



The University of Queensland School of Chemical Engineering
Master of Integrated Water Management
Final Thesis

**The Value of Community Based Monitoring in
Integrated Water Management of the Fitzroy Basin**

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Date: June 2nd 2016

Executive Summary

Cumulative impacts of natural and anthropogenic activities are complex and difficult to manage. Flood events of 2007-2008 triggered a social and economic crisis, which threatened the social licence to operate of Central Queensland's coal mining industry. Investigations highlighted the importance of integrated waterway monitoring and as a result, the Fitzroy Partnership for River Health (FPRH) was established. The partnership collaboratively develops and produces reporting products that rate the ecosystem health of the Fitzroy Basin. In addition, the partnership promotes community based monitoring (CBM) through an online portal known as MyWater. The purpose of the CBM is to raise community awareness on waterway health and increase scientific literacy of the annual report card published by the partnership.

The aim of this thesis is to understand what are the highlights and opportunities for the FPRH's CBM initiative and what value can it add to the partnership. The theoretical framework that underpins the research was Integrated Water Management and literature on CBM.

The methodology drew on qualitative research techniques to evaluate stakeholder perceptions on CBM and the MyWater portal. For the research six participants were interviewed and they included representatives from the FPRH, the Science Panel, the Fitzroy Basin Association and three end-users. The interview responses were sorted into the following thematic components: stakeholder perception of CBM, MyWater portal characteristics, portal highlights, opportunities of improvement and data use. Based on the research, the following observations were made:

- Participants interviewed shared positive views about CBM. Leadership was mentioned as the most important requirement to a successful CBM, while maintaining long-term sustainability was cited as the most challenging.
- The FPRH designed and implemented the MyWater portal following a consultative governance approach and the portal shared many similarities with the FPRH reporting products.
- Financial and human resources were identified as the principal limiting factor towards the ongoing development of the portal. For this reason, the FPRH chose to create the portal to 'run on its own'. However, interview responses indicated a need for stronger collaboration between the FPRH and communities, increased advertising and networking opportunities.
- Community contribution increased, since its launch in 2013-2014, however the challenge is maintaining long-term community interest and encourage on going contribution.
- End-users found the portal easy to navigate and understand. The users noticed that children had an increased interest in ecology indicators compared to the physical-chemical indicators suggested.
- Interview responses highlighted some positive aspects of the portal as well as some opportunities for improvement. Topics focused on data presentation,

indicators, field sheet, monitoring instructions, monitoring equipment, increasing community involvement and collaboration.

- Participants were divided on whether or not to include CBM data in the FPRH reporting products. Those in favor of the inclusion placed an emphasis on valuing community contribution. Those opposed believed that maintaining data quality and rigour were important.
- Overall, the participants expressed high degrees of satisfaction with the initiative.
- Fostering a collaborative partnership with community members would increase community understanding of natural and anthropogenic impacts on receiving environments, offer a cost-effective solution to fill gaps presented in the data and allow community members to legitimately influence decision-making.

The following recommendations were suggested to improve the MyWater portal. They included:

- Improving the data presentation.
- Providing additional information on the monitoring indicators.
- Using consistent set of terminology and units.
- Introducing different levels of technicality.
- Providing greater context to the indicators being measured.
- Updating the online monitoring instructions.
- Advertising the MyWater portal.
- Increasing networking opportunities.
- Setting up an online forum for stakeholders to interact.
- Creating opportunities for ongoing collaboration with community members.
- Partnering with existing CBM groups within the Fitzroy Basin.
- Expanding the research to determine how community members can contribute to the body of data used for the FPRH reporting products following IWM principles.

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Abbreviations

ABC	Australian Broadcasting Corporation
CBM	Community Based Monitoring
CCB	Care for Creeks Bursary
CQU	Central Queensland University
DERM	Department of Environmental and Resource Management
EHI	Ecosystem Health Index
FBA	Fitzroy Basin Association
FBA*	Fitzroy Basin Association Interviewee
FBRC	Fitzroy Basin Report Card
FPRH	Fitzroy Partnership for River Health
FPRH*	Fitzroy Partnership for River Health interviewee
GBR	Great Barrier Reef
GWP	Global Water Partnership
IWM	integrated water management
M&E	Monitoring and Evaluation
NGO	Non-Governmental Organization
SLO	Social Licence to Operate
SP	Science Panel
SP*	Science Panel Interviewee
TA	Thematic Analysis
TEP	Transitional Environmental Programs

Acknowledgements

I would like to thank Dr. Sue Vink from the Sustainable Minerals Institute and Centre for Water in the Minerals Industry of the University of Queensland for being my supervisor and providing me with invaluable guidance throughout the project; Nathan Johnston from the Fitzroy Partnership for River Health for Gatekeeper approval and getting me in touch with participants; Karen Been from the International Water Centre for her constant support and positivity; Andrew Davidson who provided great advice on how approach the project; and finally to all the participants who took some time out of their day to be interviewed. Thank you!

The Value of Community Based Monitoring in Integrated Water Management of the Fitzroy Basin

Introduction

The Global Water Partnership (GWP 2000) defines integrated water management (IWM) as a process that promotes stakeholder collaboration for the development of water, land and natural resource management strategies. These strategies aim to balance economic gains and social benefits without compromising social equity and environmental sustainability. In addition, the application of this paradigm intends to maintain or improve the state of natural resources that are currently affected by anthropogenic activities (Pahl-Wostl & Sendzimir 2005). In essence, IWM has shifted the traditional water management model to emphasise stakeholder participation, cross-sectoral collaboration and collective management of waterways. The approach promotes decentralisation, increased transparency, information exchange and adaptive management strategies (Pahl-Wostl et al. 2008). The four main principles that underpin IWM (GWP 2010) are:

- Recognising water as a limited and threatened resource that is fundamental to sustaining life on Earth.
- Enabling a participatory platform where stakeholders representing state, private and public sectors can collaborate to develop and manage water sustainably.
- Acknowledging the importance women play in the procurement, management and preservation of water.
- Understanding that water is an economic good which should be valued.

According to the GWP (2010), participation implies involving all stakeholders in the decision-making process. Stakeholder representation can take the form of local community groups, democratically elected officials, accountable agencies and spokespersons. Furthermore, the GWP states that genuine stakeholder participation goes beyond consultation. This implies that stakeholder groups can legitimately influence decision-making across various water management levels. Moreover, achieving unanimity requires stakeholders to take responsibility, recognise the impacts of their sectoral activities and be willing to negotiate compromises for the common good. The creation of institutions is considered important to enable participation to take place. In addition, opportunities to develop participatory capacity from state, private and local sectors, including marginalised groups, is necessary to enhance stakeholder involvement. Finally, a top-down and bottom-up approach must be embedded within all water management strategies.

Integrating IWM principles within watershed partnerships is fundamental especially if cumulative impacts of natural and anthropogenic activities threaten the social licence to operate (SLO) an entire industry. In addition, building trust between economic sectors and community members through community based monitoring (CBM) initiatives is an emerging trend documented in the academic literature (Conrad & Daoust 2008). This was the case for the resource industry located within the Fitzroy Basin. Following the 2007-2008 flood events the SLO of the Queensland coal mining industry was questioned. The crisis spearheaded the creation of the Fitzroy Partnership for River Health (FPRH), an integrated waterway monitoring and reporting body. As an addition, the partnership created a CBM initiative known as the MyWater portal to educate and raise awareness.

This thesis reports the outcomes of research conducted to understand what are the highlights and opportunities for the FPRH's CBM initiative and what value can it add to the partnership? In the following sections, a literature review on cumulative impacts, SLO, cross collaboration, community involvement and CBM are presented. This is followed by the FPRH case study, which provides information on the Fitzroy Basin, the flood events and the creation of the partnership. The research methodology describes the theoretical framework and presents the principles of qualitative research and thematic analysis used to conduct the study. The outcomes of the interviews are presented in results and analysis and examined in the discussion section. The report ends with conclusions followed by recommendations.

Literature Review

Cumulative Impacts

Cumulative impacts, on a catchment scale, are complex, poorly understood and challenging to manage (Franks et al. 2012). In Australia, like in much of the world, anthropogenic activities, such as agriculture, grazing, urbanisation, mining, etc., occur simultaneously within a catchment. However, it is common to see each industry manage their impacts in isolation of others. Mining operations, for example, typically manage environmental impacts on a site scale (Eberhard et al.2013). Any impacts originating from a mine site have the potential to interact and combine with impacts generated from other activities. Therefore, in order to effectively manage cumulative impacts on a catchment scale, the resulting impacts of natural events and anthropogenic activities must be considered. In Australia, catchment scale impact assessments are required as part of the project approval process. Typically they take the form of environmental impact statements and social impact assessments. Yet those requirements are vague, poorly defined and vary between states (Franks et al.2012). In addition, there is often no common database where monitoring information can be shared and used between different stakeholders. To address this gap, watershed partnerships are established to foster collaboration between different

economic and social sectors to effectively monitor and manage cumulative impacts. Cross-sectoral management of cumulative impacts is important as failing to do so could ultimately affect the SLO of an entire industry.

Social Licence to Operate and Cumulative Impacts

There are strong ties that exist between monitoring, managing cumulative impacts and maintaining a SLO. While the resource sector attempts to manage the impacts of their own operations, individually they cannot manage cumulative impacts on a catchment scale (Eberhard et al. 2013). Similarly, in a multi land-use catchment, risks and impacts on receiving environments are increasingly complex, unpredictable and can no longer be considered in isolation (Kemp et. al 2011). Public perception of the resource industry can be based on the negative performance of a single operation. As a consequence, the SLO of an entire industry can be called into question. For example, a survey performed in Queensland, Australia found that communities believed the resource sector had the greatest impact on waterway health despite scientific evidence demonstrating that agricultural land use had a greater impact (Eberhard et al. 2013). In mixed land-use catchments, collaboration and partnerships are starting to emerge in order to monitor and manage cumulative impacts more effectively and ensure that they are kept within acceptable levels. From the resource industry's perspective, engaging in cross-sectoral catchment partnerships has the added benefit of distributing accountability, demonstrating their SLO, managing community perspectives and safeguarding their corporate reputation to maintain their SLO. Therefore, involving communities in cross-collaboration is critical for catchment management and maintaining a SLO.

Cross-Collaborations and Community Involvement

Cross-sectoral collaboration refers to a partnership, which engages with stakeholders of different sectors such as governments, NGOs, industries and communities (Bryson et al. 2006) to work together to address complex and interdependent problems (Eberhard et al. 2013). Catchment scale cross-sectoral collaborations are necessary to manage cumulative impacts and maintain SLO for economic activities that are scrutinized by community members. Another reason that justifies cross-sectoral collaboration resides in the fact that all are interconnected and actions taken by one sector have repercussions on another (Bryson et al. 2006). This implies that organisations can no longer work alone to achieve what they want because of how sectors are interlinked. Therefore, bringing together resources is a strategy that is much more effective in addressing cumulative impacts and environmental challenges (Franks et al. 2012).

Bryson et al. (2006) caution that some might perceive cross-sectoral collaboration as a panacea. In reality, partnerships cannot solve all of the problems nor are all partnerships always successful at staying together. Cross-sectoral partnerships are

challenging and must meet certain conditions and overcome significant obstacles in order to become successful. The ability to build trust across different sectors is fundamental (Bryson et al. 2006; Eberhard et al. 2013). For example, communities are often sceptical of mining companies trying to engage in environmental stewardship initiatives. This distrust can be heightened in cases where mining companies have clashed with communities and/or other economic sectors. Unfortunately, distrust and adversarial relationships between stakeholders hinder meaningful change or action. According to Eberhard et al. (2013), cross-sectoral collaboration takes longer to establish between stakeholders as it involves a certain degree of uncertainty, risk and time to build trust. One form of cross-sectoral collaboration that emphasises building trust between decision-makers and community members is known as community based monitoring (CBM).

Community Based Monitoring

CBM is described as a collaborative process where concerned citizens representing stakeholders from different sectors partner to monitor, track and respond to environmental issues of social concern (Conrad & Hilchey 2011). The overarching purpose of CBM is to share monitoring data with influential stakeholders in order to contribute to decision-making processes (Conrad & Daoust 2008). Acknowledging and incorporating community contributions is considered fundamental to principles of IWM (GWP 2010). Globally, CBM has been on the rise with extensive initiatives documented in developing countries as well as in North America, Russia and Australia. Its increase in popularity has been attributed to the growing awareness of environmental impacts related to anthropogenic activities and public concerns over cutbacks in government funded M&E programs (Conrad & Daoust 2008).

There are different ways in which CBM can be applied. For example, CBM can be resource or non-resource based (Conrad & Hilchey 2011). In resource-based monitoring, the subject being monitored holds some economic value, such as fisheries and forestry. Recently, resource based monitoring has expanded to include social and ecological benefits. On the other hand, non-resource-based monitoring focuses on monitoring subjects that do not have direct economic value. They include water quality, air quality, and indicators of wildlife, marine life and invertebrates. Water quality CBM was found to be one of the most prominent types of monitoring undertaken by communities (Conrad & Daoust 2008). Furthermore, CBM can assess ecosystems according to their status (e.g., population monitoring), their impact (e.g., pollutants) and their adaptive management (e.g., M&E). Moreover, diverse elements of ecosystems can be monitored. They include composition (e.g., indicator species), structure (e.g., biodiversity) and processes (e.g., nutrient cycling). Some of the overall benefits and challenges related to CBM are presented below.

General Benefits and Challenges

According to Pollock and Whitelaw (2005) and Conrad and Hilchey (2011), there are many benefits to CBM reported in the literature. CBMs allow participants to influence ecosystem management planning as they foster community engagement on environmental problems, promote participation in community development and increase contributions in policy-making. Furthermore, democratisation of the environment is encouraged through information exchange between scientific experts and the general public, and vice versa. This is achieved by making scientific knowledge more accessible to community members and allowing experts to increase their awareness of local knowledge. Correspondingly, scientific literacy and understanding the environment is increased through active participation. CBM builds social capital by contributing towards educated and sustainable communities. This is fostered through volunteering, building leadership and increasing the problem-solving capacity of community members. Moreover, an environment of trust, understanding and cooperation is cultivated within participant communities and decision-makers. If well managed, CBM can offer cost-effective solutions to institutions and organisations looking to collect data through social initiatives.

Conversely, Conrad and Hilchey (2011) cite organisational structures, data collection and data use as the three main challenges faced in CBM. Organisational challenges include low participation rate, limited networking opportunities, insufficient funding, difficulty accessing relevant information and disengagement of decision-makers. Pollock and Whitelaw (2005) mention impediments related to data collection including data fragmentation, inaccuracy, biases and poor experimental design. There are cases where the level of volunteer training was considered insufficient to collect both representative and accurate data. For these reasons, data collected by citizens are often not used in decision-making processes due to concerns related to methodology and the credibility of the information provided.

Principles and Considerations of CBM Groups

When considering designing and implementing CBM, both the challenges and the benefits must be considered. Although the benefits are vast, the challenges need to be identified and systematically addressed. Some key principles and considerations extracted from the literature are highlighted below in order to address some of the challenges faced in designing and implementing CBM projects. They include: selecting a flexible and adaptable framework; establishing objectives; determining participants; choosing a governance structure; selecting indicators; and securing resources.

Flexible and Adaptable Framework

CBM has many applications. There is no unique blueprint of how it should be applied because it needs to be tailored to a specific project and context (Estrella & Geventa

1998). Many CBM projects are designed and operated without the guidance of a robust framework (Conrad & Daoust 2008). In such cases, the lack of direction can weaken the organisational structure of the CBM group. In essence, the framework must be flexible, adaptable and comprehensive enough for any CBM initiative to incorporate. For example, the framework proposed by Pollock and Whitelaw (2005) can be broken down into four main sections. The first step involves identifying all possible stakeholders that could benefit, influence or be influenced by the CBM project. Stakeholder engagement and goal setting are an important part of this phase to ensure that the data collected by CBM groups are valued and used in decision-making. The second step involves identifying skills and resources. This includes identifying a champion or facilitator to lead the initiative, assessing skills and capacities of members and securing resources such as partnerships with universities, funding, infrastructure, etc. The third step is where the more specific goals and objectives of the CBM are formulated. This stage also includes identifying the types of data necessary and determining how these data will be collected. The fourth stage involves the implementation of the monitoring and communication plan. This begins with collecting data, analysing the results and communicating the findings to all stakeholders. The framework needs to be a tool that is responsive to the needs of the stakeholders and changing environment. Each stage in the framework requires constant iterations, evaluation and feedback loops to ensure that the CBM management is continuously improved to cope and adapt with emerging circumstances. For a CBM to be successful and sustainable, regular evaluations and reassessments are necessary in order to achieve the desired outcomes.

Defining Objectives

Many authors stress the importance of clearly setting the objectives of a CBM project (Estrella & Geventa 1998; Guijt 1999; Conrad & Daoust 2008). Without clear objectives, CBMs can easily go astray and proceed to collect unnecessary information. Therefore, careful planning of CBM is critical for its sustainability and long-term success. Relevant stakeholder groups will need to be identified and selected to discuss key aspects of the CBM project. Different needs and objectives of actors and sectors are shared and negotiated. When defining objectives, CBM groups must determine who will be the potential actors, end-users and beneficiaries. Moreover, defining the scale of the project is important to consider. Often the length of time and complexity to develop CBM can be underestimated. Many authors agree that it is better to start with a small project and grow from there (Estrella & Geventa 1998; Guijt 1999; Parkinson 2009). Based on the lessons learnt from the smaller project, much larger projects can be then considered.

Determining Participants

CBM emphasises participation and partnership development (Estrella & Geventa 1998; Conrad & Daoust 2008). Various authors recognise the involvement and participation of stakeholders across multiple levels and sectors. They include all

actors such as NGOs, community organisations, private sector, donors, researchers, partnerships, government institutions, residential groups, community members, indigenous peoples, marginalised groups. According to Bohnet and Kinjun (2009), incorporating community participation in water management planning remains challenging because there are still uncertainties on who should be involved and what outcomes should participation yield. Public participation has evolved from providing opinions or comments at public meetings to enabling members of the community to become active participants in policy, planning and management decisions. However there are varying perceptions on how to involve the public and who should be invited to participate. Stakeholder selection determines who will have an influential role in water management. Public participation is regarded as an important component of IWM (GWP 2010). Other scholars believe that the participation of key stakeholders will determine the success of the management outcomes.

Governance Structures

There are many ways in which CBM can be governed. In fact, four types of governance structures were identified in the literature. They include consultative, functional, collaborative and transformative structures (Pollock & Whitelaw 2005; Conrad & Hilchey 2011). A consultative level of participation is considered the 'top-down' approach of CBM. In this structure, a central authority initiates a project and CBM groups are used to collect data. Citizens provide a 'watch-dog' service and raise the alarm when environmental concerns arise. Scientific experts subsequently probe issues detected by participants. According to Conrad and Hilchey (2011) the majority of large-scale ecological monitoring programs are based on consultative governance structures. Despite their popularity, community involvement is often limited to data collection. Functional governance structures share similar characteristics to consultative groups. The difference is community members are engaged in decision-making. Both models require financial support from external institutions to operate. In some cases, external funding can be very limited. To curb this dependency, some groups shift to transformative governance structures in an attempt to ensure long-term sustainability. Transformative CBM is regarded as the 'bottom-up' paradigm for monitoring groups, which are sometimes referred to as advocacy monitoring groups as they typically emerge from crisis. They advocate for causes in the hope of triggering rapid government action and influencing decision-making. These groups are self-reliant and have little to no external support. Therefore, initiation, management and funding are community driven and participants are involved in every stage of the program. Although some of these groups can be successful, they are a lot more vulnerable to challenges (Conrad & Hilchey 2011). Collaborative CBM is based on the principles of cross-sectoral collaborations mentioned by Bryson et al. (2006). In this structure, groups are governed by members, which represent multiple sectors and institutions within a community (Conrad & Hilchey 2011). They can include landowners, residents, businesses, government, educational institutions, etc. Collaborative governance is increasing in

popularity because, unlike its predecessors, it has the greatest potential to influence decision-making. This type of CBM is very common in catchment management because of its collaborative nature (Conrad & Daoust 2008) and synergy with IWM principles. Governance structure alone, cannot predict the success of a CBM. In practice, there is no ideal governance structure to use, as its application is context dependent. Furthermore, the governance structures presented are not exclusive and often overlap each other.

Selecting Indicators

According to Guijt (1999) indicators try to capture ecological conditions in a simplified way. They should be specific, measurable, valid, reliable, useful, sensitive, easy to collect, cost-effective and timely. Narrowing down indicators is a complex process, which needs to be negotiated between stakeholders. Sometimes, organisations developing monitoring projects assume that communities are interested in the same kinds of information and appoint indicators for community members to measure. However, indicators need to be relative to participants in order to keep CBM interests high. At the same time, the information collected by community members must be salient enough for it to be considered decision-makers (Conrad & Hilchey 2011). Knowing who the end-users will be and what the information will be used for is important (Guijt 1999). Through collaboration, stakeholders can combine both scientific and local knowledge to develop indicators that are rigorous and accurate while being relevant to decision-makers.

Types of Knowledge

Considering different types of knowledge is important to effectively address water management issues on a catchment scale. In recent years, many researchers have been looking to form new water management paradigms by integrating scientific knowledge with local knowledge. Authors Raymond et al. (2010) and Brown et al. (2012) have simplified the different types of knowledge into the following categories. The first is 'tacit knowledge' or 'local knowledge'. It relates to the personal and possibly expert knowledge held by people who have direct experience, skills, insight and intuition. It can also refer to knowledge that is culturally embedded through tradition, norms and rituals. In this case, information is generated and passed on from generation to generation verbally, through discussions, storytelling, songs, etc. Due to its nature, this type of knowledge is difficult to document. Another type is 'scientific' or 'articulate' knowledge', which refers to explicit knowledge generated through formal education. The application of scientific methods increases rigour, validity and reliability of the information. This type of knowledge is easily documented, testable and accountable.

Pollock and Whitelaw (2005) and Raymond et al. (2010) have proposed 'hybrid knowledge', which has emerged by the integration of different types of knowledge through cross-sectoral collaborations and multidisciplinary research. There is a

common perception that 'hybrid knowledge' inevitably affects rigour, objectivity and trustworthiness of the data. However, some of the authors argue that there have been few attempts to investigate those claims in the literature (Estrella & Geventa 1998; Guijt 1999; Reed et al. 2008). Increasingly, the accuracy, feasibility and relevance of 'traditional' data collection and interpretations are being challenged. For example, Reed et al. (2008) describe how meaningful indicators can be distilled following a systematic approach that combines scientific and tacit knowledge. In their research, indicators identified by local communities were tested against more 'traditional' scientific indicators to validate local knowledge. The authors found that it was possible to use hybrid knowledge to derive indicators that are reasonably accurate and relevant to stakeholders. Estrella and Geventa (1998) specify that conventional scientific approaches are favoured if consistency and rigour is important. However, depending on the situation, achieving the most precise data is sometimes not necessary and approximations can be good enough (Reid et al. 2008).

Financial and Human Resources

One of the major issues surrounding CBM relate to resource requirements. Factors such as finance, volunteer capacity and facilitation need to be considered as components of success. In terms of financial resources, Estrella and Geventa (1998) suggest establishing a budget at the start of the CBM project for development, planning and scheduling. Although initial costs might be high, long-term savings can be made especially if the information captured is useful. Researchers Izurieta et al. (2013) describe a case study where setting up CBM was the most costly phase due to expenditures related to community consultations, provision of training, developing indicators, appointing a specialised facilitator, etc. They noted that these expenses decreased with time as volunteer capacity increased, indicators were established and trust between stakeholders was forged. Cost benefit analysis found that using information collected by community members rather than contracting the work to consultants resulted in financial savings. Alternatively, Conrad and Hilchey (2011) mention a growing number of CBM groups partnering with academic institutions like, universities, due to their capacity to share information, provide training, arrange access to facilities and contribute to funding. Furthermore, collaboration with other institutions could ease access to information, encourage networking and provide access to training opportunities.

In terms of human resources, Parkinson (2009) observe that not all participants are willing to volunteer time and effort to monitor a project. The author cite a case where community members saw monitoring activities as labour and therefore felt entitled to compensation. In that situation, the CBM initiative struggled to succeed. The author emphasise that local perspectives need to be considered as community goals and expectations might differ towards such initiatives. Finally, Estrella and Geventa (1998) discuss the crucial yet underrated role facilitators can play. The authors explain that skilful facilitators are able to catalyse projects, bring people together and

shape the outcomes of a CBM. They can foster an environment of trust, build rapport among stakeholders and address issues of concern. Furthermore, they can decrease volunteer dropouts through skilful encouragement and by considering the needs of stakeholders (Conrad & Hilchey 2011).

This literature review shows that a top-down/bottom-up stakeholder engagement is a fundamental component of IWM. The effects of cumulative impacts in multi-land use catchments can threaten the SLO of an entire economic sector. Fostering cross-collaboration between stakeholders and encouraging genuine community involvement on a catchment scale can help address some environmental impacts sustainably. CBM have, in recent years, expanded as concerned citizens collaborate to produce monitoring data to influence decision-making. Certain aspects that characterise components of CBM have been highlighted in the literature. However, its application and subsequent success remains context specific. The following case study illustrates how cumulative impacts following a series of flood events, in Central Queensland, threatened the SLO the coal mining sector. Community concerns over mine-affected water spearheaded the establishment of a cross-sectoral catchment monitoring partnership. The partnership produced a range of watershed health reporting products to inform stakeholders on waterway health. It also engaged with community members through other strategies, one of which promoted CBM for educational purposes and awareness-raising. A brief background on the catchment and an introduction to the partnership ensues.

Case Study: The Fitzroy Partnership for River Health

Geography / Hydrology

The Fitzroy Basin (Figure 1) is the second largest ocean draining catchment in Australia after the Murray-Darling Basin (Flint et al. 2012). It covers 142 600 km² of land which stretches across Queensland on Australia's east coast. Comet, Dawson, Fitzroy, Isaac/Connors, Mackenzie and Nogoa are the six sub-catchments that makeup the Fitzroy Basin (FPRH n.d.d). Seven important tributaries cross the catchment: Callide Creek, Comet River, Dawson River, Fitzroy River, Isaac River, Mackenzie River and Nogoa River (Flint et al. 2012). The Fitzroy Basin is home to a number of native and endangered wildlife and marine life. The basin is known for its highly diverse freshwater fish, which supports both economical and recreational fishing of the region. Furthermore, the catchment drains into Keppel Bay and out towards the Great Barrier Reef (GBR) World Heritage Area (FPRH n.d.d).



Figure 1. Map the Fitzroy Basin depicting the six main sub-catchments (BOM 2016)

Climate

Due to its large surface area, high climatic irregularity is expected within the Basin. For example, in the short term, mean annual rainfall can vary from one end of the catchment to another. In the long term, prolonged periods of droughts are often followed by the intense periods of rainfall. Due to its geology, hydrology and climatic influences, basin is susceptible to flooding during the wet season (FPRH n.d.d). Two main climatic phenomena that have a great influence on the basin are the El Nino, which increases the chances of drought in the region, and the La Nina, which brings higher than average rainfall to the region. For instance, the 2001/2002 drought and the 2007-2008 floods within the basin were found to have close correlations with the El Nino and La Nina phenomenon respectively (Vink & Robbins 2012).

General Land Uses

Approximately 230,000 people live within the basin (FBA 2013) and just over half of these live in the city of Rockhampton (FPRH n.d.d). Anthropogenic activities (Figure 2) include construction of dams and weirs, land clearing for grazing (81%); cropping

(6%), forestry (5%), urbanisation (1%) and 0.5% for both mining and irrigation (FPRH n.d.d). Only 6% of the land is set aside for conservation. These activities have significant impacts on the freshwater, estuary and marine ecosystems. Without proper management, water quality catchment and the reef have the potential to degrade (DERM 2011).



Figure 2. Image of the Fitzroy Basin depicting land use (FPRH n.d.b)

Mining Industry

According to the Minerals Council of Australia (2016), Australia is the 5th largest global producer of coal. In 2012-2013, the country extracted over 400 million tonnes of the material and nearly 80% originated from open-cut mining operations. Queensland accounted for 52% of the country's production. The Australian coal mining industry is prominent and coal exports alone contributed more than \$40 billion dollars to the economy in 2012-2013.

Managing water has always been challenging for the mining industry (Vink & Robbins 2012). Competition for water resources have pushed mining operations to look for alternative water supplies, such as seawater and treated sewage, and to investigate management strategies and technologies to improve water use and reuse within its operation. Variable climatic conditions add to the challenge as mine water managements have to adapt their strategies according to extreme dry or wet conditions. In addition, mining operations have to constantly demonstrate thorough water management practices to stakeholders irrespective of climatic conditions. This is especially important if they wish to maintain their SLO (Owen & Kemp 2013). Balancing infrastructure capacity, water management strategies and financial

investment is a challenge for the mining sector, especially when considering high climatic variability.

Fitzroy Basin Flood Events

Flooding within the Fitzroy Catchment is natural and can be a beneficial for the region (Flint et al. 2012). However, from 2007-2008, heavy rains resulted in the flooding of coal mining operations and pits located within the Fitzroy Basin (ABC Rural 2011). This contributed to mine closures within the region, which was detrimental to the local economy (DERM 2011). Under normal circumstances, the Environmental Authority sets mine water discharge conditions for mining operations. However, during the floods, most operations struggled to comply with the established discharge limits and salinity regulations. As a result, coal mining operations applied for, and were granted Transitional Environmental Programs (TEP). These TEP allowed the mines to legally discharge higher than usual volumes of mine-affected water into local waterways (DERM 2011). Discharging excess water held onsite allowed operations to mitigate or reduce any production losses as well as any infrastructure losses incurred by the flood events (Vink & Robbins 2012).



Figure 3. Photograph of 2008 mine flooding (ABC Rural 2011)

However, public concerns ensued after downstream residents noticed a change in water quality following the discharge (DERM 2011). According to the Queensland Flood Commission of Inquiry (QFCI 2012), monitoring results found increased salinity levels in drinking water unacceptable. The high salinity levels triggered community members to question the impacts that mine affected water could have on human health and on the environment. In response to these public concerns, the Queensland Premier commissioned two separate investigations. The first looked at the management of the water quality in the Fitzroy Basin. The second investigated

the cumulative impacts mine-affected water had on the water quality of the Fitzroy River system (DERM 2011). Based on the findings, the Queensland Government revised TEP licence conditions for floodwater discharge and increased the requirements for environmental monitoring expected from mining operations. Following this, the FPRH was established (Eberhard et al. 2013).

The Fitzroy Partnership for River Health

The formation of the FPRH in 2012 was triggered after the 2008 floods when community members raised concerns over the potable water quality. The investigations commissioned by the Queensland Premier also highlighted the importance of integrated waterway monitoring and reporting. Prior to the formation of the partnership, a number of independent monitoring programs were already in place and produced mostly by the resource sector. However, the data were collected and analysed separately producing results that provided a fragmented picture of the basin's health. In an attempt to reconcile the information, the FPRH established affiliations with various organisations willing to share data (Eberhard et al. 2013).

In 2012, the FPRH became the official governing body that “collaboratively develops and implements integrated waterway monitoring and reporting for the Fitzroy Basin” (FPRH n.d.a). The partnership created a suite of waterway-health reporting products as tools to help improve the management of water resources and to promote community awareness of waterway health (Flint et al. 2015). The FPRH brought together 22 organisations, which included representatives from all three levels of government (local, state and federal), extractive industries, energy companies, agriculture, Central Queensland University (CQU) and a local NGO the Fitzroy Basin Association (FBA) (Flint et al. 2015).

The data collected from various partners are collated and used to provide an assessment of Fitzroy Basin aquatic and ecosystem health (Flint et al. 2012). The majority of the data is provided by the resource sector. Prior to publication, the assessments are reviewed by the Science Panel (SP), which is an independent group of waterway experts employed to provide unbiased scientific and technical advice to the partnership. Its presence ensures transparent, credible and accurate reporting of waterway health (Flint et al. 2015).

FPRH Reporting Products

The FPRH produces the *Fitzroy Basin Report Card* (FBRC) to inform the community and stakeholders. The FBRC features the *Ecosystem Health Results*, the *Drinking Water Report* and the *Agricultural Use Report*. These reports are developed in collaboration with the CQU, the FPRH project team and the independent SP. The overarching objective of the report cards is to produce a credible and representative ecosystem health assessment of the Fitzroy Basin (Flint et al. 2015). Its focus is to capture the current state of the Fitzroy Basin ecosystem and use the data to assess

potential changes in ecosystem health over time. According to the FPRH, the results are not directly involved in catchment management, but are there to inform management decisions. In addition, the information produced is designed to inform stakeholders on the outcomes and success of environmental management strategies towards maintaining or improving ecosystem health (FPRH n.d.a). To date, the FPRH has published four report cards. Its most recent report card was released in June 2015 and includes findings from data collected between 2013 and 2014.

Community Engagement

To complement the reporting products, the FPRH reaches out to community members through various avenues. One of their most recent projects involved the creation of the *MyWater* online portal (FPRH n.d.e). This initiative allows community members interested in monitoring waterway health to collect monitoring data and share the results online. Furthermore, the FPRH awards bursaries and scholarships to community members. The *Care for Creeks Bursary* (CCB) is a community initiative established by the FPRH in 2012. The purpose of the prize is to engage with the younger generation in waterway monitoring and for them to share their results with the wider community through the portal (FPRH n.d.c). Moreover, the FPRH recently announced the *HeART Scholarship* (FPR, n.d.f), which invites postgraduate students at CQU undertaking waterway health research to apply for a chance to win a \$2,000 scholarship towards research expenses.

Problem Statement and Research Question

The FPRH was formed in 2012 with the purpose of integrating waterway monitoring programs and publicly reporting waterway health at the catchment scale (Eberhard et al. 2013). In addition, a CBM initiative called *MyWater* was features on the partnership's website. Literature shows that community involvement in cross-collaborations is critical to catchment management and in maintaining a SLO. Considering that the FPRH was created after the emergence of a crisis and the majority of the data being provided to the partnership are resource based, the overarching research examines 'what are the highlights and opportunities for the FPRH CBM initiative and what value can it add to the partnership?' The following section details the research methodology adopted to support the research project.

Research Methodology

Theoretical Framework

The theoretical frameworks that underpin this research are related to the IWM principle that recognises the importance of multi-stakeholder participation in watershed management (GWP 2010). This is complemented by the growing body of

academic literature that acknowledges CBM as an integral part of IWM and natural resource management (Conrad & Daoust 2008; Pollock & Whitelaw 2005; Conrad & Hilchey 2011). Finally, CBM characteristics provide an additional lens that guides the research structure.

Qualitative Research

The literature review revealed many examples where qualitative research techniques were applied in order to evaluate stakeholder perceptions of topics that included public participation in collaborative watershed management and CBM programs (Jonsson 2005; Ferreyra & Beard 2007; Koehler & Koontz 2008; and Freitas et al. 2011). Moreover, aspects of the research methodologies established by authors Conrad and Daoust (2008) and Parkinson (2009) were used as a template to design and structure the research for this paper. Elements of the research design used by the authors were selected and tailored to structure the methodology presented here. A list of potential interviewees was proposed by the gatekeeper of the FPRH to reflect a wide-range of perspectives. Candidates included participants representing a diverse range of stakeholders. They included the partnership (FPRH*), the Fitzroy Basin Association (FBA*), a major partner, and the independent Science Panel (SP*). In addition, three end-users (User1, User2 and User3) were interviewed. The relationships between the interviewees and the MyWater portal are presented in Figure 4 and detailed in Table 1.

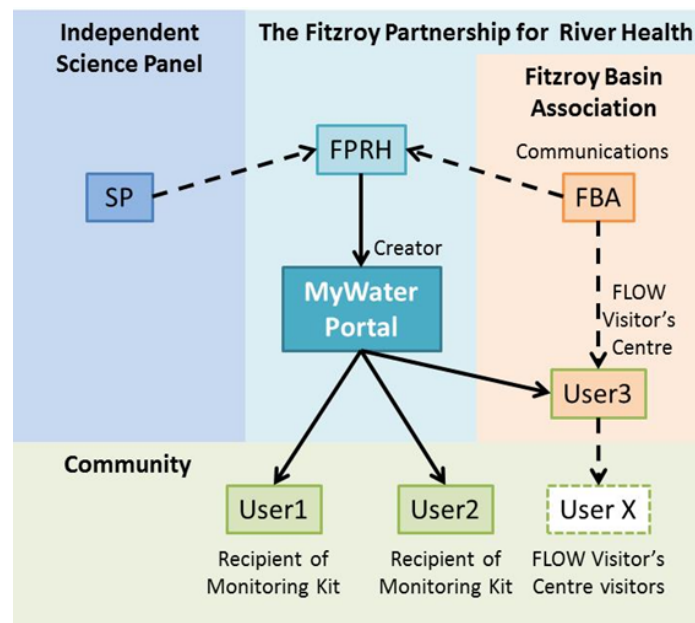


Figure 4. Visual representation of the association between participants, the FPRH and MyWater portal

Table 1. Summary of participants' background

Code	Description	Role in MyWater Portal
FPRH*	FPRH Representative	Design and implementation
FBA*	FBA Representative	Communications
SP*	SP Representative	None
User1	School Teacher / Child Educator	Recipient of Care for Creeks Bursary and end-user
User2	School Teacher / Child Educator	Recipient of Care for Creeks Bursary and end-user
User3	FBA Community Educator	FBA Flow Visitor Centre Educator

One-on-one interviews were scheduled through email correspondence and conducted by phone. Phone interviews were considered to be ideal because they were easy to schedule and cost effective to organise. Through this technique, the views, experiences and opinions of individuals were clearly tracked and straightforward to transcribe. In addition, phone interviews had the advantage of disguising personal identities, which could encourage the interviewee to feel at ease and potentially provide more candid answers (Denscombe 2010). One of the disadvantages associated with one-on-one interviews is potentially limiting the range of views, experiences and opinions expressed by interviewees who are not interacting within a group setting. Furthermore, conducting phone interviews removed the ability to capture elements of nonverbal communication as well as circumstantial factors, both of which could influence the interpretation of the data (Denscombe 2010).

The questions asked during the interview were designed to support the research questions and followed a similar format described by Conrad and Daoust (2008) and Parkinson (2009). They included questions to put the interviewee at ease; about CBM; about the MyWater portal; and about the future development of the portal. In order to collect information as consistently as possible, each participant was presented with a set of very similar interview questions. However, some of the questions needed to be modified according to the roles and responsibilities the participant played in the MyWater portal initiative. For example, participant related to FPRH were asked about the design of the initiative (APPENDIX A), while end-users were asked about their user experience (APPENDIX B). A semi-structured interview process was conducted to encourage participants to freely develop and elaborate their opinions and thoughts on the topics. Prompts, probes and checks were occasionally used throughout the interview to guide the interrogation. Both field notes and audio recordings were collected. Field notes were used to capture key responses and impressions during the interview. Additionally, audio recordings were used to capture and produce word-for-word transcriptions with the purpose of increasing the accuracy of the data collected. The transcriptions produced were subsequently sent back to the interviewees for review and validation prior to commencing data analysis.

Thematic Analysis

Once the participants had checked their interview transcripts, the data were analysed using principles of thematic analysis (TA). TA was used to sift through and organise qualitative data collected from the interviews. The method, which is incredibly flexible, allowed the systematic search of patterns or themes across the entire data (Braun & Clark 2006). Decisions and assumptions used to guide TA were applied consistently throughout the analysis in order to systematically extract emerging information.

Results and Analysis

As a whole, the views and perspectives of the participants were varied. They converged on some aspects and diverged on others. The interview results were presented according to the following thematic components: (1) perceptions of CBM; (2) MyWater portal design and user experience; (3) MyWater portal highlights and opportunities for improvement; and (4) MyWater portal data use. For each section, views were described and discussed against the background of the literature. Where necessary, additional information related to the portal or FBRC was provided to contextualise some of the responses. Finally, tables were used to highlight sample quotes from the respondents.

Perceptions on Community Based Monitoring

All the participants interviewed shared positive views about CBM (Table 2). The perspectives cited were in agreement with some of the benefits highlighted and described by Pollock and Whitelaw (2005) and Conrad and Hilchey (2011). The reasons included creating a community where people came together to address complex environmental issues; increasing community awareness through engagement and education; empowering communities to address concerns; and fostering a sense of ownership. Influencing ecosystem management, decision-making and policy-making were not directly mentioned by participants. However, the democratisation of environmental management could be perceived as a byproduct of increased community engagement, awareness, scientific literacy, empowerment and ownership.

When asked to identify and discuss an element considered essential to the success of a CBM project, all respondents alluded to leadership (Table 2). The leadership characteristics described by interviewees were in line with the facilitator attributes presented by Estrella and Geventa (1998). They included the ability to communicate with a wide range of stakeholders; to inspire volunteers; to stay positive and enthusiastic; to capacitate and delegate responsibilities. The quality of leadership skills could determine whether or not a CBM project would succeed or fail. According to User1, a facilitator or champion lacking such skills often caused CBM groups to fall

apart. Moreover, the data showed some reference to top-down and bottom-up leadership approaches as important considerations in CBM.

Interviewees were probed about principal impediments to CBM (Table 2). The aspects cited agreed with some of the barriers described by Conrad and Hilchey (2011). All the respondents referred to elements that influenced the long-term sustainability of CBM projects. They included: access to financial resources; maintaining long-term participation; continued involvement of CBM volunteers; and quality of the data. Maintaining project sustainability and consistency was an important factor to consider in CBM projects particularly if the information collected serves the purpose of informing decision-makers.

Table 2. Interviewee extracts of key characteristics of CBM

Code	CBM Perspectives	Elements of Success	Barriers to Success
FPRH*	"it's good"	"volunteer that is pushing the initiative [...] or an organisation providing the support"	"monitoring in a more regular and structured approach"
FBA*	"awareness and engagement"	"clear purpose"	"having the resources"
SP*	"education process and awareness"	"people who glue, keep it all together, facilitate the activities"	"keeping motivation"
User1	"people have ownership [...] a vested interest"	"key people to drive and motivate"	"keep a project alive over a long period of time"
User2	"create community thinking"	"enthusiastic [...] good social skills [...] adequately educate"	"continued commitment"
User3	"foundation for clarifying [...] concerns"	"promote the ability for them to do it [...] have a clear process"	"quality of the input"

MyWater Portal Design and User Experience

Design and Implementation

Based on the information gathered from the interviews, the MyWater portal was conceptualised and designed by a few members of the FPRH. According to FPRH*, the initiative started as a spinoff of an existing platform used by partner organisations to upload their monitoring data for the purpose of informing the FBRC. That same platform was adapted to create the MyWater portal.

The objectives of the initiative according to the FPRH* was to enable communities to gain an understanding of waterway health through monitoring and to associate their findings with the FPRC results. A general inspection of the FBRC and MyWater portal revealed some similarities in their design. For example, indicators selected for

the portal were similar to the indicators used in the FBRC (Figure 5). For the report card, the indicators were systematically identified and assessed according to relevant guidelines, existing monitoring programs, academic literature and knowledgeable professionals (Flint et al. 2012). They were refined to represent the complexity of the catchment system as effectively as possible while considering aspects such as costs, efficiency, data availability. As a result of this process, four main categories of indicators were selected to establish the ecosystem health index (EHI) for the report card (Jones et al. 2013). They consisted of physical-chemical indicators such as conductivity, pH, turbidity and sulphates; nutrient levels of phosphorus and nitrogen; the presence of toxicants such as heavy metals, pesticides and herbicides; and ecology indicators focused on macro-invertebrates. Likewise, the indicators presented in the MyWater portal were inspired by the indicators used in the FBRC. They included physical-chemical indicators such as salt, pH and turbidity and ecology indicators such as water bugs, fish, riparian vegetation and weeds.

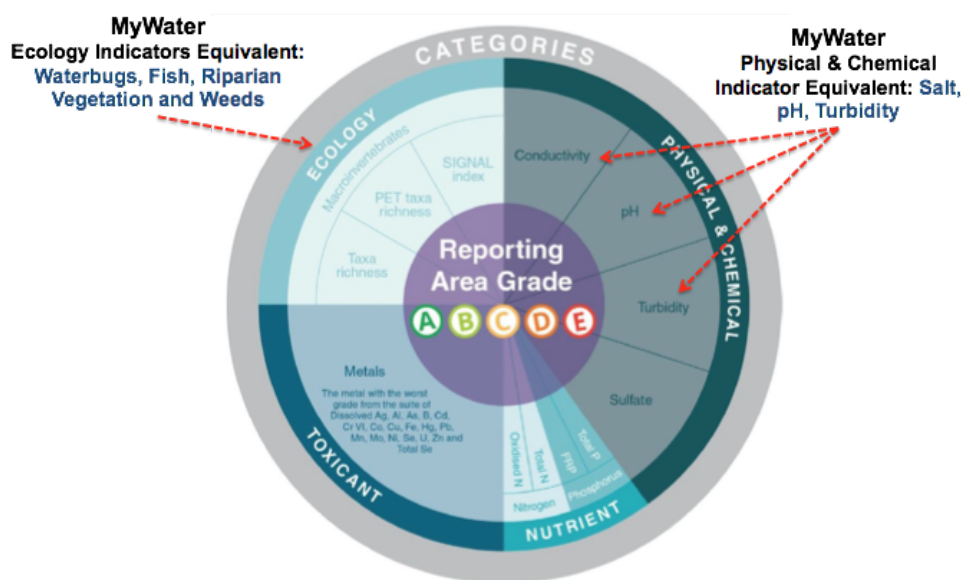


Figure 5. Fitzroy Basin Report Card Indicators (circular diagram) and MyWater Indicators (adapted from Flint et al. 2015)

Similarly, much like the FBRC presented online, the monitoring results were spatially displayed on the MyWater webpage (FPRH, n.d.c; FPRH, n.d.e). Some of the key components featured on the MyPortal website included a window entitled 'Sites Overview', which displayed the names of the monitoring sites or community groups undertaking the monitoring. Featured beside each site name was the average EHI grade, which was presented according to indicator categories. Much like the online FBRC, the website featured a two- or three-tiered interactive map (Figure 6).



Figure 6. MyWater three tiered interactive map (adapted from FPRH n.d.e)

However, some differences did exist between the MyWater portal and the FBRC website (Figure 7). For example, at a macro-level, the online FBRC featured a dynamic graph displaying annual EHI trends of the overall catchment, sub-catchments and estuary zones. In addition, at a meso-level, each sub-catchment displayed EHI trends for indicators against time or as grades for a given year. Moreover, in the website, a descriptive summary was provided for each indicator. Information included a short explanation of the indicator, a justification and a brief interpretation of the grades. In comparison, the MyWater portal did not have similar display options to facilitate comparisons nor did it have additional information on the indicators, to inform the user.

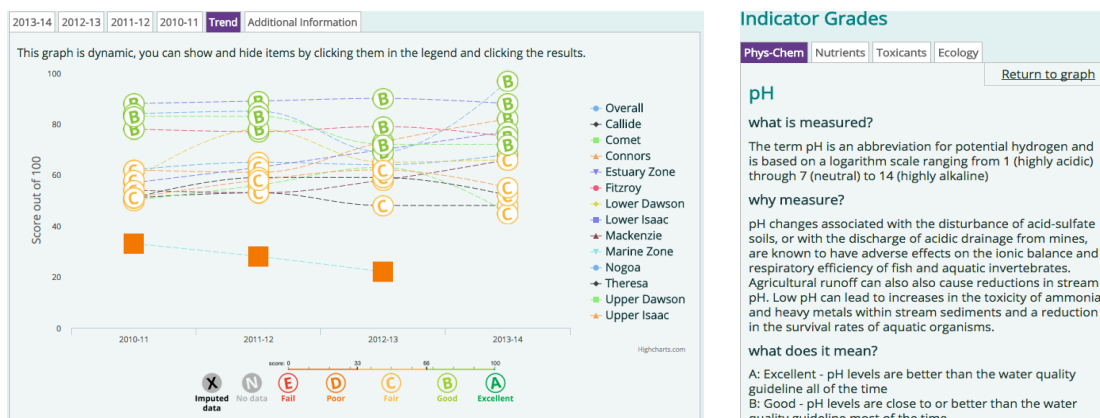


Figure 7. The FPRC dynamic graph displaying annual EHI trends of the overall catchment, sub-catchments and estuary zones (left) (FPRH n.d.d); descriptive summary (right) (FPRH n.d.d)

FPRH*, FBA* and User3 explained that the MyWater portal was designed to enable any community member or groups interested in publishing their data to do so online. However, according to the FPRH*, the majority of the community members who contributed to the portal were associated with the FPRH partner organisations or recipients of the CCB. Since its launch in 2013-2014, the FBA's communications department and FLOW Visitor's Centre have been responsible for promoting the MyWater initiatives to community groups and schools within the catchment. Following its introduction, the number of participants has steadily increased as shown in Table 3. The portal features data from 20 unique sites or groups. Based on information provided on the website (FPRH n.d.e), most of the participants have entered data once, while two groups have entered data for two consecutive years. Although the initiative is just starting, there appears to be enough interest for community groups to contribute. However, the challenge is maintaining community interest from year to year.

A small budget was allocated to establish the initiative. During the interview, FPRH* explained that concerns over financial cuts and potential shifts in priorities drove the FPRH to design the portal to 'run on its own'. This resulted in a portal able function with minimal ongoing support from the partnership while enabling community members to contribute regardless of budgetary constraints. This also meant the program would rely on community initiatives and ownership for sustained contribution.

Table 3. Participation from different groups and data entries

Site / Group Names	2013-2014	2014-2015	2015-2016
Dee River crossing in Mandalay		x	
Emerald Botanic Gardens		x	
Emerald State High School			x
Fairbairn Dam		x	
Fitzroy River at Barrage			x
Frenchman's Ck at Kalka Shades			x
Frenchman's Creek at Honour St (Scout hut)			x
Frenchmans Creek at Jard Street			x
Girl Guides		x	x
Grosvenor Creek at Moranbah			x
Gundoo Rangers Moores Creek		x	x
Kershaw Gardens		x	
Marlborough Creek at Sharps			x
Nogoa River at Denbigh Downs			x
Norman Rd Bridge		x	
Oakey Creek in Penny Royal			x
Scott's Crossing, Dee River			x
Sunset Drive		x	
Waterpark Creek	x		
Williams Farm		x	
Total Participants	1	9	12

During the interview, the participants were asked to explain what they believed was the purpose of the MyWater portal (Table 4). The responses varied between raising community awareness; encouraging community involvement; linking the monitoring activities with waterway health; and gaining a greater understanding of the FBRC report card. The overall responses indicated that objectives established by the FPRH were clearly understood by the interviewees. Authors, such as Estrella and Geventa (1998), underlined the importance of setting clear objectives to guide a CBM project to ensure that participants comprehended the project scope and its implications.

Table 4. Key responses associated with the objectives of the MyWater portal

Code	MyWater Portal Objective
FBA*	"raise awareness"
SP*	"get the community involved"
User1	"about a report card"
User2	"community involvement ...pride ...responsibility"
User3	"can be compared to the report card"

MyWater Portal User Experience

The interview responses provided a general overview of the MyWater portal user experience. A CCB was advertised to educational institutions and community organisations by the FPRH and FBA. In 2015, four prizes were awarded (FPRH, n.d.f). User1 and User2 were both bursary recipients. They received a monitoring kit each and the opportunity to attend a training workshop with the FPRH. FBA* explained that the kits were valued at \$1,000 each. They contained a suite of devices such as a conductivity meter, turbidity tube, pH strips, bait traps and reference books. Training sessions were provided by the FPRH in order to familiarise the winners with the equipment, sampling methodologies and the MyWater platform. Following the training, User1 and User2 embodied the role of facilitators and guided separate groups of children to monitor their local creeks. The groups consisted of 10 to 15 children, aged between 6 and 14 years. For User1 and User2, safety was a main concern and care was taken to select an area of the local creek that was safe to monitor. Both users followed the instructions provided and used the equipment provided to capture results. The observations and measurements were recorded on field sheets (APPENDIX C), which were downloaded directly from the website. The sheet contained a table with the physical-chemical and ecological parameters required to complete the monitoring activity. After collecting the data, the users with the children entered their data onto the MyWater portal to share their results online. On average, each group monitored their creek once to twice a term. During the interview, both users expressed their hesitance to share data following heavy rainfall or during drought due to concerns about sharing data perceived as unrepresentative of waterway health. According to the users, the CCB, training and the MyWater user experience were excellent.

User3 had a different experience of the portal. As an FBA employee who works at the FLOW Visitor's centre, this user introduced the MyWater portal to visitors and school children. This user did not have any direct experience with monitoring, but had experience demonstrating monitoring principles and the MyWater portal to community members. User3 found school groups and visitors were interested in the

initiative. Based on the responses, the overall user experience was very positive from both direct and indirect users.

MyWater Portal Highlights and Opportunities for Improvement

All participants were asked to identify highlights of the MyWater portal as well as opportunities for improvement. Based on the answers, the responses revolved around aspects of the MyWater portal design, increasing community involvement and supporting cross-collaboration.

Data Presentation

Participants were asked to identify some positive aspects of the MyWater portal (Table 5). Four of the five interviewees referred to the visual layout of the portal. Some of the main features highlighted included the spatial representation of the data on a GPS map and the ability for the viewer to compare their data with that of other community members. In addition, half of the respondents suggested visualising community data as an overall time trend to facilitate year-to-year comparisons. In other words, there was a desire to present the data much like the FBRC graph in Figure 7 (left). During the interview, SP* and User2 explained that displaying all the data against time would allow community members to easily track change and progression, which could in turn encourage sustained monitoring.

Table 5. Positive aspects of the MyWater portal data presentation

Code	Highlights	Opportunities for Improvement
FPRH*	"people gaining recognition"	"tab associated with all of the years"
SP*	"GPS locations"	"over time rather than each year"
User1	"map and ratings"	
User2	"place [...] to upload your data"	"graph where you could see the progress"
User3	"ratings on the GPS map"	

Indicators

In terms of indicators, all three users were really pleased with the indicators presented (Table 6). Based on their comments, the school children undertaking the monitoring showed greater interest in ecology indicators, such as fish and macro-invertebrates, than physical-chemical indicators. Furthermore, User3 mentioned that current indicators were perfect for the general public and young school children, but too basic for older students. User3 suggested introducing indicators of varying levels of complexity, which could capture the interest of a wider audience. These observations agreed with Guijt (1999) who explained that selecting indicators

relevant to community members is important in order to captivate and maintain interest levels.

Table 6. User Perception on Indicators

Code	Highlights	Opportunities for Improvement
User1	"macro-invertebrates study"	"They don't [...] understand why pH, turbidity and salinity are very important"
User2	"spent [...] time studying the fish"	
User3	"for community its perfect"	"[introducing] levels of technicality"

When asked the same question about indicators, SP* proposed several ways to improve the learning experience of monitoring groups (Table 7). The first suggestion was using consistent terminology to describe units. For instance, on the MyWater field sheet, participants measured salt in microsiemens per cm ($\mu\text{S}/\text{cm}$). In the MyWater portal, the salt scatter graph referred to 'salt units' and in the online FBRC, electrical conductivity (the salt equivalent) was scored out of a 100. SP* explained that keeping terminology and units consistent was important to transfer lessons learnt from the portal to the report card and into other life situations. SP* then suggested providing additional information to describe the indicators measured by the community. Much like the information presented in the FBRC website (Figure 7, right), SP* reasoned that providing additional information would allow community members to deepen their understanding of the captured data. SP* also suggested additional measurements to facilitate the interpretation of some of the results. They included capturing information about rainfall events and creek water levels to provide context on indicator variability. Finally, estimating riparian zone thickness was considered an easy and relevant measurement to incorporate.

Table 7. SP* Indicator Suggestions

Description	Key Words
Consistent Terminology	"go to the proper units"
Complementary Information	"button [...] could take your to guidelines"
Contextualising Information	"magnitude and duration of last rainfall event"
	"elevation of the water level"
Riparian Distance	"an estimate of what the distance is would be quite useful"

Field Sheet and Monitoring Instructions

When asked about the Field Sheet, all three users responded very positively about its simplicity and ease of use. According the respondents, the document was easy to

understand and follow. The opinions of the users were in line with the FPRH*, who explained that simplicity was important to encourage participation. However, the FPRH* mentioned that information requested on the Field Sheet, such as the names of the bugs, fish, vegetation and weeds, could not be transferred onto the portal. Although none of the users saw the anomaly, the FPRH* expressed plans to update that aspect on the portal.

Furthermore, the Field Sheet contained a few pages of monitoring instructions. According to the users, the instructions presented were simple and easy to follow (Table 8). However, User1 and User2 were provided with training as CCB recipients. FPRH*, FBA* and User1 agreed that community members who had not received any training may be disadvantaged. Therefore, to enable participation, FPRH* and the FBA* explained that they were in the process of creating a community MyWater monitoring guide. The purpose of the manual was to provide community members and schools with the information they needed for monitoring without relying on the FPRH for training, therefore encouraging greater participation. The FPRH* indicated that potential financial restrictions motivated the partnership to adopt this approach.

Table 8. User perception on the training received and the instructions

Code	Highlights	Opportunities for Improvement
FPRH*		"updated monitoring booklet [...] user friendly and easy to understand"
FBA*		"putting together a user friendly monitoring booklet"
User1	"[FPRH] showed us how to fill it in and rate them"	
User2	"The training was very beneficial"	
User3		"pictures to demonstrate a series of actions"

Monitoring Equipment

In addition to the Field Sheet, the MyPortal website provides an Equipment List for community members looking to purchase equipment for monitoring (APPENDIX D). The FPRH*, FBA* and User3 were aware that not all community members would have the resources to invest in monitoring kits. This was one of the reasons that motivated the partnership to create the CCB. According to FBA* the bursary was being revised to benefit the greater population. One of the proposed solutions involved using the bursary to supplement specific equipment instead of awarding an entire equipment kit to prize winners. That way, with the same budget, the FPRH could reach out to more community groups and schools instead of a few individuals or groups. Furthermore, User1 and User2 found the monitoring kits very beneficial and educational. Some aspects of the monitoring kit highlighted by the users

included the macro-invertebrate sheets and the fish identification book. Both users explained that the visual documentation captivated the school children's interest and enhanced their learning experience.

Increasing Community Involvement and Collaboration

FPRH*, FBA* and User3 explained how the MyWater portal was advertised through the FBA's network of schools and educational organisations. In addition, the FLOW Visitor's Centre and the CCB were instrumental in raising awareness and involving communities. Although this strategy was successful, both User1 and User2 explained how they were aware of the MyWater portal's existence through the bursary. Moreover, User1 and User3 believed that not many communities or groups knew about the initiative. User1 described how advertising the portal would increase involvement, encourage networking opportunities and collaboration among concerned citizens who are passionate about waterway health.

Collaboration between the FPRH and community members was a topic that emerged from across the interviews responses (Table 9). According to the FPRH* and FBA*, the MyWater portal is a platform designed to allow community members to take ownership with minimal intervention from the FPRH. However SP*, User2, and User3 eluded to the importance of maintaining, if not increasing, collaboration between the FPRH and communities. According to their responses, there was a need for ongoing engagement between the FPRH and community members for the portal to be an effective educational tool. Authors Reed et al. (2008) underlined the importance of using collaboration to combine local and scientific knowledge to empower communities to understand ecological changes more effectively. Moreover, SP* suggested annual meetings between the FPRH and community members to foster a sense of engagement or alternatively, creating a discussion forum on the MyWater portal. The idea was to encourage communities to connect, discuss issues and seek advice from the partnership on topics related to monitoring concerns. Furthermore, FPRH*, SP* and User1 suggested increasing collaboration with educational institutions by incorporating the MyWater portal within the school curriculum.

Table 9. Perception on community ownership and ongoing collaboration with FPRH

Code	Description	Key Words
FPRH*	Community Ownership	"[The MyWater Portal] is designed to allow those who want to get involved to get involved"
FBA*		"Hoping that more people can do it on their own [...] without the support of the FPRH staff"
SP*	Ongoing Collaboration	"It needs both [...] Fitzroy would need to drive it so that local champions would really pick it up"
User2		"the professional people could actually come out"
User3		"engaging with people that are using it"

CBM Data in Report Card

One of the final questions of the interview related to the current use of the data collected by communities and its possible inclusion within the FBRC. According to the responses, most respondents were aware that the data uploaded on the portal raised awareness and provided education. User2 saw her contribution as a way to alert the FPRH of any anomalies detected in the local waterway, which would encourage further investigation from appropriate authorities. However, when asked if the community results should be included in the report card, the responses were more divided (Table 10).

The FPRH*, FBA* and User3 all because of the lack of rigour and consistency related to the collection of the data. However, SP*, User1 and User3 saw it as an opportunity to increase community involvement and ownership. SP* and User1 both commented on the ability to use the data collected by community members as a way to 'fill a gap'. If monitoring is not occurring within a region then there is a spatial or temporal gap within the data used to produce the report card. According to SP*, there should be no reason why the data should not be included in the report card, provided that the data had some validation. This perspective is in line with authors Reed et al. (2008) who reasoned that for certain situations, obtaining approximations was good enough.

Table 10. Perceptions of the inclusion of MyWater CBM with the FBRC

Code	CBM in Report Card	Justification in Key Excerpts
FPRH*	No	"the data was about education and awareness raising rather than being really robust scientific data."
FBA*	No	"until we have a greater level of information I don't think we can put the data in there."
SP*	Yes	"where there is gaps spatially and temporally and there has been at least some validation [...] no reason why not"
User1	Yes	"it's the only monitoring site that we have got in our area"
User2	Yes	"because its community ownership isn't it? [...] We are making a contribution to data that is being collected"
User3	No	"I'm not sure how they would be able to guarantee the integrity of the [community] information"

Discussion

The Fitzroy Basin is the largest catchment to drain into the GBR. Its landscape, hydrology and climate varies spatially and temporally. To add to its complexity, the land is shared and used across economic sectors whose anthropogenic activities produce environmental impacts that are challenging to quantify and predict. The

flood events of 2007-2008 triggered a social and economic crisis, which threatened the viability of the region's extractive sector. Studies following the events found no conclusive evidence that the detected increase in salinity originated from mine-water discharge. Moreover, the coal mining operations acted in accordance to the Environmental Authority's licence conditions. They followed standard procedures and applied for TEPs to legally discharge excess water into the catchment. Despite that, community perceptions and concerns on the impact of mining activities within the region remained high (Eberhard et al. 2013). The case study highlights a disconnect between people's perception of water quality and the cumulative impacts of activities that occur within the catchment. Moreover investigations highlighted the importance of integrated waterway monitoring and reporting through the creation of the FPRH.

The aim of this research is to understand what are the highlights and opportunities for the FPRH CBM initiative and what value it can add to the partnership? To address this question, this discussion will centre on characterising the MyWater portal according to (1) CBM literature and (2) IWM principles.

The MyWater Portal

CBM guidelines are broad allowing its application to be variable. Referring to the literature, the MyWater portal is based on a consultative governance structure as described by authors Conrad and Hilchey (2011). This structure follows a 'top-down' approach where the project was initiated, designed and implemented by a central authority, which in this case, was the FPRH. As a result, community participation is restricted to end-users. This means that community groups have very little involvement in the design and implementation of the MyWater portal. One difference between the consultative governance structure and the MyWater portal resides in the use of the data collected by community members. In the report card, the data are used to inform decision-makers whereas in the portal the data does not have any applications beyond educating users and increasing report card literacy.

Based on interview responses, no framework was used to guide the development of the initiative. This agrees with the observations reported by Conrad and Daoust (2008), who found most CBM groups or initiatives operated without a framework. In addition, the partnership has no program to measure participant progress against set objectives. Moreover, adaptation or changes to the portal appears to be conducted on an 'ad hoc' basis with little consultation with partners, the SP and end-users. This compromises the ability of the FPRH to respond to stakeholder needs and concerns. Without a comprehensive adaptive management program, the project risks stagnating or losing interest in the long run (Estrella & Geventa 1998).

The indicators chosen by the partnership emphasise the development of scientific knowledge. According to User1 and User2, there was noticeable preference for ecology indicators from school children. Overall, the indicators were found to be simple to measure, easy to collect, timely and cost-effective to undertake - once equipment was supplied. Other characteristics such as rigour, validity and

consistency, as mentioned by Guijt (1999), were not prioritised due to the nature of the monitoring program. Furthermore, monitoring equipment availability was identified as a limiting factor by most interviewees. However the FPRH and FBA are looking to improve the CCB to reach-out to a greater number of people.

In terms of leadership, the FPRH can be considered as a 'top-down' facilitator of the MyWater portal because they created an environment, which encouraged CBM. For instance, the partnership developed the portal; advertised the initiative; created the bursary; provided training to bursary winners; and implemented improvements to the program on a regular basis. Likewise, bursary recipients can be perceived as community champions. They demonstrated leadership through their involvement with the initiative and used the opportunity to educate children and raise awareness of the Fitzroy catchment.

In this situation, both the MyWater creators and the end-users were involved in CBM without collaborating with each other. Half of the interview respondents called for stronger cooperation between the FPRH facilitators and community members. The other half emphasised the ability for the communities to drive CBM on their own. In addition, the MyWater portal has limited networking opportunities for the stakeholders to interact. This underlines the need to use the portal to link communities with each other and with the partnership.

Financial and human resource limitations were the main factors that restricted the development of the portal. These barriers are consistent with literature findings (Conrad & Hilchey 2011; Estrella & Geventa 1998). However, these obstacles did not hamper communities from getting involved. Literature demonstrates that there are many variables to consider when creating a CBM and either approach can be equally successful. Since its establishment, the MyWater portal has demonstrated a promising level of success. The portal has seen a growing number of participants contribute their findings online and the stakeholders interviewed expressed high degrees of satisfaction with the initiative. The challenge is to maintain community interest and to encourage ongoing participation. To summarise, the MyWater highlights and opportunities for improvement are shown in (Table 11).

Table 11. Summary of highlights and opportunities for improvement

	Highlights	Opportunities of improvement
MyWater Portal Website	<ul style="list-style-type: none"> • Easy to navigate • Offers clear spatial representation of the data using GPS mapping 	<ul style="list-style-type: none"> • Visualise data against all time and other monitoring sites
Indicators	<ul style="list-style-type: none"> • Simple to measure • Ecology indicators captivate users 	<ul style="list-style-type: none"> • Provide additional information on the indicators • Ensure consistency in terminology and units • Introduce levels of technicality • Include additional indicators to contextualise the measurements in the Field Sheet and the portal
Field Sheet and instructions	<ul style="list-style-type: none"> • Easy to understand • Clearly guided monitoring activities 	<ul style="list-style-type: none"> • Introduce a visual monitoring booklet
Care for Creeks Bursary	<ul style="list-style-type: none"> • Allows access equipment and training 	<ul style="list-style-type: none"> • Revise bursary to benefit more in the communities
Monitoring Kit	<ul style="list-style-type: none"> • Comprehensive kit to facilitate monitoring • Equipment, visual aids and books 	<ul style="list-style-type: none"> • Revise bursary to benefit more in the communities
Involvement and Collaboration	<ul style="list-style-type: none"> • Growing community interest • Encourages community ownership 	<ul style="list-style-type: none"> • Maintaining involvement • Opportunities for increasing collaborations with FPHR • Networking with FPHR and other CBM groups

MyWater Portal and IWM Principles

IWM is underpinned by principles that promote stakeholder-participation and cross-sectoral collaboration. As a whole, the FPHR appears to embody these characteristics as they have established partnerships with multiple stakeholders representing a wide range of sectors (FPHR n.d.a). Nonetheless, the ability for community members to contribute to the report card and influence decision-making is limited.

To meet IWM requirements, strategies need to be established to give community members a voice because resulting management decisions might affect the community. The MyWater portal offers opportunities for communities to contribute and legitimately influence decision-making. Through stakeholder-participation and cross-sectoral collaboration, involving community members can increase their understanding of natural and anthropogenic impacts on receiving environments (Franks et al 2012). For example, User1 and User2 did not share monitoring data on the portal following extreme climatic events because they believed that the results were unrepresentative of waterway health. Alternatively, if the results were contextualised, then the users would gain greater insight of how waterway health

shifted under varying conditions. Collaboration and discussions between specialists and local communities promotes the democratisation of scientific knowledge. Providing context and encouraging a deeper understanding of waterway health might help relieve social stigma placed on industries, such as mining, as environmental polluters. It will encourage community members and decision-makers to look at the catchment and address cumulative impacts holistically.

Moreover, CBM has the potential to address gaps found in the data. For example, in the FBRC, eight out of 11 freshwater reporting zones had missing ecology grades due to lack of data (Figure 8). Similarly, spatial distribution of data density showed irregularities and spatial gaps for physical-chemical indicators (Figure 9) as well as for certain heavy metals (not shown). The quantitative gaps observed in the reports and on the website are in line with some of the data already being collected by community members. Interview responses found that users and, in particular, school children had natural interest for ecology indicators such as macro-invertebrates and fish. This interest can be used to address the gap. To maintain public engagement in monitoring, indicators must draw from the interests and capacities of community members. Furthermore, the FPRH have shied from collaborative practices with communities because of resource limitations. Provided that an environment of cross-collaboration is established between all stakeholders, the MyWater portal could offer a cost-effective solution that enables community members to fill gaps presented in the partnership's reporting products.

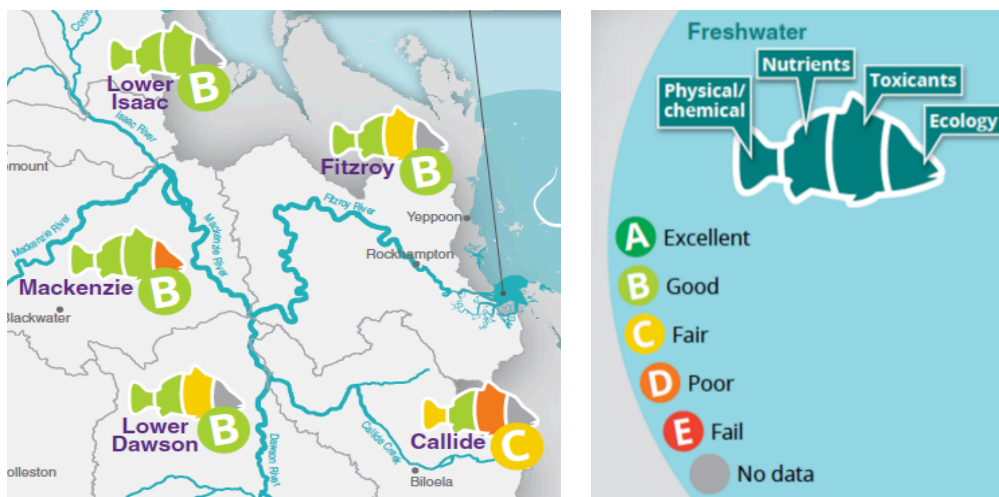


Figure 8. (left) Small section of the Fitzroy catchment; (left) An illustration showing the report card legend (FPRH n.d.d)

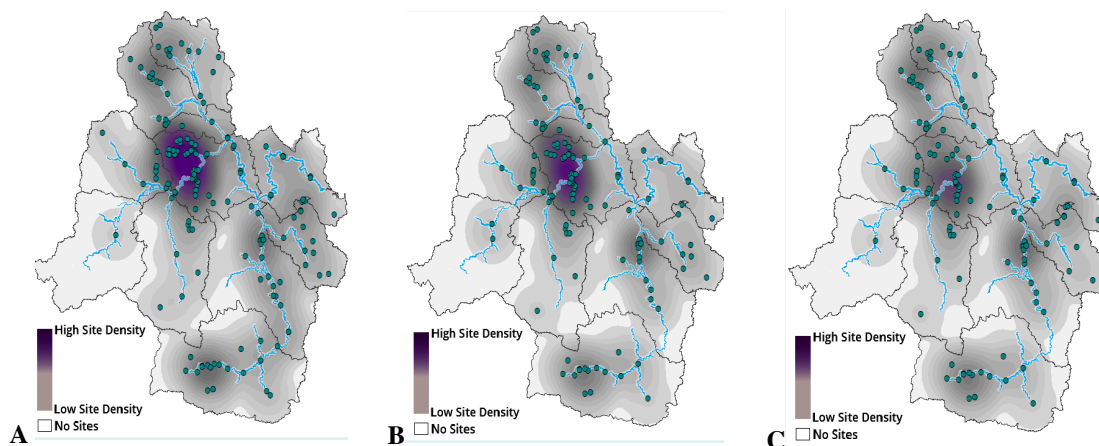


Figure 9. Spatial distribution of data density for (a) pH, (b) turbidity and (c) salt (FPRH, n.d.g)

At the same time, the interviews highlighted a divide between interviewees who believed MyWater data should be included in the FBRC and those who disagreed. Disagreements were justified and legitimate because they raising concerns over the quality of the data collected by community members. If the data is to contribute towards decision-making then characteristics such as rigour, validity and consistency must be prioritised to a certain degree (Reed et al. 2008). Close collaboration between stakeholders is essential to develop indicators and methodologies that can be used accurately by concerned citizens. Participatory indicator development, knowledge sharing and demonstrations of competency can help forge a relationship of trust amongst stakeholders in terms of the validity of the data collected.

To summarise, both ‘top-down’ and ‘bottom-up’ collaboration between stakeholders is essential to move the MyWater portal beyond its current purpose. Incorporating IWM principles will require revising the current MyWater portal paradigm to include some of the following aspects: (1) shifting from consultative to collaborative governance structure (Conrad & Hilchey 2011); (2) tailoring an existing framework to guide the development of the CBM and integrating adaptive management strategies (Pollock & Whitelaw 2005); (3) collectively reviewing CBM objectives and deliverables (Estrella & Geventa 1997); (4) scaling down MyWater by developing a pilot CBM program within a sub-catchment, evaluating its success before growing the initiative across the catchment (Guijt 1999; Parkinson 2009); (5) developing indicators through collaboration to ensure data relevance (Raymond et al. 2010); (6) ensuring rigour through capacitation; and (7) adjusting rigour where approximations are sufficient enough to estimate waterway health (Reed et al. 2008). For the FPRH to ensure long-term sustainability of the MyWater portal, it is essential that cross-collaboration be established. Integrating IWM principles within the MyWater portal will take time and many iterations before it is established, however, this challenge provides the opportunity for the FPRH to pioneer this initiative and set the example for other partnerships within Queensland Australia.

Conclusion and Recommendations

Cumulative impacts of natural and anthropogenic activities added a layer of complexity in the management of the Fitzroy Basin. The creation of the FPRH demonstrated a successful working example of cross-collaboration between economic, educational, governmental and non-governmental sectors. In addition, it has showcased the desire to engage with communities through various initiatives. The research conducted highlights an opportunity for community members to contribute to the body of data used to create the Fitzroy Partnership's reporting products.

As it is currently structured, the MyWater portal is used to raise awareness and increase report card literacy. Participants interviewed highlighted aspects of the portal that contributed to its success. Some of the characteristics included ease of use, simplicity, visual diagrams and access to monitoring equipment through the CCB. At the same time, the research revealed opportunities for improvement that either converged certain views or underlined some differences in perspectives. For instance, visual improvements to the website and issues concerning the availability of the monitoring kits were consistent between stakeholders. Conversely, topics related to data use, increased collaboration and networking opportunities displayed a divide amongst the interviewees.

Through the lenses of IWM, the MyWater portal has the potential to provide additional benefits to the partnership by adapting a collaborative governance structure. This shift can increase community understanding of natural and anthropogenic impacts on receiving environments, offer a cost-effective solution that enables community members to fill gaps presented in the partnership's reporting products and allow community members to legitimately influence decision-making.

To date, the partnership does not produce the data for their reporting products as it is sourced from both major and minor partners. However, the partnership established the MyWater portal and created a framework that encouraged community members to participate. As a way forward, the partnership could choose to expand their current initiative by increasing collaboration with communities. Alternatively, they could partner with existing CBM groups, within the Fitzroy Basin, and negotiate strategies to effectively engage with communities. That way, the partnership could share the responsibility of expanding the portal and communities can contribute more effectively with the guidance of an established monitoring group.

The research presented was conducted on a small group of participants and provides an insight on stakeholder perspectives and attitudes towards CBM and the portal. Future research could expand this to include a greater number of participants representing major and minor stakeholders, FPRH, FBA, SP, bursary winners and non-bursary winners. The results would provide the partnership with representative perspectives, important information for developing CBM program and maintaining long-term community interest. Until then, the FPRH should continue to run the

MyWater portal and support to community members through the CCB. Based on the research findings, some of the following recommendations should be considered for implementation:

- Improving the data presentation by including a tab displaying all the community data against time.
- Providing a link with additional information related to the indicators used in the monitoring program.
- Using a consistent set of terminology and units in the MyWater portal as in the FPRC.
- Introducing different levels of technicality suitable for wide range of participants.
- Capturing additional information to provide a greater context to the parameters being measured.
- Updating the online monitoring instructions.
- Advertising the MyWater portal to reach out to a wider range of communities interested in monitoring.
- Increasing networking opportunities between community members and FPRH experts.
- Creating an online forum where community members can interact with each other and with the FPRH experts.
- Creating opportunities for ongoing collaboration with community members.
- Partnering with existing CBM groups within the Fitzroy Basin.
- Expanding the research to include major and minor stakeholders, FPRH, FBA, SP, bursary winners and non-bursary winners to determine how community members can contribute to the body of data used for the FPRH reporting products following IWM principles.

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Appendix A

FHPR*, FBA* and SP* Questionnaire

Opening Questions:

1. Can you tell me a little about yourself?
2. How did you get involved with the FPRH? And what is your main role and responsibilities?
3. What were some of the reasons that inspired you to get involved with FPRH through the MyWater Portal?
4. Aside from the FPRH MyWater Portal, have you been involved in other community based monitoring (CBM) initiatives?

General Questions on Community Based Monitoring (CBM) / Citizen Science:

5. In general, what are your perspectives on CBM? Why?
6. In order to create a good CBM what do you think needs to be done? Why?
7. What aspects of the CBM do you consider to be the most important? Why?
8. What aspects of the CBM do you consider to be the most challenging? Why?

General Question on MyWater Portal:

9. Can you tell be about the objectives behind the MyWater Portal? Why was it created? What is its purpose? Do you think it is meeting its objectives?
10. Can you tell me how the MyWater Portal was designed (e.g. who was involved, was a framework used? What was the role of community members. etc.)?
11. What aspects of the MyWater Portal, Field Sheet, and Equipment Lists would you consider to be a useful/beneficial? Why?
12. What aspects of the MyWater Portal, Field Sheet, and Equipment Lists would you think could be improved? Why?
13. How would you suggest improving MyWater Portal, Field Sheet, and Equipment Lists those aspects mentioned? Why?
14. What are your thoughts on how the data collected by community members are currently being used? How would you like to see the data collected by community members used?

Future Development of MyWater Portal:

15. In an ideal situation, how do you see the FPRH further develop the MyWater Portal? What aspects could be improved? And why?
16. Do you have any suggestions on how community members could increase their contribution in MyWater portal?
17. Do you think the data collected should be used in the FPRH report card? Why or why not?
18. Is there anything important that has been overlooked that could help improve community involvement?

Appendix B

Community Member Questionnaire

Opening Questions:

1. Can you tell me a little about yourself?
2. How did you hear about the FPRH?
3. How did you find out about the MyWater Portal initiative?
4. What were some of the reasons that inspired you to get involved with FPRH through the MyWater Portal?
5. Aside from the FPRH MyWater Portal, have you been involved in other community based monitoring (CBM) initiatives?

General Questions on Community Based Monitoring (CBM) / Citizen Science:

6. In general, what are your thoughts about CBM? Why?
7. In order to create a good CBM what do you think needs to be done? Why?
8. What aspects of the CBM do you consider to be the most important? Why?
9. What aspects of the CBM do you consider to be the most challenging? Why?

General Question on MyWater Portal:

10. Can you tell me about the objectives behind the MyWater Portal? Why was it created? What is its purpose? Do you think it is meeting its objectives?
11. Can you describe to me your experience with the MyWater Portal?
 - a. When did you monitor?
 - b. How many people participated?
 - c. How often did you monitor? And why?
 - d. What did you monitor? And why?
 - e. Would you participate again?
 - f. Have you recommend others to participate?
12. What aspects of the MyWater Portal, Field Sheet, and Equipment Lists would you consider to be a useful/beneficial? Why?
13. What aspects of the MyWater Portal, Field Sheet, and Equipment Lists would you think could be improved? Why?
14. How would you suggest improving MyWater Portal, Field Sheet, and Equipment Lists those aspects mentioned? Why?
15. What are your thoughts on how the data collected by community members are currently being used? How would you like to see the data collected by community members used?

Future Development of MyWater Portal:

16. Do you have any suggestions on how community members could better be involved in MyWater portal?
17. Do you think the data collected should be used in the FPRH report card? Why or why not?
18. Is there anything important that has been overlooked that could help improve community involvement?

Appendix C

Community Monitoring Field Sheet Version 1.1 November 2014

If you have a tablet or smartphone and wireless connectivity available in the field you can enter this information at www.riverhealth.org.au/report_card/community/. Otherwise use the sheets to record your data in the field and then enter the results on the website back at the computer.

Recorder	
Site Name	
Date	
Time	
pH (1-12)	
Salt (us/cm)	
Turbidity (10 to 240)	
Water Bugs (select one)	Bugs Found: <input type="checkbox"/> Very sensitive bugs present with lots of diversity (3+ types) <input type="checkbox"/> Very sensitive bugs present <input type="checkbox"/> Only sensitive to tolerant bugs present <input type="checkbox"/> Only tolerant to very tolerant bugs present <input type="checkbox"/> Only very tolerant bugs present
Fish (select one)	Fish Found: <input type="checkbox"/> 4 or more native species <input type="checkbox"/> 3 native species <input type="checkbox"/> 2 native species <input type="checkbox"/> 1 native species <input type="checkbox"/> 0 native species
Riparian Vegetation (select one)	Plants Found: <input type="checkbox"/> 5 strata's present <input type="checkbox"/> 4 strata's present <input type="checkbox"/> 3 strata's present <input type="checkbox"/> 2 strata's present <input type="checkbox"/> 1 or no strata's present
Weeds (select one)	Weeds Found: <input type="checkbox"/> 0% weed invasion <input type="checkbox"/> 1 to 25% weed invasion <input type="checkbox"/> 25 to 50% weed invasion <input type="checkbox"/> 50 to 75% weed invasion <input type="checkbox"/> 75 to 100% weed invasion

Sampling Instructions

Fish

Bait and set the fish traps in three spots (with different habitats if possible) and leave undisturbed for at least 15 minutes. It is best to set the traps first and then complete the other sampling before returning to the traps after all other activities are completed. If the water is clear, sit and quietly observe water for five minutes to identify fish not trapped. Place fish caught in the traps in a bucket of water while identifying them using a fish id guide (*A Wild Australia Guide: Freshwater Fishes is an inexpensive and suitable resource for freshwaters in Australia*) and release them as soon as possible to minimise harm. List fish found and results on field sheet or at www.riverhealth.org.au/report_card/community/

Water Quality

Collect water sample and use EC tester for salt, test strips for pH and the tube for turbidity. Enter results on field sheet or on the website

Riparian Vegetation

Inspect the riparian zone for up to five different strata of vegetation (Strata types: Canopy Trees, Woody Shrubs, Herbs/Forbes, Sedges and Waterplants). Identify plants using an appropriate field guide if time allows. List vegetation found and results on field sheet or on the website. This activity can be done along with the weeds assessment to save time.

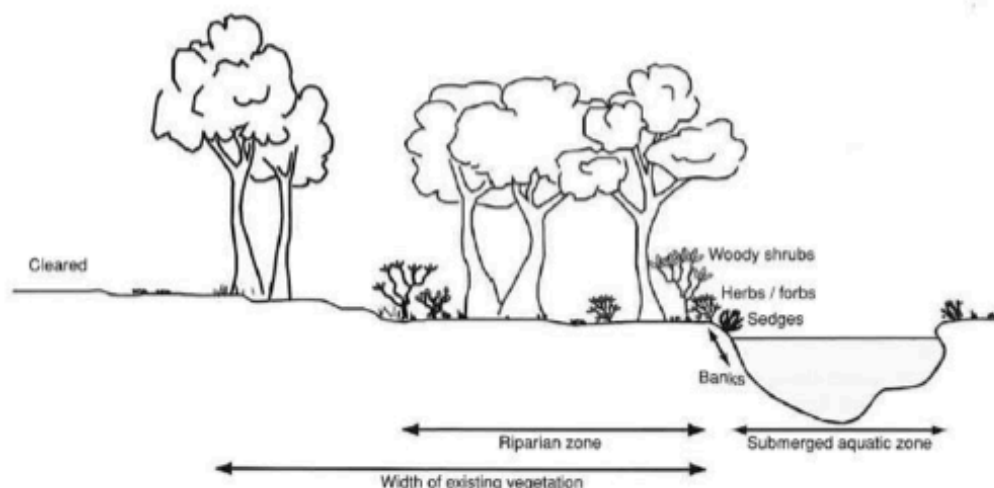


Figure 7-18 Location of riparian vegetation on the stream bank

Weeds

Inspect the riparian zone and use an appropriate weed identification guides to classify weeds (*Grow Me Instead* and *Priority Weeds of the Capricorn Region* are useful guides for Central Queensland). Remove weeds and dispose to the garbage when possible and time allows. List weeds found and results on field sheet or on the website. This activity can be done along with the riparian assessment to save time.

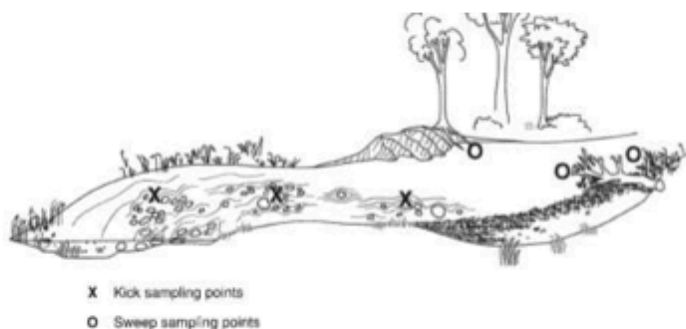


Figure 6-4 Example of where kick sampling and sweep sampling should occur at a site

Waterbugs

Use the net to catch waterbugs using sweep and kick sampling techniques (Extract from Queensland Community Sampling Manual provided). Pour samples into white trays and separate bugs into ice cube trays if necessary using a pipette or spoon. Identify bugs with appropriate identification charts and magnifying glasses. List water bugs found and results on field sheet or website

Sweep sampling

This method is best suited to stream edge, pool and backwater habitats with vegetation overhanging from the stream bank, aquatic plant (macrophyte) beds, undercut banks, root mats, leaf packs, woody debris, and other stream features that provide suitable living places for macro-invertebrates.

The following steps are recommended in order to gain the truest representation of a site's macro-invertebrate community when conducting sweep sampling:

1. Insert the net among the key features of the habitat (such as overhanging vegetation) and use a short, upward sweeping movement at right angles to the bank. Stir up the bottom while doing so, ensuring that bottom-dwelling animals are suspended and then caught when sweeping through the cloud of suspended material. Continue this procedure along 10 m of the habitat to sample the full range of stream features.
2. Stop regularly to rinse mud and fine silt out of your net. The sample should be free of sediment prior to sorting. An easy way to rinse your net without losing your sample is to wash water into the side of your net while you are holding it with the mouth of the net pointing upwards above the water.

3. Once finished, scoop the net out of the water in a forward motion to prevent fauna from escaping. Flush the net with water to remove any remaining sediment prior to sorting.
4. Empty the contents of the net gently into about 2 cm of clear stream water in a white sorting tray. Rinse down the sides of your net into the tray to ensure that you transfer the full sample into the tray. Pick off any stray macro-invertebrates still clinging to the net using a pair of tweezers.

Kick sampling

This method is designed for sampling stream bed habitats and can be used to sample a range of depths and flows. It is performed most effectively in riffles—fast-flowing, rocky sections of the stream bed—where the highest diversity of macro-invertebrates is generally found. However, kick sampling is also an effective method for sampling silty or sandy beds and rocky or gravel beds in slightly slower-flowing sections of the stream. All types of bed habitat present at a site should be sampled using the kick method.

The following steps are recommended in order to gain the truest representation of a site's macro-invertebrate community when conducting kick sampling:

1. Approach the sampling area from downstream to prevent disturbing fauna prior to collecting.
2. Holding the net downstream with its mouth facing the sampling area upstream, disturb the stream bed by digging your foot underneath the stones and turning them over. Macro-invertebrates will become suspended in water and will be pushed into the net by the flow of the stream. If there is little or no flow, you will have to use a short sweeping action with the net while stirring up the bed.
3. If you encounter large rocks, place them in the net by hand and rub off fauna any into the net before placing the rock back on the stream bed.
4. Stop regularly to rinse mud and fine silt out of the net.
5. Repeat these procedures over a distance of 10 m, aiming to sample the full range of flow velocities and key features of the bed habitat.
6. Once finished, scoop the net out of the water in a forward motion to prevent fauna from escaping. Flush the net with water to remove any remaining sediment prior to sorting.
7. Empty contents of the net into 2 cm of clean water in the white sorting tray.
8. Before taking another sample, rinse the net so that all fauna and debris are removed.

Appendix D

Waterway Monitoring Kits	Potential Supplier
4 x Magnifying glass	Westlab
4 x ice cube trays	Westlab
4 x trays	Westlab
1 x Net frame	Westlab
1 x Sweep net	Westlab
1 x Extendable poll	Westlab
3 x Bait trap	BCF
1 x 20L bucket	BCF
1 x Conductivity meter	Instrument choice
1 x Turbidity tube	Southern Biological
2 x PH strips (50)	John Morris Scientific
100 x Pipette	John Morris Scientific
1 x Priority Weeds of the Capricorn Region book	Produced by CPMG (Rockhampton Regional Council)
1 x Fish trap and guide	http://www.pascalpress.com.au/steve-parish-wild-australia-guide-freshwater-fishes/
1 x Qld dry tropics grow me instead guide	Stationery / printing http://www.growmeinstead.com.au
1 X USB with field data sheets to grade the health of waterway	Stationery