sum. The summary table covers only ecosystem services that can be valued.

Values should be read for example as 'Flood control benefits provided by Gwen Finch Wetland Reserve are estimated to have an annual value of between £96,000 and £2.2 million with a best guess of £785,000'. Generally, the specific valuation methods and assumptions should be stated as well.

For both, annual and capitalised values, a *ceteris paribus* scenario is implicit. This means that other influencing quantities such as population growth, extent of habitats

etc. are assumed to be constant over time. The capitalised values reflect the totalised annual benefits over the next 100 years. Technological progress is considered by applying a discount rate of 1.5% for the best guess.

6. Cost-Benefit Analysis

6.1 Benefit-Cost Ratio

To proof the profitability of the investment in Gwen Finch Wetland Reserve a cost-benefit analysis has been applied. This approach is referable to welfare economics. The benefit-cost ratio (BCR) is an indicator for the cost-effectiveness of the invested money. Because we want to estimate the effect of the investment on the public welfare, private as well as social costs and benefits are considered. Every BCR bigger than one means that the investment is rewarding.[26]

Fig. 6.1 Benefit-cost ratio for Gwen Finch Wetland Reserve

To calculate the benefit-cost ratio (BCR) the following formula has to be applied:

$$BCR = \frac{\sum Benefits}{\sum Investment\ Costs + \sum Running\ Costs}$$

Applying the inflation adjusted/discounted costs and benefits (best guess) gives:

$$BCR = \frac{£3,156,197}{£579,453 + £178,157}$$

$$= \mathbf{4.17}$$

A benefit-cost ratio of 4.17 means that every pound invested in the project generates a net benefit of £3.17

Source: Own calculations

The ratio above shows that the investment in Gwen Finch Wetland Reserve is rewarding. Note that this calculation is for the capitalised values over 100 years

[26] Note that this is the gross-concept of a benefit-cost ratio. The net benefit-cost ratio (benefits – running costs / investment costs) would produce “extremer” outcomes but would not change the general tendency.

beginning in 2010. Underlying assumption is that the one-off investment is written off over the total time period over 104 years (4 years in the past and 100 years from 2010 on). This includes costs of £35,178 that are already written off from 2006 till 2009. This explains the lower one-off costs than stated before. Additionally, future costs as well as future benefits have been discounted to actual values, applying the discount rate of 1.5%.

The capitalised net benefits provided by Gwen Finch Wetland Reserve add up to **£2,398,587**; considering all costs and benefits. This is the best guess. The annual net benefit of the site is **£51,039**. Note, that "net benefit" in this context does not consider former land-management options. However, in this case the effect can be estimated to be slight. The assumption is reasonable that the private benefits are covered by the purchase of the land and the fishing rights. The social benefits of the former land-management option as agricultural land with low biodiversity values can be estimated small, even if some uncertainties remain.

The sensitivity analysis can be used to picture a worst case and a best case scenario. The worst case scenario calculates with lowest estimates for the benefits and highest estimates for the costs and vice versa for the best case. To avoid distortions always the discount rate of 1.5% has been applied. Only in the very unlikely worst case scenario an unfavourable BCR of 0.62 would occur. This would lead to net costs of £289,019 over a 100 year period. Keep also in mind that not all ecosystem services (benefits), e.g. non-use values, could have been valued. For the best case scenario a BCR of 6.26 has been valued.

6.2 Payback Period

Another very useful ratio commonly used in investment is the payback period (PBP). It refers to the period of time required for the return of investment. In other words it shows the time that it takes for an investment to pay for itself.

Fig. 6.2 Payback period formula

To calculate the payback period (PBP) the following formula can be applied:

$$PBP = \frac{\sum Investment\ Costs}{\sum Benefits - \sum Running\ Costs}$$

Because our calculation includes values in the future as well as values in the past, a dynamic calculation is necessary. Because the present value of future net benefits declines (discount rate) the static formula above leads to a distortion, especially over a long time period. Table 6.1 below shows the dynamic calculation for the best guess.

As noted before the presumption has been made that Gwen Finch Wetland Reserve has provided the full range and value of benefits from 2006. Between 2002 and 2005 the assumption has been made that the annual costs are equivalent to the annual benefits which is still a very conservative assumption. Therefore the net benefits for these years are zero. From 2006 the full benefits are provided by the site which leads to net benefits of £56,834 each year. For years from 2011 the discount rate of 1.5 percent has been applied which leads to lower costs and benefits in 2010 prices. The net benefits ad up in the written-off investment costs. The remaining value reflects the one-off investment costs of £602,632 minus written-off investment.

Tab. 6.1 Dynamic calculation of the payback period

Year	Discount factor	Costs	Benefits	Net benefits	Written-off investment	Remaining value
2002	1.00	£3,400	£3,400	£0	£0	£602,632
2003	1.00	£3,400	£3,400	£0	£0	£602,632
2004	1.00	£3,400	£3,400	£0	£0	£602,632
2005	1.00	£3,400	£3,400	£0	£0	£602,632
2006	1.00	£3,400	£60,234	£56,834	£56,834	£545,798
2007	1.00	£3,400	£60,234	£56,834	£113,668	£488,964
2008	1.00	£3,400	£60,234	£56,834	£170,501	£432,130
2009	1.00	£3,400	£60,234	£56,834	£227,335	£375,296
2010	1.00	£3,400	£60,234	£56,834	£284,169	£318,462
2011	0.99	£3,350	£59,344	£55,994	£340,163	£262,468
2012	0.97	£3,300	£58,467	£55,166	£395,330	£207,302
2013	0.96	£3,251	£57,603	£54,351	£449,681	£152,951
2014	0.94	£3,203	£56,751	£53,548	£503,229	£99,403
2015	0.93	£3,156	£55,913	£52,757	£555,985	£46,646
2016	**0.91**	**£3,109**	**£55,086**	**£51,977**	**£607,962**	**-£5,331**
2017	0.90	£3,063	£54,272	£51,209	£659,171	-£56,539

Source: Own calculations

As one can see in 2016 the remaining value becomes negative. This means that within 2016 is the payback period where all one-off investment costs are written-off completely. In other words in 2016 Gwen Finch Wetland Reserve will turn cost-effective and will have an annual net return on investment what means that the investment is rewarding.

7. Conclusion

As discussed in section 6.1 only in the worst case scenario of high management costs and lowest benefits cost-effectiveness of the investment in Gwen Finch Wetland Reserve is not reached. However, taking also other conservative assumptions such as the very low benefits provided between 2002 and 2005 into account and considering that non-use benefits, which were the main reason for site creation, could not have been valued, this scenario is very unlikely.

Considering the arguments before, even the best guess for net benefits of **£51,039** annually or **£2,398,587** capitalised remain likely to be an underestimation. You can also say that the investment will pay back within 2016. Table 7.1 below summarise the findings.

Tab. 7.1 Summary of findings for Gwen Finch Wetland Reserve

Annual costs & benefits			
	High estimate	**Best guess**	*Low estimate*
Annual costs	*£9,395*	**£9,195**	*£8,995*
Annual management costs of the wetland site	*£3,600*	**£3,400**	*£3,200*
One-off creation costs divided by year	*£5,795*	**£5,795**	*£5,795*
	Low estimate	**Best guess**	*High estimate*
Annual benefits	*£9,043*	**£60,234**	*£89,295*
Flood control	*£3,233*	**£14,984**	*£22,214*
Surface and ground water supply	*£43*	**£201**	*£298*
Water quality improvement	*£2,859*	**£13,251**	*£19,645*
Non-consumptive recreation	*£0*	**£6,467**	*£9,588*
Amenity and aesthetic services	*£0*	**£11,860**	*£17,583*
Biodiversity	*£2,906*	**£13,469**	*£19,968*
	Worst Case	**Best Guess**	*Best Case*
Annual net benefits	*-£352*	**£51,039**	*£80,301*
Annual net benefits per ha	*-£17*	**£2,815**	*£4,264*
Capitalised costs & benefits			
	High estimate	**Best guess**	*Low estimate*
Total costs over the next 100 years	*£768,090*	**£757,610**	*£747,130*
Management costs	*£188,637*	**£178,157**	*£167,677*
(Non written off) one-off costs	*£579,453*	**£579,453**	*£579,453*
	Low estimate	**Best guess**	*High estimate*
Capitalised value over 100 years	*£473,831*	**£3,156,197**	*£4,678,998*
Flood control	*£169,426*	**£785,157**	*£1,163,979*
Surface and ground water supply	*£2,273*	**£10,534**	*£15,617*
Water quality improvement	*£149,834*	**£694,366**	*£1,029,384*
Non-consumptive recreation	*£0*	**£338,885**	*£502,390*
Amenity and aesthetic services	*£0*	**£621,473**	*£921,321*
Biodiversity	*£152,298*	**£705,782**	*£1,046,307*
	Worst Case	**Best Guess**	*Best Case*
Capitalised net benefits	*-£294,259*	**£2,398,587**	*£3,931,867*
Capitalised net benefits per ha	*-£14,574*	**£118,801**	*£194,743*

Source: Own calculations

Comprising the cost-benefit analysis of the creation of Gwen Finch Wetland Reserve was rewarding and provides high net benefits to human welfare. This indicates that investments in likewise projects such as The John Bennett Reserve on the adjoining property are likely to be cost-effective as well.

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