CLIMATE CHANGE EFFECTS ON AQUATIC ECOLOGY AND THE FUTURE FOR STORMWATER MANAGEMENT

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ABSTRACT

Climate change is predicted to have varying effects on the regions of New Zealand. The general effects in the eastern regions will be extended drought periods and decreased seasonal rainfall. In contrast, northern regions will likely experience more intense rain and storm events.

The environmental effects of climate change will be extended periods of low base flow during drought in the eastern regions and subsequent stress on aquatic biota. In Auckland effects will be increased flash floods and seawater inundation of freshwater systems, with similar detrimental effects on aquatic species.

Regional and District Plans are starting to give strong direction towards water sensitive design and the requirement to improve the aquatic environment during stormwater management planning. It is likely these statutory requirements will increase in the future. It is difficult to predict what the stormwater industry will be like post 2050 but it is obvious the nuanced effects of climate change will require adaptation and management, we are already seeing some of these effects.

In this paper we look at the likely environmental effects of climate change in two contrasting regions of New Zealand, how these will affect aquatic ecology and the implications for stormwater management. Risks and opportunities to aquatic biota along riparian margins will be discussed, with a multidimensional assessment of climate change impacts on aquatic species and its impact on the water quality in our waterways given. Technical developments and potential tolls for adapting to climate change in New Zealand are also provided.

KEYWORDS

Climate Change, Aquatic Ecology, Water Quality, Water Sensitive, Northern, Eastern, Hydrology

PRESENTER PROFILE

Paul has 5 years' consulting experience in ecology and environmental science disciplines, specialising in terrestrial and aquatic ecology with a strong emphasis on stream assessments and restoration. Paul also has experience in wetland and estuarine ecology. Paul is a member of the Opus Auckland Environmental team, specialising in ecology.

Emily is an experienced marine ecologist and environmental consultant. She has expertise in the assessment of ecological effects and mitigation options, environmental risk assessment, ecological survey design, and marine biosecurity management. Emily is a Principal Ecologist in the Opus Auckland Environmental team.

1 INTRODUCTION

The effects of climate change are unavoidable and the best response is preparation and management. New Zealand is already experiencing higher temperatures (0.9 °C warming over the past 100 years), fewer frosts, ocean warming and acidification, less snow cover in alpine areas, glacier retreat and sea level rise (about 17 cm over the past 100 years) (Ministry for the Environment, 2017). As well as the warming of the Earth there are effects on wind, rainfall and oceans. Climate change will alter the frequency and intensity of environmental risks and hazards, as well as introducing long-term shifts in climate regimes. This includes extreme weather-related events such as heat waves, floods, storms, cyclones, droughts and landslips. Many of these changes impact on stormwater quantity and quality, requiring adaptation of management practices to avoid and mitigate effects on freshwater and marine receiving environments.

This paper seeks to highlight the issues we face as the impact of climate change on stormwater management becomes more acute. The best areas we can influence as stormwater professionals and the potential to work together with ecologists and other specialists is presented.

Changes to intensity, frequency and duration of stormwater volumes will result from altered rainfall patterns and these will impact stormwater systems. Increased water temperatures will result in the lowering of pH and increased solubility of metal contaminants. Integrated management options such as riparian vegetation management, integrated water management, green infrastructure, and technological advances are suggested as methods to manage stormwater during future climate change events.

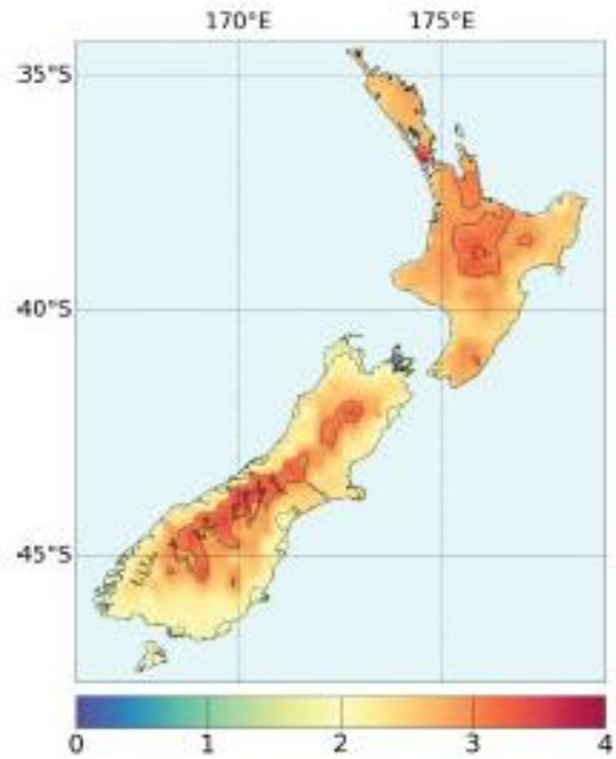
2 CLIMATE CHANGE PREDICTIONS FOR NEW ZEALAND

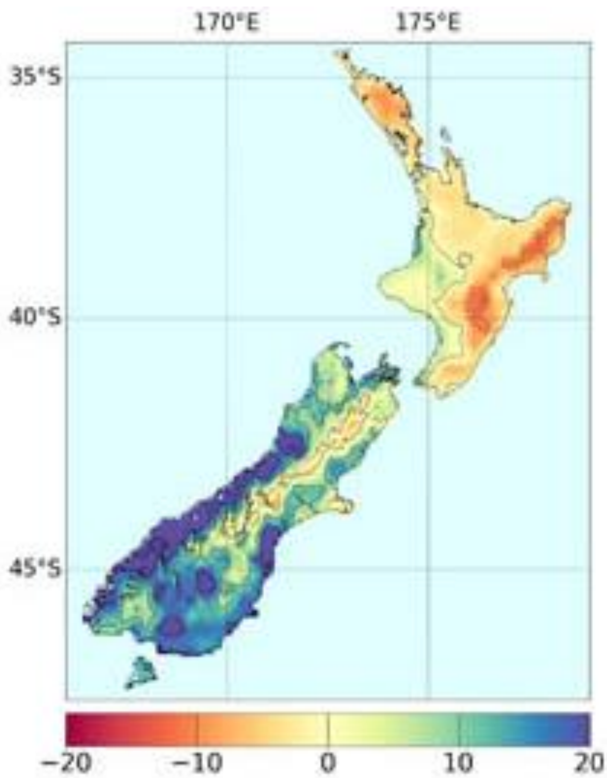
Table 1 presents a summary of the main features of New Zealand climate change projections for 2040 and 2090 of relevance to future stormwater management in New Zealand, adapted from the Ministry for the Environment (2008). Figure 1 shows the annual average temperature (left) and rainfall (right) changes for New Zealand by 2090 under a high emissions scenario compared to the 1995 baseline (Ministry for the Environment, 2017). The best estimates of New Zealand temperatures are for an expected increase of about 1°C by 2040, and 2°C by 2090 (Ministry for the Environment, 2017). Projected rainfall and wind patterns show a marked seasonality. During winter, there will be more rainfall in the west and drier conditions in the east and north and, conversely, in summer and autumn there will be drier conditions in the west of the North Island and possible rainfall increases in the east.

Table 1: Main features of New Zealand climate change projections for 2040 and 2090 (Source: Ministry for the Environment, 2008)

Climate variable	**Direction of change**	**Magnitude of change**	**Spatial and seasonal variation**
Mean temperature	Increase	0.9°C to 2040, 2.1°C by 2090	Least warming in spring
Daily temperature extremes	Fewer colder temperatures and frosts, more high temperature episodes	Frequency distribution moves towards higher temperatures	-
Mean rainfall	Varies around country and with season Decreases in annual means in north and east	Substantial variation	Tendency to decrease in eastern coasts in summer and autumn.
Extreme rainfall	Heavier and/or more frequent extreme rainfalls, especially where mean rainfall increase predicted	Halving of heavy rainfall return period by 2040 and to fourfold reduction in return period by 2090	Increases in heavy rainfall most likely tin areas where mean rainfall is projected to increase

Figure 1: Annual average temperature (left) and rainfall (right) changes by 2090 under a high emissions scenario compared to the 1995 baseline. (Source: Ministry for the Environment, 2017).





3 CLIMATE CHANGE IMPACTS ON STORMWATER

3.1 OVERVIEW

Based on the projections described above, there will be a number of impacts on stormwater and receiving aquatic environments (Royal Society of New Zealand, 2016). Changes to intensity, frequency and duration of stormwater volumes will result from altered rainfall patterns. Timing of storm events will change, driven by a shift in seasons. Water quality will be altered through increases in water temperature lowering pH and increasing metal solubility. Nutrient concentration will increase from higher runoff volumes and changes in water chemistry

There may be increased risk to coastal roads and infrastructure from coastal erosion and inundation, increased frequency and intensity of storms, and sea level rise. Warmer temperatures will alter habitats that are critical to some species, increasing the risk of localised extinction and introduction of tropical species. Warmer temperatures will favour conditions for many exotic species as well as the spread of disease and pests, affecting both fauna and flora. Flow-on effects from changes in stormwater quality and quantity will further impact on already impacted coastal environments.

Planning for stormwater management is based on local weather and climate. These changing conditions have implications for stormwater management as local decision makers look to improve existing infrastructure and build new stormwater systems. Climate change risks that could impact on stormwater management are likely to include:

- More variation in water volumes/increase in intensity
- Increased frequency and/or volume of drainage system flooding
- Increased peak flows in streams and related erosion
- Sedimentation and weed growth
- Changes in type/distribution of pest species
- Effects on water quality; lowering of pH, increased metal solubility

3.2 FRESHWATER QUANTITY IMPACTS

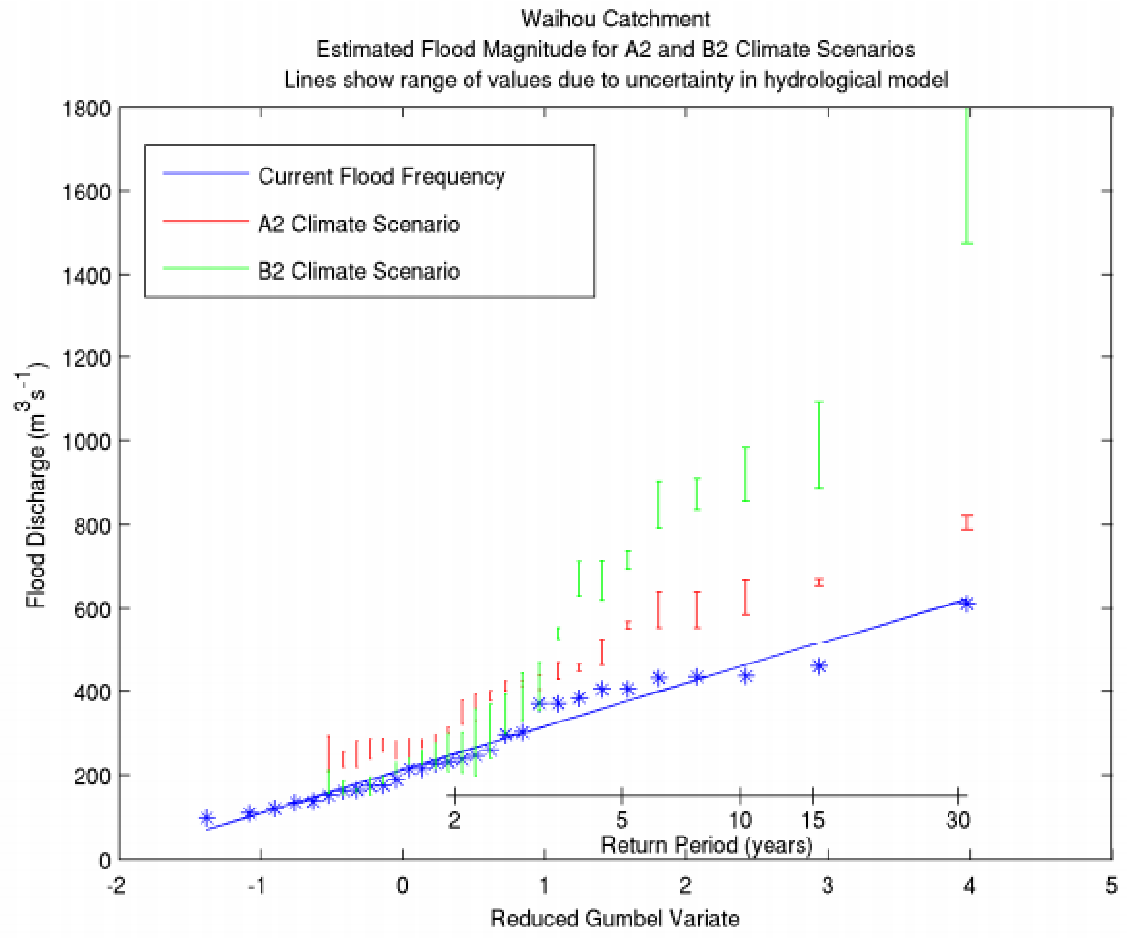
Altered hydrology through changes in rainfall patterns, intensity, and snow/glacier melt is predicted to occur as global temperatures increase. Any alteration in intensity, duration and frequency of major storm events or droughts will have a detrimental effect on aquatic ecosystems. Physical characteristics of the water and geometry of the channel are a result of stream flow. These aspects combine to maintain specific taxa that are suited to the particular habitat. High flow or prolonged low flow can reduce periphyton biomass, fish populations and reduce invertebrate diversity (Paul and Meyer, 2001). High flow in particular can have a direct effect on invertebrates by transporting them downstream or reducing refuge sites for fish.

The natural timing of hydrological events is particularly important in fish for environmental cues for spawning. Reduced flow eliminates this signal, resulting in disruption to fish's life history processes and a decrease in sensitive species. The types of stressors present will also elicit a functional shift in the biota that can persist in the stream. For example if there is an increase in macrophyte biomass due to prolonged low flow there should be an increase in macrophyte piercers (Miserendino and Masi, 2010). This can then have a cascade effect that alters the whole food web as other functional feeding types such as predators increase in response to the increase in macrophyte piercers.

Models have predicted that floods will be significantly larger over a 15-30 year return time in two New Zealand catchments in Northland and Gisborne, as shown in Figure 2 for the Waihou River in Northland (McMillan et al., 2010). These more frequent, larger floods will have associated increases in sediment transport and stream bank erosion. Mobilisation of sediment will have negative effects on aquatic ecosystems through deposition and smothering of streambed habitat. Changes to the structure of the streambed from sediment deposition can decrease invertebrate abundance and diversity. Fish will then be impacted through lack of prey availability. Water clarity is also impacted by increased sediment mobilization, with corresponding impacts on photosynthetic activity and ability of fish to move through the water column.

Erosion is another issue that will result from more intense rainfall events. Channel incision and widening may occur to accommodate the larger discharge rate. Scouring of the stream bank will have a similar effect to sedimentation, whereby the streambed habitat is modified and a decrease in aquatic biota occurs. Erosion of streambanks will also have a detrimental impact on habitat for *Galaxiid* native fish that require stable, slightly undercut banks for shelter (Hale et al., 2014).

Figure 2: Predicted changes in flood frequency expected under two climate change scenarios in the Waihou Catchment, Northland (Source: McMillan et al. 2010).



3.3 FRESHWATER QUALITY IMPACTS

3.3.1 WATER CHEMISTRY

Many organisms living in natural waterways are pH sensitive and even small changes in pH levels can reduce the diversity of organisms in aquatic conditions. The pH concentration is largely influenced by the natural processes of photosynthesis and respiration in aquatic plants and algae. In waterways, plants and algae consume CO_2 and water, and harness light energy from the sun to produce glucose (organic matter $C_6H_{12}O_6$) and oxygen (O_2) during the natural biological process of photosynthesis. Photosynthesis occurs close to the surface because this is where sunlight exposure is greatest and, as a result, the upper layers of waterways are oxygen rich (Water Encyclopedia, 2017). Stored chemical energy is released by respiration whereby plants and algae consume oxygen and glucose while water, carbon dioxide and energy are released. Respiration occurs deeper in lakes and rivers where sunlight does not penetrate and results in zones that are poor in oxygen.

The varying levels of dissolved oxygen in the water will affect the redox reactions that occur, thus influencing pH. The presence of dissolved oxygen promotes oxidation and a lack of oxygen encourages reduction processes to occur. Common examples include SO_4^- being reduced to H_2S and CO_2 dissolving in water after respiration occurs to create carbonic acid. The consequence of reducing dissolved oxygen levels and producing basic compounds through reduction processes such as OH^- and SO_4^- is that the pH of the water will increase (Lenntech, 2017). If the concentration of dissolved oxygen drops and reducing conditions are promoted, nitrate is reduced to ammonia and ferric iron is reduced to ferrous iron which enables phosphorous to be released into the water and encourages organic growth.

Increasing atmospheric temperatures as a result of climate change have several important effects on the biological and chemical processes which naturally occur in waterways. Increases in atmospheric temperature cause the temperature of water to rise. As the water temperature increases, the solubility of oxygen decreases and the concentration of dissolved oxygen starts to drop. Native species that cannot survive with reduced oxygen levels will often be replaced by invasive exotic species that can survive in these conditions (Franklin, 2014). Upper layers of waterways become warmer as a result of increasing temperature slowing the exchange of oxygen between air and water. This causes large dead zones to form where oxygen levels are depleted and toxic algal blooms form as a result.

Changes in pH also affects the solubility of organic compounds, metals and salts. When the pH of the water is low, minerals can dissolve more easily and release harmful chemical substances into the water. In more acidic conditions, metal contaminants become more mobile and are released into the water.

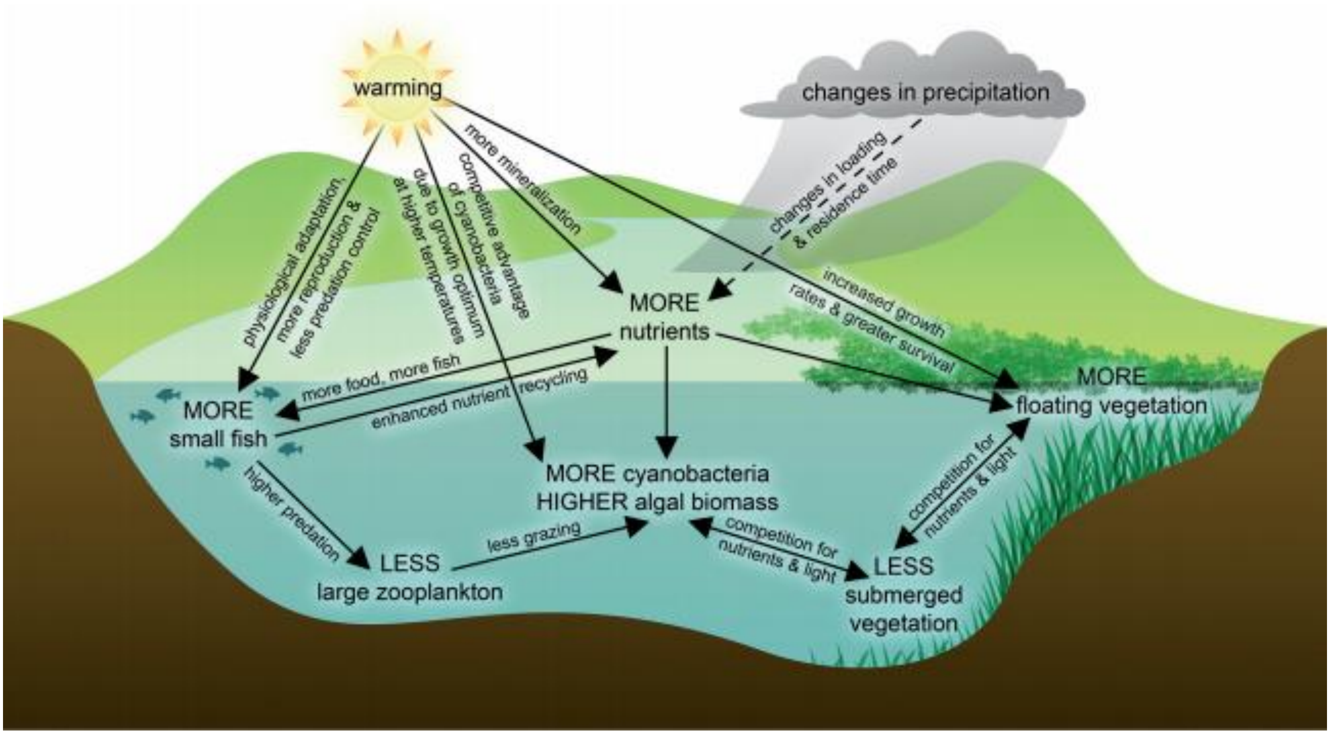
3.3.2 EUTROPHICATION

Climate change is predicted to increase the intensity of storms and shift rainfall patterns to be more irregular. Altered rainfall will increase runoff and thereby increase the diffuse nutrient load entering waterways (Figure 3). The commonly understood human drivers of eutrophication, including nutrient run-off from soil and fertilisers, and untreated sewage discharge have been recognised as the primary drivers of eutrophication. However, when the nutrient load is reaching a constant level in waterways, physical factors such as increasing temperature, precipitation, and solar radiation are generally expected to increase the risk of eutrophication.

Eutrophication usually occurs more easily in small, still waters such as lakes or reservoirs. Mounting evidence shows that eutrophication has occurred in many large and free-flowing waterways (Xia et al., 2016). The increase in nutrients, coupled with faster reproduction and physiological adaptation, will skew fish populations to smaller individuals. More abundant smaller fish will predate and deplete zooplankton numbers. The combination of higher temperature optimizing growth, less zooplankton grazing, and more nutrients available, will result in more cyanobacteria and higher algal biomass caused by climate change.

The consequence of eutrophication is to increase the biological oxygen demand (BOD) within the system. BOD is a measure of the amount of oxygen consumed by microorganisms when organic matter decomposes. Oxygen is consumed by organisms in the water to breakdown organic material from primary producers and this causes the concentration of dissolved oxygen in the water to decrease. When the dissolved oxygen concentration is reduced below a critical threshold, the habitat becomes unable to support life and dead zones dominated by cyanobacteria or algae are formed.

Figure 3: Some established relationships linking climate change and eutrophication (Source: Moss et al. 2011)



3.4 IMPACTS ON MARINE ENVIRONMENTS

3.4.1 SEDIMENTATION

Estuaries and coastal areas are also particularly vulnerable to climate change and alterations in stormwater run-off and streamflow quality and quantity. Significant increases in rainfall intensity will likely undermine design assumptions of stormwater systems and increase the frequency of overflow events. Sediment loading to the marine environment is typically a non-linear function of streamflow with an increase in total suspended sediment concentration as flow increases. High suspended and deposited sediment loads pose a serious threat to coastal ecosystems (Kelly 2010). Excess sediment contributes substantially to poor coastal water quality (Najjar et al., 2010). Thus climate change has the potential to either undo efforts to meet water clarity goals.

Sedimentation has contributed to the expansion of mangroves in New Zealand resulting in a reduction in the extent of other habitats (primarily sand and mud flats) and species. Deposits of land-derived sediment rapidly kill most benthic macrofauna or, at the least, lead to a reduction in species diversity and abundance. The rate of recovery after deposition tends to be slow, taking more than a year. Suspended sediments reduce water clarity, light levels, food quality, and the feeding efficiency of animals. Typically, the physiological condition and survival rates of marine species frequently decline as suspended sediment concentrations increase (Kelly, 2010).

3.4.2 POLLUTION

Metal and organic contaminants (such as copper, lead and zinc) in stormwater runoff are bioavailable and accumulate in the tissues of shellfish, fish, birds and other invertebrates. The risk of contamination is increased for coastal water with the risk of more frequent stormwater overflow events resulting for extreme rainfall. Furthermore, stormwater contaminants are known to compound the effects of other environmental stressors and differentially affect rare species and large species. These effects could, therefore, compound in marine systems that are already under stress from other climate change effects such as ocean acidification and warming, coastal inundation and sea-level risk which will subsequently create stressed biological communities and habitats. Elevated stream temperatures (i.e., by the discharge of warm water from stormwater detention ponds) are also likely to be harmful to temperature sensitive invertebrates and fish.

3.4.3 TROPHIC DISRUPTION

Phytoplankton production and species composition in coastal waters generally follow predictable seasonal patterns dictated primarily by streamflow, light, and temperature (e.g., Najjar et al., 2010). The seasonality of streamflow into coastal waters is extremely important because it helps to regulate the timing of the phytoplankton blooms and is also very important in regulating nutrient delivery marine environments (Najjar et al., 2010). Overflows and increased streamflow have the potential to increase nutrient loading (eutrophication) in coastal areas, leading to higher planktonic production. Combined with higher water temperatures, these impacts could result in changes in the timing of phytoplankton blooms, which could cause trophic uncoupling (i.e., affecting food webs) or change the spatial distributions of particular taxa (Edwards and Richardson, 2004). Concern about nutrient runoff and eutrophication is increasing, particularly from rural catchments.

3.4.4 SHORELINE STABILITY

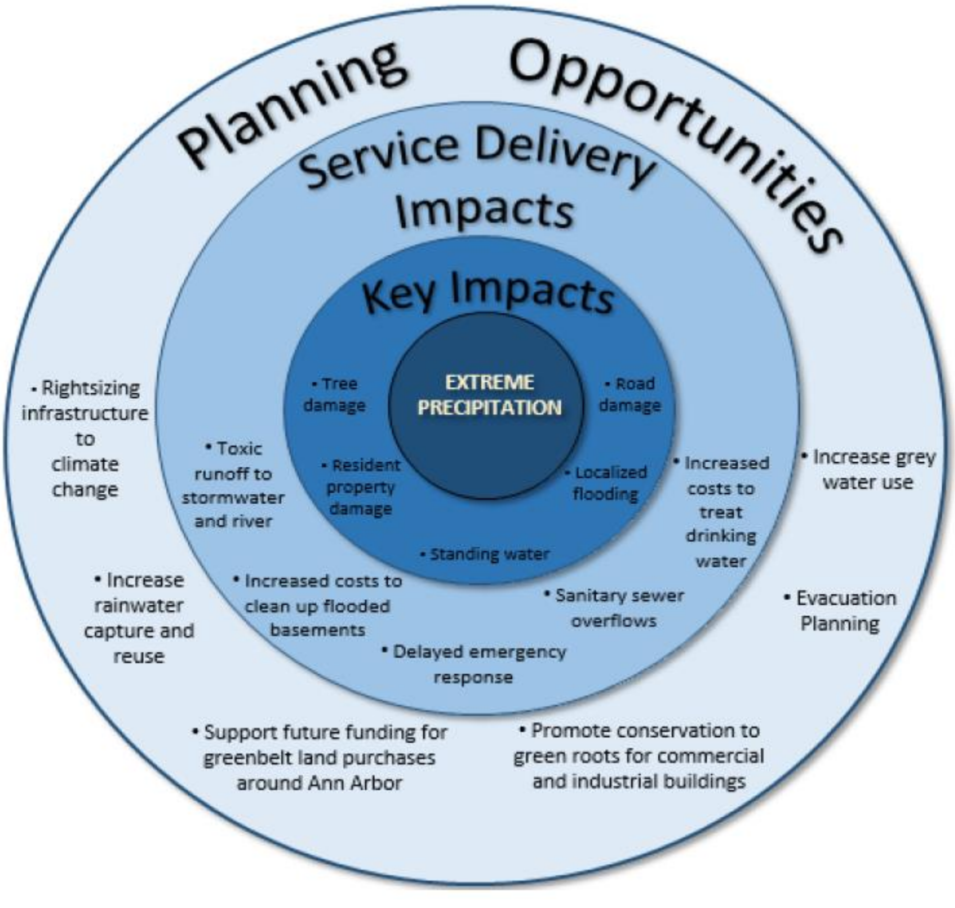
Changes in the flow regime of rivers could cause modifications to river mouths, which in turn could impact on estuarine systems. Shifts in sediment delivered to the coast from the adjacent catchments could also lead to long-term shifts in coastline geomorphology and shoreline stability (Bell et al., 2001). Sediment supply or availability may increase above historical rates due to increased storm rainfall intensity, leading to advancing shorelines. Changes in coastal habitats have flow-on impacts on biological communities and habitats, typically altering the type and quality of the habitat available to native species and allowing for non-native organisms to invade where they are more tolerant of changing conditions.

4 FUTURE STORMWATER MANAGEMENT

4.1 OVERVIEW

There are likely to be a variety of scenarios and options available for managing climate change effects and adapting stormwater management. For example, the diagram in Figure 4 shows planning opportunities for management of increased rainfall, including stormwater management issues, brainstormed for the Great Lakes states of Minnesota and Michigan, United States (Asam et al. 2016). The exercise considered how this aspect of climate change might trigger a series of impacts across a city's service areas and infrastructure and is a tool intended to help participants see how the impacts that their service area may experience are related to other service areas in the city.

Figure 4: Example of climate change management tool for determining climate change impacts and adaptation strategies, for extreme precipitation in US cities (Source: Asam et al. 2016)



Stormwater management is planned based on local weather and climate. However, climate changes, such as the amount, timing, and intensity of rain events, in combination with land development, can significantly affect the amount of stormwater runoff that needs to be managed (Bell et al. 2001). Climate change has implications for stormwater management as local decision makers look to improve existing infrastructure and build new stormwater systems. Incorporating climate change predictions into stormwater design is important if infrastructure is to maintain the same level of service throughout its lifetime, particularly stormwater drainage systems, irrigation schemes, and development of low-lying land already subject to flood risk (Ministry for the Environment, 2008).

Addressing climate-driven changes in runoff can be done through altering or modifying stormwater practices and land use management decisions. The vulnerability of New Zealand's freshwater systems and the variability of the coastal environment means that mitigating or adapting to the impacts of climate change for such a wide range of environments will entail different local investigations and solutions (Bell et al. 2001). Some options are discussed below. The identification of knowledge gaps and opportunities is key to forward planning for adaptive stormwater management.

4.2 RIPARIAN MANAGEMENT

The need for riparian management is even greater under future climate change scenarios. Shade provided by native trees is critical to maintain lower water temperatures and adequate DO levels. Water quality can be improved as most runoff passes through the soil and vegetation of the riparian margin before it enters the water column.

The presence of a functioning vegetated riparian margin helps protect the physical aspects of a stream. Vegetation roots hold stream banks together and reduce erosion and channel incision caused by higher peak flows. Flooding effects can be mitigated by a riparian margin composed of a diverse set of plants by reducing water velocity when flows overtop stream banks (Auckland Regional Council, 2001). As more frequent, intense rainfall events increase under climate change it will be important to expand riparian planting programmes to help reduce the detrimental effects of increased water quantity on natural conveyance systems.

Shade provided by vegetation over the channel serves to moderate water temperatures and DO levels within an optimal range required by native biota. The temperature and DO moderating effects of shade also contribute to the maintenance of neutral pH levels and metal insolubility. As water temperatures broadly rise under climate change, expanding and maintaining riparian margins will be a vital management strategy. A large focus is on the width of the riparian margin, however stormwater practitioners may need to concentrate on the lineal length of planting as well. Connecting fragmented riparian margins would also be critical to maintain even water temperatures throughout the catchment.

4.3 EROSION AND SEDIMENT CONTROL

We already have robust sediment and erosion control for the construction phase of projects. The guidelines set out by many TLAs are tailored towards retaining large enough proportions of mobilised sediment during earthworks. It is likely future iterations of these guidelines will improve the construction sediment and erosion control as technology advances. The challenge will be to counter the increased sedimentation that will occur in waterways as a result of more frequent and severe peak flows becoming more common. More extensive riparian planting will help, however stormwater conveyance channels will need to widen to accommodate the increased flow. A consideration is would the widening that needs to occur be done through engineering or could it be left to occur naturally? It is feasible for dewatering and diversion to occur on some waterways to enable engineered widening. In situations where the engineered solution is impractical or too expensive, how would sedimentation be controlled during natural widening that would take place over an extended period of time?

4.4 WATER SENSITIVE DESIGN

The likely increased quantity of stormwater under climate change will require management in the form of detention and water sensitive design. At source management as opposed to 'end of pipe treatment' will become more important. The Auckland Unitary Plan is moving towards this objective and it is likely future regional plans throughout New

Zealand will go even further. Integrated water management is a vital concept to reduce the amount of stormwater generated by a development. Future cities could be entirely composed of buildings that harvest rainwater for potable water, thus reducing stormwater outflows (watersensitivecities.org.au, 2017). Imperviousness could be reduced through semipermeable pavement. The same cities could have vertical gardens and hanging raingardens to treat stormwater runoff from any impervious areas that cannot recycle rainwater.

Urban design can be an effective way to manage stormwater. Long commute times increase vehicular traffic and contribute to the contaminant load on stormwater systems. Cities that have well designed public transport corridors and where employment opportunities are close to where people live will help reduce the number of commuting vehicles on the road. Reducing a building footprint by going up instead of out would reduce the roof area and minimise stormwater generation.

Green urbanism is an interdisciplinary concept that has been developed over the last 35 years (Lehmann, 2010). Green urbanism combines the skills of stormwater engineers, ecologists, urban designers, sociologists, economists and other specialists. Water and biodiversity, including climate change management, urban water management, water recycling, stormwater detention, and aquatic ecology combines with energy and materials and urban planning and transport to create the three pillars of green urbanism. The desired outcome is a fully sustainable city that creates zero waste and is self-sufficient. Such an interdisciplinary approach is one of the key strategies that can be employed to manage the effects of climate change on stormwater management.

4.5 TREATMENT

Current treatment procedures concentrate on reducing total suspended solids (TSS) within the stormwater system. This is important and should continue, however it may be necessary to also target dissolved solids (DS). If water temperatures increase as a result of the planet warming, it is likely contaminants will become soluble and a larger proportion will not be attached to solid particles. Phytoremediation is the use of plants and associated soil microbes to reduce the toxic effects or concentrations of contaminants in the environment (Ali et al., 2013). It is useful for heavy metals, organic pollutants and radionuclides. Multiple methods have been developed to remove contaminants through plant uptake (Figure 5).

Figure 5: Different techniques available for phytoremediation (Source: Ali et al. 2013).

Technique	Description
Phytoextraction	Accumulation of pollutants in harvestable biomass i.e., shoots
Phytofiltration	Sequestration of pollutants from contaminated waters by plants
Phytostabilization	Limiting the mobility and bioavailability of pollutants in soil by plant roots
Phytovolatilization	Conversion of pollutants to volatile form and their subsequent release to the atmosphere
Phytodegradation	Degradation of organic xenobiotics by plant enzymes within plant tissues
Rhizodegradation	Degradation of organic xenobiotics in the rhizosphere by rhizospheric microorganisms
Phytodesalination	Removal of excess salts from saline soils by halophytes

Treatment or alteration of chemical properties of toxic metals through microorganism bioremediation has been developed in recent decades and could become more common as a future treatment option. Bioremediation involves biomolecules or types of biomass to bind and concentrate selected ions present in aqueous solutions (Coelho et al., 2015). Algae, bacteria, fungi, and yeast have been shown to lower concentrations of cadmium, lead, zinc, copper, arsenic, nickel, cobalt, cadmium, iron, or manganese.

Phytoremediation and bioremediation process offer flexible treatment approaches. As they are natural treatment process, they are also cost effected and can be easily integrated into the urban design. Phytoremediation and bioremediation are effective for removal of TSS in stormwater, however removal of DS is more problematic. It may be more effective to ensure water temperatures do not become elevated with subsequent lowering of pH to minimise the extent of metal solubility.

As dissolved oxygen is decreased through water temperature increases and an increase in BOD from eutrophication effects it may become more common to oxidise stormwater. Providing shade through riparian management is a simple way to moderate water temperature and maintain dissolved oxygen. Natural aeration may be another viable option where natural cascades are added to stormwater systems to oxygenate water.

Stormwater treatment ponds are currently designed to the maximum land development potential for the area they serve. It may be necessary to design them in the future to be deeper and larger to minimise stagnation and the likelihood of algal growth associated with higher water temperatures.

5 CONCLUSIONS

Some aspects of future stormwater management can be fixed by further refinement of standards such as GD04 for Water Sensitive Designs, GD05 for sediment and erosion control in the Auckland Region or the National Policy Statement on freshwater quality and quantity nationwide. Nutrient and DS removal may be incorporated into stormwater standards in addition to the current TSS requirements.

Policies can be changed to focus on a more interdisciplinary approach that incorporates the concepts of green urbanism. The Auckland Unitary Plan is moving in this direction with a catchment scale focus and a focus away from 'end of pipe treatment'.

New technology will play an increasing role in future decades. While at source treatment will be the guiding strategy, it will be important to monitor downstream systems to ensure desired outcomes are being met. New technology such as artificial intelligence will play a critical role in getting better and more data than is feasible with current technologies.

Environment in design is a fundamental concept that is incorporated throughout Opus projects through the collaboration between different specialists, industry, and regulators. We have adopted this to guide and educate the professionals in our company to address the future challenges while delivering the projects for our clients. As an industry we need to look at how we provide guidance to practitioners to give consideration to options that have a better outcome for the environment.

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