Chapter 3

Emerging policy instruments for the control of diffuse source water pollution

This chapter examines innovative policy approaches to help meet the challenge of diffuse pollution. It presents and draws lessons from a select number of case studies submitted by OECD member countries and discussed at the OECD Workshop on Innovative Policy Responses to Water Quality Management held in March 2016. All case studies are provided in full at www.oecd.org/water.

Key messages

The complexity of water quality challenges in a rapidly changing world means that new, locally-adapted and innovative solutions are often required. Policy makers seek innovations that help meet water quality objectives at a lower cost; current water pollution control policies could often deliver better environmental outcomes at a lower cost for society. In particular, policy innovations that realise greater diffuse pollution control are essential for advances in water quality.

Policy approaches used to date for the control of diffuse pollution tend to be voluntary and developed at the local level via partnership, around watersheds or cities, and most often include government's paying farmers to reduce pollution. However, there is evidence that voluntary participation may not reach the major polluters and subsidy-based programmes can have limited impact due to public budget constraints and a lack of environmental regulations on diffuse pollution.

Enforceable limits on diffuse pollution are required and can be designed in relation to an acceptable level of risk to water quality. The greatest challenge of regulating outputs of diffuse pollution is how to allocate a pollution "cap" (or maximum permitted load) to individual land owners in a way that is equitable and cost-efficient. A natural capital based approach to allocating diffuse pollution limits is an emerging development that has the ability to reach the full economic potential of natural resources, based on the underlying capacity of the soil to filter and retain water and nutrients.

Payments for ecosystem services can generate financial flows, and engage stakeholders in water management, but must be underpinned by enforced environmental regulations so as to achieve additionality. Water quality trading offers a way to promote practices that reduce pollution at least cost to society by revealing preferences and water pollution costs. Markets and payments for ecosystem services are not a perfect substitute for robust regulations. Equity and fairness in burden sharing do not preclude efficiency.

It is necessary, and more effective, to use a combination of the available policy mechanisms, including regulatory, economic and voluntary regimes, to improve pollution control. Stakeholder engagement through inclusive water governance is increasingly recognised as critical to secure support for reforms, raise awareness about water risks and costs, increase users' willingness to pay, and to handle conflicts. Striving for consensus through collaborative governance can pave the way for action provided safeguards to enable participation and equal representation of all stakeholders are provided for.

Introduction

There is a regulatory imbalance on the control of point source versus diffuse source pollution. Policy instruments to address point source and diffuse source pollution are different due to their different characteristics[1]. The dominant approach to managing point source pollution is regulation via effluent standards (OECD, 2004), which has created significant improvements in water quality in OECD countries (OECD, 2013a). Such point sources of pollution are under the direct control of polluting firms and utilities and can be accurately monitored, policed and enforced at a reasonable cost. For example, the US Clean Water Act established a regulatory framework with stringent federal effluent standards for industrial and municipal point source pollution that led to significant water quality improvements in the US (Shortle and Horan, 2013), although there is some debate over whether incremental costs have exceeded the incremental benefits since the late 1980s (as discussed in chapter 2).

For diffuse source pollution, the most prominent methods are the use of voluntary payments and regulatory instruments. However, voluntary measures (e.g. payments to farmers to incentivise pollution reductions) have generally had limited success (Shortle and Horan, 2013), and regulatory measures to control diffuse water pollution are typically poorly enforced (Parris, 2012). There is evidence that voluntary participation may not reach the major polluters (OECD, 2012, 2004) and subsidy-based programmes can have limited impact due to public budget constraints (Shortle and Horan, 2013). Indeed voluntary codes of good practice have not proved able to remedy a problem that does not stem from a lack of information, but from the absence of internalisation of pollution costs (OECD, 2004). There is opportunity to better design, target and implement voluntary and regulatory instruments to achieve water quality outcomes.

Economic instruments, such as pollution taxes, charges and water quality trading, could be strengthened and used more extensively to increase the cost effectiveness of pollution control and promote innovation. Taxes on inputs (i.e. product charges and other proxies for pollution) can be used to create incentives to reduce pollution from urban and rural sources (Hoffmann and Boyd, 2006), and to raise funds for investment in water quality infrastructure and management (Köhler, 2001; Hoffmann et al., 2006). Taxes on impervious surfaces in urban areas can incentivise reductions in stormwater runoff and finance a greater proportion of urban land to be connected to a drainage system with stormwater treatment.

In essence, alternative approaches to monitor and manage diffuse pollution are required. The following sections will present new and innovative approaches to control, finance and govern water pollution, with a particular focus on diffuse source pollution. While the chapter is split into subsections depending on the type of policy instrument, in reality a policy mix is required for effective outcomes. For example, information instruments are required for determining the maximum nutrient load a catchment can sustain before certain water quality indicators are breached; stakeholder engagement is necessary to determine the acceptable risks and desired water outcomes at the local level; regulatory nutrient pollution allowances are required for diffuse pollution before markets can be established to achieve economic efficiency; and compensations may be required to improve equity outcomes and stakeholder agreement.

Regulatory approaches

Regulatory policy instruments to reduce diffuse pollution from agriculture typically restrict the use of polluting inputs such as fertilisers, manure and pesticides, and require farm management practices that reduce pollutants reaching water bodies. This is for two reasons: *i)* there good evidence to show that "good" or "best" management practices can reduce the losses of diffuse contaminants, and *ii)* up until recently, there was limited ability to adequately calculate farm scale losses of diffuse source contaminants with computer models. As an example, the following two case studies present regulations to reduce diffuse nitrogen pollution from agriculture through mandatory best management practices in the EU (Box 3.1) and Canada (Box 3.2).

Box 3.1. **European Union nitrate pollution prevention regulations**

The Nitrates Directive (1991) aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices. The Nitrates Directive complements the Water Framework Directive and is one of the key instruments in the protection of waters against agricultural pressures. The first step in implementation of the Directive is the identification of waters that are polluted or could become polluted if no action is taken. These are considered as waters where the concentration of nitrates is above 50 mg/L or that could contain (if no action is taken to reverse the trend) more than 50 mg/L of nitrates and waters that are eutrophic or could become eutrophic if no action is taken. Eutrophication caused by phosphorus as well as nitrates must be considered when designating nitrate vulnerable zones (NVZs). Member states can also choose to apply measures to their whole territory rather than designating specific zones. Farmers within NVZs must comply with specific measures such as:

- Limiting when nitrogen fertilisers can be applied on land in order to target application to periods when crops require nitrogen and prevent nutrient losses to waters;
- Limiting the conditions for fertiliser application (on steeply sloping ground, frozen or snow covered ground, near water courses, etc.) to prevent nitrate losses from leaching and run-off;
- Requirements for a minimum storage capacity for livestock manure;
- Crop rotations, soil winter cover, and catch crops to prevent nitrate leaching and run-off during wet seasons; and
- Limits on the total amount of livestock manure that may be applied to land.

Every four years member states are required to report on: *i)* nitrates concentrations in groundwaters and surface waters; *ii)* eutrophication of surface waters; *iii)* assessment of the impact of action programme(s) on water quality and agricultural practices; *iv)* revision of NVZs and action programme(s); and *v)* an estimation of future trends in water quality.

Source: Case study provided by the EU.

Box 3.2. **Agricultural nutrient management regulations, Canadian provinces**

In response to ongoing problems with eutrophication and algal blooms, Canadian provinces have mandated nutrient management plans at the farm level through regulatory changes for some time. For example, buffer strips around surface water and groundwater sources have become a common requirement to limit nutrient leaching. Federal programmes to reduce diffuse nutrient pollution – Environmental Farm Plans and the Environmental Stewardship Incentive - are designed and implemented at provincial level, which enables policy to be adapted to local circumstances and facilitates the transfer of knowledge.

Box 3.2. **Agricultural nutrient management regulations, Canadian provinces** *(cont.)*

Under municipal by-laws, the location of manure storage, as well as setback distances from neighbouring properties or streams, may be regulated. Examples of regulatory measures to reduce diffuse pollution from agriculture at the provincial level include:

- Ontario: The Nutrient Management Act (2002) sets out regulatory requirements for certain nutrient management practices and requires farmers to document these practices to reduce risk of water contamination by agricultural sources. The practices regulated include the management of manure (e.g. storage and application), application of non-agricultural materials (e.g. sewage bio-solids and vegetable processing wastes) and the treatment of manure and other materials in on-farm anaerobic digesters.
- Manitoba: The Livestock Manure Mortalities Management Regulation (1998) prescribes various requirements for the use, management and storage of livestock manure to reduce water pollution from livestock. Permits are required for the construction, modification or expansion of manure storage facilities and specific constraints, such as maximum livestock population, fencing restrictions, restrictions to drainage and water work, apply on crown land.
- Quebec: The Agricultural Operations Regulation (2002) seeks to address the problem of diffuse pollution caused by agricultural activity, by achieving an effective balance of phosphorous in the soil to maintain soil fertility and limit losses from excessive use of manure. It includes norms for livestock buildings and manure management, and restrictions on land use to limit water pollution. Other regulations deal with the use of fertilisers and pesticides in agriculture.

Source: OECD (2015a).

In Israel, national policy calls for the gradual replacement of freshwater allocations for agriculture with reclaimed effluents in an effort to improve water security, water quality and nutrient recycling. The case study from Israel (Box 3.3) details the number of regulations that have increased the cost-effectiveness of, and investment in, tertiary wastewater treatment plants which is enabling unrestricted irrigation of crops while ensuring diffuse pollution is limited. Similarly, Turkey is exploring options for the safe reuse of treated water and wastewater in agriculture, industry, tourism, energy and households.

Box 3.3. **Regulations to incentivise wastewater reuse and reduce water pollution, Israel**

For Israel, overcoming the challenges of an arid climate and scarce natural water reserves has always been a vital necessity for the growth of the population and economy since the founding of the state. Currently, Israel annually requires almost a billion cubic metres per year (MCM/yr) more water than average natural replenishment provides. Nevertheless, average annual sustainable natural water consumption has been achieved, providing for all of the country's water needs, via innovations in wastewater reuse and desalination.

National policy calls for the gradual replacement of freshwater allocations to agriculture by reclaimed effluents. A number of important advances in policy were required for sustainable wastewater reuse to become a reality while safeguarding groundwater from diffuse pollution:

1. In 1992, the Ministry of Health (which controls potable water quality and manages the effluent irrigation permitting system) released new regulations that set secondary wastewater treatment plant (WWTP) quality standards for biochemical oxygen demand and total suspended solids. As a result, municipalities built intensive WWTPs with national loans of USD1.5 billion and restricted wastewater reuse was permitted for agricultural irrigation.

Box 3.3. **Regulations to incentivise wastewater reuse and reduce water pollution, Israel** *(cont.)*

2. In 2001, the Water and Sewerage Corporations Law was passed. The Law transferred the management and ownership of water and sewerage infrastructure and services from public municipalities to corporate entities. This was the first step in the transformation of the water sector from administrative management to a more commercial orientation. The process was initially a voluntary one, but since 2008 state loans in the water sector are given only to private water and sewerage corporations.
3. In 2006, Parliament approved the establishment of a National Water Authority (under the Ministry of National Infrastructures, Energy and Water Resources) with overall responsibility for water, sewage and water resources management policy. One of the main principles introduced was that water tariffs should enable full cost recovery in the water sector, including costs of water conveyance, piping systems and wastewater treatment. This principle, together with construction of desalination plants along the Mediterranean coast, dramatically increased water prices in Israel for all sectors. Today, the domestic sector is paying about USD 2.6 per cubic meter of potable water. Therefore, the incentive for wastewater reuse was further enhanced.
4. In 2010, tertiary WWTP water quality standards came into force to enable unlimited irrigation of crops while ensuring diffuse pollution is limited and water and soil quality are protected. The standards have 37 water quality parameters, including heavy metals, nutrients and oxygen demand.

Investments in WWTPs and the volume of treated wastewater have increased over 5-fold and 3-fold respectively between 1992 and 2008. The reuse of wastewater treated at the secondary level for use as irrigation (under restrictions) was originally encouraged through zero fees from the WWTP. Farmers and water associations had the responsibility to construct the piping and distribution systems, and the reservoirs to collect the water for irrigation. Since wastewater quality was upgraded to tertiary level, farmers pay USD 0.3¢ /m^3; the additional cost to attain the improved water quality standard (from secondary to tertiary level treatment) is approximately USD 0.1¢/m^3 (capital + O&M). The benefits of tertiary treatment and unlimited effluent irrigation are much greater than the costs. In addition, freshwater ecosystems are flourishing due to a permanent and steady environmental flow of treated wastewater that can be used for various purposes downstream of WWTPs. This has triggered further investment in advanced treatment technologies at WWTP's, carrying out nitrogen and phosphorus reduction, filtration and disinfection.

Currently, treated wastewater constitutes about 21% of total water consumption in Israel and approximately 45% of agricultural consumption. Out of a total of about 510 million cubic metres of wastewater produced in Israel annually, 97% of the wastewater is collected and about 85% of it is reused. 52% is treated to tertiary level and 41% is treated to secondary level. The ultimate objective is to treat 100% of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk of pollution to soil and water sources.

Sources: Summary of case study provided in full by Alon Zask, Ministry of Environmental Protection, and Adi Yefet, Israel NewTech - National Energy & Water Program, Israel; Rejwan and Yaacoby (2015).

Regulating diffuse pollution outputs

Instead of regulating the use of inputs to reduce diffuse source pollution, policy makers are increasingly looking to computer models to regulate calculated outputs of pollution from individual landowners and "cap" various users to meet calculated total maximum pollution loads for catchments. Advances in computer modelling can predict diffuse pollution based on farm practices (such as crop rotations, stocking ratios, tillage practices, fertiliser and pesticide applications, irrigation), and the hydrological, soil, and geographical conditions that effect the transport of pollutants to surface and groundwater bodies (Fishmana et al., 2012). Land managers can innovate farm and land management practices within their pollution cap without being restricted by the inputs they use. Furthermore, regulating pollution through proxies such as fertiliser use and livestock numbers can be less effective at reducing pollution[2] (OECD, 2010). Models can then be progressively adapted to account for innovations that improve water quality.

There are some limitations to modelling, one of which is simplification and assumptions made of complex environmental systems. Models are also only as good as the data with which they are calibrated and validated. Uncertainties in data and model components can propagate to other model components and model outputs. Greater data collection and reliability can lead to continual improvements in the accuracy of models, and their capacity to make informed policy decisions. A concerted scientific effort can reduce uncertainties in predicting water quality and the consequence and benefits of current and alternative trends and scenarios. Some regions of New Zealand have used nutrient modelling to inform policy design (Box 3.4). Water quality modelling is an important part of the Total Maximum Daily Load Management System in Korea, which aims to control both point and diffuse pollution sources through a permitting system (see case study below).

Box 3.4. **Nutrient modelling in New Zealand**

OVERSEER®, a national model for farm-scale nutrient budgeting and loss estimation, calculates nutrient flows in a productive farming system and identifies risks of environmental impacts through nutrient loss, including run-off and leaching. The model was originally developed as a tool for farming to create nutrient budgets and has been adapted to overcome barriers that arise from an inability to clearly identify diffuse source polluters. It is recognised as the best tool currently available for estimating nitrate leaching losses from the root zone across the diversity and complexity of farming systems in New Zealand. A summary of the model inputs and outputs are summarised in the table below.

Inputs: Farm level	Inputs: Management block level (i.e. paddock/field scale)	Outputs
Farm location	Topography	*Nutrient budget.*
Types of blocks and block areas (e.g. pastoral, fodder crop, house, scrub, wetland, riparian)	Climate	Nitrogen (N) sources: atmospheric, fertiliser, animal transfer, supplements fed on block, irrigation and nutrients out
Types of enterprises (e.g. pastoral, cropping)	Soil type	N losses: produce (e.g. milk), animal transfer, supplements (e.g. hay), leaching/ runoff, atmospheric (e.g. N_2O).
Stock	Drainage	*Farm-level and block-level reports.*
Stock numbers, breed	Soil fertility tests	e.g. Total N lost to water for blocks and farm; Average N concentration in drainage based on N leached; N surplus per block.
Production	Pasture type	*Advisory reports.*
Placement (grazing off, wintering pads)	Supplements made on the block	e.g. N conversion efficiency (%); total GHG emissions; maintenance fertiliser requirements.
Types of structures	Fertiliser applied	
Effluent management of structure	Irrigation applied	
Stock management on structure	Effluent applied	
Type of effluent management system	Animals (type, timing) grazing the block	
Supplements imported and where they are fed	Crop rotation; crops grown – yield, fertiliser applied, harvesting method	
Wetlands		

Box 3.4. **Nutrient modelling in New Zealand** *(cont.)*

OVERSEER® can, and has, supported environmental policy development, most notably around Lake Taupō and as part of Horizons One Plan in the Manawatū-Wānganui region. New Zealand farmers will increasingly use the model to develop nutrient management plans and budgets, as required by regional councils. While such a model is essential for enabling a water pollution cap to be imposed, it is accepted by both farmers and regional councils that it has high uncertainties. The model is not designed to provide economic analysis, so outputs need to be combined with other economic models to assess the impacts of options on the farm business.

The accuracy of OVERSEER® will be critical to maintaining the credibility of policies. In order to improve the accuracy of OVERSEER®, further investment is required to better calibrate and validate the model under different soil types, farm types, farm management practices and mitigation methods, and under extreme weather conditions (such as high rainfall), uncommon situations (e.g. specialist types of horticulture) and under highly complex operations. Improved versions of OVERSEER® will need to be recognised in policy so that innovative mitigation methods can be implemented by farmers.

Source: OECD (2017).

***Case study: The Total Maximum Daily Load Management System, Korea*[3]**

Rapid economic growth in Korea has increased the demand for water tremendously, and accelerated urbanisation and agriculture intensification has caused deterioration of water quality in rivers and lakes, which has resulted in an increase of social conflicts regarding water use among various stakeholders.

In 2004, the total maximum daily load (TMDL) programme was introduced to improve water quality management policy, which had previously focused on the regulation of the concentration of point sources of pollution. The TMDL allocates pollution load reductions necessary to reduce the sources of pollution and achieve desired water quality. The TMDL program in Korea is aimed at water quality improvement and economic growth simultaneously. Since implementation of the TMDL, further reductions in point source pollution have been achieved. However, the proportion of diffuse sources in relation to point sources has increased; the proportion of total pollution attributed to diffuse pollution is projected to reach over 70% by 2020. In response to the shifting challenge, the control of diffuse sources of pollution has been the focus of water policy since 2011. Central government oversees water quality management by local government and sets overarching policies for both economic development and environmental protection. Water quality targets are set periodically for each of the four main watersheds (the Nakdong River, the Geum River, the Youngsan Seomjin River and the Han River). Local water quality targets and implementation plans are then established to achieve the overarching target for the watershed.

Target parameters are BOD and total phosphorus. It is envisaged that the TMDL system will go beyond simple parameters like BOD and total phosphorus, to also manage non-biodegradable substances in the future. Targets near the boundaries between provinces and cities are required to be notified so that water quality targets can be attained in co-operation.

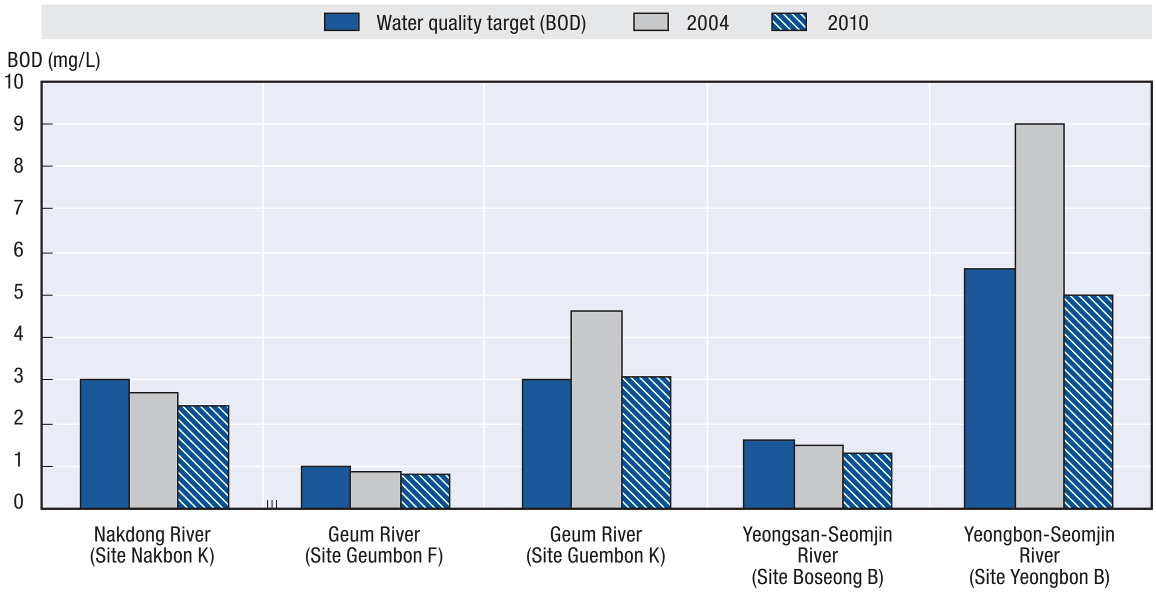
Permissible total maximum daily pollutant loads are calculated using scientific water quality modelling at the watershed, local and individual property levels. Economic development, population growth, pollutant reduction and local development planning are considered together. The TMDL management system clarifies the responsibility of each relevant entity by identifying each pollution load by local government, sub-local government and individual polluter, with a view to meeting and staying on the water quality target.

Once the water quality targets are set, governors and mayors develop detailed local development plans and the annual plans for pollution reduction, with a view to meeting the load allocation of each watershed. In co-operation with stakeholders, governors and mayors then decide how to allocate pollution load permits to individuals in order to attain and maintain the overarching target for the watershed. It is up to each local government and the stakeholder how to allocate these pollution loads. Technical Guidelines for TMDL Management provided by the National Institute of Environmental Research require pollution load permits be set through water quality modelling, considering equity, efficiency and effectiveness of reducing pollution loads. Several methods are given as options in the Technical Guidelines, such as the grandparenting approach, catchment average approach, sector average approach, proportional to revenue generation, and the minimum cost method, among others (see Table 3.1 for an explanation of these methods). Voluntary allocation through stakeholder co-operation and engagement is also encouraged in the Technical Guidelines (NIER, 2014).

Implementation and performance of the TMDL system is evaluated every year by central government. When improvements are required, the central government may ask a governor or mayor to establish and take necessary measures: for example, putting further restrictions on urban and industrial development projects, suspension or cutbacks of financial support, or restriction on installation or modification of facilities where discharging wastewater. Central government also offer support for implementing the TMDL system. Since 2004, when TMDL system was implemented, government subsidies have been provided to support investments in wastewater treatment plants, and land purchases to retire sensitive areas from intensive land use (such as riparian buffer strips) with the aim of meeting water quality targets. In addition, for keeping the TMDL system sustainable, the development of new pollution reduction technologies and approaches through R&D projects is a factor attributable to the success of the TMDL system.

The nationwide introduction of TMDL management system is considered to have contributed to improving water quality, particularly in areas where the existing water quality was worse than the water quality target. In 2013, water quality targets were achieved for 81% of rivers. Figure 3.1 is a demonstration of the success of the TMDL system in the Nakdong, Geum and Yeongsan-Seomjin Rivers. However, water quality targets were achieved in only 12% of lakes; Korean’s lakes and reservoirs are particularly vulnerable due to the high residence time in comparison to rivers (as are most lakes around the world). Strict management is considered necessary to achieve continuous water quality improvements in future stages of TMDL implementation (Kim et al., 2016).

Figure 3.1. **Water quality improvements under the Total Maximum Daily Load Management System, Korea**



Source: Summary of case study provided in full by Jihyung Park and Sang-Cheol Park, Ministry of Environment, Korea.

Allocating diffuse pollution allowances within a cap

The greatest challenge of regulating outputs of diffuse pollution is how to allocate pollution "caps" (or maximum permitted loads) to individual land owners in a way that is equitable and cost-efficient. Table 3.1 describes the different approaches for allocating modelled nutrient discharge allowances to achieve water quality objectives within a catchment. Nutrient management measures must then be put in place to avoid increases in nutrient output from land use changes or intensification if a catchment is at full pollution allocation.

Table 3.1. **Allocation approaches for nutrient discharge allowances**

Allocation approach	Description
Grandparent	Nutrient discharge allowances (NDAs) allocated based on nitrogen leaching rates during a baseline or benchmarking period and proportional to nutrient reduction target.
Catchment average	All landowners are given the same NDA regardless of land use (i.e. the average of total nitrogen discharge from land-based sources per productive land area).
Land cover average	Landowners managing a specific land cover (e.g. pasture, forest, arable) are given the same NDA per productive land area.
Sector average	Landowners within the same sector (e.g. dairy, sheep, beef, horticulture) are given the same NDA per productive land area.
Natural capital	NDAs allocated based on the biophysical potential of the land, soil and environment. Land use capability can be used as a proxy for natural capital, with a greater NDA allocated to higher class land. The allocation is independent of existing land use.
Nutrient vulnerability	NDAs allocated based on the nutrient leaching capacity of the soil. A greater NDA would be allocated to land with lower "vulnerability" or greater capacity for filtering nutrients. The allocation is independent of existing land use.
Least cost	NDAs allocated to meet nutrient cap/target at lowest cost.
Auction	Auction or reverse auctions to allocate NDAs. Those who can afford to pollute or wish to intensify production can buy the rights to do so. In facilitating such an auction, pollution rights can shift to the most productive land users.
Community-negotiated allocations	NCAs negotiated and allocated among stakeholders.
Ballots	Lucky draw.
Merit-based criteria	Based on best economic, environmental and/or social returns.

Note: NDA is nutrient discharge allowance.
Source: Adapted from Daigneault et al. (2017).

The efficiency and equity of each of the allocation approaches differ based on their existing land use, land characteristics, stakeholder preference, and the stringency of the regulation. A study by Daigneault et al. (2017) demonstrates that there is no most or least preferred allocation option based on cost-efficiency criteria. Allocation of pollution allowances should be made at a level that is consistent with good land management practice to encourage reductions in pollution, particularly those who lag behind such practices. Additional regulations may be necessary to protect vulnerable areas such as near water bodies (e.g. requiring riparian zones be planted and fenced off from livestock).

In terms of equity, the grandparent approach (the most frequently used approach), can be considered inequitable with historic polluters rewarded, which may also be the polluters most likely to be able to reduce pollution at a lower cost. The grandparent also has high opportunity costs for those property owners who have not developed land or who may wish to intensify production. The natural capital approach is an emerging approach that decouples the pollution allocation from land use. Such an approach encourages the adaptation of land activity to better use soil and water resources, and shift land use activities to more sustainable outcomes based on the underlying natural capital stocks of soils. The approach is being implemented in two of New Zealand's sixteen regions (see case study below). Economic analysis and stakeholder engagement can identify the most efficient and equitable allocation option in a given context.

Case study: The natural capital approach to allocating diffuse nitrogen pollution, Manawatu-Wanganui, New Zealand[4]

Freshwater is the backbone of New Zealand's economy. In addition to tourism, recreation, power generation and cultural identity, it is vital to the primary sector. New Zealand is unique among developed countries as nearly three quarters of its export earnings are generated from the primary industries of agriculture, horticulture, viticulture, forestry, fishing and mining. The expansion of intensive dairy farming, in particular, has yielded significant economic benefits, but has also had significant consequences for water quality (OECD, 2015b).

In recognition of the need for limits on natural resource allocation, the National Policy Statement for Freshwater Management (2014) directs all Regional Councils to set limits on water quality and quantity in all water bodies above a specified minimum level required to ensure ecosystem and human health by 2025. The Statement also requires that overall water quality within a region must be maintained or improved. For the agricultural sector, systematic setting of water quality and water quantity limits in catchments throughout New Zealand poses both opportunities and risks.

Regional Councils have taken different approaches to address the issue of setting nutrient loss limits. For the Horizons Regional Council, who manages the natural resources of the Manawatu-Wanganui region, an innovative approach using the natural capital of the soil has been used to allocate nitrogen diffuse pollution limits to individual farmers as part of the One Plan[5].

Allocating a nutrient loss limit based on the natural capital of the soil (inherent capability) in a catchment offers an approach for developing policy that is linked directly to the type of underlying natural biophysical resources in the catchment, recognising that different soils and topographies differ in not only their productive potential, but also their ability to filter and retain water and nutrients under the pressure of grazing animals (Mackay, 2009).

The New Zealand Land Use Capability Survey (Lynn et al., 2009) is a land use classification system that been used in New Zealand to help achieve sustainable land development and management on individual farms, in whole catchments, and at the district, region, and the national level since 1952. The Land Use Capability (LUC) system has two key components. Firstly, Land Resource Inventory (LRI) is compiled as an assessment of physical factors considered to be critical for long-term land use and management, and secondly, the inventory is used for LUC Classification, whereby land is categorised into eight classes according to its long-term capability to sustain one or more productive uses. The LRI is compiled from a field assessment of five factors: rock type, soil type (including depth, structure, texture, drainage, and nutrient supply), slope angle, erosion type and severity, and vegetation cover. The LRI is supplemented with information on climate, flood risk, erosion history and the effects of past land management practices. The greater the limitations imposed by the physical constraints of the soil and the environment, the greater the number and complexity of corrective practices that are required for productive use.

The productivity indices (i.e. attainable potential carrying capacity) in the LUC survey offer a proxy for the natural capital of soils. An attraction of the approach is that this information is already established as the basis for land development and evaluation, and it is available throughout New Zealand. Using the productivity indices, combined with the national OVERSEER® nutrient budget model[6] (Box 3.4), nitrogen losses can be calculated based on the LUC classification. As the limitations to use of the soil increase (i.e. Class 1 to 7), the underlying capacity of soil to sustain a legume-based pasture system declines, as does the potential nitrogen loss by leaching, since carrying capacity also decreases. In other words, the most vulnerable landscapes that have little natural capital and/or lack versatility in either land use options and/or mitigation strategies should have the most stringent limits on nitrogen leaching.

The nitrogen leaching limits for each LUC in the Operative One Plan (Table 3.2) are staged over a period of 20 years (see table below). The nitrogen leaching limits have legal effect ranging from 1 July 2014 to 1 July 2016, depending on the Water Management Zone. Landowners with existing and new intensive land use activities (dairy farming, commercial vegetable growing, cropping and intensive sheep and beef farming) must prepare and implement a nutrient management plan. Nutrient management plans outline specifically how farming operations will comply within the One Plan nitrogen leaching limits, thereby allowing for a customised farm scale level assessment and plan to deliver on the water quality outcomes that is reflective of each farms unique collection of biophysical resources and business structure and operation. In practice, it provides a vehicle for the progressive implementation of actions that might first target adoption of low cost strategies that achieve a high cost-benefit return, progressively adopting more expensive input cost options, and constraints on production as farms strive to achieve nitrogen and other contaminant targets. As new knowledge and technologies become available, they can be readily incorporated into the nutrient management plans.

Table 3.2. **Cumulative nitrogen leaching maximum by Land Use Capability Class, Manawatu-Wanganui Region, New Zealand**

Period (from the year that the rule has legal effect)	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2

Source: Horizons Regional Council (2014).

Horizons Regional Council began the One Plan development process with community consultation in 2004 and first notified the plan in May 2007. There has been strong opposition by farmers to many of the changes, in particular to those concerned with the cost of nutrient management regulating unsustainable practices. The majority of the Plan was settled through mediation, but 20 % of appeals went to the Environment Court to rule on some of the more contentious issues surrounding nutrient management. The appeal process of the One Plan has caused long delays for the Horizons Regional Council and users; after some amendments to the original proposed One Plan, the One Plan became operative on 19 December 2014 (over 7 years since notification). Pathways forward are required to manage the challenges associated with the longer-term transition to such a policy, in a similar way to which stranded assets in the climate sector need to be managed. Bank lending to the dairy sector, in particular, should be monitored to ensure that these policy requirements are being taken into account when assessing the ability of farmers to repay debt (OECD, 2014).

It is still early days in the One Plan's implementation, and to date its impact on surface water quality outcomes in the priority catchments have not been assessed. Striking the balance between achieving the environmental gains set out within the One Plan, with the expectations of communities seeing tangible improvements in surface water quality, with the rate at which farmers could or should be required to comply with this environmental legislation, is still being openly debated in the Region.

The Natural Capital approach sets limits on emissions to water that are linked directly to the underlying land resources, by providing a boundary condition that future land uses and practices have to operate within to achieve the required water quality outcomes. This approach encourages the adaptation of land activity to better use soil and water resources, and shift land use activities to more sustainable outcomes. It also encourages transitioning from policy that looks to regulate land use to one that ensures the finite underlying resources are being sustained and available for future uses. The approach may not always optimise economic outputs within water quality limits, particularly in the short term as the full transition is made to shift intensive land use from low class soils to high class soils. Trading of water pollution allowances could assist with such a transition. Shifting to a natural capital based approach offers a basis for assessing the capability of wider landscapes to provide multiple ecosystem services for a range of desired outcomes beyond just economic growth and water quality. The approach has more recently been adopted in the Hawke's Bay region[7].

Policy can be designed to further improve the economic efficiency of nutrient allocation approaches. For example, water quality trading (discussed in the following section) offers a solution whereby farmers within a catchment can exchange nutrient allocations to achieve a cumulative nutrient limit for a catchment in a flexible manner that maximises economic efficiency and maintains environmental integrity. In order to improve equity, those most affected by allocation regimes can be compensated, where necessary. Where trading may not be appropriate, communities and individuals can use outcomes-driven approaches and collaborative management to plan mitigations. The following sections will discuss a range of these approaches.

Economic instruments

Growing recognition of the importance of diffuse pollution problems has stimulated interest in the design of economic instruments to control pollution sources (Shortle and Horan, 2001), especially since fiscal consolidation and budgetary constraints at national and local level has reduced financial assistance (subsidies) to reduce pollution (Shortle et al., 2012).

Pollution charges and taxes

Putting a price on negative externalities is one way negative impacts to the environment can be internalised, and economic valuation can assist policy makers to make informed decisions on the most beneficial solutions for society. Pollution taxes, user fees and product charges can be used to create incentives to reduce pollution from urban and rural sources, increase the cost-effectiveness of pollution control and promote innovation in pollution control strategies (Hoffmann et al., 2006).

Examples of water pollution taxes do exist, but on the whole, the use of economic instruments in water pollution control is much less common than in air pollution control (Hanley et al., 2013) and in the control of diffuse source pollution than in point source pollution. The heterogeneous impacts and damage costs of water pollution makes their management more difficult than air pollution. Additional reasons for the slow uptake of economic instruments in the management of water pollution may include: political resistance from polluters; limited data on the costs of environmental degradation; difficulties in measuring diffuse sources of pollution and attributing them to landowners; and the complexities of ambient pollution concentrations which are a function of both point and diffuse pollution sources, natural background levels, watershed characteristics, fate and transport parameters, and stochastic environmental variables (Figure 1.2, Chapter 1) (Shortle and Horan, 2001).

Taxes on polluting inputs (i.e. product charges on inputs that are believed to have environmentally harmful effects) and pollution charges (i.e. a charge based on the quantity of pollutants that are discharged into the environment) can be used to create incentives to reduce pollution from urban and rural sources (Hoffmann and Boyd, 2006), and to raise funds for investment in water quality infrastructure and management (Köhler, 2001; Hoffmann et al., 2006). There is a large variation in how and for which pollutants water pollution taxes and charges are implemented in different countries or regions. Table 3.3 provides a few examples.

Table 3.3. **Examples of features of pollution charges in selected OECD countries**

Country	Levied by	Tax name	Specific tax base	Tax structure
Australia	State	Water effluent charge	Volume, pollution content (types of pollutants)	per kg assessable load
Canada	Province	Charge on discharge	Volume and pollution content	per litre or per tonne
Denmark		Diffuse source	Chemical deterrents of insects and mammals	tax on retail price
France		Diffuse source	Pesticides	per kg
		Water effluent charges	Households	per m^3
Netherlands		Tax on the pollution of surface waters	BOD, COD and heavy metals, for large polluters	per pollution unit
Sweden	Municipality	Wastewater user charges	Wastewater and drinking water	varies by municipality; full cost charging
		Diffuse source	Pesticides	per whole kg active constituent

Source: OECD database on Policy Instruments for the Environment (Accessed 20/03/2016).

In France, taxes are used to encourage and finance reductions in water pollution and water consumption (Box 3.5). In Denmark, a pesticide tax has been applied since 2013 so that farmers are taxed according to the environmental and health toxicity of pesticides used rather than their nominal value. In Norway, since 1999 the pesticides tax has been area-based with seven tax bands according to the environmental and health related risks of the pesticides. The tax was initially introduced in 1988 as a revenue raising tool, but was revised in 1999 to reflect a stronger objective of reducing the use of pesticides. This system has been effective in encouraging more conservative use of pesticides and provides an incentive to use less harmful products (OECD, 2010; Withana et al. 2014). Although revenue raised is often earmarked for improvements in water quality, revenue should be allocated to the general budget of governments for use for policy and projects that may render the greatest benefit to society.

Advances in nutrient pollution modelling (e.g. Box 3.4) provides an opportunity to tax diffuse pollution outputs, rather than taxing inputs as proxies such as fertiliser use and livestock numbers, which can be less effective at reducing pollution[2] (OECD, 2010). Using such models, pollution charges could be directly proportional to the amount of pollution generated.

Box 3.5. **Taxes to encourage and finance reductions in water pollution and water consumption in France**

French water policy is based on using water and pollution taxation to finance actions to protect and restore water resources and aquatic environments, and to follow the polluter-pays and user-pays principles. This system, implemented by the Water Agencies, involves stakeholders at basin level working together in Basin Committees to determine the size of charges to levy within statutory national limits. This participatory model facilitates the acceptance of taxes by liable entities and permits periodic adjustment in order to take new issues into account, remain representative of water users and retain its levels of acceptability.

Taxes are designed to internalise environmental externalities in the price and pollution of water resources, taking into consideration: *i)* costs and impacts generated by pollutants released into water bodies; *ii)* costs and impacts of obstacles in rivers, such as dams and weirs which can effect environmental flows, freshwater ecosystems and water quality; and *iii)* costs and impacts relative to a chronic shortage of a water resource, generating conflicts of use and changes in flows which have an impact on the management of water quantity and water quality (as flow reduction causes a greater concentration of pollution). However, given the low tax levels used (see table below), it is unlikely the external environmental and opportunity costs are fully internalised.

Tax revenues are earmarked for reinvestment in water quality and scarcity improvements at the basin level and are managed by the Water Agencies. National government has capped total tax revenue from water-related taxes for the 2013-2018 period at EUR 13.8 billion. The allocation of tax revenue to specific projects is assessed on environmental effectiveness and economic efficiency. Records of funded projects are made publically available to comply with transparency obligations.

2013 water-related tax levels, Rhone-Mediterranean and Corsica Water Agency, France

Water agency tax	Uses	Calculation	2013 tax level
Water abstraction charge	All users	Proportional to water withdrawn	Depends on the use, the level of water scarcity, and the collective or non-collective management of water
Domestic pollution	Urban users	Proportional to water consumption	EUR 0.23/m^3
Industrial pollution	Industrial users	Proportional to generated pollution	Depends on type of pollutants
Sewer systems modernisation	Users connected to a public sewerage network	Proportional to volume discharged in sewer network	EUR 0.15/m^3
Diffuse pollution from livestock	Farmers with >90 livestock units	Proportional to livestock unit, which factors type of livestock and age	EUR 3.0 per livestock unit from the 41st unit
Hydroelectricity production	Hydroelectric operators (>1 billion cubic metres per year diverted)	Proportional to volume of diverted water	EUR 1.2/billion m^3 and per metre of waterfall height
Obstacles in rivers	Those who modify natural river systems (except hydroelectric operators)	Proportional to length of the barrier	EUR 150/m
Storage in low water level periods	Entities who store water	Proportional to the volume stored in low water level and high demand periods	EUR 0.01/m^3 stored
Protection of freshwater environments	Recreational fishers	Per recreational fisher	EUR 8.8/year/adult plus EUR20.0 for specific fish species

Sources: Summary of case study provided in full by Maude Jolly and Emmanuel Steinmann, Ministry of Ecology, France; Montginoul et al. (2015).

Water quality trading

It is recognised that there can be inefficiencies associated with regulations, taxes and subsidies. Where property rights are established, market-based instruments, such as water quality trading[8], involves less control from government and offers a mechanism for achieving a cost-effective allocation of environmental effort across alternative sources, without environmental regulators knowing the abatement costs of individual agents (Parris, 2012). When carefully designed, trading can address water quality problems by using trade ratios that define allowable rates of exchange between sources that reflect the marginal damage of emissions from each source (Farrow et al., 2005; Muller and Mendelsohn, 2009).

Although they can be complex in nature, water quality markets can stimulate innovation and often achieve water quality targets at a lower social cost than traditional performance standards, taxes and payments/subsidies (OECD, 2013b). Water quality trading can potentially enable continued growth in a capped watershed without jeopardising water quality, and water quality goals may be met at a faster pace than without trading. To date, market-based instruments to address water pollution in OECD countries have been limited (primarily to point-point sources), but there is growing interest in their use. The case of point-diffuse source water quality trading to reduce nutrient pollution of Chesapeake Bay, United States is illustrated as an example below. Another case study, the Lake Taupō nitrogen market, New Zealand is the first diffuse source pollution market in the world, enabled by the nutrient model OVERSEER® (Box 3.4) to cap nitrogen emissions at the catchment scale and allocate discharge allowances to individual farmers for trading (OECD, 2015c; 2017).

Case study: Lessons learnt from water quality trading, Chesapeake Bay, United States[9]

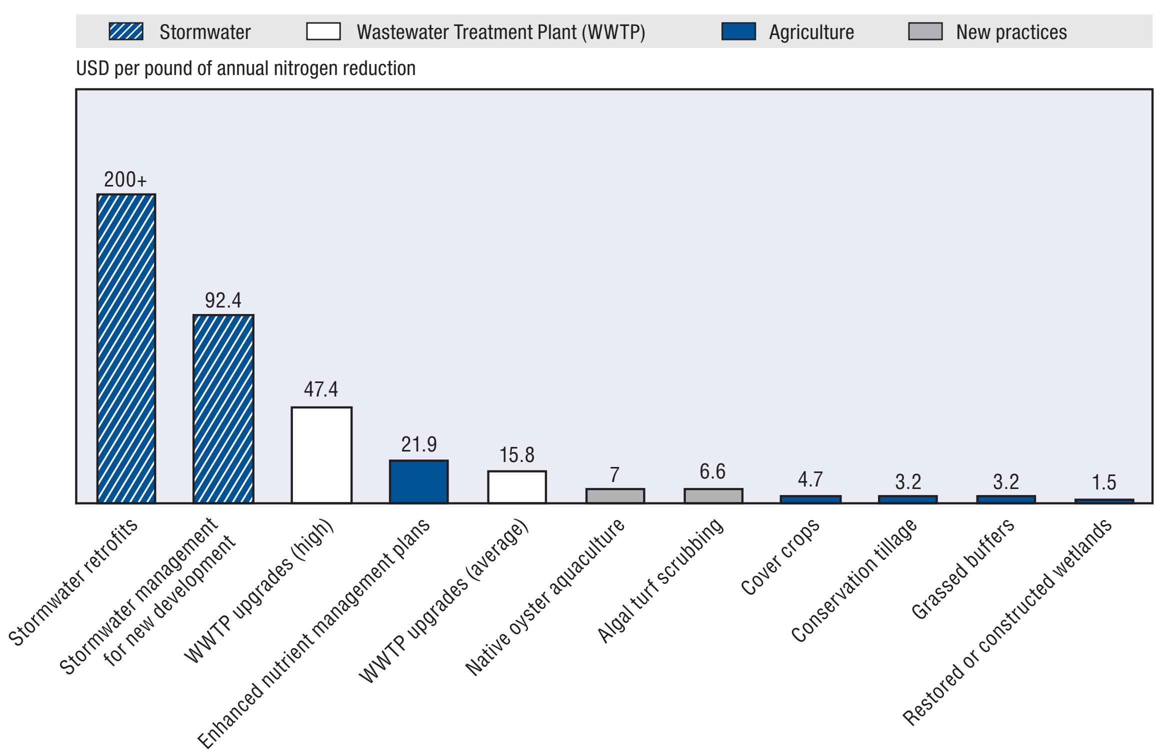
The Chesapeake Bay watershed on the east coast of the United States is considered a "national treasure and resource of worldwide significance" (Chesapeake Bay Restoration Act of 2000). It is also the largest estuary in the United States and one of the largest and most productive in the world. However, the Chesapeake Bay watershed has suffered from excess nutrients and sediment for decades. In particular, diffuse pollution from agriculture, has been largely unregulated and remains a significant contributor to water quality impairments not only in the Chesapeake Bay watershed, but across the country. The Chesapeake Bay Foundation (2014) has estimated that the Chesapeake Bay area provides more than USD 107 billion in ecosystem services, such as flood and hurricane protection, air and water purification, and food production every year. However, if current trends continue, it is estimated that the region could lose USD 5.6 billion annually in benefits.

After voluntary attempts at improving water quality failed to deliver adequate results, the United States Environmental Protection Agency (EPA) worked with the states in the watershed in 2010 to pioneer the largest and most complex total maximum daily load (TMDL) for nutrients and sediment in the country. Maximum loading rates were determined by the Chesapeake Bay Watershed Water Quality Model (calibrated to in-stream monitoring data) to ensure protection of the Bay ecosystem and its tidal tributaries. In total, the TMDL called for a 25% reduction in nitrogen, 24% reduction in phosphorus, and 20% reduction in sediment. In consultation with the states, the EPA allocated nutrient reduction requirements to the states and the major river basins based on their pollution contribution (i.e. a grandparenting approach). Other factors considered included the relative effectiveness of nutrient reduction efforts among river basins, and the degree to which the loads were controllable. Pollution control mechanisms to meet these allocations, and fully restore the Bay, must be in place by 2025. In addition to the reduction requirements, all new sources of pollution loads must be offset, as there are no allocations for future growth.

After each major basin had an allocation, the states sub-allocated their major river-basin loads to individual sources in their Watershed Implementation Plans. The decisions guiding this process varied by state, but generally, point sources of pollution face stringent nutrient discharge limits and are expected to achieve limit of technology. Diffuse pollution from agriculture remains largely unregulated but is collectively subject to a load allocation under the TMDL. States report to the EPA each year on what nutrient mitigation practices and activities have been implemented. This gets fed into the Chesapeake Bay Watershed Water Quality Model which produces a "progress run", using the latest in-stream monitoring data, to determine the annual loading rates, reductions and improvements in water quality.

Traditionally, TMDLs and other water quality goals have been primarily addressed through traditional and costly command-and-control approaches on point sources. However, as shown in Figure 3.2, costs for nitrogen mitigation varies greatly among sectors, with agricultural diffuse source practices having significantly lower costs than point sources. Based on the dramatic price differentials among sectors for nutrient mitigation options, water quality trading has emerged as a market-based mechanism for cost-effectively meeting water quality goals and the TMDL in three states – Pennsylvania, Virginia and Maryland. Furthermore, given that there are no load allocations for future growth under the Chesapeake Bay TMDL, there is the risk of stifling development without flexible mechanisms in place for handling growth. Trading is considered to be a critical mechanism for accommodating growth through acquiring pollution offsets.

Figure 3.2. **Cost comparison of options to reduce a nitrogen loading, Chesapeake Bay Watershed, United States**



Source: Jones (2010).

The regulations are slightly different in each state, but in general, trading is permitted between regulated point source entities, such as wastewater treatment plants, urban stormwater municipalities and concentrated animal feeding operations (point-point trading), and with diffuse pollution sources (point-diffuse trading). The buyer is therefore the regulated point source entity, and the seller may be another regulated point source entity or an unregulated entity, such as a farmer who has gained credits for reducing diffuse pollution. Regulated entities and new and expanding facilities can offset their pollution loads by purchasing credits from other point sources or from diffuse sources at lower cost that could be attained on site. Water quality credits are issued to entities that have achieved pollution reductions beyond their allocated pollution load (after onsite verification).

Water quality trading in the Chesapeake Bay watershed has enabled regulated entities to meet permit requirements at a reduced cost than under traditional command and control approaches, and credit generators, such as farmers, have earned additional revenue through the sale of credits. For example, in Pennsylvania, trading has been successful as a flexible compliance option for WWTPs. From 2013-2015, 600 000 - 1.1 million nitrogen credits, and 55 000 – 100 000 phosphorus credits have been sold annually. These represent a mix of point-to-point trades and point-to-diffuse trades. Virginia's Nutrient Credit Exchange has proven to be an effective mechanism for facilitating compliance trading between point sources with permanent phosphorus offsets selling for upwards of USD 20 000/pound, largely generated by land conversion activities. Maryland's nutrient trading program has yet to experience any trades. This is likely due to a lack of binding regulations, which may have led to uncertainty and risk for regulated entities to purchase credits in lieu of addressing requirements onsite.

Based on experiences from the Chesapeake Bay watershed and elsewhere, critical requisites for a water quality trading programme to be viable include: *i)* a strong regulatory driver (cap) to create demand; *ii)* stakeholder involvement and buy-in to the concept of trading; *iii)* certainty in the program that mitigation results in credits and that enough credits will be available to meet regulatory requirements; and *iv)* low transaction costs relative to the anticipated credit prices and improvements in water quality. Because of the long ecosystem response-time delays associated with nutrient reductions, water quality improvements in Chesapeake Bay, and the effectiveness of the water quality trading programmes, are yet to be verified.

Case study: The Lake Taupō nitrogen market, New Zealand[10]

Water quality of Taupō Lake, a UNESCO World Heritage Site, had been consistently decreasing since the 1970s; elevated nitrogen levels were causing proliferation of microscopic algae, reducing water clarity and increasing the growth of weeds in near shore areas. Diffuse source pollution from pastoral farming was estimated to account for over 90% of anthropogenic nitrogen inflows to Lake Taupō, despite efforts of Taupō farmers to reduce diffuse pollution with extensive stream fencing, planting and riparian land retirement under a Taupō Catchment Control Scheme in the 1970s.

In response, the government, Waikato Regional Council, Taupō District Council and Ngati Tuwharetoa (the local iwi) implemented an innovative diffuse water quality trading project, comprising three components: *i)* a cap on nitrogen emission levels within the Lake Taupō catchment by OVERSEER® (see Box 3.4 for description); *ii)* establishment of the Taupō nitrogen market; and *iii)* formation of the Lake Taupō Protection Trust to fund the initiative. The costs were to be spread across local, regional and national communities; the independent Lake Taupō Protection Trust was established in 2007 to use public funds (NZD 79.2 million) to buy back allocated nitrogen allowances to retire land and to reduce the economic and social impacts of the nitrogen cap. The trading scheme was also complemented by the New Zealand Emissions Trading Scheme, which came into force during the early stages of the project and advanced the achievement of nitrogen reductions; the promotion of land-use change from pasture to forestry not only surrendered nitrogen discharge allocations, but also received carbon sequestration credits for a time.

The target was to reduce manageable nitrogen emissions to 20% below current recorded levels, so as to restore water quality and clarity to 2001 levels by 2080. The reduction of manageable nitrogen was initially estimated at 153 tonnes of nitrogen but later increased to 170.3 tonnes annual discharge reduction by 2018 as a result of improved benchmarking data. This was equivalent to reducing 153 tonnes of nitrogen annual discharge by 2018. Based on this catchment cap, each farm was allocated an individually-calculated nitrogen discharge allowance, consistent with the desired reduction in emission levels. This permitted them to leach a certain level of nitrogen every year, based on their previous levels of nitrogen use. This approach, known as "grandparenting" (see Table 3.1 for explanation), was not without contention among different stakeholders. Forest landholders and sheep and beef farmers saw it as inequitable; land development had opportunity costs, and farmers who had been a major cause of the pollution of Lake Taupō were rewarded with higher allowances. The OVERSEER® model provided the basis for generating farm-specific figures to establish nitrogen discharge allowances.

The ability to trade through establishment of the Taupō nitrogen market was a critical part of the negotiations. Farmers wanted flexibility and ability to increase production, or to receive direct financial benefits for reducing nutrient leaching. As part of the market design, only landowners in the catchment can buy, sell and trade nitrogen allowances; this was thought necessary to avoid outside investors purchasing and trading allowances for capital gain. The cap-and-trade policy began in July 2011. By 2013, all farms in the catchment had applied for resource consents and had been benchmarked for their nitrogen discharge allocation. By mid-2015, the Trust had secured contracts to meet the 170.3 tonnes of nitrogen target reduction, and there had been 12 private nitrogen discharge allowance trades between regulated farmers (totalling 18 tonnes of nitrogen).

A recent review of the Lake Taupō nitrogen market (Duhon et al., 2015) found that a cap on nitrogen has limited the nitrogen leaving agricultural land. However, the cap has also had negative impacts on those affected, including reduced ability to intensify production, decreased land values and significantly increased administration and compliance costs. All of these trade-offs were necessary to address the environmental problem of excessive pollution. The Lake Taupō Protection Trust, which funded decreases in nitrogen, significantly reduced the costs borne by farmers but came at a high cost to government. Motu (2015) suggests that regulators should continue to reduce trading transaction costs. Making allowance price information available to farmers would be useful, as would any policies that increase the future liquidity of the market.

The policy package has been fully implemented. It is providing the flexibility for land to move to its highest value and best use, and still meet the overall nitrogen load reduction targets. The use of the model OVERSEER® is essential to the cap-and-trade programme, providing incentives for farmers to reduce nitrogen emissions. The Lake Taupō Protection Trust has permanently retired 20% of the original nitrogen discharge allowances. New lower-nitrogen ventures are emerging in the catchment, such as growing olives, farming dairy sheep, and producing and marketing "sustainable" beef. The environmental certainty enables development of added-value products with credible green branding. It also generated positive environmental impacts, particularly carbon sequestration, from the reforestation of more than 5 000 ha of land to pine plantations.

Payment for ecosystems services

Payment for ecosystems services (PES) can internalise water pollution and other environmental externalities through the Beneficiary Pays Principle by incentivising polluters to change their behaviour. For example, downstream beneficiaries of improved water quality (such as water utilities, industry, city councils and recreational users) pay upstream farmers in return for land management practices that reduce pollution. Payments to reduce diffuse water pollution from agriculture in OECD countries are most commonly for a reduction or cease in the use of fertilisers and pesticides, for the retirement of arable land, and for the establishment of riparian buffer strips.

In Germany, a voluntary payment scheme offered by the municipal water provider of Munich gives payment to upstream farmers to convert to organic farming processes to reduce nitrates and pesticides (Box 2.4). The scheme was more environmentally effective and cost-efficient than upgrades in water treatment to remove nutrients and pesticides.

In England, PES schemes are gaining in popularity with water utilities, with improved outcomes not only for water quality and reduced water treatment costs, but also for biodiversity, flood management and environmental flows (Box 3.7). To reduce concerns about equity that can arise if PES payments are seen to "reward polluters" while neglecting producers already demonstrating best practice, there is a need for collective compliance by farmers with baseline regulation so as to achieve "additionality" in response to PES incentives (OECD, 2013b).

Box 3.6. **Co-operation with farmers for catchment protection in Munich, Germany**

The Mangfall Valley in the Bavarian Alps supplies around 80% of Munich's drinking water for its 1.2 million inhabitants. The Valley is predominantly used by farmers and agricultural producers whose activities were causing slow but significant increases in nitrates (15 mg/L) and pesticide concentrations (0.065 µg/L) in the city's water resources. To address the issue, in 1991 the municipal water provider Stadtwerke München (SWM) implemented a voluntary payment scheme to encourage local farmers to adopt more sustainable organic farming practices.

After estimating the target area using hydro-geological models, SWM launched a public information campaign targeting 120 farmers (mainly dairy producers). The payments were constructed to cover the expected lost income and investments needed to switch to organic farming; more precisely, farmers received a payment of EUR 280 per hectare per year (ha/year) for the first 6 years after the change, and EUR 250/ha/year for the following 12 years.

The programme successfully halved nitrate concentration to 7 mg/l; the price increase for final urban consumers due to the payment scheme (EUR 0.005 per cubic metre [EUR/m^3]) was lower than the avoided cost of water-treatment facilities (EUR 0.23/m^3). More than 90% of the farmers adhered to the programme. The Munich area is now considered the largest and most active market for organic farming products in Germany.

One of the key success factors of the programme was the city's strong involvement in purchasing and promoting the organic products from the Mangfall Valley. Not only did the city purchase the organic farming goods to supply its schools and municipal restaurants, it also funded several marketing and advertising campaigns aimed at creating a brand identity for the targeted area's agricultural goods. These measures helped build trust between urban and rural water consumers and – together with a clearly defined set of legal rules regulating organic farming practices in Germany – reduced the contractual and transaction costs of implementing the payment scheme.

Sources: OECD (2015d); Grolleau and McCann (2012).

Box 3.7. Collaboration with farmers and Payment for Ecosystem Services schemes in England

Problems of water pollution from point sources such as factories and other industrial activity have declined through both structural change in England's economy and effective regulation. Although some legacy water quality problems from industrialisation (e.g. old mine workings, now managed through public investment in the absence of historic polluters), and morphological alteration to waterbodies as a result of human activity (e.g. navigation, hydropower, flood defence activity), the most significant modern water quality problem is diffuse pollution, particularly from agriculture. Agricultural subsidy frameworks, inconsistent land use planning systems, and under-reported and under-regulated diffuse pollution, have contributed to water quality pressures.

The primary pollutants which water utilities have to deal with are nitrates, phosphates, sediments and pesticides. It is estimated that since the 1989 privatisation of the water sector (supervised by three regulators and national government), water utilities have invested around GBP 1.7 billion in traditional drinking water treatment approaches to reduce the levels of pesticides and nitrates. The scale of these costs has been a key driver for the industry to pursue new ways of working with land managers to reduce pollution at the catchment scale. In recognition that, in a wider social sense, it is not efficient to pollute at source through sub-optimal land management practices and then have to consume resources downstream to remove pollution, water utilities began considering diverting investment from traditional water treatment into land management as payment for ecosystem services (PES).

"Upstream Thinking" is South West Water utility's catchment management scheme which has been applying natural landscape-scale solutions to water quality issues since 2008. The PES scheme draws upon the knowledge and expertise of a number of partners including South West Water, the Devon Wildlife Trust, the Cornwall Wildlife Trust, the Westcountry Rivers Trust, the Exmoor National Park Authority, and local farmers to improve raw water quality at source. Over the 2015-20 period, the latest GDP 11.8 million programme is focussing on 11 catchments across Devon and Cornwall. The target for the programme is 750 farms and 1 300 ha of moorland and other semi-natural land under revised management.

Upstream Thinking targets priority pollutants associated with different catchments – typically nutrients, pesticides, and sediments. Farm advisers visit farms and carry out an assessment resulting in a whole-farm plan to reduce nutrients, pesticides and sediments. This includes a water management plan and future capital investment proposals targeted at water quality improvements. Up to 50% of capital investment proposals are funded by Upstream Thinking. These can include improvements to slurry storage, fencing to keep livestock out of rivers, providing alternative water sources for livestock, and improved pesticide management including investment in new equipment such as weed wipers which deliver targeted doses of herbicide.

The Upstream Thinking programme has also successfully investigated and restored over 2 000 hectares of sensitive upstream land on Exmoor in 2010-15 to improve peatland, and reduce sediment loads and flood risk downstream. The overall programme is fully endorsed by the Environment Agency, Natural England and the Drinking Water Inspectorate. The work is targeted to benefit 15 water treatment works supplying 72% of the total daily water to customers.

Although physical evidence is emerging on the water quality benefits of working with land managers in catchments through water companies making investments to pay for ecosystems services, the economic evidence on the costs and benefits of the approach has been slower to emerge. In its 2011 report, *From Catchment to Customer*, Ofwat (the economic regulator) acknowledged a lack of hard economic evidence on the net benefits of land management PES approaches. It also highlighted the role for polluter-pays mechanisms alongside the beneficiary-pays approach which characterises the water company schemes.

Box 3.7. **Collaboration with farmers and Payment for Ecosystem Services schemes in England** *(cont.)*

Nevertheless, Ofwat does see a role for PES schemes, saying "Water customers could legitimately expect to pay for those elements of catchment management that bring direct and measurable benefits to them, under the principle of paying for ecosystem services" (Ofwat, 2011). In 2009, Ofwat approved ultilities' proposals to spend £60m on water quality investigations and PES schemes throughout England and Wales, representing something of a departure for Ofwat.

Sources: Summary of full case study provided by Nick Haigh, Defra, UK; UK Environment Agency (2015); National Audit Office (2010); Ofwat (2011).

Financing mechanisms

Improved financing models and public-private partnerships (PPPs) are required to finance investments to replace aging infrastructure, and adapt to population growth, urbanisation, climate change and increasing water quality regulation. For example, it is estimated that the United States faces a water infrastructure investment deficit of USD 384 billion over the next 20 years (US EPA, 2011). Capital is needed for investment in thousands of miles of pipes, as well as thousands of treatment plants, storage tanks, and other key assets to ensure the public health, security, and economic well-being of cities, towns, and communities (US EPA, 2011).

Two case studies are presented:

- The United States State Revolving Funds provides an example of a sustainable infrastructure financing model. Set up with "seed money" from the United States Congress, the State Revolving Funds capitalise a state-administered financial assistance program to build and upgrade wastewater treatment plants and drinking water infrastructure, as well as invest in other projects to improve water quality (such as measures to reduce diffuse pollution and water recycling). In doing so, the Funds support a longer transition and ample flexibility to set up long-term financing to promote state and local self-sufficiency.
- London has established a novel Government Support Package, to attract private financiers and reduce insurance liabilities, to deliver the Thames Tideway Tunnel project – a major construction undertaking to intercept London's combined sewer overflows for treatment to improve water quality of the River Thames.

Case study: State revolving funds for water quality protection, United States[11]

In 1987, after the United States Congress amended the Federal Water Pollution Control Act, the federal government handed down responsibility for funding and constructing wastewater infrastructure, and improving the nation's water quality, to state and local government. In doing so, the United States Congress created the Environmental Protection Agency-administered, state-domiciled Clean Water State Revolving Fund (the "CWSRF" or "SRF") programme to replace the EPA administered Construction Grants Program. This programme was designed to replace direct federal assistance that had been provided in the form of grants, in favour of a new funding model that offered states resources to operate a financial assistance program on behalf of local governments where dedicated resources would revolve in perpetuity.

There were a number of objectives served by the change to the CWSRF. Firstly, it conformed to a long held federal view that local governments are ultimately responsible for funding projects needed to protect the nation's water quality. Secondly, shifting day-to-day control for financial assistance to the states was thought to be a better delivery model for state and local governments. The change was also expected to reduce the claim on federal resources supporting municipally-owned treatment works, and to expand the menu of eligible projects, including projects that address diffuse sources of pollution.

The CWSRF programme created authorised federal funding ("seed money") for a limited five year period. Federal funding was contingent on a 20% state match for every federal dollar appropriated. The law provided that funds could support a number of financial assistance options including loans, the purchase of debt obligations, to use as pledged security for municipal bond transactions, financial guarantees and investment. Repayments of obligations to the state by eligible recipients of CWSRF financial assistance would provide for build-up of a renewable source of capital for future investments. The intention was that states would have flexibility to set priorities and administer funding.

Since its creation, states have used the CWSRF financial assistance to support more than USD 110 billion in financial assistance. Such assistance has largely been delivered as loans, debt obligation purchases and bond security. Through 2015, financial assistance has leveraged federal investment by 280%. The early success of the CWSRF encouraged the United States Congress to create the Drinking Water SRF (the "DWSRF") as part of the 1996 amendments to the Safe Drinking Water Act. The reasons for doing so were: *i)* increased nutrient contamination (from both point and diffuse sources) was putting drinking water sources at risk, *ii)* increased regulation of a number of new contaminants required large investments in treatment technology to meet statutory requirements, and *iii)* many of the nation's 52 000 small community water systems were likely to lack the financial capacity to meet the rising costs of compliance with Safe Drinking Water Act. Through 2015, the DWSRF had leveraged federal investment by 171% and delivered USD 30 billion in financial assistance to public water systems. The majority of states have leveraged federal and state investment by entering the bond market to boost programme capacity.

The table below illustrates the amount of funds leveraged from federal seed money of the SRFs between 2010 and 2015. Bond financings undertaken on behalf of multiple local governments have merited triple-A ratings due to the level of equity overcollateralization and loan portfolio diversification. Under most SRF credit structures, the net loan rate to the borrowers is a function of the over-collateralized cash flows. This is, in turn, a function of federal tax law which limits investment to the related tax-exempt bond issues' cost of funds.

Table 3.4. **Clean Water and Drinking Water State Revolving Funds: Funds Available for Projects**

2010-2015 (Billions of U.S. Dollars)

Funding mechanism	CWSRF	DWSRF
Federal Capitalization Grant	39.5	17.5
State Match	7.4	3.2
Net Leveraged Bonds	35.7	8.1
Net Interest Earnings	8.2	1.7
Net Transfers between SRFs	-0.3	
Funds for re-funding	-1.6	
Administration Set Aside	-1.6	-0.6
Other Set Asides		-2.1
Total funds	**87.3**	**27.8**

Note: CWSRF = Clean Water State Revolving Fund; DWSRF = Drinking Water State Revolving Fund
Source: Environmental Protection Agency, United States

The CWSRF and the DWSRF have enabled States to shape their programmes to their specific needs, characteristics and capabilities. Projects served under the CWSRF include wastewater treatment plant (WWTP) upgrades to secondary and tertiary treatment, combined sewer overflow corrections, measures to reduce diffuse pollution, and recycled water. In addition to investment in water infrastructure, the DWSRF was critical in quickly channelling much needed resources to boost economic activity and remediate storm-damaged infrastructure in the aftermath of Hurricane Sandy in 2012.

Twenty five years in, the attributes of the SRFs increasingly look like that of an endowment, designed to operate in perpetuity. The CWSRF and the DWSRF are currently in a position to not only meet their mission objectives as presently understood, but are also in a position to expand their product offerings to support new water quality and public health funding solutions while employing endowment investment strategies to grow the capital base. For these opportunities to be realised, EPA and the SRF administrators need to reconsider existing legal and institutional frameworks that present barriers to higher programme performance. This can be done by *i)* implementing endowment-like investment strategies that could subsequently accelerate returns based on general market investment; and *ii)* developing targeted investment strategies that could yield both investment returns and innovative technological advancement (such as investment in green infrastructure and market-based solutions to diffuse pollution). The CWSRF and the DWSRF also require a more concerted effort to engage and educate stakeholders of the SRFs' true capabilities.

Case study: A public-private approach to delivering the Thames Tideway Tunnel, United Kingdom[12]

London's combined sewer system was constructed over the period 1859-75. Designed to serve a maximum of 4 million people, and to accommodate both domestic sewage and stormwater runoff, the significant increase in London's population to 8 million over the last 150 years means that there is no longer sufficient capacity in the sewer system during periods of rainfall. As a consequence, the combined sewer overflows (CSOs) originally designed as "safety valves" discharge untreated sewage and stormwater to the River Thames, on average, once per week (in excess of 40 million tonnes of sewage each year).

After assessing a range of options to address the problem, the most economically feasible solution was to build a new tunnel – the Thames Tideway Tunnel (TTT) – under the bed of the Thames, to intercept the CSOs, transferring wastewater to the Beckton sewage treatment works for processing. Other options considered, such as widespread introduction of sustainable urban drainage systems to deal with surface water runoff, and constructing a new separate drainage network for stormwater water (in both cases, to release pressure on the main combined network), were found to be too costly or not feasible. End-of-pipe, in-river solutions to deal with CSO pollution once it had entered the Thames, such as skimmer vessels and oxygen bubbling, were also considered, and although not found satisfactory as a long-term solution, have been employed on a limited scale to mitigate the worst impacts pending the construction of the TTT.

An economic cost-benefit analysis of the TTT estimates welfare benefits of GBP 7.4-12.7 billion for a whole-life project cost of GBP 4.1 billion (Defra, 2015; Eftec, 2015). However, despite the economic benefits significantly out-weighing the capital investment costs, the exceptionally high risk profile of the project (i.e. the unprecedented scale and major tunnelling work under one of the world's most complex cities) inflated the cost of borrowing (high risk premium) and reduced the ability of Thames Water (the private water utility) to secure finance for the project through the normal capital markets at something approaching a reasonable cost for its customers.

In response to the difficulty of attracting finance for the TTT, the national government, Ofwat (the financial regulator) and Thames Water put in place public-private arrangement to enable risks to be managed and underwritten to the point that private capital markets were prepared to finance the project on reasonable terms. The key principle behind developing a risk-sharing model for the TTT was that different parties have different capacities to mitigate and absorb different risks, which in turn affects financing costs and ultimately the feasibility of a project.

A novel Government Support Package for the TTT project was constructed, which provided contingent public financial support under very specific circumstances. It is provided for a fee and comprises five agreements:

- *Supplemental compensation agreement:* the government provides an insurance facility to the project for cover above the limits of commercial insurance, including if commercial insurance were available at the beginning of the project but subsequently becomes unavailable.
- *Contingent equity support agreement:* if the costs of completing the TTT are forecast to escalate beyond a specified point (the "Threshold Outturn") the project will have the option of requesting that government make an injection of equity to allow it to be completed. If the government receives such a request, it is committed to provide this equity, subject to its right to discontinue the Project (see below).
- *Market disruption facility:* in the event that the project is unable to access debt capital markets as a result of a sustained period of disruption in these markets, the government would provide temporary liquidity.
- *Special administration offer agreement:* if the provider should go into Special Administration and not have exited after 18 months, the government commits to either make an offer to purchase the provider (at a price at its discretion), or to discontinue.
- *Discontinuation agreement:* the government will have the right to discontinue in a number of circumstances, in particular, in the event that the costs of completing the TTT are predicted to escalate beyond the Threshold Outturn and the project requests an injection of equity from the government, or if insurance claims exceed a specified amount. Where the government opts to discontinue the project, it commits to paying compensation to existing equity and debt investors. This agreement of the government support package acts to ensure that the government does not assume unlimited liabilities.

As a result of the public-private risk-sharing model and the Government Support Package, an infrastructure provider and a construction consortium have now both been appointed and construction of the TTT is proceeding and expected for completion in 2023. The competition for both the infrastructure provider and the construction contracts were highly competitive. The winning bid for the infrastructure provider offered a weighted average cost of capital of 2.497%, which is fixed, subject to the terms of the project licence, until the first price review following construction. The construction procurements delivered a target build cost which is unchanged from that estimated in 2011 (GBP 4.1 billion).

Under a scenario without the support of the government, it is very likely that the TTT project would have been unfeasible; assuming financing would be forthcoming, an estimate of the cost was approximately GBP 10 billion. Therefore, as a result of the public-private risk-sharing model, water and wastewater bills for households (the ultimate funders of water sector investment) are kept at reasonable levels, and protected in the event of catastrophic risks (the maximum additional cost is estimated at GBP 20-25 per customer per annum by the mid-2020s (in 2015 prices), down from an earlier estimate of a maximum of GBP 70-80 (in 2011 prices).

Costs to the government have been carefully defined to only arise in very specific, low probability circumstances. In the absence of risks materialising, the cost to the government is zero, but the presence of the Government Support Package as a "backstop" gives comfort to the private sector and enables efficient private financing.

A collective management approach to water quality management

Stakeholder engagement through inclusive water governance is increasingly recognised as critical to secure support for reforms, raise awareness about water risks and costs, increase users' willingness to pay, and to handle conflicts (OECD, 2015c). In the last decade, stakeholder engagement has gained traction in the water sector in OECD member countries in response to new legislation and guidance requiring greater inclusiveness, transparency and accountability (OECD, 2015c). A collective management approach with stakeholder engagement in setting regulations at the local level (with an overarching national water quality baseline) can create buy-in, increase trust in government processes, and ultimately find effective solutions to achieve desired water quality outcomes. This is demonstrated in the case of the Canterbury region, New Zealand, which also includes challenges and requisites for success. An additional case study on the "Catchment Based Approach" in England further illustrates the importance of local governance arrangements for improving water quality management (see oecd.org/water for the case study).

Case study: A collaborative governance model: The Canterbury Water Management Strategy, New Zealand[13]

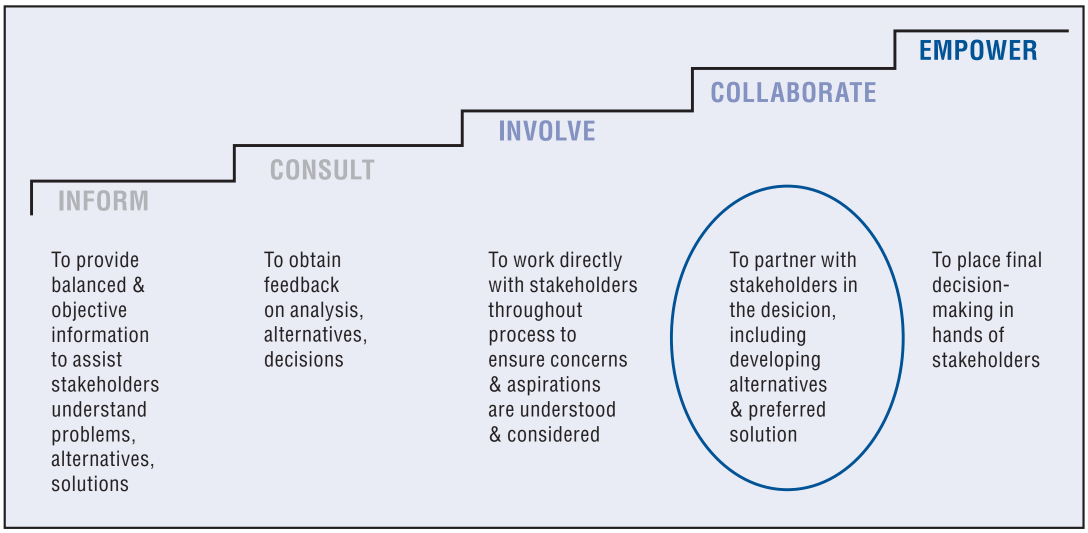
The region of Canterbury contains 70% of New Zealand's irrigated land, 65% of the nation's hydroelectricity storage capacity, an extensive groundwater system, highly prized coastal lagoons, lowland waterways valued for cultural and recreational use, and world-renowned braided river systems. In the early to mid-2000's, public concerns about deteriorating water quality, reduced reliability of water supply for irrigation, and dissatisfaction with the adversarial approach to water management became widespread. The community at large had reached breaking point due to over-allocated water resources, pressure from droughts, and degraded water quality, primarily from diffuse pollution from agriculture.

In response to these problems, the Canterbury Water Management Strategy (CWMS) was developed over the years 2007-2009 to provide a framework for a collaborative approach to water management and with targets across all interests in water. The CWMS is a new paradigm for water management in Canterbury. It has three key features: *i)* delivering environmental, economic, cultural and social outcomes together ("parallel development", defined as 10 targets); *ii)* A shift from effects-based management of individual resource consents for individual landowners to integrated management of catchments; and *iii)* A collaborative governance framework where "local people, plan locally".

The CWMS is a partnership between the regional council, district councils, and the Māori (indigenous) tribal authority in Canterbury - Ngāi Tahu. The region is divided into 10 zones (based on a combination of hydrology, administrative boundaries, and communities of interest) and each zone has a Zone Committee comprising of four-eight representatives of the local community with a range of interests in water, representatives from district and regional councils, and representatives from the local rūnanga (Māori sub-tribe). The task of each committee is to develop Zone Implementation Programmes with recommendations and actions for achieving each of the ten targets laid out in the CWMS.

The committees operate at the "collaborate" step on the engagement staircase (Figure 3.3), and "involve" their local communities in their deliberations and decision-making (in the form of field trips, workshops, and one-on-one meetings) to ensure that communities are part of the solution. Each of the committees is supported by facilitation, planning, and technical (including scientists) staff to help them understand issues and develop potential solutions. The Committees and support staff are funded through general regional taxes.

Figure 3.3. **The stakeholder engagement staircase**



Source: Case study submitted in full by Nic Newman, Environment Canterbury, New Zealand.

Once committees have developed their Zone Implementation Programmes and submitted them to the Canterbury Regional Council and district and city councils, they are given effect to through any one, or a combination of, the following three pathways:

- Regional plans under the New Zealand Resource Management Act (1991) to give effect to statutory recommendations e.g. catchment load limits for water quality;
- Agency work programmes to give effect to non-statutory recommendations e.g. stream restoration, or irrigation efficiency programmes; and
- Infrastructure work programmes and matching central and regional government funding to give effect to recommendations related to infrastructure and restoration.

As an example, the Upper Waitaki Zone Committee (established in 2010), with the help of the local community and technical support (with expertise in economics, cultural values, social science, modelling, water quality and ecology) developed a Zone Implementation Programme comprising of: *i)* desired community water quality outcomes; *ii)* recommendations for water quality limits based on maintaining the trophic state of Lake Benmore; *iii)* catchment nutrient loads for all activities; *iv)* the method of allocating the nutrient loads; *v)* methods to incentivise biodiversity protection (e.g. an easier resource consent pathway for development that is accompanied by biodiversity protection); *vi)* non-statutory actions such as an education campaign for visitors; *vii)* a rehabilitation programme for degraded water bodies; and *viii)* an integrated monitoring framework for the Zone to track progress and to share data.

In terms of nutrient loading, the technical assessment indicated that any further development (that resulted in an increase in nitrogen loss) beyond what was consented in the Ahuriri Arm of Lake Benmore, would risk the lake moving from an oligotrophic state to a mesotrophic state. The community considered this risk to be unacceptable. In accordance with this decision, the decision made to "grandparent" modelled nitrogen losses to individual land owners based on current land-use at "good management practice", and then use a "modified equal" method of nutrient allocation where there was room for intensification. This solution sought to make the best use of the potential for further development by allowing intensification on the most productive land in an equitable way without comprising water quality outcomes.

The Collaborative Governance Model not only resolved how to set water quality (and quantity) limits and other actions to deliver on the CWMS targets, but also facilitated delivering on the National Policy Statement for Freshwater Management. Recommendations made to the Canterbury Regional Council by Zone Committees for specific planning provisions have been implemented through plan changes to the Canterbury Land and Water Regional Plan (2015).

Six of the ten Zone Committees have now been through a rigorous process and reached consensus on water quality and water quantity limits for their zones. There is widespread agreement that there is no going back and collaboration is the only way forward; the paradigm has changed. The success of the collaborative approach is now spilling over in to other sectors, such as public transport governance.

One of the most tangible outcomes is community ownership of solutions. For example, in one zone, the community (via the Zone Committee) agreed to increase local taxes to support the maintenance of a key water infrastructure asset now that the wider benefits provided by this asset are more clearly understood. In another zone, the community have taken ownership of lagoon augmentation as part of the local solution and they (not the council) are working together to figure out how to design and pay for it. When people are part of developing solutions, they are invested in seeing them come to fruition. An outcome most frequently quoted by participants is the personal development of their own skills and knowledge, and appreciation for alternative views. Additionally, the relationships and social capital built has enabled progress to be made on issues that have been stuck for years that are outside of the CWMS, for example dealing with gravel aggradation in a river. By bringing people together to solve problems, the sum is greater than the total of the parts.

Challenges associated with a collaborative governance process include speed of implementation and delivery; inherently, collaborative processes move at the "speed of trust". There is variable capacity of community members to understand and assimilate information that includes complex biophysical, cultural, social and economic data. Also, community members have to dedicate considerable time to the collaborative process (time commitment can vary from a minimum of at least half a day a month to fortnightly meetings and workshops, with pre-reading). Added to this, committee members are often exposing themselves to their community by fronting difficult conversations and solutions. Finally, if safeguards are not put in place to ensure all stakeholders have equal representation, disproportionate capture of vested interests in collaborative groups can reduce the potential to achieve ambitious water quality limits in a timely manner.

Based on the experience of the CWMS, requisites for a successful collaborative governance approach include:

- *Objective and clarity of the process*. The CWMS set out the principles, targets, and methodology "up-front" and removed any doubt over scope, process, and what was trying to be achieved.

- *Commitment and clarity from governors on the lines of decision making.* The Canterbury Regional Council delegated significant power to the zone committees by agreeing to endorse all of the committees' recommendations where these are the consensus of the committee and have been developed with strong stakeholder and community engagement.
- *Absolute transparency with information and process,* including having difficult conversations in sessions that are open to the public and making all technical information freely available. Traceability is important; the wider community needs to be able to know when, where, why and how, certain decisions were made. It is critical to get right, and be clear about, the scale of operation - hydrological, social, and administrative.
- *Resourcing needs to match the level of ambition for stakeholder engagement and responsibility.* The most substantial expenditure is the support staff. Facilitators need to be able to deal with ambiguity, to think and work across disciplines, and be committed to developing resolutions but not transposing their own ideas (i.e. to be "knowledge brokers"). Technical support staff who provide science, hydrology, planning, biodiversity, cultural and infrastructure advice need to be able to communicate at various levels and the facilitators need to be prepared to "hold a space" for stakeholders who may not be well resourced or articulate.

Notes

1. Refer to Chapter 1 for an explanation of the different characteristics of point versus diffuse source pollution.
2. Fertiliser taxes can cause an additional burden on horticulture production while making livestock production more profitable. They may also provide unintended incentives to increase livestock levels, leading to greater manure production through more intensive protein feeding, larger acreages devoted to nitrogen-fixing plants and reorganisation of crops in favour of those with less nitrogen consumption, but not necessarily less nitrogen surplus (OECD, 2010).
3. Summary of case study provided in full by Jihyung Park and Sang-Cheol Park, Ministry of Environment, Korea.
4. Summary of case study provided in full by Dr. Alec Mackay, AgResearch, New Zealand.
5. The One Plan is the new regional plan to guide the management of natural resources in the Manawatu-Wanganui region of New Zealand. It is called the One Plan because it weaves together resource management plans (air, land, water quantity, water quality, biodiversity, coastal, natural hazards) and the Regional Policy Statement into one easy-to-use document. The Plan became operative on 19 December 2014. www.horizons.govt.nz/about-us/one-plan/.
6. OVERSEER® is a software application that supports farmers and growers to make informed strategic management decisions about their nutrient use on-farm to improve performance and reduce losses to the environment. New Zealand farmers will increasingly use the model to develop nutrient management plans and budgets, as required by regional councils. The model does not include economic analysis, so outputs needs to be combined with other economic models to assess impacts of options on the farm business. http://overseer.org.nz/.
7. For details, www.hbrc.govt.nz/hawkes-bay/projects/tukituki/plan-change-6/.
8. Water quality trading is a market-based mechanism that allows sources with high pollution control costs to purchase credits, or pollution discharge reductions, from sources with lower pollution control costs.
9. Summary of case study provided in full by Sara Walker, World Resources Institute, DC, United States.
10. Case study sourced from: OECD (2017), *OECD Environmental Performance Reviews: New Zealand 2017*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264268203-en.
11. Summary of case study submitted in full by Jim Gebhardt, Environmental Protection Agency, United States.
12. Summary of case study provided in full by Nick Haigh, Defra, United Kingdom.
13. Summary of case study submitted in full by Nic Newman, Environment Canterbury, New Zealand

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