WATER QUALITY AND CLIMATE CHANGE

ORPHANAGE STREAM PILOT PROJECT

PRESENTED TO NELSON CITY COUNCIL

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Landcare Research
Manaaki Whenua

Contents

Introduction

Human populations have historically settled along freshwater streams and rivers. These “water-scapes” have utilitarian value such as access to food resources, drinking water, transportation, cleaning and sanitation, as well as aesthetic, recreational and spiritual values. Through all of these uses, human settlements including the domestic animals upon which we rely have had significant impacts on aquatic ecosystems. Humans have increasingly sought to live in urbanized landscapes for improved access to education, employment and higher socio-economic opportunities. Urbanization and population densification have exacerbated our impact on waterways. Impacts such as the physical modifications to rivers through channeling and straightening, water quality degradation and loss of aquatic flora and fauna have largely been driven by urbanization and land-use change.

The trends have not all been negative. Urban planning and design have allowed many cities to lessen, and in some cases reverse, the degradation of water quality through the use of improved use of water and wastewater infrastructure. However, urban streams in Nelson have consistently scored poorly in water quality monitoring tests (Nelson City Council, 2010). According to the summary report of the Land and Water Forum, an inter-disciplinary consultation on a future freshwater policy statement for New Zealand, “urban waterways remain highly polluted, including on account of sewage leakages, stormwater run-off and discharges from processing factories” (Land and Water Forum, 2010).

Water quality deterioration also impacts the coastal and marine environment (Forrest et al., 2007). New Zealand’s coasts and marine resources have high economic value through tourism, recreation and aquaculture, as well as cultural and spiritual value.

The impacts from a changing climate are an emerging threat to freshwater resources, especially coastal rivers and streams. Projected impacts include coastal erosion and innundation, higher storm surge flooding, drainage problems in adjacent low-lying areas, seawater reaching further inland in estuaries and coastal aquifers, changes in surface water quality, groundwater and sedimentation rates and increasing seawater temperatures (MfE, 2009).

Considering the interaction between freshwater and coastal ecosystems through an integrated approach provides a useful perspective for addressing these various issues. In short, freshwater and riverine systems affect the coast through degraded water quality entering coastal habitats, and in turn coastal processes impact freshwater ecosystems, especially in light of projected climate change impacts. Focusing on improving the resilience of urban coastal streams and rivers can help address both these issues. Controlling point source and non-point source pollution entering rivers will help reduce the contaminant and sediment load entering coastal estuaries.

A stream that is able to move within the floodplain and which has natural riparian corridors can provide a buffer against flooding, storm surges and extreme weather events, and other predicted impacts from climate change. Thus, working to build the resilience of urban coastal streams can have multiple benefits such as improved water quality and climate change adaptation.

Climate change is a global issue, but it is at the local level where most of the impacts will be felt. As such, regional governments need to be prepared to respond to climate change impacts. While impacts are forecasted to have effects in the long term, there are actions that can be taken now that will contribute to building more resilent communities today while also improving water quality.

Improved stormwater management is one area where immediate action can be seen as an investment in climate change adaptation and can help improve water quality in urban streams. Stormwater, during high flow conditions can have significant economic costs, through disruption of transportation links, damage to infrastructure, property, as well as degradation of water quality and other aquatic habitats.

Nelson is a coastal city with approximately 20 streams of varrying sizes flowing within the Nelson City Council boundaries. These streams, although small can swell rapidly and pose a risk to the surrounding area and floodplains. Moreover, flowing through rural as well as urbanized landcapes, the rivers carry sediments, nutrients, metals and a suite of other contaminants. These affect water quality, fish habitat and the offshore marine environment.

Improved management of stormwater through a suite of options can help to reduce contaminant loading in streams, can help reduce the speed at which water travels over the landscape, thereby reducing the peak flow conditions during extreme weather events that can lead to property damage. According to the Land and Water Forum, “floods are among the most frequent and costly natural disasters in New Zealand” (2010).

Local governments are often best placed to address land-use issues that give rise to degraded water quality as a result of stormwater. Land-use planning at the city council level can greatly help to prevent negative impacts from stormwater while also helping to prepare for hazards (natural or otherwise) that could damage infrastructure.

The research described in this paper examines one urban catchment in Nelson city. The purpose is to determine areas where land management practices can be improved in order to reduce the effects on Orphanage stream. Additionally climate change adaptation options are proposed that can help increase the resilience of the urban catchment.

The research conducted for this report included a synthesis of the monitoring data collected in the Orphanage Stream catchment since 2000, multiple site visits of the catchment and meetings with large land owners in the upper catchment, and an assessment of a range of climate change impacts on land and water in the catchment.

Nelson City Council Achievements

Nelson City Council (NCC) has been monitoring urban streams since 2000. Results from the monitoring indicate a downward trend in water quality in the urban streams. The council has therefore made urban water quality improvements a priority, which is in line with the community and wider interests.

NCC policies generally have worked to preserve riparian corridors through the application of Esplanade Reserve policies. As greenfield development occurs, the council aquires land adjacent to the stream, ten meters on either side of the stream and a minimum stream width of five meters. This helps to preserve riparian margins, which provide many benefits to the stream ecosystem, and forms a natural and vegetated corridor through the landscape. Moreover the Land Management department of NCC can assist property owners with 50% of the cost of fencing and planting along stream lengths in order to help improve land management practices through erosion control and nutrient management. Discussions are currently ongoing to encourage land owners in the upper catchment to install fencing along the streams to keep out grazing cattle and sheep.

The council is also working toward enhancing fish habitat, a ‘fish-friendly’ dam was constructed at the lower end of Orphanage stream as it flows into the Waimea Inlet, so as to allow diadromous fish to reach the upper stream. These efforts contribute to enhacing stream water quality, yet much more can be done to enhance the ecological value of Orphanage and other streams.

Developer Achievements

There is an observed positive shift amongst some developpers for improved land management practices. For instance Marsden Park, a proposed mixed-use subdivision in Marsden Valley, Stoke won the Nelson Environment Awards in 2010 for the Urban Design category because of its stormwater management design features. Developpers currently operating in the Orphanage catchment see the environmental and socio-economic benefit of investing in environmental assets and have worked to conserve the natural landscape features where possible.

One developer has worked to preserve mature trees on the properties where the new homes have been constructed. They have also embraced the natural features of the landscape and worked to incorporate them into the properties, thereby recognizing the stream as an ecological asset. Other developers have invested significantly in revegetating stream banks on exposed and erosion-prone slopes. This will help to reduce sediment load in the stream and once more canopy cover is established, will help lower water temperatures and algae growth by providing shade.

While these efforts by both city council and developers are good initiatives more is needed to improve the water quality ranking of Orphanage stream as well as other urban streams in Nelson. New developments in the growing residential area around Orphanage Stream result in significant change to the overall landscape of the catchment. More roads, driveways, footpaths, roof surfaces all increase the impermeability of the soil. Moreover, soil compaction during building also results in more impermeability.

Orphanage Stream Catchment Ecological Features

A summary of the monitoring results from Orphanage Stream are included to provide a background on the ecological features of the stream and the overall catchment. The monitoring results have been summarized from Wilkinson, 2007 of Cawthron Institute.

Orphanage Stream has a catchment area of 1,023 hectares and is located within the larger Stoke Fan and York Catchment area. Land-use in the catchment is varied; pine plantations and forestry operations dominate the slopes of the upper catchment on Nelson City Council land. Below, much of the land has been cleared where dairy cattle, sheep and goats are grazed. Stock have access to the stream in the upper area of the catchment, especially along the true left branch of the stream as well as the land between the true right branch and the true left branch.

Monitoring in the Orphanage Stream catchment has been ongoing sice 2000, when a sampling station was installed where the stream intersects Saxton Road. Data has been kept on record with Nelson City Council, with reporting taking place every two years through the State of the Environment Report.

Physical features

Orphanage Stream has a mean flow of 216 liters/second, a median flow of 84 liters/second and a 5-year low flow of 3 liters/second, it has the highest mean and median flows of all of the Stoke fan and York Streams. There are frequent culverts in the lower reaches of the stream as it flows through the urbanized and developed landscape. Approximately 400 meters upstream of the intersection with Suffolk Road, the stream splits into two branches, the East branch and the South branch.

In these upper reaches of the stream, the catchment area of both branches encompasses largely greenfields or undeveloped land. Some sections are being grazed, while other areas are in preparation for further residential development. The middle section of the East branch, above the intersection with Sunningdale Road, the stream runs parallel to Montebello Road and passes through what was previously a government-run orphanage known locally as Stoke Orphanage. On the property the stream flows through open culverting, and is also piped underground through certain sections, resulting in significant alteration to the natural flow of the stream.

In both of the upper branches of the stream the stream banks are well-vegetated with a mix of native and introduced species (willows, flax, etc). The canopy cover and vegetation along the stream banks helps to maintain water temperatures and provide a buffer for sediment and nutrients entering the stream. The coarse woody debris in the stream also provides habitat and refuge for fish species.

Bed composition

Where the stream has retained its natural bed composition it is largely dominated by gravel/cobble and boulder/cobble. Monitoring results show that the bed composition of the stream changes over time, varying from larger gravel and cobble to fine gravel and cobbles.

Water quality

Orphanage Stream has a history of extremely high levels of E. coli (> 410 cfu/100 ml and as mush as 3000 cfu/100 ml). The median concentration of E. coli has been at the upper limit of, or even exceeded the MfE guidelines for contact recreation.

High concentration measurements were generally associated with rainfall runoff events “when the flushing of diffuse catchment sources leads to concentrations that are greater than during dry weather flow” (Wilkinson, 2007, p.20). Water temperature was at a median of 13 degrees and generally good for the protection of aquatic organisms (trout and mayfly *Delaetidium*). Generally the acidity of the water was neutral, with a median pH of approximately 7.3 and a range of 6 to 8. Orphanage stream recorded a low percentage saturation for dissolved oxygen. The median concentration of dissolved oxygen in the Orphanage Stream was higher than

ANZECC (Australia New Zealand Guidelines for Fresh and Marine Water Quality) guideline level of 6 mg/L with some lower values recorded.

Nutrients

Nitrate (NO_3) concentrations have been recorded in the Orphanage stream to be at, or above the MfE guideline for limiting periphyton biomass. Such concentrations are sufficient to promote periphyton biomass.

Phosphorous (or disolved reactive phosphorous DRP) was below the MfE guideline for upper limit of periphyton biomass and above the ANZECC standard for adverse risk effects for lowland rivers.

Turbidity

Water clarity is generally poor, with low black disc measurements and high total suspended solids measurements. The median turbidity measurement in Orphanage stream is slightly above the Ministry of Health drinking water standards guideline value, and below the ANZECC default trigger value (upper limit) for the protection of aquatic ecosystems.

Macroinvertebrates

Orphanage stream has a low macroinvertebrate community index (MCI) score which indicates a moderate to severe level of pollution. This has resulted in a dominance of pollution-tolerant species *Potamopyrgus*, crustacea and worms and has prohibited the survival of pollution-sensitive species. The percentage of pollution-sensitive species (mayflies, caddis flies, stoneflies) fell from over 40% to below 20% in 2001 to 2002, and has remained low ever since. The reasons for this decline are unknown.

Periphyton

Periphyton scores indicated a strong presence of green filamentous algae (*Spyrogyra* and *Tribonema*), which is indicative of nutrient enrichment. This can be explained by the low levels of shading at the sites and high concentrations of nitrate and phosphorous.

Monitoring results from 2003 onwards indicate a drop in green filamentous algae and a much higher presence overall of thin brown mat. There was a strong presence of medium black/dark brown mat and thin black/dark brown mat in November 2005 and almost total dominance of thin brown mat in December 2006.

Stormwater

Information on stormwater quality for the Orphanage stream can be acquired from survey work done in the lower part of the catchment, where the land use is partly suburban and partly pasture and greenspace, with low gradients in the developed sections. Because of the mixed land-use in this test catchment it is a good indicator for the larger Orphanage catchment (Sneddon and Barter, 2004). The area surveyed is indicated in the figure below.

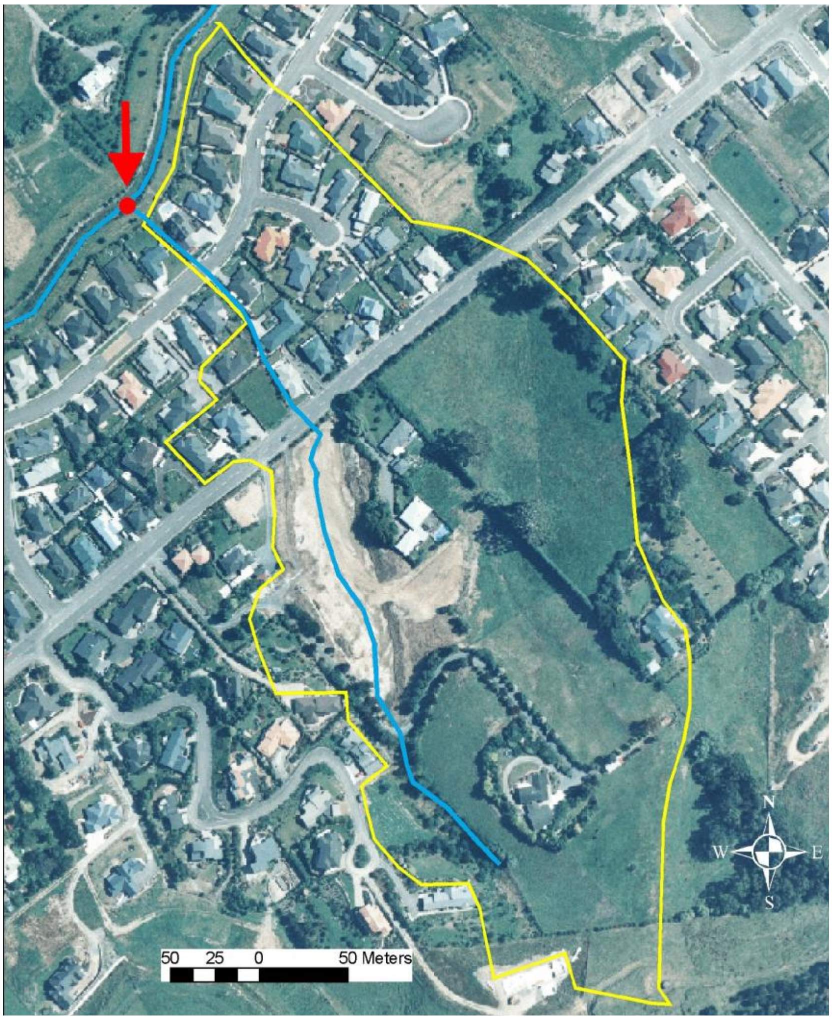


Figure 1: Kingsford Rd Test Catchment (Cawthron, 2004)

The catchment area surveyed flows into Orphanage Stream and encompasses one of the stream’s tributaries which is culverted under Suffolk Rd and Kingsford Rd.

The total area of the Kingsford catchment is 90,098 m^2, with a roof area of 6.2% of the total area, 12.3% is paved, for a total impervious surface cover of 18.5%. This test catchment reflects only part of the overall catchment type. Feacal coliforms were generally high in the Kingsford Rd test catchment, as compared to class C recreational bathing water quality MfE standards. Kingsford Rd had low suspended solids as compared to the other catchments in the NCC area (although it did have bare ground in its eastern boundary, low TSS values may have been due to low gradients in the developed sections). Total nitrogen and disolved reactive phosphorous exceed class C water quality guidelines. Copper and Zinc were the metals that were found in concentrations higher than class D NCC water quality guidelines. VOCs and SVOCs tested for were found to be below detection limits for “first flush” grab samples.

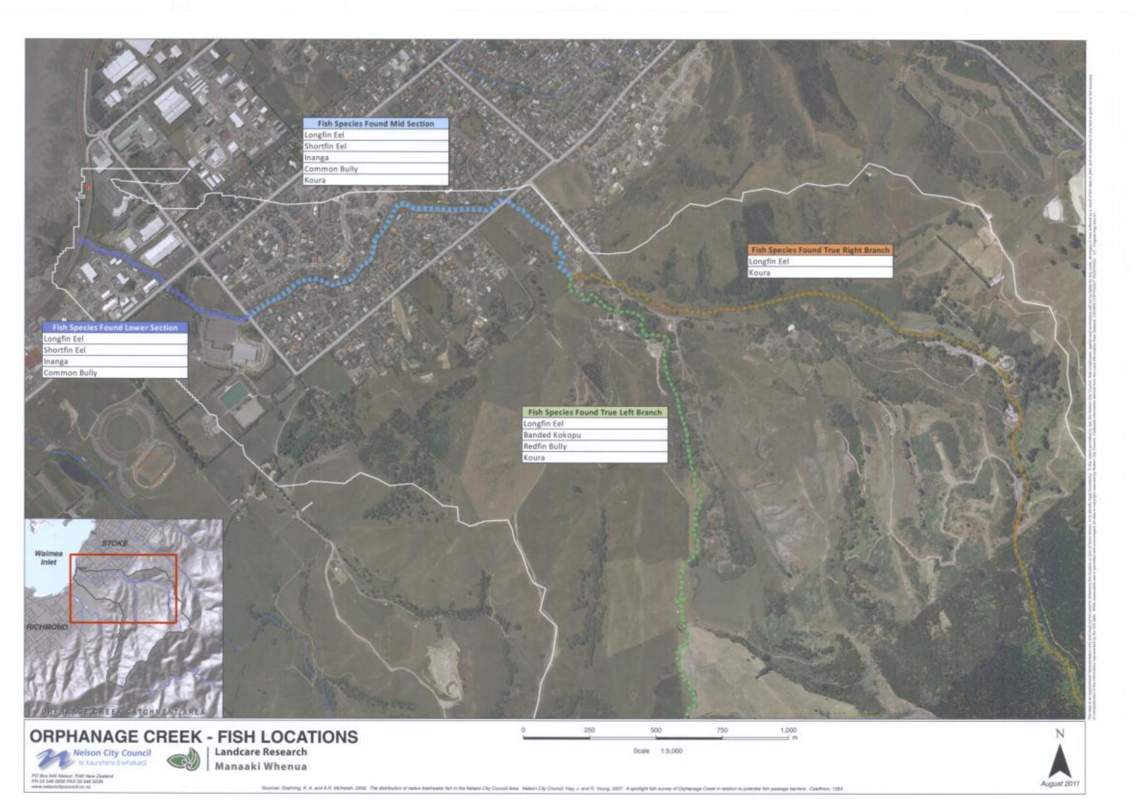
The range and concentration of contaminants found in the stormwater samples of the the Kingsford test catchment result from impervious surfaces such as roads and roofs. These surfaces are thought to contribute disproportionally to the area surveyed due to the absence of infiltration processes and direct chanelling of runoff.

Fish population

Two spotlighting surveys held in March 2007 and in February 2008 of Orphanage Stream yielded the following variety of fish species (Hayes and Young, 2007; Doehring, 2008):

- Inanga
- Short fin eel
- Longfin eel
- Common bully
- Yelloweye mullet
- Freshwater shrimp
- Koura
- Banded kokopu
- Redfin bully

The following image indicates where the various fish species were found in Orphanage Stream.



The coastal-freshwater interface is very important for native migratory fish species and fish survival is strongly affected by migratory barriers in urban streams. The fish surveys conducted in Orphanage Stream indicate fish species are present along the length of the stream.

Inanga were abundant to very abundant in small pools all along the river, even at Suffolk Road and above the Ngawatu flow recorder. Yelloweye mullet were found near the estuary and the Common bully was just upstream of the Whakatu Drive culvert. The Koura were quite abundant upstream of the the bridge at Saxton Rd. There were several recordings of Banded kokopu in Orphanage Stream, especially in the upper reaches, while shortfin eel were found in the downstream reaches. Longfin eel are more ubiquitous and found throughout the stream. Common bully is found in the lower reaches of Orphanage but absent in the upper reaches. Brown trout were absent from the stream.

The presence of banded kokopu in Orphanage Streams demonstrates that upstream migration and survival in urban upland streams is possible. However, Shortjaw kokopu (*Galxias postvectis*), a migratory native fish that is generally present in the upper part of the South Island was absent. Shortjaw kokopu is one of the five whitebait species, hence access to and from the sea is crucial for a successful life cycle (Doehring, 2008). Moreover, Shortjaw kokopu also rely on pristine spawning habitat with intact riparian vegetation and sufficient instream debris (Charteris *et al*. 2003). These conditions are rare in the lower reaches of NCC urban streams (Doehring, 2008). The only fish species found in the true right tributary to Orphanage stream was koura.

Sediment

Monitoring the sediment in a stream can provide valuable information on contaminant loading over time, creating a more accurate picture of water quality issues in the stream. Sediment samples from Orphanage Stream were analysed for grain size distribution, organic content, and a suite of metals and semi-volatile organic compounds (SVOCs) typically associated with urban stormwater. Trace metals and SVOCs are commonly occurring stormwater related contaminants that may be derived from road transport, urban road runoff, and agricultural runoff. The suite of metals analysed in this study (Cd, Cu, Pb, Zn) are often used as indicator metal contaminants that are typically associated with anthropological sources (Bennett, 2010).

Sediment samples for Orphanage Stream were taken from the lower section of the stream, near the Waimea Estuary. Primary issues of concern within the catchment are residental/urban impacts and issues and contamination related to livestock grazing. In comparaison to 2003 data for Orphanage Creek there was a small increase in metals (excluding Cu) and a small increase in PAHs. Marginal increases in total PAHs were recorded in sediments from Orphanage Stream but these were generally just above MDLs and all were below the corresponding ISQG-low (Interim Sediment Quality Guideline) criteria (Bailey and Conwell, 2006).

PAH's are produced as a by-product of fuel burning (either fossil fuel or biomass). Elevated levels of PAH could also be due to the burning of wood, coal or other fuel for home heating in the winter months and road runoff (Bailey and Conwell, 2006). .

Contaminant levels were below ISQG-Low metal concentrations in the Orphanage catchment (*ibid*). Change in coarseness of sediments from 2006 (mostly clay and silt) to 2010 (mostly coarse gravel).

Coastal Influence

The interaction between the coastal receiving body and the stream is crucially important for ecological processes such as fish migration, nutrient balance, water chemistry and maintenance of coastal and tidal processes. Orphanage Stream flows into the Waimea Inlet, which is the South Island's largest enclosed estuary (3,455 hectares) with a 65 km internal coastline. It is fed by 22 rivers and streams and is an important site for migratory birds including bartailed godwits and other endagered birds. It holds many recreational, commercial, tourism, cultural and spiritual values for the community.

There is a significant amount of development around the estuary margins, including an important transportation motorway for the South Island, Nelson Airport, as well as many commercial and industrial operations. Much of the land along the estuary has been infilled and coastal ecosystems such as salt marshes, muflats and wetlands are no longer present. With projected climate change impacts and sea-level rise, the absence of these ecosystems contributes to the vulnerabilities of the infrastructure and property along the coastline.

Coastal processes are having an impact on the urban streams, including Orphanage Stream with high tides, and storm surges becoming more likely.

Summary

E. coli levels in the Orphanage Stream are high, and frequently exceed MfE/MoH guidelines for contact recreation. A study undertaken by Cawthron Institute, commissioned by the Nelson City Council revealed that the sources of E. coli in Orphanage Stream come from General *Bacteriods sp.*, ruminant (livestock), and wildfowl (ducks and geese). Human associated *Bacteriods sp.* were not detected in water samples from Orphanage Stream. Ruling out the possibility of human sources of E. coli contamination can help target remediation efforts to livestock and other sources.

Erosion and landslips from steep and unstable slopes in the upper area of the catchment where cattle are being grazed is a source of sediment in the stream. High measurments of turbidity are indicative of unstable soils with sediment being washed away. Lack of vegetation on such surfaces could be a contributing factor to erosion and sedimentation.

Although some planting along stream banks has been done in newly developped sections, a concerted effort to fence and plant along riparian sections in the upper catchment, especially where stock is being grazed would assist in reducing E. coli levels in the stream, as well as suspended sediment. Both E.coli contamination and sediment are of primary concern for the coastal receiving water body and the stream itself.

The character of the stream in the upper catchment, above the Ngawatu monitoring station is varied. The North Branch flows through the site of a former government-run hospital and orphanage (the namesake of the stream). Certain sections of the stream are piped through the property, other sections have channeling and concrete culverts. The riparian corridors are well-vegetated and the catchment is relatively undeveloped.

Further water quality issues within Orphanage Stream stem from stormwater impacts and road runoff in the residential part of the catchment. This is mostly the area from the mouth of the river at the Waimea inlet to Montebello Sunnydale Road.

Even if planting is undertaken in the catchment along riparian corridors but nothing is done to control the quality or limit stormwater from its source then the stream ecology will remain degraded (Van Roon, 2009).

The various sources of contamination from different land-use types in the catchment require site-specific approaches for mitigation and water quality improvement. Approaches include preventing soil erosion and slips on steep terrain, fencing of streams to keep cattle out of the river, and planting along stream banks to provide a vegetative buffer for absorbing nutrients and other contaminants.

Current and Future Land-use in the catchment

The upper catchment of the Orphanage stream is currently in a position of transition and future residential development in the catchment needs to be undertaken with care to preserve the ecological integrity of the stream wherever possible. Although water quality indicators are currently low, there still remain a diverse variety of fish species of commercial importance. Moreover water quality and sediment loading in the stream has a significant impact on the Waimea Estuary, an important migratory bird sanctuary which has high ecological, economic, social and cultural value for the area.

With expanding residential development occuring in the Orphanage Stream catchment, the primary areas of concern are reducing impervious surface cover, preserving green space and vegetation on the landscape, maintaining riparian buffers for the stream and managing stormwater runoff through improved practices.

Innovative stormwater management practices are already in use in other parts of Nelson, and recent residential developments in the Marsden Valley showcases a number of these best practices.

Vegetated swales in Nelson

In addition, other cities in New Zealand are considering the benefits of improved stormwater management, Wellington's re-developed harbour front and Waitagi Park is a prominent example of how to provide public space while also working to protect urban water quality.

Stormwater management features in Waitangi Park, Wellington

It is anticipated that urban and suburban population in the Nelson, Stoke and Richmond region will continue to rise, including new developments in the orphanage stream catchment. Expanding suburban areas in this region can have significant impacts on water use, water quality and stream health as well as impacts on coastal receiving bodies. Nelson City Council, in collaboration with developers must take a proactive approach to ensuring new developments have a minimal impact on water quality by adopting best practices for stormwater management.

Best management practices for stormwater in rural and urban areas in the catchment include the following steps:

- Work collaboratively with developers to encourage the use of vegetated swales along roadsides, car parks and around impermeable surfaces.
- Provide educational material for homeowners on methods for controlling stormwater runoff on their properties. Consider amending building code regulations to allow rainwater tanks for use in garden irrigation, as storage can help to significantly reduce peak flows during high rain events.
- Encourage the use of rain gardens through educational initiatives and incentives.
- Continue outreach initiatives with land owners and farm managers in the upper catchment to encourage further fencing and planting along stream margins. Consider establishing additional monitoring stations in the upper catchment to monitor the effectiveness of fencing and planting initiatives.
- Continue to encourage developers in plans to minimize land-use change by protecting mature trees, preserving greenspace and valuing ecosystem assets.
- Provide incentives for green roofs and green design in future commercial space.
- Initiate community stewardship programs, in collaboration with the Waimea Inlet and other urban catchments.

Projected Climate change Impacts

Overall climate change impacts in the Nelson region are forecasted to be drier conditions and a rise in air temperatures by 1 degree by 2040. Other expected changes are "decreased frost risk, increased frequency of high temperatures, increased frequency of extreme daily rainfalls, decreased seasonal snow cover, and a possible increase in strong winds" (MfE, 2008. p.9).

> "Climate is often thought of as only the long-term averages of weather elements, but it actually also includes the range of likely values and the occurrence of extremes. Indeed, it is recognised that the largest impacts of climate change will probably be felt through changes in these extremes. […] Small changes in average values (for example, in average annual temperature) can result in large changes in the frequency with which climate extremes occur (for example, for frosts and very high temperatures, and similarly for heavy rainfall, floods and drought)" (MfE, 2008, p9).

While climate predictions can be difficult to assess overall, there is an increased agreement and recent observations confirm higher frequency and severity of extreme weather events such as high rainfall. It is the higher extreme rainfalls that are of concern for urban coastal streams. The concern is around water quality as well as hazard reduction.

Climate change and impacts such as sea-level rise, salt water intrusion and extreme weather events are important issues for Nelson as 99% of the population lives within 5 km of the coast (Statistics New Zealand, 2006). Institutions such as the New Zealand Climate Change Centre and Adaptation science have done much research into various IPCC models to assist policy decisions. More work is needed at the local government decision-making level to better assist regional governments in preparing for climate change.

Regional governments can no longer excuse delaying planning and decision-making on climate change impacts for want of more information. Actions can be taken in the short term to better prepare for climate change impacts and increase the resiliency of coastal communities. Improved stormwater management is one aspect of climate change adaptation that can reduce flooding risks in urban and suburban areas. Improved stormwater management at the catchment scale can be done in the short term and in some cases do not require large infrastructure costs.

The projected climate change impacts for 2040 and 2090 in New Zealand include:

- Increased mean temperature and daily temperature extremes
- Increased annual mean rainfall and increased severity and frequency of extreme rainfall
- Increased sea-level
- Increased frequency of heavy swells, especially in regions exposed to westerlies
- Higher storm surges (MfE, 2008)

These impacts have important implications for a coastal urban catchment. It is expected that higher temperatures will exacerbate existing water quality problems and lead to further eutrophication due to higher water temperatures causing algal growth. More extreme weather events such as high rainfall and/or droughts will result in both higher risk of flooding as well as water shortages requiring water conservation measures. Storm surges and higher sea-levels will lead to increased coastal erosion.

Adaptation options

With uncertainties regarding the extent and severity of climate change impacts, taking the precautionary approach to decision-making can prevent damage or loss to property and infrastructure. Moreover, being prepared for climate change impacts can increase the resiliency of coastal communities. Adaptation options for the coastal and urban communities in Nelson include the following:

- Improved stormwater management using low impact urban design and development principles such as vegetation swales: can capture peak flow of urban runoff and allow excess water to percolate into the soil, thus reducing flooding risks

- Water capture and storage: can also reduce peak flows and provide the added benefit of backup water supplies during times of drought.
- Protecting coastal ecosystems:
    - Waimea Inlet (mudflats, saltmarsh, estuary)
    - Beaches (allowing migration of dunes)

Coastal ecosystems provide a buffer against climate change impacts such as storm surges and increased sea-levels. These natural features are better equipped to absorb and retain sea water and protecting and enhancing them through reclamation also helps to increase habitat and biodiversity. Sedimentation is a primary concern for the Waimea Inlet (Stevens and Robertson, 2010). Sedimentation is leading to the rapid infilling of the inlet and could drastically change its habitat of function.

> "The main cause is runoff from land disturbance in the catchment and shoreline erosion. This load is likely to increase with predicted increased storm runoff associated with climate change and predicted accelerated sea level rise. To address this issue it is recommended that catchment sediment inputs be reduced to a level that maintains the estuary sedimentation rate below 2.0mm/year. This process should involve the production of a long-term catchment sediment budget that identifies areas of high sediment release in the catchment, i.e. sediment 'hot spot' areas" (Stevens and Robertson, 2010, p.xv).

Recommendations and Conclusion

Urban streams in Nelson are under increasing pressure and in recent years many have exhibited signs of degradation and severe degradation. Changing land use in the catchment is a prime driver for water quality degradation. Clearing of native forests, intensive pine plantations, grazing dairy, beef and sheep cattle on the landscape in large part account for sediment and biological contaminants to the river and downstream ecosystems. In the more suburban and urban areas, residential development and road construction leads to increased permeable surface cover and soil compaction, preventing the infiltration of surface water to replenish groundwater aquifers. Road traffic also leads to accumulation of contaminants in the stream and coastal receiving body.

Moreover, the coastal zone and estuary into which many of the urban streams in Nelson flow is also under increasing pressure from climate change impacts. If Nelson City aims to be a leader in environmental sustainability and prosperity, immediate action needs to be taken to reverse the downward trend of water quality degradation in our urban streams and better care for our coastal estuaries, such as the Waimea Inlet.

Numerous actions can be taken immediately to enhance the freshwater and coastal ecosystems and contribute to the resiliency of Nelson's environment and community. Adoption of low impact urban design and development (LIUDD) approaches to controlling stormwater such as vegetated swales, rain gardens, green roofs, rainwater capture and storage and increasing the permeability of soils and road surfaces can in large part reduce stormwater peak flows as well as capture and filter runoff. Both of these actions contribute to the reduction of flooding risks and improve water quality.

Further education and outreach work is needed with the residents of the catchment, both in the upland area of the catchment and in the new residential developments. Encouraging and fostering an ethic of stewardship and conservation within the community will be an important asset for the long-term care of the stream.

Adopting policies for the protection of coastal ecosystems such as salt marshes, wetlands, mudflats and beach dunes will help to protect coastal communities and infrastructure from the impacts of climate change. Such efforts will also enhance coastal flora and fauna and contribute to greater terrestrial, marine and aquatic biodiversity. Nelson City Council can be a leader amongst regional governments in protecting and preserving our ecological capital and in so doing, uphold the ecological, recreational, economic, social and cultural values that Nelsonians share.

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