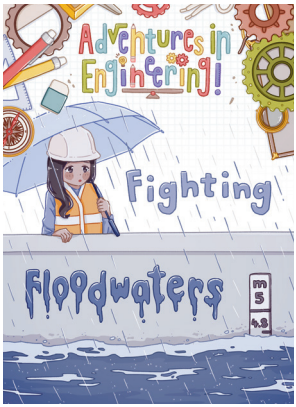
Adventures in Engineering!

QUEENSLAND NORTHERN TERRITORY
IPWEA
INSTITUTE OF PUBLIC WORKS ENGINEERING AUSTRALASIA



Adventures in Engineering:
Fighting Floodwaters

First published April 2022

ISBN: 978-0-6454055-9-0

Ebooks are available for download at https://www.ipwea-qnt.com/adventures-in-engineering.

Our thanks to our featured public works engineer, Monishaa Prasad for sharing her engineering project.

Written by Juliet Schaffer, in the course of her employment with IPWEA-QNT.

Illustrated by Narissa Amies.

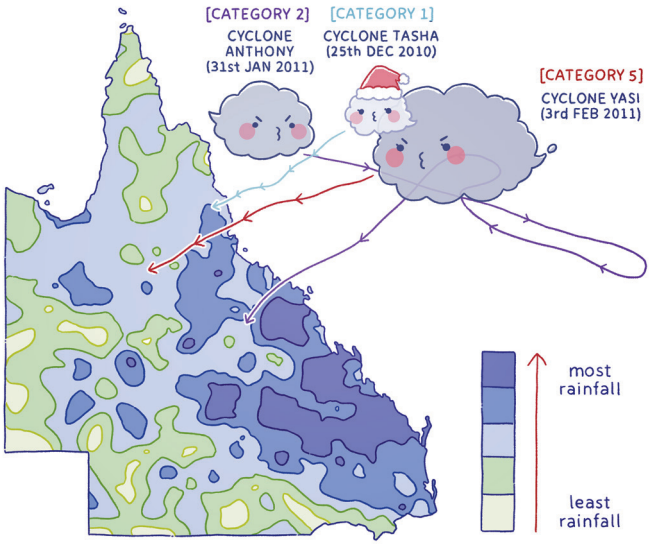
QUEENSLAND NORTHERN TERRITORY
IPWEA
INSTITUTE OF PUBLIC WORKS ENGINEERING AUSTRALASIA

Fighting Floodwaters

First Edition

With thanks to the National Careers Institute

Chapter 1



2011 was a very wet year for Queensland. From about September 2010 through to April 2011 it just rained and rained and rained. A La Ni a weather system meant that the oceans to Australia's north were warmer and brought increased rainfall and more than usual tropical cyclones. Tropical Cyclone Tasha crossed the coast south of Cairns early on Christmas Day 2010 as a Category 1 cyclone. A month later Tropical Cyclone Anthony crossed the coast near the town of Bowen. The biggest though was Tropical Cyclone Yasi – a Category 5 that crossed the coast on 3rd February 2011. It was so large and strong that its windspeed and rain caused damage from Mission Beach on the coast, all the way inland to Mt Isa – a distance of over 1,000 km.

There had been so much rain across the spring and summer that slightly more than three-quarters of Queensland had been in flood. The length of time and the amount of rain meant that the soil across Queensland was water-logged. It took a very long time for the water to soak into the earth. The rain sat on the ground, causing flooding in many towns from the north to the south of Queensland. Towns such as Chinchilla, Dalby, Warwick, Bundaberg, Emerald, Rockhampton, Toowoomba, and Grantham flooded. Metropolitan areas flooded in Ipswich and even the city of Brisbane suffered from terrible floods. The flooding was so bad that roads, rail lines, cars, houses, and businesses were destroyed, and very sadly, people died.

Monishaa is an engineer – specifically an environmental engineer. These are people trained to help the natural and man-made environment be **resilient** and sustainable, to cope with the changing climate, and with natural disasters such as cyclones and flooding.

Monishaa worked for the Ipswich Council during that terrible summer. On 12th January 2011, the Bremer River that runs through the city of Ipswich reached a peak height of 19.4 m. The floodwaters reached so high that it lapped at the rooves of people's houses, almost reaching up to the electric power lines. Around 3,000 homes were flooded that day. The river depth of 19.4 m was very deep – about eight stories high.

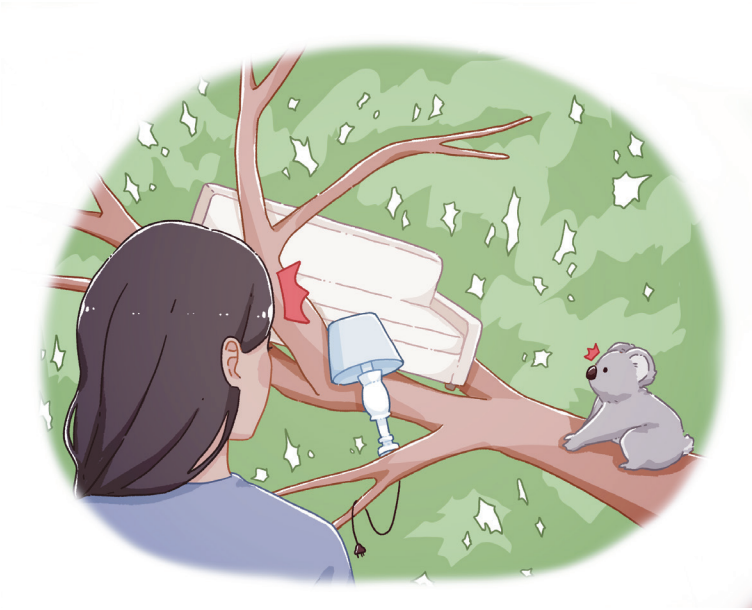
During the flood emergency in Ipswich, Monishaa and her colleagues were very busy. They worked late all week and all weekend. Monishaa had to monitor the flood warning network and **gauges**, and work with the Disaster Management Team. Her work involved preparing observation notes, running computer modelling programs and producing maps of flood areas. People who made decisions about how to keep the residents of Ipswich safe needed to have updated information of where the floods were going to occur. They had to warn people to evacuate their homes before the water levels rose and they would be stuck.

Monishaa learned a great deal about flooding during this time. She learned that it could happen with very little warning.

When it happened unexpectedly, people were often stranded when roads, bridges, and railway lines were submerged under water. It was very challenging for people to get to and from school and work. No one could live their normal everyday life during a flood.

When the floodwaters finally receded, Monishaa's work didn't end. She went out and surveyed the damage, recording how high the waters had reached by looking out for **debris** marks on fences, doors and windows. When looking at the roads, Monishaa firmly understood why people were encouraged to never drive through floodwaters. Not only does floodwater flow fast, which can lift a car off its wheels, but sometimes the roads are washed away completely! After checking 53 bridges in three days, Monishaa discovered that water can even damage bridge structures, making them extremely dangerous to drive on.

The oddest thing that Monishaa saw during the flooding was how often heavy items such as cars, fridges and couches could float away. One day, after the flooding, Monishaa looked up to see that someone's couch and lampshade was stuck 15 m up a eucalyptus tree. Either koalas liked to sit on sofas, or the floodwaters had carried parts of someone's loungeroom away!



Monishaa remembered the look of panic on people's faces when they were afraid of losing their houses, and the sadness they felt when they saw the damage that the floodwaters caused. Mud and **silt** lay deep on the floors of their houses, their possessions swept away forever.

Although Monishaa learned that floods could be scary and dangerous, she also learned that engineers have the skills and knowledge to help keep people safe and to feel less frightened. Monishaa decided that she would move to Central

Queensland, to Rockhampton. This was a town that had flooded many times, and that needed expert help. Monishaa knew that she could help Rockhampton prepare better for floods so that fewer people would be so badly affected.

Chapter 2

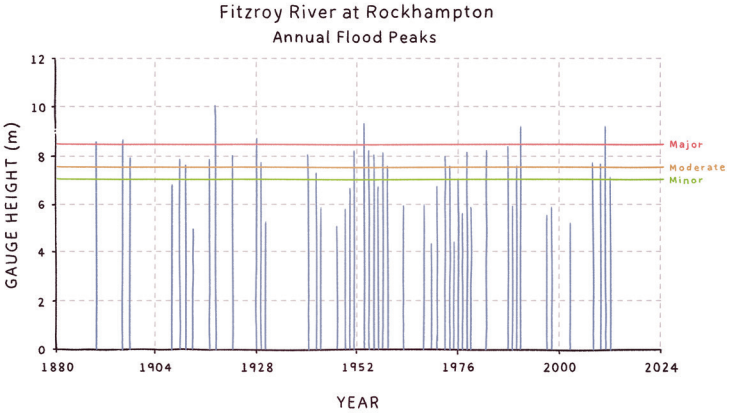
Once Monishaa had settled into her new home and workplace, she met with her engineering colleagues. To be able to solve the problem of flooding, they had to understand why Rockhampton flooded.

'As I am new here', said Monishaa, 'I have many questions to help me understand how floods behave here in Rockhampton. I would like to know, what **gauges** best track the movement of floodwater? How much time have people had to prepare for flooding in the past? Which parts of the town flood the most often? Which areas don't get flooded but might be isolated by floodwater? If people need to evacuate quickly, what is the best emergency access route in and out? I have lots of questions and I need lots of solutions!'

Monishaa's new work mates nodded knowingly. These were questions they had asked themselves and were already investigating.

'I'm glad you asked those questions, Monishaa,' said the Chief Engineer. 'I'll run you through what we have discovered already, then we can work out what our next steps will be'.

Back at her desk Monishaa turned on her computer to research on the internet. She needed reliable information – data that had been obtained by reputable institutions. She remembered from her university study that web addresses ending with .org, .edu, .gov tended to be the most credible providers of accurate information. Government websites such as for the Bureau of **Meteorology** (BOM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) would be two good places to start her investigation, as would organisations such as Geoscience Australia and the Australian Institute for Disaster Resilience.



Through the Bureau of **Meteorology** (BOM) website, Monishaa was able to find a lot of useful data. There were line graphs showing annual flood peaks for the Fitzroy River, and tables showing the month and year of flood events. Also helpful were the flood height measurements at various flood **gauges** within the system.

Chapter 3

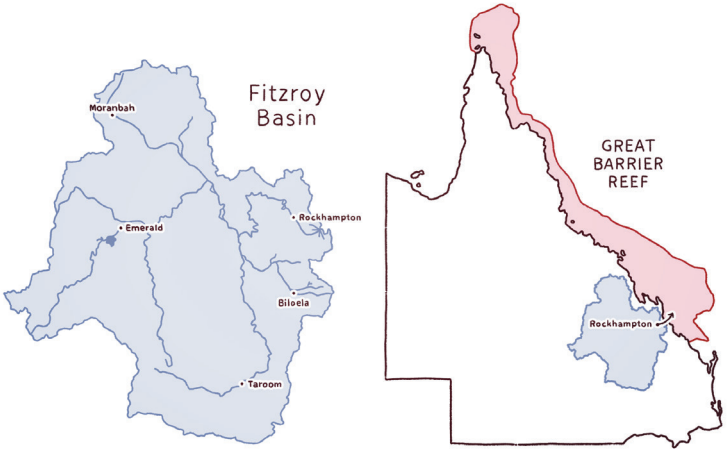
As well as the flood levels, it was necessary for Monishaa to have a good understanding of the geography of the area. This included the various creek systems that feed into the Fitzroy River. Monishaa made herself a list of notes from the information she found on the council website.

What gave Monishaa the first clue about the cause of Rockhampton flooding was learning how large the Fitzroy River Catchment area is. Called the Fitzroy Basin (a large area that holds water, like a shallow dish), it is the biggest river basin on the east coast and is the second largest river system in Australia. Only the Murray Darling River system that runs through Queensland, New South Wales, the Australian Capital Territory, Victoria, and South Australia is bigger.

With six major rivers from 11 catchment areas flowing into the Fitzroy River, Monishaa understood why Rockhampton was prone to flooding. She could also understand why, when it flooded, the water could sometimes take weeks to **recede**. The area where Rockhampton had been built, particularly the area between Rockhampton and the ocean, were wetlands. This meant it was very flat and consisted of a series of saltpans, mudflats, and marshes. It was almost like a kitchen sponge. Any water tended to sit on the land and not drain out to the sea quickly.

To manage flooding in Rockhampton it was important to realise that the Fitzroy River system flowed out to the southern section of the Great Barrier Reef. The Great Barrier Reef is

famous for being the world's largest coral reef, and one of the seven natural wonders of the world. It is so important that it is world heritage listed – meaning that the reef is so special that it needs to be protected for the benefit of all people around the world. Monishaa knew that whatever flowed out to the ocean from the Fitzroy River could negatively impact the reef. She thought of all the things that could get washed away by floodwater – parts of buildings, vegetation, oil, chemicals and fertiliser. It was, therefore, very important to help protect the residents and buildings of Rockhampton from flooding, but also essential to reduce polluted flood water that could eventually flow out to sea and impact the reef.



Monishaa also wanted to research the impact of the floods on the town of Rockhampton. How did they affect the people who lived there, the buildings in which they lived and worked, the roads they drove on and the landscape itself? There was information on the internet, and in the historical archives of the council library. There were newspaper articles describing the flooding, as well as photographs showing how high the floodwaters had reached.

Instead of being able to walk or ride down their streets during floods, people rowed in boats and kayaks. Even though many homes are built off the ground in the traditional Queenslander

style, water floods into people's homes, and even up to their rooves. Once the water eventually **subsides** the houses are then full of mud and **silt**, the walls are soaked, and the electric wiring is damaged. Commercial buildings and shops, which aren't usually built off the ground in the same way, are also flooded and experience the same problems from the floodwater. It could take many weeks, sometimes months, for the buildings to become inhabitable.

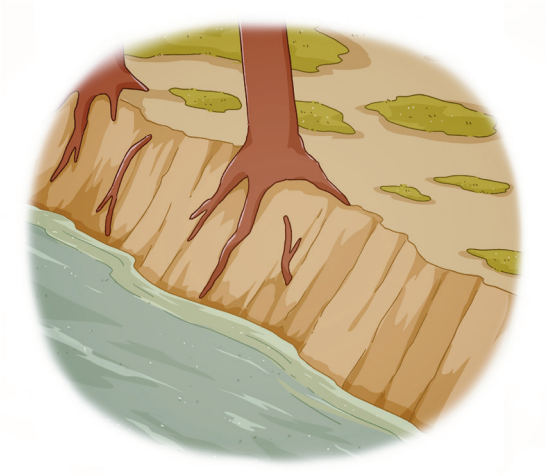
Also causing the residents of Rockhampton difficulty is that the town becomes isolated, cut off from other towns in the region when the Bruce and Capricorn highways and rail lines are flooded. This means that resources such as food and water need to be flown in. This can be difficult, especially when the airport also floods, and planes cannot land safely.

Armed with background knowledge of why the Fitzroy River flooded and the terrible impact it had, Monishaa knew that it was time to do her own primary research. Her first task was to conduct a site analysis on various areas around the town and Fitzroy Basin catchment.

Chapter 4

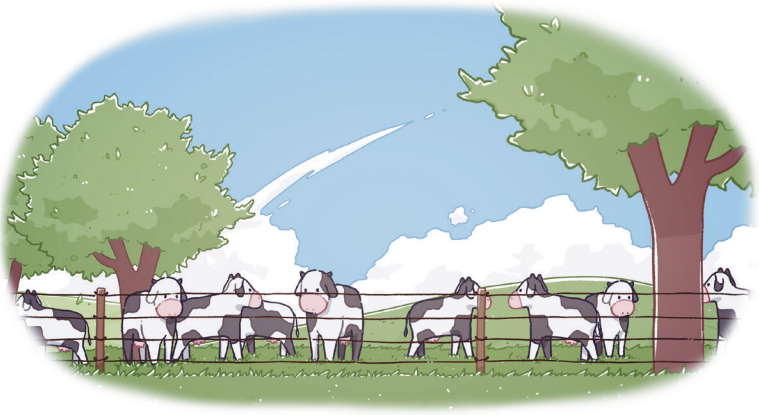
Monishaa felt that to understand the water movement in the city, investigating the creeks was a logical place to start. Armed with her notebook, pencil and camera, Monishaa took photos of the creek. She could see by the exposed tree roots that the years of flooding had eroded the bank. This meant that soil had been washed away and also explained why so much mud and **silt** ended up in flooded buildings. Monishaa knew from her research, that over time, this **silt** and mud also flowed out to the ocean and the Great Barrier Reef. It built up the land along the riverbanks and coast. It formed sandbars, which changed the shape of the river and impacted how much water it could carry. If the river holds less water, then that water will spill over and cause flooding.

Monishaa also knew that trees are important along rivers and creeks because the roots help to hold on to the soil, and so when these are damaged the **erosion** becomes worse.



She could see that a lot of the land was used for grazing. One of her colleagues reported that 80% of the land in the Fitzroy Catchment was farmland used for grazing cattle. This meant that over decades, many trees had been cut down to grow more food for the livestock. Grazing cattle is so important to Rockhampton that it is known as the Beef Capital of Australia. There were real cows, statues and paintings of cows all over Rockhampton.

Just as trees are important on river and creek banks, they are important on flat land as well. The roots help to keep the land stable, as well as soak up water. Without these trees the flood water erodes the topsoil from the farmland and makes the water slower to be absorbed. Again, the soil can end up through people's homes as **silt** or be washed out to sea.



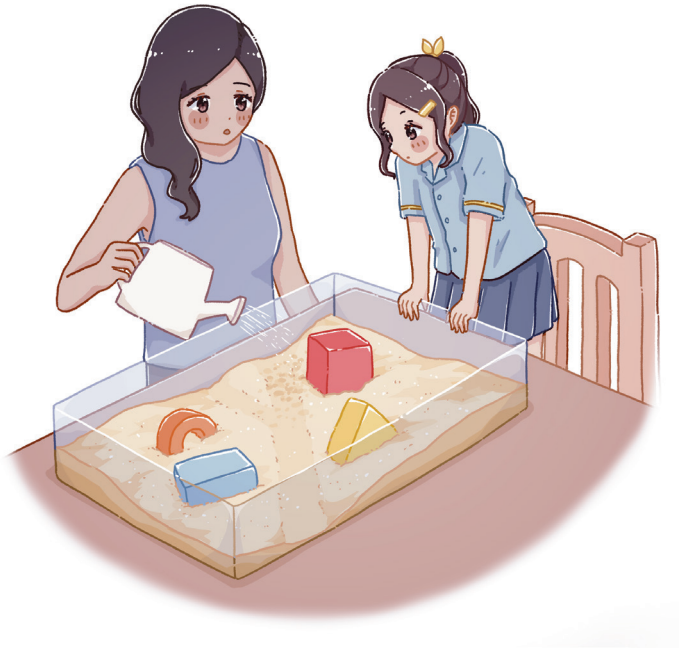
Monishaa and her team conducted flood studies to evaluate how the changed landscape affected water movement when it flooded. Historic and recent rainfall levels were entered into a computer modelling program. Using this information it could

predict where the water would go during future high rainfall. They collated this data into a map so that residents could see what would happen during certain levels and duration of rain. It meant that residents, Council and emergency services knew when to evacuate specific areas of Rockhampton during heavy rainstorms. It was crucial information for people who lived near creeks or rivers.

What was clear from the results of this data was that the town of Rockhampton had progressively been built on land which would naturally hold water during floods. As more buildings and roads were constructed, the landscape changed, and the natural flow of water pooled and flooded wherever it was able to. One day Monishaa explained it to a young friend by using a tray full of sand.

'Let's make our own miniature Rockhampton. Build the sand up here around the edges of the tray', Monishaa said. 'Rockhampton is like a shallow basin, remember. And dig out a riverbed for the Fitzroy River, and lots of little creek beds. We'll use your blocks to be houses and shops. Now let's make it rain'. Monishaa poured water over the tray of sand.

'See where the water flows in the rivers and creeks?' she asked. Her friend nodded.



‘Let’s pretend there is a big storm, and I’ll keep adding water.’ The more water that was added, the higher it rose until it flowed over the bank of the river and creek beds and was moving up the sides of the blocks.

‘Now, watch what happens when more houses and businesses are built’. Monishaa added more blocks to the tray. The more blocks that were added, the higher up all the blocks the water reached. The water even started to flood in new places on the tray that had previously been dry.

‘See this?’ asked Monishaa. ‘This is what has been happening to our town over the last hundreds of years. We have altered the landscape of Rockhampton by constructing more buildings. When we have big storms like those caused by tropical cyclones, the massive amount of water changes the

rivers and creek beds again and again. This makes the flooding from the next storm worse'.

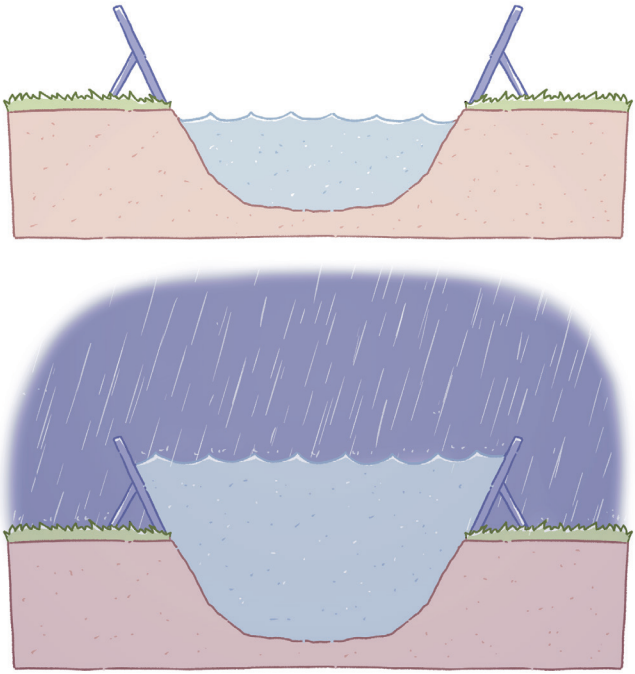
Monishaa and her friend both let out a big sigh as they looked at their miniature Rockhampton. Monishaa wondered what she and her team had to do, to stop the ever-increasing damage caused by flooding.

Chapter 5

Monishaa worked with her engineer colleagues to use all the data they collected to come up with a plan.

The first part of their plan was to protect the people and property of Rockhampton. This involved the building of levees. Levees are large mounds or 'embankments' of land that are purposefully built up along the banks of rivers and are designed so that the river water must reach higher before it spills over into the surrounding area. These are built to hold any future floodwaters back from low-lying areas that tend to flood.

Some levees are permanent whilst others are designed to be constructed quickly as soon as a flood warning is issued. Flood warnings come from the BOM (Bureau of **Meteorology**). Sometimes local farmers and graziers who have lived on the land for many generations advise the council of flooding concerns. Quite often farmers keep their own rain records and working on the land for so long means they know when things are changing. With the potential to protect hundreds of homes, businesses and farms, levees are considered to be a good protective measure against flood.



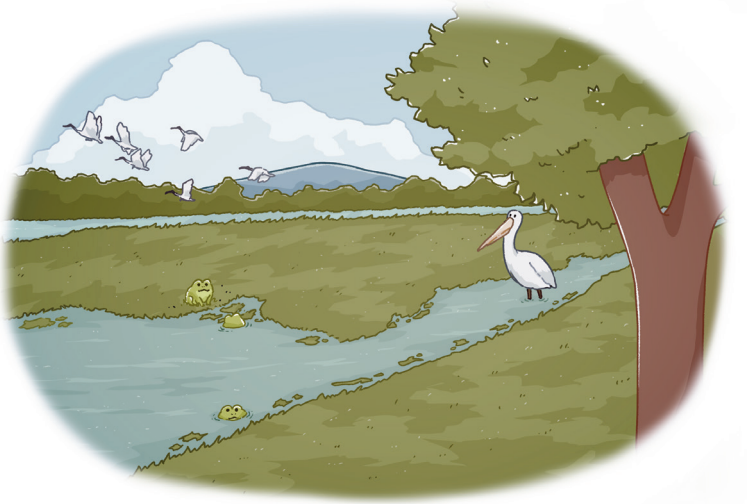
Chapter 6

Protecting was a good first step, but it couldn't be the only solution. Monishaa and the team knew that they also had to help the town and its residents adapt. The whole town couldn't be moved, and there was no way to stop heavy rain or tropical cyclones from forming. Therefore, adapting to the risk was the next best option.

Improving the drainage system, by making sure the pipes were clear and wide enough to carry water away, was one way of achieving this. It means that stormwater overland flooding would be better able to flow out to sea and spend less time flooding the town. Other actions included constructing buildings better able to cope with flooding, such as making sure they were built high enough off the ground with materials that are less damaged by water. It was also very important to ensure that all people living in Rockhampton were educated about the risk of flooding, and what to do when a flood warning was issued.

Being able to detain or contain rainwater when it fell was another solution to flooding. More rainwater tanks in people's yards would mean the water could be captured, kept and used. Large planter boxes could also hold water and keep it off the ground. Building gardens on the rooftops of buildings was another great idea that Monishaa had seen in other countries like Singapore. Open ditches with grass and other vegetation, called a bioswale, were used in countries like The Netherlands. If this could work well in a country that was almost one third

below sea level, then Monishaa felt it could also work in the city of Rockhampton.

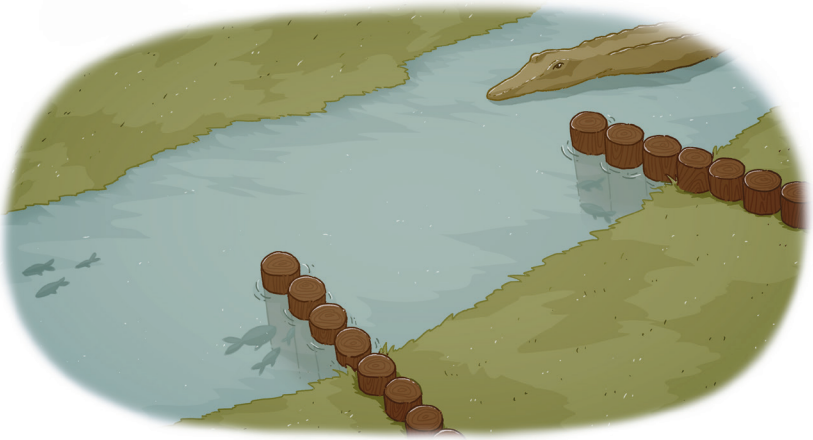


Monishaa approved of the plan for the improving and constructing of wetland areas. This involved creating areas of dams, marsh land and vegetation to help retain the water within the wetlands. This would slow down the water flowing into the town. Plant species local to the region were chosen that would cope both with the heat, as well as the prolonged wet conditions that Rockhampton's climate causes. An additional benefit would be that the wetland plants improve the water quality by holding back fine **sediment** and preventing it from flowing out to sea and damaging the reef.

Monishaa loved it when one solution could solve many problems, especially when it involved restoring natural environments.

Chapter 7

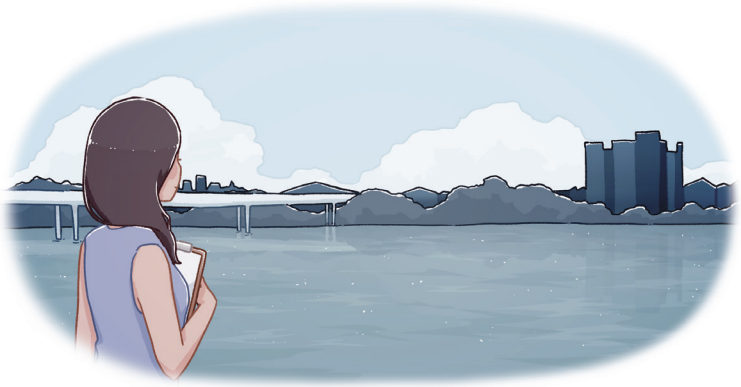
The part of the plan that Monishaa thought would have the best impact was the '**retreat** and restore' options. **Retreat** meant ensuring that areas vulnerable to flooding had the risk removed. This meant to move people and homes out of those areas most prone to flooding and finding them somewhere to live outside of the flood zone. She knew of another Queensland town, called Grantham, that relocated almost their whole town off a floodplain and up onto safer land. Rockhampton was too large a city to move altogether, but selected areas of high risk could be managed.



Restore was Monishaa's favourite part. It meant doing things like rebuilding the banks of the creeks and rivers to make them stable and less likely to be eroded. Sometimes this included adding rocks to the banks to protect the soil during flooding, especially when the water is flowing fast. Other creek areas were made flatter so that water had space to spread out, which

would slow down the speed of any flowing water. Another method was to build a structure called pile field groynes using tree logs and placing them upright along the banks of creeks and rivers. This was useful for two reasons. The first, that it helped to hold up the bank, and the second, that it provided a protected habitat for local fish.

Chapter 8



Monishaa felt increasingly confident that she and the team at the Council were putting in place a range of solutions to help reduce the risk of flood damage in Rockhampton. It pleased her to travel around the town and see all the positive steps that had been taken, whether they were constructed or whether they were helping to improve the natural environment. Monishaa was pleased also, that there were so many organisations in Rockhampton working to protect the town and the landscape – including volunteer organisations such as Landcare Australia. Being able to talk with other people passionate about the environment was another part of her job that Monishaa really enjoyed. She knew that it would take many passionate people, a long time, to be able to restore the land around Rockhampton back to a healthy state. Monishaa was glad that she had decided to be an environmental engineer because she could then ensure Rockhampton could become a safer place for all its residents. What a wonderful achievement!

Glossary

debris	(n) pieces of wood, metal, building materials etc. that are left after something has been destroyed
erosion	(n) the process by which the surface of something is gradually destroyed through the action of wind, rain, etc.
gauge(s)	(n) an instrument for measuring the amount or level of something
meteorology	(n) the scientific study of the earth's atmosphere and its changes, used especially in predicting what the weather will be like
recede	(v) to move gradually away from somebody or away from a previous position
resilient	(adj) able to recover quickly after something unpleasant such as shock, injury, natural disaster, etc.
retreat	(n) a movement away from a place or an enemy because of danger or defeat
sediment	(n) the solid material that settles at the bottom of a liquid
silt	(n) sand, mud etc. that is carried by flowing water
subside	(v) to sink to a lower level; to sink lower into the ground

survey	(n) the act of examining and recording the measurements, features, etc., of an area of land or sea in order to make a map or plan of it
sustainable	(adj) that can continue or be continued for a long time

Glossary definitions sourced from
https://www.oxfordlearnersdictionaries.com/

Activities

Chapter 1

Ask your parents and/or grandparents about what they remember about the summer of 2010 – 2011. Were they affected by any of the cyclones or flooding? What did they do to prepare for them? What have they learned to do now to be better prepared?.

Chapter 3

The Great Barrier Reef is one of the 'seven natural wonders of the world' and is world heritage listed. Look up the world heritage site list on the unesco.org website. How many world heritage sites are in Australia? How many are in Queensland? Have you visited any of them? Why do you think it is important to protect these areas?

Chapter 6

List the solutions discussed in this chapter and categorise them into natural and constructed solutions. What are the benefits of each kind of solution? Can you find images of the solutions used in other countries?

Natural	Constructed

Chapter 7

Restore is part of the final method of helping protect Rockhampton from flooding. Why were pile field groynes constructed in some of the creeks and rivers? Do you think this benefits all fauna in the

Chapter 8

The last chapter mentions some groups who contribute to helping the environment. Research other groups in your local area and what they do to help. What kind of things can a young person like you do to help the environment?

Discuss

What steps can individual people, families and businesses take to prepare for the wet season and for cyclones and flooding? What kind of organisations are providing guidance and credible information about how to best prepare for natural disasters?

What kind of tasks did Monishaa perform in her job as an environmental engineer?

What kind of skills did Monishaa use to help solve the problem?

Are there any aspects of Monishaa's job you think you would like to do?

Monishaa has seen the devastation that floods cause Queensland towns. How can Monishaa use her engineering skills to lessen the damage of floodwaters to people, homes and businesses?

Monishaa has seen the devastation that floods cause Queensland towns. How can Monishaa use her engineering skills to lessen the damage of floodwaters to people, homes and businesses?

QUEENSLAND NORTHERN TERRITORY
IPWEA
INSTITUTE OF PUBLIC WORKS ENGINEERING AUSTRALASIA

Level 1, 6 Eagleview Place
Eagle Farm Q 4009

info@ipweaq.com
Phone 07 3632 6800

www.ipwea-qnt.com