Pathways for museums to community engagement through citizen science: examining the experiences of Streamwatch

Figure 1 Australian Museum Streamwatch staff member training volunteers in-situ. David Bush©

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Statement of original authorship

This thesis contains only original and unpublished materials, except where acknowledged in the text. No part of this work has been submitted for a higher degree to any other university or institution.

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LIST OF ABBREVIATIONS

AM	Australian Museum
AMCCS	Australian Museum Centre for Citizen Science
ECSA	European Citizen Science Association
ICOM	International Council of Museums
the Lab	the Cornell Lab of Ornithology
NSW	New South Wales

ABSTRACT

Museums function as a place of informal scientific learning and are increasingly starting to administer citizen science programs. Academic discourses in new museology and citizen science, which prioritise practical methods over pure theory, are beginning to emerge but the capacity for community engagement through citizen science has yet to be investigated properly from a museum perspective. More specifically, the capacity for citizen science to satisfy aspects of new museology concerned with community engagement has not been fully examined. Understanding engagement within a museum as the development and satisfaction of community expectations therefore involves judging the success of these engagements by the experiences of community within the museum space.

This thesis explores the potential for stakeholder expectations in both citizen science and new museological public programs to be met simultaneously, through a case study of the Australian Museum's Streamwatch program. Interviews with stakeholders in the program—chiefly citizen scientists and museum administrators—are used to explore the effectiveness of the Streamwatch to function as both a museum public program and citizen science program.

By re-examining citizen science through the lens of new museology, the dual ability of citizen science to not only produce usable data for research, but facilitate meaningful engagement within a museum space through programming is revealed. Conclusions are then drawn to assist in the development and management of citizen science programs and to extend new museological theory.

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Just as museums are spaces reflective of their surrounding communities, my well-being and passion for museology reflects a group of amazing people who endlessly encourage me. Thank you for sticking with me through tantrums, sleep deprivation, self-righteousness, and despair. The following work was only possible with your support; this work is the result of my heartbreakingly wonderful community.

CHAPTER 1 | INTRODUCTION

RESEARCH AIMS AND QUESTIONS

This thesis will explore the potential for stakeholder expectations of both citizen science and new museological[1] public programs to be met simultaneously. It will achieve this by applying the new museological framework to a case study of the citizen science program Streamwatch, and gauging whether the program could be considered successful as both a citizen science and new museological public program. Interviews with Streamwatch citizen scientists and program administrators will further reveal whether the program is 'successful' (see Chapter 5). In this way, this thesis will examine how a new museological framework traditionally used in a cultural capacity can be reappropriated for science engagement and education within a museum space. The singularity of this case study does not provide enough data or evidence to apply findings across the board, but what emerges is a scaffold that will help to foster understanding of the overlap of citizen science and new museology. The aims of new museology discussed in this thesis relate to the educational goals of public programs only. The wider aims of new museology are rich in potential for a better understanding of the intersection of the museum space and citizen science, but are beyond the scope of this thesis. Similarly, the use of data produced by citizen science programs is not the main focus of this thesis. The scientific value of the data produced is not commented upon as the expertise to

[1] New museology is the museological theory that encourages a museum space to 'represent not just the world views of ruling classes, but also popular culture and the histories of non-elite social strata... [they are] altogether more accessible - the old atmosphere of exclusiveness and intellectual asceticism has largely given way to a more democratic climate.' (Ross 2004, p. 84-85). Museums that embrace new museology are 'visitor-centred' (Hudson 1998), aim to 'facilitate attitudinal changes' (Lloyd 2014) and 'through its public-service orientation...contribute positively to the quality of individual human lives and to enhance the well-being of human communities' (Weil 1999). New museology is not a single theory or approach which can be easily applied within the museum space. Practice can be highly contested and embody opposing views.

evaluate this sits outside the parameters of this thesis. Data use is discussed in reference to experience and expectations within the museum space.

This study builds on foundational arguments that have been made to conduct citizen science programs within museum spaces, and investigates the wider potential for museums to effectively utilise citizen science as a form of community engagement. Qualitative data was collected through individual interviews, designed to capture views of various stakeholders in citizen science within the museum space. This data was then compared across the stakeholder groups—citizen scientists, program administrators and external users—to reveal both parallels and divergences in experiences and expectations. This was done with the intention of enhancing an understanding of how museums can engage and interact with volunteers through citizen science, how they can foster the co-creation and sharing of knowledge, and encourage a positive relationship between communities and their environments. Based on these findings, recommendations are made for further research that could develop our understanding of how museums can best engage in citizen science—specifically, recommendations on how to maximise the potential of citizen science programs to act as a narrative device for museums to increase organisational transparency.

This case study of the Streamwatch program explores the capacity for citizen science to be understood through the lens of new museology and additionally will examine the perceptions that Streamwatch citizen scientists and program administrators have, particularly concerning the role of the data to support scientific research. This thesis then considers the ability of Streamwatch to satisfy organisational goals of citizen science, as outlined by Australian Museum (AM) strategic documents. The tacit goals of a museum based in new museological theory—that is, what a museum should ideally be achieving—will be examined in relation to Streamwatch. Finally, this thesis explores the capacity for the new museological

narrative framework to achieve these dual goals of community engagement and data production.

Museums function as places of informal education, through public programming and administer citizen science programs, and yet the capacity for community engagement through citizen science programs has not been substantially investigated to date. The theories of new museology and citizen science have only recently started to produce literature that prioritises practical methods over more traditional theoretical discourse. A wide range of materials advising on best practices concerning the aforementioned theories have been published, but are generally published as grey literature[2]. New museology is the contemporary theory and current accepted practice of museum studies that prioritises the construction of viewing environments that are conducive to visitors contributing their personal reflections and understandings to the knowledge surrounding them (McLean 2004; Walsh 1997). Citizen science traditionally refers to programs that facilitate the production of scientific data by volunteers, in collaboration with and for use by research scientists (Dickinson et al. 2010; Hollow et al. 2014).

Despite being recognised as complementary by museum practitioners, new museology and citizen science are not often discussed in conjunction with one another. Rarer still is the discussion of the potential for citizen science to embody new museological theory and engage communities in new ways. Current literature concerning citizen science in the museum space is sparse and focuses on justifying the combination of the two terms and the development of

[2] 'Grey Literature' refers to materials and research produced by organisations published outside of the traditional academic outlets, often contributing to discussions regarding best practice for example, the European Citizen Science Association's *'Ten principals of citizen science'* (2015), the International Council of Museums '*Running a Museum'* (2014) and Tweddle et al. '*Guide to citizen science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK*.' (2012).

a framework in which they can function to produce quality data (Bunten & Arvizu 2013; Ramshaw 2001; Wolfson 2010). While quality data defines success for a citizen science program, the success of museum public programs is defined by a more complex matrix of stakeholder experience and education. Museums actively engaging in citizen science should to ensure they not only produce quality data, but also provide experiences; citizen science can to meet both research and new museological goals within the museum space.

If we can profile visitors to the extent of knowing what they experience within the museum context, we can gain a comprehension of what the public considers to be the "*value and benefits from museum-going"* Falk (2009, pg. 21). Thus the museum can adapt in response to visitors, thereby strengthening their experience and increasing the chances of crucial identity formation occurring. This visitor-centric understanding also has both a financially and sociologically economic value, and can make positive contributions to the succession planning of these programs. Evaluation within the museum sector now recognises this beneficial duality of function, and promotes audience evaluation as a necessary practice (Sheng & Chen 2011; Soren 1999).

CHAPTER 2 | BACKGROUND INFORMATION

In this section, background information is provided about the Streamwatch program and the AM. New museology and citizen science theories are then examined for complementary goals.

DEFINITIONS

Museums are complex sites where a multitude of disciplines and practices intersect for a variety of purposes. New museological theory reflects this complexity by incorporating a multi-disciplinary approach to understanding, representing, reacting and interacting with the ideas and theory of modern museums (Macdonald 2006). For museums that embrace new museology a priority is the provision of a democratically accessible space that facilitates positive identity formation for visitors (Hudson 1998; Lloyd 2014; Ross 2004; Weil 1999). **Figure 2** is a mind map exploring one function of a museum: as a place to tell stories. This is a good starting point from which to explore the complexities of themes and disciplines at play within the museum space as it shows the breadth of functions and roles of a museum within communities. It is not, however, a comprehensive representation of everything a museum does or can achieve.

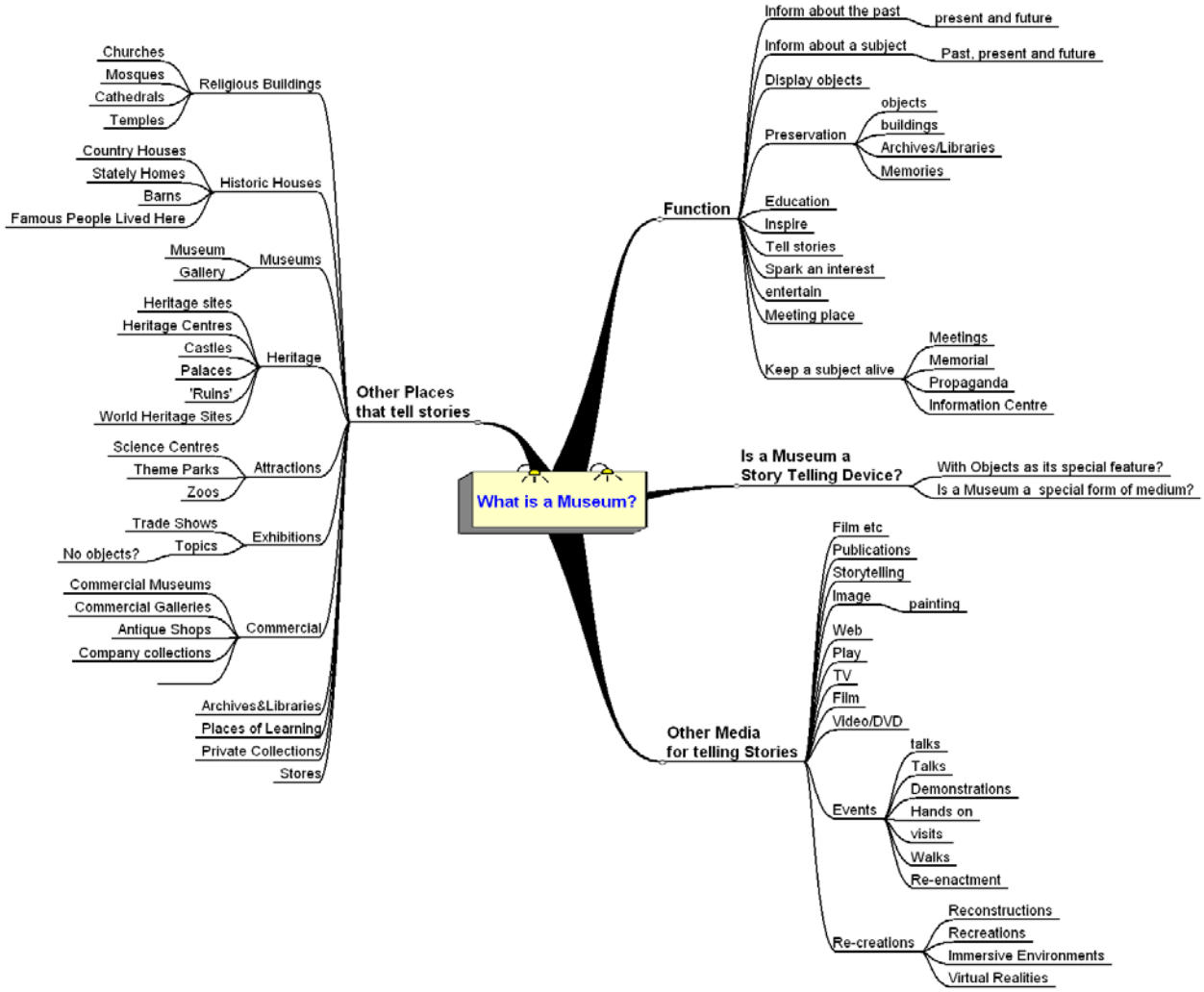

Figure 2 What Is a Museum?[3]

For the purpose of this study, a museum is defined in accordance with the International Council of Museums (ICOM) (2007) as:

> *a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment.*

In the course of this thesis the museum will be examined predominantly in relation to its educational role, as well as its role in communicating with the public. The issue of

[3] Flude, 2006

transparency between the museum and the community will also be addressed as part of the new museological discourse. Transparency here is understood as relating to decision-making processes, governance of the museum, and the societal benefits museums can offer.

Citizen science is not a new concept; one could argue that Charles Darwin employed citizen science as other people's observations were used to verify his own theories and findings. The National Audubon Society started an annual Christmas bird count in 1900 and is regularly cited as one of the first major examples of citizen science in practice (Cohn 2008). For the purpose of this study, citizen science is understood to be:

> *…scientific work undertaken by members of the general public in collaboration with or under the direction of professional scientists and scientific institutions for a variety of scientific, educational, societal, cultural and policy goals concerning the natural and cultural world.*[4]

CITIZEN SCIENCE IN CONTEXT

The Cornell Lab of Ornithology (the Lab) has been a prolific contributor of materials surrounding the practice of citizen science, and a leader in establishing the contemporary academic discipline. The Lab was integral in establishing the Citizen Science Association (in the United States of America) in 2012, which, along with the European Citizen Science Association (ECSA) established 2014, influenced the model of the Australian Citizen Science Association (established 2014).

[4] This is a combination of the definitions used by the Citizen Science Association, the European Citizen Science Association - two of the associations on which the Australian Citizen Science Association is modelled - and of the definition for citizen science put forward by the Australian Museum. (Australian Museum 2015c; Citizen Science Association 2016; European Citizen Science Association 2016).

Over the last five years in Australia, there has been a growing interest in and focus on citizen science. An article in 'The Conversation' in August 2013 gave an introduction to citizen science, summarising the purpose and stakeholders, and reviewing projects that have successfully contributed to scientific research (Simpson 2013). The article explains the innate desire of citizen scientists to make a "*meaningful donation of their time*" to science; the understanding of citizen science as a way to build scientifically minded communities (Simpson 2013).

By definition, citizen science recognises the benefits of partnerships between volunteer participants and scientists, as can be seen in the Cornell Lab of Ornithology definition: *"projects in which volunteers partner with scientists to answer real-world questions"* (Cornell Lab of Ornithology 2014). This definition suggests that citizen science holds the potential to facilitate relationship development between stakeholder groups in order to act as a form of community engagement, centred on issues relating to the environments and lifestyles of communities. Integral to the success of citizen science as a form of community engagement is the clear presentation of accessible information (Smallbone 2010). A commitment to transparency and accessibility of the data to groups external to research scientists is foundational to the success of citizen science programs.

The Australian Museum (AM) is a natural history and sciences museum located in Sydney and is a public sector museum for New South Wales (NSW) communities. Its self-defined role:

> *…is to be the custodian and provider of access to the oldest and largest natural sciences and cultural collection in Australia…combine research, exhibitions, and programs about the natural world.'*
>
> *(Australian Museum 2012, p. 1)*

The year 2015 marked the inaugural conference of the Australian Citizen Science Association (Australian Citizen Science Association 2015) and the launch of the Australian Museum Centre for Citizen Science (AMCCS), which is committed to hosting an officer of the Australian Citizen Science Association (Australian Museum 2015a).

While the goals of the AM concerning citizen scientists are integrated into various strategies and statements, at this stage there is no specific citizen science strategy; current goals of the AM in regards to citizen science are broad. As outlined by its strategy statements, the AM wants to use citizen science as a way to engage communities and bridge scientific literacy gaps in communities, while simultaneously using citizen science as a way to mitigate the effects of funding cuts on the production of research and meaningful data (Australian Museum 2015c).

The AM is the host institution of the citizen science program Streamwatch. Streamwatch is "a citizen science water quality monitoring program that empowers community groups to monitor and protect the health of local waterways" (McDonald 2016), and was started in 1990 by Sydney Water. Described as "the only independent watchdog monitoring water quality in Sydney" (O'Brien & Cubby 2011) the funding and model of the

program changed in 2011 after Sydney Water budget reviews. The AM successfully acquired the program in 2012 with a reduced operating budget and smaller engagement aims; the majority of school participation was not continued under the AM's administration of the program.

The move to the AM was cautiously received; media coverage at the time reported that it had "*divided environmentalists*" (Carr 2013). The citizen scientists themselves were highly anxious about the change of administrator:

> *When we heard that Sydney Water didn't want to keep running Streamwatch, then we got quite anxious about what would happen to Streamwatch. I know a lot of groups got very anxious.*
>
> *– Citizen scientist*

On one hand, the AM's involvement was welcomed because the institution "*clearly has the expertise to run the program*" (Tremain 2012). On the other, influencing factors surrounding the decision to move the program, as well as the processes of the move, were questioned. For example, headlines covering the transition reported: "*Revealed: secret plan to muddy the waters", "Streamwatch school's program dropped", "Funding cut axes Streamwatch*" (Cubby 2012; Eriksson 2012; Petrinic 2013). Comprehension of the current state of Streamwatch was garnered from interviews with stakeholders, as well as a reading of media coverage of the accession of Streamwatch into the AM. Interview respondents revealed that a severe lack of trust in the governance of Streamwatch under Sydney Water, combined with the pride and loyalty citizen scientists felt for the program meant that the AM had to manage their reputation and relationships within Streamwatch mindfully. Stakeholder management with pre-existing citizen scientists was the first undertaking of AM staff administering Streamwatch. Communicating the AM's genuine appreciation and respect for what the program had already achieved was integral for administrating staff, as was

highlighting the benefits and additional functions able to be provided by their governance. Scientific methods used by Streamwatch at the time did not have the rigour to comply with AM research standards. Training was provided to citizen scientists to bridge this gap. This helped to communicate with citizen scientists and build rapport. This conscientious employment of change management helped ensure the continuity of the program and meant that citizen scientists moved with Streamwatch under facilitation by the AM. It also set the tone for what Streamwatch would be under the AM's banner: a citizen science program that prioritised interpersonal relationships and valued the knowledge and experience of citizen scientists, as well as the data producing data.

Since taking on the administration of the Streamwatch program, the AM has made changes to the way data is communicated, analysed and presented, as well as the way citizen scientists experience and participate in the program. In the financial year of 2014-15, there were 195 volunteers, making up 63 groups testing 170 sites across Sydney, greater Sydney, the Blue Mountains and the Illawarra region (McDonald 2016).

Streamwatch has the potential to satisfy the increasing demand for the AM's learning and educational services to be delivered using new technologies, and in increasingly diverse ways.

CHAPTER 3 | REVIEW OF LITERATURE

SECTION 1. RESPONSIBILITIES OF A MUSEUM TO COMMUNITIES

Historical Review of a Museum's Role

New museology explores the potential for museums to function as a collaborative space for communities and individuals, fostering positive engagement and experiences to contribute to the formation and affirmation of identity and culture[5] (Rowe, Wertsch & Kosyaeva 2002; Ross 2004). Underpinning the shift from traditional to new museological theory is the ongoing commitment to museums as places of public betterment; they are expected to be inherently for the public, supporting the creation of knowledge communities (Harris 1990; Hedstrom & King 2003).

Throughout the history of museums, education for perceived public betterment has been a foundation upon which museums were established; from Greek and Roman idolatry houses which were sites of education and moral guidance (Alexander & Alexander 2008) to museums built during the industrial revolution in response to the illiteracy and anti-social behaviours of the working communities (Bennett 1995). Modern museums are complex embodiments of museological history and need to balance plural pasts with traditional and contemporary cultures, along with a multitude of other roles. Museums are spaces in which education occurs: space is intentionally created to empower visitors, to add to knowledge surrounding objects by personalising them and adding the visitors' own stories to the understanding, history and culture of objects within the museum (Clifford 1999; McTavish 2013). Museological theory reflects this complexity by providing a multi-disciplinary space

[5] Through methods such as narrative construction, creation of community, and shared experience.

where theories and ideas are intricately interconnected (Macdonald 2006). The complexity and breadth of concepts relating to modern museums have led some museologists to claim that the modern museum simply does not exist; the range and function of contemporary museological institutions are too broad and thus escape simple definition (McTavish 2013). In accepting that an over-arching definition for modern museums is hard to conceptualise, understanding can instead come from dissecting the goals of museums and the conception that museums must use resources to achieve these goals.

A traditional goal of the museum was to educate the every-person by 'raising the level of public taste' (Harris 1990). This simplistic aim for museums placed rather superficial importance on the aesthetic function of the museum while hinting at the larger, subtler goal of education. Other motivations are entrenched within the history and intended purposes of museums, but it is the educational goal of museums that underlies the thesis of this study. Education in museums is understood as not only the conveying and comprehending of knowledge, but also the communicating and understanding of individual and group cultures and identities (Falk & Dierking 2000). This was traditionally accomplished through exhibit, with the goal of public education and audience growth[6] (Alexander & Alexander 2008). Exhibitions achieved this through the placements of objects in space to reflect a consciousness of the knowledge value of an object which were supported by verbal and nonverbal signage (Vergo 1994). Visitors, when experiencing display, are encouraged through these curatorial styles to find a "*common pastness*" (Bann 2003, p. 122) with the exhibition to understand the importance of objects, and the museum's goal for the exhibition, thus providing an opportunity for education. In this way the museum is able to create a dominant story around

[6] Growth both in terms of diversity and in actual attendance numbers.

objects which passes into local communities; the museum can produce and influence how things are understood. In the controlling of what is seen and how it is seen, museums gain social authority and produce cultural gaze[7] (Casey 2003). The main way this authority is formed is through exhibitions and education.

The museum's ability to produce cultural gazes as they function to educate and exhibit objects has changed the understanding of the museum's purpose to include cultural mediation (Basu & Macdonald 2007; Casey 2003). This is linked to the role of a museum to foster the creation and negation of cultural identity within visitors and therefore fundamental to modern museums in service of their communities (Falk 2009). Cultural memory is often selective and can become interchangeable with 'history' for an individual visitor (Gilbert 2009). Museums can have an influence on the identity of an individual and the way they interact with communities through the mode of knowledge and understanding their exhibitions and educational programs produce.

The role of a museum has shifted from simply displaying their repository of objects, to using their social authority to foster positive behaviours in their communities, and encouraging public betterment. This has resulted in the ethical role of the museum to facilitate access to tangible and intangible objects and heritage in such a way that all facets of communities have the opportunity to learn about, study and enjoy them (International Council of Museums 2007).

[7] Cultural gaze here refers to the dominant way in which something is understood, achieved through the exhibition and education programs of a museums.

Ethical Responsibility

The complexity of the modern museum comes in part from challenges inherent to being a public institution, for those like the AM that are. A public institution has an ethical responsibility to be transparent in its actions, as communal 'taxpayer' money is used to fund the organisation (Tam 2012). Musing on the concept of 'fairness'[8] within public institutions, Gurian (2006, p. 12) poses two methods for achieving transparency, both of which reveal an underlying ethical responsibility of a museum. The first method encourages exhibitions and public programs to be produced with the express intention of inspiring communities to evaluate and question the imbued knowledge of content presented so that it may be applied to their own life (Gurian 2006). The second encourages the individuals producing content to reveal their identities, qualifications, beliefs and opinions and make them a secondary display to support the primary exhibition of a museum (Gurian 2006). Underlying this concept of 'fairness' is transparency; transparency of authority, knowledge, and intention.

The need for transparency sits within the museum's history of being developed and continuing to be developed in response to their surrounding communities; the definition and expectations of which are constantly changing (Crooke 2007). The narratives displayed within the museum are often understood to be authoritative to the visitor, meaning that the memories and experiences created as a result of personalisation of objects are veracious (Anderson et al. 2002; Whitehead 2009). A key shift of power within modern democratic societies has been from the primacy of the nation-state to individualisation; inclusion can no

[8] Gurian suggests 'fairness' to mean, among other things, "teaching the audience to adopt a sceptical approach to 'knowledge' and to learn to ask for a second opinion." (2006, p. 12). This definition for museums environments lends itself well when examining the concept in conjunction with science: a foundational theory of science encourages curiosity to find explanations and theory, which are first evaluated by peers before being accepted as fact.

longer be achieved through a single national identity (Schwarzmantel 2003). It is important to note that this theory is one interpretation of what is a definitively complex social change, something that this thesis does not intend to explore comprehensively. This change in political theory, however, has been reflected in changing museological theory; intentional arrangements of objects and narrative to create historic continuityto encourge shared values and legitimises the idea of nation and a definable national identity have been superceded. Instead, viewing environments conducive to enabling the visitor to add their personal reflections and understandings to the knowledge surrounding the objects are being constructed (Hooper-Greenhill 2007; McLean 2004; Walsh 1997). The shift in power from the museum as an authority of knowledge to the museum as a facilitator of knowledge creation underlies and prioritises the theories of community engagement in modern museology or new museology.

Community Engagement

Traditionally, museum programs were concerned with transforming the museum into a space of education, culture and identity formation (Falk 2009). New museology expands this rigid understanding of visitors only coming to the museum space to learn, instead proposing that a desire for learning can be synthesised with—or sit completely separate to—a desire to engage in culture and leisure activities (Doering 1999; Falk & Dierking 2000). Traditional educational goals no longer restrict museums to have 'successful' community engagement initiatives. There is now capacity for museum visitors to come to the space to relax, socialise or meet other individuals (Doering 1999). This has enabled programs such as volunteering and citizen science to become accepted forms of community engagement within museum environments as the spectrum of visitor motivations has expanded to include a variety of reasons from learning to leisure (Falk 2009). This study, while it may reveal some citizen scientist motivations for involvement, is more concerned with their experiences and

expectations of the program. More research would need to be done to adequately explore citizen scientist motivations, which lie outside the scope of this research.

Museums are widely accepted as centres for informal scientific learning, which contributes to the larger communication of scientific knowledge to the public (Bandelli & Konijn 2012). While increasing their accessibility and ability to manipulate individuals' experiences, this role as a scientific educator simultaneously gives the museum new ethical roles. As well as the museum's responsibility to be transparent and be in service to their communities, there is also increasing pressure for museums to pay more conscientious attention to exhibitions and educational programs on scientific issues and embody the educational messages within their own institutional mission and practices (Brophy & Wylie 2008). One way museums can achieve transparency of scientific research, mission and responsibility, while achieving educational goals and community engagement, is through citizen science programs.

SECTION 2. CITIZEN SCIENCE AND MUSEUMS

Scope of Citizen Science for this Study

A quick look at references to citizen science in books catalogued by Google, as shown on the following page in Figure 3, shows the sharp growth in literature using the terminology since 1990. There is research to suggest that this growth is in response to inadequate or a complete lack of monitoring, compounded by increasing financial pressures on professional scientists and government agencies (Conrad & Hilchey 2009).

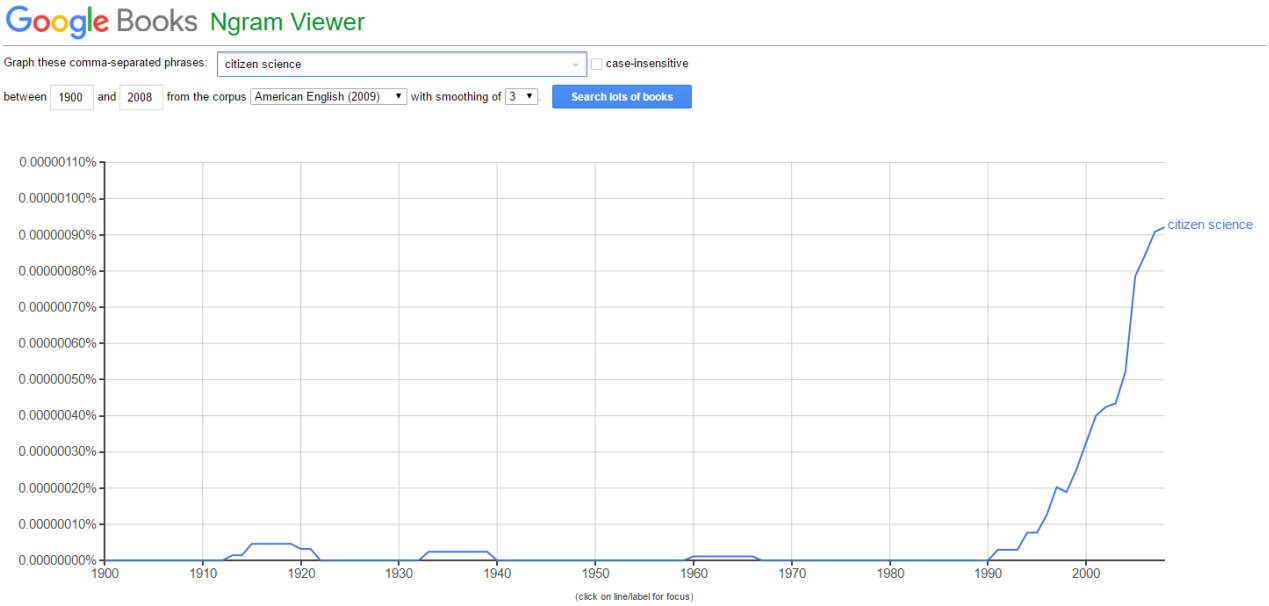

Figure 3 Occurrence of term 'citizen science' in books catalogued by Google Books, 1900 - 2008. [9]

This study is focused on exploring citizen science programs within a museum as an active form of community engagement. Understanding citizen science as a collaborative initiative to meet a variety of scientific, educational, societal and policy goals, provides a starting point for discussion about the expectations of citizen science.

Marlow proposes that citizen science can be a way to engage and activate community, as it "evokes a science which assists the needs and concerns of citizen', and is 'a form of science developed and enacted by citizens themselves" (Irwin 1995, p. xi). The definition of citizen science Marlow postulates is more aware than other definitions of the potential of citizen science programs to act as a form of intentional community engagement and empowerment, which is also an outcome of programs run within museum spaces. This definition of citizen science can be seen as a starting point for addressing the gap in academic discourse between examinations and implementations of citizen science and new museology. Understanding citizen science in this way has the potential to act as a theoretical bridge

9(Google Books 2016).

between current citizen science literature and the theory of New Museology. Focusing on the 'citizen' aspect of citizen science, as opposed to only focusing on the 'science', is integral to the understanding and exploration of citizen science participants; the former gives them agency and potential acknowledgment, ownership and utilisation of the knowledge, skills and experience they could bring to the program, whereas the latter prescribes the citizen to be understood simply as a vehicle for data.

Citizen Science Theory

Theory surrounding citizen science was initially largely concerned with methods of producing quality data, justification for the existence of programs and success stories to encourage other research scientists to use the data produced (Cohn 2008; Dickinson et al. 2010; Hollow et al. 2014). More recently, articles have taken a wider approach to citizen science, looking at citizen science programs in relation to the changing epistemological beliefs of participants (Price & Lee 2013); the role of citizen science in governance (Couvet & Prevot 2015); and the overt potential of citizen science as an education vehicle (Phillips et al

2014). Underlying the expanding of the discipline is the desire to evaluate participants better and to gauge the impact of citizen science on scientific knowledge, literacy and attitudes, and ultimately understand their motivation for involvement (Brossard et al. 2005). As this is a relatively new discipline however, there are still gaps concerning how to administer programs and what the experience of participation should be. Conrad and Hilchey (2009) call for more literature and case studies addressing the gap in the literature concerning citizen science stakeholders and for theory that provides a improved understanding of the social benefits of citizen science.

The ECSA's '*Ten Principles for Citizen Science*' (2015) advocates the importance of understanding and encouraging positive participant experiences, designing programs that benefit the community, and citizen science as a way to facilitate the democratisation of

science. These explicit best practice guidelines for citizen science evidently align with new museology; an issue stems not from the actual practice of citizen science, but the theoretical framing of it within the museum space. Literature that specifically addresses the stakeholder relationships of citizen science programs within a museum space is nearly impossible to find, despite the thematic links between citizen science impact and museum visitor experiences. The dearth of specialised literature complicates the application of the current broader literature about citizen science to the museum setting; the terms 'citizen scientist' and 'volunteer' are often used both in conjunction with one another and interchangeably[10]. These are currently understood as two very separate concepts within a museum. A basic difference between the two being that unlike literature concerning citizen science, literature focused on volunteers in museums uses data from interviews or surveys with volunteers as a base for recommendations. Trying to understand citizen scientists in the theoretical framework of a museum volunteer further reveals issues with simply applying current citizen science theory to a museum space without moderation. As Holmes argues, there are two conceptual frames applied to understanding volunteering within the museum. One frame focuses on the leisure motivation of volunteers, and the other frames the way volunteers can be utilised by the museum as a resource (Holmes 2003). While citizen science theory accommodates the latter economic frame for understanding volunteers in terms of what research scientists gain from the interaction, the framework concerning the former leisure model where volunteers derive pleasure from involvement is not fully developed within citizen science. Museum front of house volunteers[11] are understood to be largely leisure motivated, yet literature on the 'volunteers' of citizen science tends to classify them under the economic model with limited

[10] As can be seen in the Cornell Ornithology Lab's definition of citizen science as well as a range of articles discussing citizen science, such as Cohn 2008; Conrad and Hilchey 2009; Couvet and Prevot 2015.

11 The largest group of volunteers upon which most museum volunteer literature is based.

capacity for understanding their leisure motivation. Citizen science programs often have the benefit of being longitudinal public programs, which means that literature about volunteer relationship management has the potential to be applied if it is revealed that there are common goals and motivations between citizen science stakeholders concerning community engagement. Literature addressing this question of citizen science motivations is starting to be produced, but is still framed around the capacity for them to produce quality data.

The scope of this thesis is not wide enough to explore whether citizen science could be designed to primarily satisfy leisure motivations and still produce quality, meaningful data. This thesis is, however, able to contribute to the understanding of leisure motivations as framed by the experiences of Streamwatch citizen scientists.

Engaging Communities Through Citizen Science within Museums

Central to both the success of a museum and the success of a citizen science program is the involvement and relationship with the participant: the visitors and communities of museums and the volunteers who participate in citizen science programs. Phillips propose that there are three types of citizen science: contributory, collaborative and co-created (Phillips et al 2014). This study focuses on the third type of citizen science—co-created—where citizen scientists "*are more deeply involved with analyzing* [sic] *data or* [may] *even help to develop project protocols"* (Phillips et al 2014, p. 1). The narrowing of scope to focus on this type of citizen science is because in new museology the experience of this group who simultaneously function as an individual visitor and representation of the wider community, and the creation of a space where they are given agency to be co-creators of the knowledge surrounding objects, is paramount (Barrett 2010; Hooper-Greenhill 2007; McLean 2004; Worts 1995). Bann (2003) suggests that visitors cannot deny the personal interpretation that is triggered by their own curiosity. Accepting the understood theory that visitors cannot help but project their own subjectivity onto an object when viewing, it follows that it would be illogical and unethical for

an institution with apparent didactic value to communities to deny the significance and importance of this projection. This is a main argument underlying the theory of new museology. On a more pragmatic level, it could be understood to be an effort to make museums relevant and meaningful to communities as a way to engage them (Silverman 1995). In discussing the adult education programs within museum spaces Hemming (1995) cites communication not only about the programs specifically, but about how the programs relate to the mission of the museum as a main factor of their success. It can be argued that there is capacity and indeed a need, for citizen science programs to be understood through the lens of new museology in order to fully comprehend their social benefit.

If citizen science programs are to be run within museum spaces, then they should be reflective of their communities as far as the new museology is concerned. Among other potential benefits, this approach has the capacity to build the relationship between citizen scientists, the museum and the research scientists without affecting the quality of the data produced.

CHAPTER 4 | METHODS

BACKGROUND

Streamwatch is a citizen science program started by Sydney Water in 1990 and taken over by the AM in 2012. Streamwatch citizen scientists regularly monitor local waterways and test indicators of water quality such as pH, turbidity, and electro-conductivity. A case study of the Streamwatch program will be used to examine citizen science within a museum space, with the specific goal of finding out the expectations and experiences of various stakeholders. Streamwatch was selected as it is a long running citizen science program and was previously administered outside of the museum space by Sydney Water (1990 to 2012).

The thesis was inspired by conversations the author had with AM colleagues about the value of citizen science as a way to engage with communities. Specifically, informal comments about the program's ability to reveal research and collections of the AM hidden from public view were discussed and of interest. Prior to their interview, all participants were made aware that the author is currently employed by the AM, but is not in a position of power regarding the administration or decision making processes related to Streamwatch.

INTERVIEWS

To better understand the potential of citizen science to engage communities within a museum setting, the expectations of Streamwatch stakeholders were examined to see if they align with goals of the AM. This enabled the experiences of interviewed Streamwatch stakeholders to inform the wider discussion of how museums can best manage citizen science programs within their spaces. Underpinning this case study were structured interviews with Streamwatch stakeholders, with a target of twenty-four consenting individuals (eight per

stakeholder group). Three stakeholder groups were defined for the purpose of this case study and all participants were asked to self-identify as one of the following:

- Citizen Scientists (Group 1)
    - Individuals who are largely involved with the collection of data and/or administration of a specific Streamwatch site in a voluntary capacity.
- Program Administrators (Group 2)
    - Individuals who are largely involved with co-ordinating citizen science initiatives and/or involved with public programming within a museum context.
- External user (Group 3)
    - This group was originally defined as individuals who self-identify as professional research scientists and are not involved in the voluntary collection of Streamwatch data. After Interview recruitment and initial interviews with citizen scientists and program administrators revealed that there were no known research scientists currently using the data of Streamwatch. Individuals from local councils who were working in an environmental management capacity were suggested as a substitution for research scientists as Streamwatch data was being used by councils across the Sydney Water catchment area. This was revealing in as of itself, as participants still considered the program successful despite the traditional users of citizen science data (research scientists) not currently using the data.

Final interviews totalled seventeen; nine citizen scientists, seven program administrators and one external user. Interviews were recorded with participant consent and then transcribed. Transcripts were sent to participants to provide an opportunity for them to review and edit text before it was analysed for this thesis.

QUALITATIVE ANALYSIS METHODS

Conventional content analysis, also known as 'inductive category development' is when researchers avoid using preconceived categories (for example categories as defined by literature) and instead derive categories from the terms evident in the data (Hsieh & Shannon 2005). Hsieh and Shannon (2005) suggest that it is best suited for research where there is limited prior research and/or literature to inform the framework for analysis, as in the instance of this thesis. While a characteristic of this thesis is combining disciplines to explore the potential for citizen science programs to satisfy requirements of both citizen science and museological public programming, both disciplines do have stringent frameworks and goals that a citizen science program must satisfy.

Directed content analysis could be argued as being a more deductive form of qualitative content analysis as it uses existing theory to inform the framework used to initially code and analyse data. While this complements the goals of the thesis to explore the potential of citizen science to simultaneously function both as a citizen science program and a public program, it also has the capacity to obscure the experience of citizen science stakeholders. The experience of the citizen scientists is an important aspect of new museological theory as previously mentioned. As such, this thesis will use a combined method of both conventional and directed qualitative content analysis to code and interpret data. An initial conventional analysis of data will explore experiences of citizen science stakeholders, while a second directed analysis will examine common expectations of the program.

DIRECTED ANALYSIS FRAMEWORK

The review of current research literature provided a loose framework to guide analysis of the interview data gathered. New museological literature discussing public programming practice was used in conjunction with citizen science literature to create a matrix to

simultaneously evaluate Streamwatch as a public program for a museum and a citizen science program.

New museology—the current accepted museological theory—is shifting the historic understanding of museums as authoritative institutions, which disseminate knowledge through a firmly structured framework to visitors, to the more fluid concept that a desire for learning can be merged with, or sit alongside, the desire to participate in culture/leisure activities (Falk & Dierking 2000; Doering 1999; Ross 2004). As the experiences and expectations of the visitor are vital to the accomplishment of a museum defined by new museology, participants of Streamwatch made up the first group of stakeholders interviewed for this case study. Additionally, interviews with AM stakeholders provided insight into the Museum's goals and administrative processes of Streamwatch and contextualised experiences of the program solidly within the museum space from a museum perspective.

Interview responses were predominately read through the lens of new museological theory. Throughout the analysis of interview data, the experiences of each participant were examined to see if they aligned with the theoretically ideal new museological experience. The mains categories isolated were:

1. Community
2. Education
3. Environment
4. Science
5. Data
6. Organisation
7. Recruitment

Categories were selected from key themes of both citizen science and learning in the museum space as described in **Chapter 3 Review of Literature**. They were inductively refined based on interview responses and then cross-checked with the Cornell Ornithology Lab's '*User's Guide for Evaluating Learning Outcomes from Citizen Science'* (2014). These categories are expanded upon and explored in **Table 6** through to **Table 9**.

The ‘success’ of Streamwatch was analysed in terms of its function as a citizen science program that produces data, as a program of the AM that is required to meet strategic goals, and as a public program that embodies new museological educational aims.

CHAPTER 5 | RESULTS AND DISCUSSION

This chapter provides an overview of the results of interviews with participants, discussing them in the wider context of citizen science and museology. It will explore the ability of Streamwatch to concurrently satisfy the expectations of both a citizen science program, and a new museological public program. The findings derived from the data produced from this study are specific to Streamwatch, and therefore are not applicable to all citizen science programs. However, a framework can be derived that straddles the disciplines of citizen science and new museology to help understand the dual practice of these disciplines and bridge current gaps in literature. These findings will contribute to a better understanding of best practice for citizen science in museums, and more specifically how it can be used by museums to meaningfully engage with communities in a scientific context.

Demographics of participants are presented first, followed by an exploration of experiences and expectations of Streamwatch, and the data produced. The ability of Streamwatch to satisfy strategic goals of the AM concerning citizen science is then explored. Evidence for successfully achieving the new museological goals of self-motivated learning and identity formation is then examined to inform a judgement concerning the feasibility of the dual goals for citizen science, that is, community engagement and quality data, being satisfied. The ability of the narrative framework to achieve these dual goals is investigated to recreate some of the unique elements of Streamwatch.

For brevity and clarity throughout the discussion of results, stakeholder groups will be referred to by their function within the program as opposed to their group number:

- Group 1 – citizen scientists
- Group 2 – program administrators
- Group 3 – external users

In discussing the findings of this study, it is important to acknowledge the context in which the data were gathered in relation to the wider experiences of museology and citizen science.

In particular, it is vital to note the sample size:

- 9 participants (5% of the total reported participants of Streamwatch in 2014-2015) were interviewed and classified into group 1: citizen scientists. This is a small sample size of this program, and of these 9 participants, 7 were involved in an off-shoot program of Streamwatch called 'MicroVols' which requires a high level of commitment and scientific interest. The experiences examined here are of participants who are particularly committed to Streamwatch.
- 7 participants were interviewed and classified as group 2: program administrators.
    - Some these participants identified themselves as directly involved in the administration of Streamwatch; some felt they functioned more in an advisory role.
    - These participants were not involved in the original development of the program. Rather they have been steering the change and stakeholder management, and data clean up and qualification of Streamwatch.
- Invisibility of 'Group 3': external users.
    - This group was originally planned to be a sample group of research scientists who were using data produced from Streamwatch. A key component of citizen science is that it produces data that can be used. In the case of Streamwatch, data is currently being used very loosely by councils and environmental managers, not research scientists as such. One participant who worked for a council who was involved in Streamwatch was found. The experiences of this

individual are included in this study to contribute to a broader understanding of Streamwatch, but cannot be understood as being representative of a group.

- It was revealed throughout the course of this thesis that Streamwatch data was being used by the citizen scientists themselves, with research communicating their intent to use the data in the future. The lack of traditional 'users', i.e. local councils and Streamwatch participants themselves, actively using Streamwatch data is important to note as it reveals a common assumption that citizen science data is only for use by 'research scientists'. An exhaustive exploration of the use of Streamwatch data by non-research scientists is beyond this thesis, but is examined in reference to the experiences of interview participants and their expectations of the program.

Samples of this size, from a single citizen science program, are not large enough to enable a comprehensive understanding of the citizen science experience. They are, however, sufficient to examine the potential of citizen science to enhance the museum experience and illuminate areas for future research.

DEMOGRAPHICS OF INTERVIEW PARTICIPANTS

The limits of this study restricted the understanding of experience as a product of gender, age, ethnicity and language in groups. Instead, a conscious decision was made to try and focus exclusively on experiences of citizen science within the museum space exploring how participants were involved with Streamwatch. Apart from answers concerning the capacity of involvement in Streamwatch (see **Table 5**) interview answers were generally not analysed in context of the individuals' demographic information unless specifically noted.

Basic demographic information was collected to understand any major differences in demographics across participant groups. From the researcher's personal experiences of

Streamwatch and conversations with participants and experience of the program administrators, the below demographic represents the demographics of Streamwatch citizen scientists well (group 1). For the sake of completeness, data from the single external user interviewed is included in the following tables.

Gender

The collection of data in this study involved interviews. Breakdown can be seen in **Table 1**. Exploration of differences in gender representation in citizen scientists needs additional investigation to examine whether these results are representative of the sample group only or also of the wider Streamwatch program and indeed citizen science, and is not encompassed in the scope of this study.

Table 1 Gender of interviewee participants

	Options	Citizen scientists N=9	Program administrators N=7	External users N=1	**TOTAL N=17**
Gender	Female	7 (78%)	4 (57%)	1 (100%)	**12 (71%)**
	Male	2 (22%)	3 (43%)	-	**5 (29%)**
	Other	-	-	-	**-**
	No Response	-	-	-	**-**

Age

Participants were asked to identify their age according to age groups used by the Australian Census (see **Table 2**). Almost 65% of all participants identified as being over 50, and 18% identified as being over 75. Only 6% were under 30.

Table 2 Age groups of interviewee participants

	Options	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Age (years)	18-19	-	-	-	-
	20-24	-	-	-	-
	25-29	1 (11%)	-	-	**1 (6%)**
	30-34	-	-	-	-
	35-39	-	1 (14%)	1 (100%)	**2 (12%)**
	40-44	-	2 (29%)	-	**2 (12%)**
	45-49	1 (11%)	-	-	**1 (6%)**
	50-54	1 (11%)	1 (14%)	-	**2 (12%)**
	55-59	-	-	-	-
	60-64	1 (11%)	1 (14%)	-	**2 (12%)**
	65-69	1 (11%)	-	-	**1 (6%)**
	70-74	1 (11%)	-	-	**1 (6%)**
	75+	3 (33%)	-	-	**3 (18%)**

Primary Activity

Participants were asked to nominate their primary activity, as shown in **Table 3**.

Table 3 Primary activity of interviewee participants

	Options	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Primary Activity	Student (School, TAFE, University, College, etc.)	-	-	-	-
	Home Maker and/or Carer	1 (11%)	-	-	**1 (5%)**
	Government Employee	2 (22%)	6 (86%)	1 (100%)	**9 (53%)**
	Private Enterprise Employee	-	1 (14%)	-	**1 (6%)**
	Self Employed	1 (11%)	-	-	**1 (6%)**
	Retired Citizen	5 (56%)	-	-	**5 (29%)**
	Looking for Work	-	-	-	-
	Other (please specify)	2 (22%)	-	-	**2 (12%)**
	TOTAL	**10**	**7**	**1**	**19**

NB- Participants were able to nominated more than one primary activity

The trend of program administrators largely identifying as 'Government Employee' and the citizen scientists as 'Retired Citizen' can be explained by the requirement for program administrator participants (group 2) to be involved in the administration of Streamwatch[12], and the age of participants (as previously discussed). Further studies are required to

[12] The Australian Museum is a government organisation and responsible for the administration of Streamwatch. It is a fair conclusion then that most of these respondents (6 people, 32% of total participants) would be government employees.

understand the effect of primary activities on experiences and expectations, however that analysis lies outside the scope of this study.

The trend of most citizen scientists nominating 'retired citizen' as their primary activity is notable within the context of concerns about the sustainability and continuity of the program, as citizen scientists stop being able to participate due to age (see **Weaknesses of Streamwatch**).

Length of Involvement with Streamwatch

Citizen scientists and program administrators were asked how long they had been involved with Streamwatch (see **Table 4**). Participants were able to nominate both 'not involved' and the length of time they had previously been involved in Streamwatch, i.e. a participant could say both 'not involved' and '3 to 5 years'.

Just under 65% of participants have been involved in Streamwatch for over 3 years, meaning they experienced the program while it was under Sydney Water and moved with it when the AM took over.

Table 4 Length of participant's involvement in Streamwatch

	Options	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Length of Involvement	Not involved	1 (11%)	2 (29%)	-	**3 (18%)**
	1 year or less	1 (11%)	-	-	**1 (6%)**
	1 to 2 years	4 (44%)	3 (43%)	-	**7 (41%)**
	3 to 5 years	2 (22%)	4 (57%)	-	**6 (35%)**
	6 to 10 years	3 (33%)	-	-	**3 (18%)**
	More than 10 years	1 (11%)	-	1 (100%)	**2 (12%)**

It is notable that citizen scientist participants, on average, have a similar if not longer experience and memory of Streamwatch than program administrators. Of the four program administrators who said they had been involved in the program for '3 to 5 years', only one of the program administrators had been actively involved in Streamwatch as a program, as opposed to being involved with the scoping of Streamwatch for the hand over to the AM.

Participants who were no longer involved in Streamwatch were asked to explain briefly why they were no longer involved. Responses were:

- No longer part of that school community

  (1 participant, 11% of citizen scientists, 6% total)
- Past employment

  (1 participant, 14% of program administrators, 6% total)

Capacity of Involvement

Participants were asked to self-identify with one of the three options on their demographics sheet to help categorise them either as citizen scientists (group 1), program administrators (group 2), or external users (group 3) (see **Table 5**). Answers to the interview questions are largely understood in the context of these groupings, as well as the combination of these groups.

Table 5 Capacity of participant involvement in Streamwatch

	Options	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Capacity of involvement	Citizen Scientist You are largely involved with the collection of data and/or administration of a specific Streamwatch site in a voluntary capacity	8 (89%)	1[2] (14%)	-	**9** **(53%)**
	Program Administrator You are largely involved with coordinating citizen science initiatives and/or involved with public programming within a museum context	-	6 (86%)	-	**6** **(35%)**
	Research Scientist	-	-	-	**-**
	Other	1[1] (11%)	1[3] (14%)	1[4] (100%)	**3** **(18%)**

1 This participant was placed in group 1 as through the course of the interview it was revealed that their role was in a voluntary capacity and involved the collection of data at a Streamwatch site. A key differentiation between citizen scientists and program administrators is that citizen scientists are involved in a voluntary capacity. Another is that program administrators are involved in the administration of the program, as opposed to only the data collection.

2 One of two self-nominated roles for this participant, this option ended up being discounted when it was revealed through the interview that involvement with Streamwatch was not in a voluntary capacity. The participant also nominated themselves as a program administrator; the group they ended up being placed in.

3 This participant was categorised as a program administrator as through the course of the interview it was revealed that their role involved decision making about the development and administration of Streamwatch. This decision was in conjunction with the participant's answer concerning their primary activity (see Table 3), to which they responded 'Government Employee'.

4 This participant was placed in group 3 as through the course of the interview it was revealed that their role involved using the data. They were not directly involved in the administration of a group, or in the collection of data at a Streamwatch site.

Alternative roles were nominated by three respondents of citizen scientists (22% of group, 12% of total participants). The logic behind their final placement within the three groups are outlined in the notes following **Table 5**. Nominated roles were:

- **Additional supervision of school group**

  (1; 11% of citizen scientist)

- **Manage**r

  (1; 14% of program administrators)

- **Council administrator**

  (1; 100% of external users)

PERCEPTIONS OF STREAMWATCH

BACKGROUND

Results of this study are presented as part of the larger discussion about the best way to understand and frame citizen science in the museum space. The primary function of Streamwatch as a citizen science program will be examined first, in terms of stakeholder experience, expectations and data use. Streamwatch will then be examined for compliance with outlined goals of the AM. This will act as foundation for the larger exploration of the alignment of Streamwatch with new museological theory. From this analysis, the potential for a citizen science to dually function as a citizen science program and a new museological program will be explored. Finally, the use of narrative to act as a potential scaffold into achieving the aforementioned proposed dual functions will be discussed. Narrative in this

thesis refers to the ability of a museum experience (of exhibitions or programs) to allow for multiple interpretations and understandings to exist simultaneously.

All groups were asked '*What, if any, have been Streamwatch's successes?*' and conversely, '*What, if any, have been Streamwatch's failures?*'. These questions were designed to ascertain what participants felt defined the success of the program, and to see whether this aligned with the requirements of a citizen science program to produce usable data. Alignment with the wider goals of the AM are discussed in **Goals of the Museum**.

As **Table 6** and **Table 7** show, there were contrasts both within groups and across groups. Notably, there was a difference in perception concerning the data of the program. A number of aspects were mentioned as both a success and a weakness of Streamwatch. These issues are outlined in the following section.

SUCCESSES OF STREAMWATCH

The principal success that both groups identified was the community the AM has fostered around Streamwatch (9 of 17 participants; see **Table 6**). This was the most common response for program administrator (4 of 7 program administrators), and the second most common response for citizen scientists (4 of 9 citizen scientists). The biggest success of Streamwatch as perceived by citizen scientists as a group was its ability to increase environmental literacy, both for themselves and the wider community (5 of 9 citizen scientists).

Other identified successes of Streamwatch didn't have the same rate of mention as these two categories. Underlying both of these categories was the consideration of confidence, both in an individual's own ability and the program as a whole.

Just talking to other Streamwatch people was great. Otherwise, you're in isolation and you don't get to hear about their problems and their issues with their council. It helps not feeling isolated and sometimes we get despondent in what we are trying to do...you find that you aren't really working as an isolated community. That people really all over have the same issues.

-Citizen scientist

Creating the sense of community and the sharing of knowledge between the volunteers...instead of people being a bit, "close enough is good enough" they were like, "but you can tell by this and this that it is actually an X".

- Program administrator

I think we've made people more confident in doing Streamwatch activities and doing them well. So having confidence in their output rather than going along "Oh, I think I'm doing the right thing."

- Program administrator

This demonstrates that the Streamwatch program is making a marked contribution to the shift in the way that museums engage their publics in the way that new museology envisages (Streamwatch interview). Specifically, it is successful in creating a group with an avid involvement in the AM's activities, which links in with the new museological goal of transparency (Gurian 2006). Streamwatch connects the AM with a much smaller group than the public visiting the physical site. However, the depth of the connection created in Streamwatch reveals the possibility of forming a spectrum of involvement for the wider

community, creating additional ways to foster this deep engagement and comprehension of what the AM is. This is further explored in the sections **Tacit Museum Goals** and **Identity Formation**.

The ability of Streamwatch to enhance environmental literacy within the community through the sharing and use of its data is one way in which Streamwatch is helping the AM to achieve the new museological goals of creating knowledge communities, and fostering initiatives for public betterment (Ross 2004; Weil 1999). There is evidence that through the program, citizen scientists have formed a strong relationship with their local environment, and their wider community. This is expanded upon in the sections **Tacit Museum Goals** and **Identity Formation**.

A complete overview of the perceived successes of Streamwatch are provided in **Table 6**, detailing the strengths as identified by participants. Of particular note are comments relating to the characteristics of the data. Aspects of Streamwatch relating to the data was nominated by program administrators more than citizen scientists; the reality of the data was more of an achievement for those managing it than for those producing it. Citizen scientists were more focused on the way the data and the framework of Streamwatch itself has enabled them to connect with community and in sharing information with their peers. These results can be understood as satisfying both the goals of citizen science and new museology; program administrators are satisfying the goal of citizen science to produce high quality data, and citizen scientists are satisfying new museological goals by using the data to connect and communicate with their community.

Table 6 Successes of the Streamwatch program

Concept	Specific area	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Community	Opportunity for people to be involved	1	-	-	**1**
	Accessible/approachable program	2	-	-	**2**
	Awareness of environmental issues w/in community	1	1	-	**2**
	Knowledge community fostered by Streamwatch	4	4	1	**9**
	Engagement with AM	1	-	-	**1**
	Framework to enact change	1	1	-	**2**
Education	Framework for peer-to-peer education exchange	1	1	-	**2**
	Increase environmental literacy	5	2	-	**7**
	Access to scientific skill training	1	1	-	**2**
Environment	Remediation of sites	1	-	-	**1**
	Filling in monitoring gap	-	1	-	**1**
	Connection to local area encouraged	-	1	-	**1**

Concept	Specific area	Citizen scientists N=9	Program administrators N=7	External users N=1	TOTAL N=17
Science	Application of learned skills with results	2	-	-	**2**
	Better testing methods	1	1	-	**2**
Data	Quality of data produced	1	1	-	**2**
	Ability of data to enact change	1	1	-	**2**
	Longevity of data production/ longitudinal data sets	-	2	-	**2**
	Usability of data – more interactive	-	1	-	**1**

NB- Participants were able to nominate more than one concept in their open-ended response.

Participants did not nominate these concept areas directly, rather concepts emerged from their open-ended questions.

WEAKNESSES OF STREAMWATCH

The biggest weakness of Streamwatch identified by participants related to the website and database currently being used to input and host data (5 of 17 participants; see **Table 7**). This was raised mainly by program administrators (3 of 7 program administrators). This issue was closely linked with issues of accessibility (3 of 17 participants) and usability of data (3 of 17 participants). The fact that the main concern identified by the majority participants related to the information systems supporting the citizen science program underlines that—for these groups at least—the basic *shape* of the program is satisfactory, and makes sense to them.

Other than the issues outlined above, there were few instances of issues being nominated across groups. A complete overview of perceived weaknesses is provided in **Table 7** on the following page.

Table 7 Weaknesses of the Streamwatch program

Concept	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
Community	Not more actively involved with schools	1	2	-	**3**
	Legacy reputation of program effecting perception of data	1	-	-	**1**
Education	Importance of quality control and assurance not properly understood	-	2	-	**2**
Data	Not easily accessible (both internally and externally)	1	1	1	**3**
	Not getting used	1	1	1	**3**
	Data integrity	-	1	-	**1**
	No clear goal for data	-	2		**2**
	Website/database is not sufficient/performing well	1	3	1	**5**
	Quality of legacy data	-	1	-	**1**
Organisation	Scheduling/ time requirements	1	-	-	**1**
	Lack of obvious succession planning for continuity	2	1	-	**3**
	Perception that core of group too old/aging	1	-	-	**1**
	Communication[‡]	1	-	-	**1**
	Site visits from AM	1	-	-	**1**
	Recruitment	1	-	-	**1**
Nothing	Do not think there are any weaknesses	3	-	-	**3**

NB- Participants often nominated more than one concept in their open-ended response

NB- Participants did not nominate these concept areas directly, rather concepts emerged from their open-ended questions.

[‡] Specified that this was while the program was under Sydney Water and conceded it had gotten better since under the AM.

Apart from participants who felt that Streamwatch had no failings, (3 of 9 citizen scientists), no other issues had the same mention rate as the website. Issues for citizen scientists were largely to do with the organisation of Streamwatch. The possibility that the program might not continue because the core group are retired citizens with decreasing mobility, and there does not appear to be active recruitment, was the next biggest perceived weakness of Streamwatch (3 of 7 citizen scientists).

The inconsistency between groups concerning the perception of the data (being mentioned as both a success and a weakness) can be understood in context of the different administrators of Streamwatch. When talking about weaknesses of the data, reference was made specifically to issues stemming from when Streamwatch was under the administration of Sydney Water;

> *There is a lot of noise for a lot of reasons but I think a part of that is an artefact of a wide reaching program that was trying to meet a lot of different needs and scientific rigour was not high enough on the agenda. Failing is that we have a great, long history of data that we need to filter a lot of rubbish out of.*
>
> *- Program administrator*

The flow on effects of the data problems inherited by the AM have influenced the potential use of it for research.

> *From our point of view, it's really difficult to get meaningful extracts of data and you know, we end up having to request those [from external providers] rather than being able to generate those ourselves. So I think that's an inherited failure. We're looking at moving the decent quality data into something better that is a lot more open and transparent, so it's not just us being able to use the data; we'd like everyone to use it.*
>
> *- Program administrator*

This is a problem that has been noted and is being actively addressed by the current program administrators. It has been asserted that because of the function and ability of citizen science to bridge gaps caused by inadequate monitoring and lack of financial resourcing, these outcomes are increasingly the primary goal of institutions employing citizen science programs (Conrad & Hilchey, 2009). The role of the data in Streamwatch needs to be examined as it is a vital component of any citizen science program.

USEABILITY OF DATA

One of the differentiating factors between citizen science projects and public programs within the museum is the production of high quality, useable data for research. At its core, a program is not citizen science without data. As such, the role and importance of the data needs to be explored across both citizen scientist and program administrator demographics.

While the data from Streamwatch is yet to be used in the traditional sense of research, it has been used to motivate environmental management action. Two instances where Streamwatch played a role in the remediation of a site, or in the management of a site were mentioned by several citizen scientists and program administrators. The first instance was the intervention of Sydney Water and local council to construct a wetland on a floodplain to help treat highly polluted water in the Georges River. Understanding the severity of the pollution was assisted by the data collected by citizen scientists from the Streamwatch program

(Streamwatch interview). The second involved using data to prove that a major development was not complying with environmental policy and run off was polluting Redbank creek. Action from the Streamwatch citizen scientists resulted in the site shutting down until the developers had proper methods in place to guarantee compliance (Streamwatch interview)

These outcomes do not reflect how the data from citizen science programs is conventionally used. Further, the role of the citizen scientist to use the data for activism like this is a deviation from the traditionally perceived use of data. However, this use the data by citizen scientists for their own cause aligns with Marlow's 1995 definition of citizen science as a science which "*assists the needs and concerns of citizens*" (Irwin 1995, p. xi). A wider case study of how data is used by citizen scientists is needed to comment further on this, but it is an important aspect to note when considering citizen science in a museum. The citizen scientists were able to cause such action not only because they had data, but because they had the framework and support of Streamwatch and the AM. This ability of Streamwatch was aptly surmised by two program administrators:

> *It is amazing what some of the people have been able to uncover and use the support of Streamwatch as a big name, not even the Australian Museum as such but Streamwatch as a name on its own to get movement in councils, local government, EPA and those sorts of things. It's really just supporting and encouraging working as a citizen science and community action as much as we can.*
>
> *- Program administrator*

> *They're using Streamwatch and the Australian Museum to help strengthen [the understanding and reception of their results]: they're not just a couple of kooks in the backyard. They are trained citizen scientists doing work on behalf of Streamwatch and the Australian Museum. They're got media coverage. They've got stuff back from the local council. They've got EPA coming back to them.*
>
> *- Program administrator*

This alternative use raises questions around the perceived role of data for citizen science; does use of the data by citizen scientists qualify Streamwatch as a successful citizen science program, or does the data need to be used by research scientists in order for a citizen science program to be successful. In the case of Streamwatch and understanding citizen science through Marlow's definition of citizen science assisting the 'needs and concerns of citizen' (Irwin 1995, p. xi) evidence suggests that Streamwatch satisfies this function.

Full exploration of the larger questions about how to define the success of a citizen science program is beyond the scope of the current thesis, but something that provides a natural platform for further investigation. The use of the data by citizen scientists aligns well with new museology as it can be understood as relating to the goals of public betterment and education. The validity of the data being used primarily by citizen scientists themselves as opposed to research scientists, the implicit users of the data, needs to be explored in the context of citizen science theory.

PERCEIVED ROLE OF DATA

All groups were asked what they saw 'as the role(s) of the data collected by the Streamwatch program'. This was designed to ascertain what the relationship between the actual data output of Streamwatch—the goal of citizen science—and the expectations of the program were, and whether the desired goals represented new museological aims for public programs.

As was expected of a citizen science program, high value was placed on the long term nature of the data to provide baseline data sets by all groups. Notably, the same value was placed on the ability of the program and data to monitor the environment. The concept of 'monitoring' as opposed to providing longitudinal data is imbued with a sense of responsibility, and the potential to act if required. Indeed, data as a facilitator of remediation and conservation was mentioned, as was the ability of the data to facilitate activism within community (Streamwatch interview). A specific example of this was offered by one citizen scientists who suggested that the data should be used to '*lobby Sydney Water for less wet weather sewer overflow'.* A complete overview of perceived roles is provided in **Table 8** below.

Table 8 Perceived role of Streamwatch data

Concept	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
Community	Altruism- Give back to community	-	1	-	**1**
	Influence decision makers/policy	-	1	-	**1**
	Foster relationships between science, community and decision makers	-	1	1	**2**
	Support/facilitate activism	2	1	-	**3**
	Educate community	1	2	-	**3**
	Integrate with and unite community for common cause	1	-	1	**2**
Environment	Better management of waterways	1	-	-	**1**
	Remediation	3	-	1	**4**
	Conservation	1	-	-	**1**
	Monitoring health of environment	6	3	1	**10**

Concept	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
	Early warning/alert system	1	2	-	**3**
Science	Make science accessible	1	1	-	**2**
	Create rigorous data for scientists	-	2	-	**2**
	Longitudinal/ historical/ baseline record	6	3	1	**10**
	Modelling/ mapping	4	2	-	**6**
	Contribute to Climate Change research & discussion	1	-	-	**1**
	Raise awareness of issues	-	1	-	**1**
Other	Contribute to AM collection and knowledge	1	1	-	**2**

NB- Participants often nominated more than one perceived role in their open-ended response

Another citizen scientist, upon further questioning regarding whether or not they would continue in the program if the data was not being used responded: '*Yes of course I would participate, because the data is being used by us. We're using it and acting on it within our own community.*'

This idea that the produced data should be used by communities was common among citizen scientists and supports Marlow's (Irwin 1995) definition of citizen science. Other uses for the data are present, but the idea that the data was produced to address a need within, and for use by, communities was strong, as was the idea that the data was for an audience bigger than just research scientists. The absence of research scientists able to speak about the program can be understood to support the existence of alternative audiences, such as local council and environmental managers as well as citizen scientists.

> *Community groups should have access to their own data and the data from other sites to help them interpret their data with the view to using the data to lobby local government.*
>
> *- Citizen scientist*

> *Streamwatch makes the data more accessible and understandable for community, because it's coming from them.*
>
> *- Citizen scientist*

Citizen scientists of Streamwatch are participating to empower the themselves and their local community directly, as opposed to actively supporting specific research scientists or research goals as in other citizen science programs. It is rare for a citizen science project to be running without a research question or project driving the data production: Zooniverse[13], SciStarter[14] and even another of the AM's citizen science programs, DigiVol[15] all have specific questions or goals they are speaking to. Streamwatch on the other hand exists to monitor, with no current discernible goal for the data being produced. At this stage, use of the data is determined by citizen scientists; it has the potential to aggregate indefinitely at the AM until citizen scientists decide to utilize it for their own purpose. Program administrators of Streamwatch indicated that they are working to get the historical data sets of Streamwatch to the same quality standards as the rest of the AM's scientific outputs, so they can be used for research, and be made accessible to the wider public (Streamwatch interview).

[13] www.zooniverse.org

[14] www.scistarter.com

[15] http://volunteer.ala.org.au/

The potential for citizen science to act as a way to foster grassroots, environmentally conscious action is a feature of citizen science that museums should investigate further. This potential function is related to new museological goals for museums, and is discussed further in **Tacit Museum Goals**. Another important facet of these examples, particularly the second example of use of the data from Streamwatch instance concerning the developers, is the ability of Streamwatch data use concerning the developers, is the ability of Streamwatch to foster peer-to-peer education: the citizen scientists involved in the site shutdown were able to present to their wider Streamwatch community at an end of year function and share how they got media traction, and ultimately council action. The function of the program to create a community focused on peer-to-peer education is being encouraged and celebrated by program administrators;

> *... (They) were able to tell the other people who came to our end of year event, 'this is how you use it, this worked well, this didn't work well', and that I think has been really positive. Rather than people feeling like they're sitting in isolation, giving them a chance to actually network and communicate.*
>
> *- Program administrator*

This culminates in recognising the opportunity for citizen science to help the museum transition into the role of facilitator rather than disseminator and to meet implicit, as well as delineated, goals of the museum (Lloyd 2014; Ross 2004; Weil 1999).

GOALS OF THE MUSEUM

Any program that is run within the museum space needs to meet goals of that museum. These are both the explicit goals of the institution as set out in strategic documents, and the plans and tacit organisational goals of all museums as public spaces. This thesis will now explore the ability of Streamwatch to satisfy explicit strategic goals of the AM, specifically

the Science Strategy of the AM. It will then examine the participant's goals for the program based on interview responses to determine whether Streamwatch is currently meeting, or planning to meet, these expectations. Finally, it will investigate the potential of Streamwatch to embody the tacit goals of the museum to see how well Streamwatch fits within the framework of new museology.

The institutional goals of the museum examined in this study, as outlined in **Section 1. Responsibility of a Museum to Communities** above, involves the capacity to foster identity formation through self-motivated learning and positive experiences. Underlying this is the goal to be transparent to the public, and support initiatives for public betterment. Public betterment, achieved through education and exhibition, is the constructive influence on the learning experience of visitors to foster positive behaviours and social inclusion (Garcia 2012). This didactic purpose creates knowledge communities, and is the driving ethical purpose of the modern museum (Harris 1990; Hedstrom & King 2003).

This section will first examine the language and experiences of stakeholders to understand the ability of Streamwatch to satisfy goals outlined by the Australian Museum. It will then analyse Streamwatch through the lens of new museology to see if the program complies with the tacit goals of a museum.

OUTLINED GOALS

The AM specified that they wanted to engage "*amateur naturalists with a view to engaging further groups in museum citizen science programs"* (Australian Museum, 2015b, p. 15). No explicit reason is given for this goal in the strategy, though it does comply with new museological theory to foster avenues of engagement between museums and communities, to support agency within.

Interview responses**,** mainly from the citizen scientists**,** were analysed for the following categories to assess the potential of Streamwatch to fulfil outlined goals:

- Involvement with other citizen science projects
- an indicated interest in the environment;
- awareness of biodiversity;
- recount of, or desire for fostering in others, a positive form of engagement;
- recount of, or desire for fostering a safe space for affirmation of identify and culture; and
- interest in heightening or encouraging scientific skills.

Responses from the program administrators are discussed where relevant, but as their professional role is conceivably to ensure the success of the program, the existence of these considerations in their experience of Streamwatch is a given. If interview data showed that this expected relationship was not present it has been noted.

Interest in The Environment

All stakeholder groups indicated an interest in the environment in their interview responses. This is unsurprising as Streamwatch is a water quality program, the results of which relate to and reflect the health of the local environment. The program understandably has a high level of environmental education involved.

Participants often referred to wanting to look after the environment and raise awareness for it as part of a holistic care for local areas:

> *Letting the public know the impact of what they do on the creeks and rivers...the impacts of pollution, the impacts of what they put in their gardens, with the weed infestation getting into the creeks and rivers, just letting the public*

know that they need to take care of the creeks and rivers because we had pristine creeks when we, when the Europeans came to Australia and now there are so few pristine creeks left.

- Citizen scientist

It gives you an ability to talk to the community on a knowledgeable basis, the community association depends on us to provide information and so we, what we do is moved out so people are aware and I think we can raise awareness of anything environmental it can only be good.

- Citizen scientist

We're engaging people to look at their freshwater systems locally, take a bit of a stewardship role on, and educate them. Tell them what they're looking at is good or bad, how they can make it better: how they can engage with their local fresh water environments

- Program administrator

Environmental interest was often strongly linked with concepts of education within the community and remediation of sites, as displayed in the above response. This commonality across all groups is indicative of citizen science programs like Streamwatch being able to engage with '*amateur naturalists'* on behalf of the AM (Australian Museum 2015b p. 15). As the AM is a natural history museum, and an active scientific research institution, the ability to foster a connection with the natural environmental is important as it supports their collections and research outputs.

Summary of Streamwatch's Alignment with Outlined Museum Goals

Interview respondents indicated an involvement in a wider network of citizen science initiatives, sensitivity to the environment and an awareness of biodiversity. The presence of these considerations within the Streamwatch community, a community that moved into the AM space through an externally developed citizen science program, highlights how incredibly achievable it is for the AM to achieve its goals relating to citizen science. There is a lot more to be gained from citizen science than goals relating only to education, community formation and/or research centred on the idea of the naturalist. As one program administrator aptly commented:

> *The people that are involved in community programs like Streamwatch are already those people who are quite environmentally aware. That's an audience that the Museum has attracted for a very long time.*
>
> *– Program administrator*

In the case of Streamwatch, and arguably a lot of long-running citizen science programs, participants are attracted to the program because it speaks to their existing scientific and environmental interests. One citizen scientist described their recruitment call-out as simply being '*no experience needed...just an interest in the environment*.' The goal of engaging sectors of the community to satisfy purely scientific and environmental goals is no longer difficult to achieve. New goals need to be defined if the contribution of citizen science to the museum sector is to continue and grow. One goal that aligns with both the Science Strategy of the AM and the responses of interview participants is the use of citizen science programs like Streamwatch to proactively support community groups. Additionally, this provides a supportive network and resources so that they are able to develop actionable data. This goal is instilled with the consideration of communication, education, community growth and public betterment.

The desire within respondents for wider community education was often found to be imbued with the consciousness of the environment: active environmental literacy. Identifying this reveals the potential for the development of peer-to-peer educational opportunities within citizen science, resulting in the shift of the museum from education and scientific disseminator, to facilitator. One program administrator revealed that the program was already achieving this, '*it's not us telling them things, it's these guys having the opportunity to share with each other...we are doing training a trainer, and that's a perfect model.*'

The educational aspirations of citizen scientists, combined with their desire for knowledge and their interest in applied skills, supports the idea that citizen science could help meet larger, tacit goals of the museum (Ross 2004; Weil 1999.). Though the logic behind the AM's support is not explicitly stated in strategic documents, it reveals an alignment with the new museological practice of fostering positive experiences and delivering programs that benefit the community (Grenier 2010; Weil 1999). This potential is explored more in '**Tacit Museum Goals**'.

DESIRED GOALS

All groups were asked to 'set three goals for Streamwatch to achieve over the next five years', to see if desired areas for development aligned with each other. Though they were asked to set three goals, there were often more than three concepts and opportunities identified in answers, as seen in **Table 9** on the following pages.

Table 9 Goals for Streamwatch as set by participants

Opportunity	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
Community	More collaboration with other citizen science groups	2	-	-	2

Opportunity	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
	More celebration and wider involvement with community	2	-	-	2
	More awareness of Streamwatch	2	-	-	2
	Make stories out of the data	-	-	1	1
	Support activism	-	-	1	1
Education	For self	1	-	-	1
	In community	1	-	-	1
	Stronger link to schools/curriculum	3	2	1	6
	Increase competency of citizen scientists	1	-	-	1
	More training opportunities	1	-	-	1
Environment	Remediation	1	-	-	1
	Monitor more sites, including nominated key sites	1	2	-	3
Science	Incorporate other sciences for more holistic approach	1	1	-	2
	Continue and increase links with programs like MicroVols and ALA[16]	1	1	-	2
	Stronger link to AMRI[17] science	1	-	-	1
	Extend biological component	-	1	-	1

[16] Atlas of Living Australia (ALA) is an online resource contains aggregated information about all the known species in Australia from a network of research institutions

[17] Australian Museum Research Institute (AMRI) is the science research branch of the Australian Museum.

Opportunity	Specific area	Citizen Scientists N=9	Program Administrator N=7	External User N=1	TOTAL N=17
	Set waterway health quality values for	-	1	-	1
	Contribute to discussion about climate change	-	1	-	1
Data	Ensure record keeping quality of Streamwatch	1	-	-	1
	Historical mapping/modelling	1	1	-	2
	Present it in more meaningful way	1	1	-	2
	Significance of data recognised	1	-	-	1
	Get data used	-	1	-	1
	Increase data integrity	-	1	-	1
	Increase access-science and public	-	1	-	1
Recruitment	Recruit more	1	2	1	4
	Increase social inclusion aspects, wider demographic	-	1	-	1
Organisation	Ensure continuity of program	-	3	-	3
	Secure funding	-	2	-	2
	More publicity	1	-	-	1
	Eureka prize for Streamwatch[18]	1	-	-	1

NB- Participants often nominated more than one goal in their open-ended response

The most common response across all groups was to have more involvement with schools (6 of 17 participants). This was the most popular response for citizen scientists (3 of

[18] The Eureka Prizes are presented by the Australian Museum to reward excellence in research & innovation, leadership, science communication, and school science.

9), and one of the second most popular goals for program administrators (2 of 7). This desire to be more involved with the wider community, specifically in an educational capacity, aligns well with new museological goals (Hooper-Greenhill 2007; Ross 2004).

The predominant goal for program administrations related to ensuring the continuity of Streamwatch (3 program administrators), which was often mentioned in relation to recruitment (2 program administrators) and funding sources (2 program administrators).

Other nominated goals for Streamwatch from citizen scientists concerned the wider community; they suggested more collaboration with other citizen science groups (2 citizen scientists); more obvious celebration of Streamwatch successes with other communities to inspire greater involvement (2 citizen scientists); and to achieve greater awareness of the program within communities (2 citizen scientists). These goals often had a variety of undertones to them, varying from wanting communities to have greater participation with Streamwatch as a precursor to recruitment, through to being able to have a more holistic scientific data set.

The nomination of using the data to create stories by the external user is revealing in that this was not an expected goal for the program for this group; it lies outside of the scope of research and is more focused on engagement and education.

Creating this link with communities was also mentioned in terms of being able to have 'influence', in terms of development of the neighbourhood. Influence within communities was also touched upon by another citizen scientist who spoke about their desire to create a link with communities so that people would be less likely to pollute:

> *Trying to make people aware about what flows in to the wetlands and how it affects it. So simple things like rubbish on the street gets washed in the storm water, then into the creek and wetland, picking up dog poo when taking your*

> *dog for a walk, washing your car on the grass rather than the street There must be 50-100 Streamwatch groups that all trying to do the same thing. So a wider publicity would make the groups feel that sort of belonging to a larger group that are working towards learning about and improving our water ways.*
>
> *- Citizen scientist*

This goal of greater awareness within communities, specifically in relation to the above quote, is imbued with ideas of public betterment, environmental care and informal learning practices; all implicit, although sometimes overt, goals that a museum aims to achieve with public programming (Grenier 2010; Weil 1999). These responses demonstrate how easily the desired goals of Streamwatch can align with the goals of new museology.

TACIT MUSEUM GOALS

New museological goals of a museum are rarely outlined explicitly in strategic documents, but rather inform the development of best practice and as such are encouraged to be imbued within the everyday activities of the museum.

This study is concerned with the goals of the museum to encourage self-motivated learning and contribute to positive identity formation, to be transparent to their public and to foster public betterment (Hooper-Greenhill 2007; Rashman et al. 2009). Education is at the core of the museum's function, the vehicle through which these larger institutional goals are achieved, and part of the museum's ethical remit to its public.

Self-Motivated Learning

This initial analysis is looking for evidence of self-motivated learning within Streamwatch, based on compliance with defined requirements of flow as outlined below. The

outcomes of this analysis are then compared with the ECSA's '*Ten Principles for Citizen Science*' (2015) to see if these outcomes align with best practice guidelines.

Flow is the theory of Csikszentmihalyi (1997) to explain the requirements for self-motivated learning to occur. The experience of flow often occurs '*when one's skills are neither overmatched nor underutilized to meet a given challenge'* (Shernoff et al. 2003, p. 160).

The elements required to achieve this can be understood to be:

1. a defined goal for experience;
2. a goal that is challenging, yet achievable;
3. when feedback is provided; and
4. individuals are in a safe, supportive environment.

More research is required to establish the individual experiences of Streamwatch citizen scientists and map their individual flow. However, an initial analysis can be done of the aggregated experience of citizen scientists of Streamwatch to test for the presence of the requirements of flow. Flow is a form of learning where the individual is rewarded with positive identify formation (Csikszentmihalyi 1997; Hooper-Greenhill 2007; Shernoff et al. 2003). This reward encourages the individual to repeat the behaviours that resulted in this positive experience, and results in an almost cyclic habit of self-motivated learning.

> *You really do look at the creek in a different light...you think "my goodness, that wasn't a feck of rubbish in the water. It's got 6 legs, a mouth and it's got a tail. But it's only 6mm long!" So yes, it's an amazing insight into another world.*
>
> *- Citizen scientist*

The benefit of encouraging flow is that it achieves the museum's tacit educational goal, simultaneously making the museum central to these positive and rewarding behaviours (Hooper-Greenhill 2007; Shernoff et al. 2003). It makes the museum synonymous with

enjoyable, educational activities and thus individuals are more likely to become repeat visitors, to talk about their experiences and encourage their community to participant with them.

1. Defined Goal for Experience

This section is testing whether the conditions necessary for 'flow' are present in the Streamwatch program, based on responses given by citizen scientists and program administrators during interviews.

For flow to occur, there needs to be a relatively well defined task; this enables experience of achieving and learning to be tracked (by both participants and facilitators), and helps minimise anxiety, and encourages concentrated engagement (Shernoff et al. 2003). The ECSA recommends in their best practice guide that citizen science programs are developed with the explicit goal of generating '*new knowledge or understanding*', along with a '*genuine science outcome*' (European Citizen Science Association 2015, p. 1). To comply with both flow and best practice, there needs to be a specific, scientific goal that citizen scientists are contributing knowledge to.

There was a clear goal expressed by the sample of Streamwatch participants interviewed as part of this study as shown in **Table 8**; monitoring local waterways and providing baseline data. This focus has united the citizen scientists in their Streamwatch groups and created a bridge linking these groups initially with Sydney Water and now with the AM. There is the perception among study participants, and program administrators in particular, that this focus has become more refined under the administration of the AM.

> *I guess in a way, coming under the Museum the program has certainly developed a focus that it hasn't had before...I may be expressing my own bias, but it has scientific*

integrity...it's more targeted in its audience...and far more respectful of the appellation of citizen science.

-Program administrator

The high instance of this perception being mentioned by program administrators may be because program administrators are more aware of the issues they have resolved across the whole of Streamwatch and have a better understanding of what the program was when it came across from Sydney Water versus what it is now. There is weight behind the idea that the scientific integrity of Streamwatch has increased under the AM, directly related to the AM's role as an active scientific research institution, as discussed in the following section.

2. Challenging Yet Achievable

A challenging, yet achievable goal is a flow as it provides opportunities for learners (citizen scientist) to improve their skills (Shernoff et al. 2003). Setting and then achieving a challenging goal also evokes a 'growth principle' (Shernoff et al. 2003, p. 161), encouraging participants to set increasingly challenging goals for themselves, culminating in the development of a more complex skill set. This can benefit citizen science as technical skills required to ensure quality control are met, and data standards are high.

The ECSA recommends that citizen science programs adopts a '*considered research approach'* and that citizen scientists, if they desire, '*participate in multiple stages of the scientific process'* (European Citizen Science Association 2015, p. 1). The challenge of any citizen science program is to ensure the data being produced by citizen scientists, who may not have a traditional science background, is robust enough for use in scientific research. This encompasses a plethora of training requirements related to scientific literacy, quality compliance and actual testing methodology

On top of the clear goal of monitoring, there is the challenge to get the quality of the data recognised; this desire manifests in different roles for each stakeholder. For citizen

scientists, their primary role is to ensure that they are using proper testing and data recording techniques. For program administrators, their main role is to ensure that the data is properly catalogued and interpreted from the citizen scientists and robustly presented for external users in an accessible way. There is a plethora of other roles that sit beside these key functions that challenge the participants to get a return on the data collection. One such example is to ensure data is to the same standard as the other scientific data sets being produced by the AM's research scientists, in the same way that programs run within the museum space are held to the goals and ethics of a museum's public program, so are scientific outputs of Streamwatch held accountable to the standards of other scientific content published by the AM.

> *We're trying to make it much more robust and scientific methodology I guess, so that it can be subject to scrutiny.*
>
> *-Program Administrator*

> *The Australian Museum is a reputable scientific institution; we cannot afford anything that is going out not to be of the highest calibre...so if something isn't being done correctly or these protocols aren't right, we're fixing that...because we can't put our name to something that won't stand up in the scientific community.*
>
> *-Program Administrator*

This challenge is for both the citizen scientists and the program administrators, as the former carries out the skills learnt through the latter's training methods. It is an obvious opportunity for conversations to be carried out between the two groups about best practice, what is and is not working, opportunities for development and generic feedback to be provided in a constructive way (Soren 1999).

3. Feedback Provided

To foster a positive experience of working on a challenging task, feedback needs to be provided to help learners —in this instance, citizen scientists—build their skill sets (Shernoff et al. 2003). Having a feedback cycle enables the provider, or facilitator of learning to adapt their instructions to participants' "*developmental levels and individual interests*" (Shernoff et al. 2003, p. 173). Feedback is also an explicit recommendation of the ECSA, specifically in regards to what the outcomes of the program are, and how the data is going to be used (European Citizen Science Association 2015). Feedback, specifically in the form of evaluations, is an important aspect of new museology as it enables the museum to build profiles and identify gaps in audiences (Soren 1999).

Integral to the successful production of high quality data is the assurance that proper quality control and assurance processes are being followed and any supplementary equipment is properly calibrated. This requires the training of both program administrators to oversee data aggregation and output and citizen scientists to produce and log the data. There is a natural dialogue that happens during this process, especially where quality control and assurance are concerned as they are the foundation supporting the integrity of any data produced. Unless collection methods can be proven, and show to align with scientific processes, the data will most likely not be used by research scientists. As such, there is an in-built feedback process in Streamwatch. On a basic level, this process can simply be program administrators disseminating information concerning quality data to the citizen scientist, and choosing to discount any data sets that do not comply with standards. In the case of Streamwatch however, the experiences of participants reveal that there is a more positive process and that it builds their confidence.

> *The scientific basis of it [Streamwatch] allows you to collect data in a very meaningful way. The mentoring and learning that we've been able to do through the program over the years has allowed us to learn more as we go and I guess to be better data collectors over the years.*
>
> *- Citizen scientist*

> *I see that the [Australian] Museum has gotten benefits out of it but the community have got great benefits because, they feel more engaged with the program. It's not just a community engagement activity; it's actually collecting something that they can be confident in and we run them through QA activities and let them know how they're doing too. So that's feedback loop.*
>
> *- Program administrator*

Constructive feedback has the potential to foster a positive environment in which skills can be properly explored, people can access the support they need, and programs are sensitively developed in response to participant experience (Hooper-Greenhill 2007; Ross 2004; Soren 1999)

4. The Creation of a Safe, Supportive Environment

The balance between completing a challenging task or experience and the generation of new skills is fragile as there is potential for anxiety and critique to detract from the learning opportunities (Shernoff et al. 2003). This can be mitigated by the creation of a safe and supportive environment, of which constructive criticism and positive feedback are a pillar. The positive reinforcement and acknowledgement of the contributions of citizen scientists are also recommendations of the ECSA, along with the recommendation to evaluate participant experience (European Citizen Science Association 2015).

The amalgamation of a defined goal that is challenging yet achievable, and supported by feedback within a safe, supportive environment is what enables flow to occur. As Streamwatch monitoring is conducted largely in-situ at various waterways across the Sydney, greater Sydney, the Blue Mountains and Illawarra region, the safe space exists in forms other than a traditional physical 'space'. It is predominately a dialogue between program administrators and citizen scientists, but is also starting to exist online and on-site during training days as citizen scientists participate in peer-to-peer training, building their confidence and ownership over the skills and knowledge.

> *[the AM has] a closed Facebook page. Not a lot is posted, but it gives people a forum to float ideas and raise awareness, keeping people keen and motivated. Otherwise they might have had people dropping out because of lack of enthusiasm.*
>
> *-Citizen science group*

Identity Formation

Flow enables individuals to be rewarded with positive identity formation as a result of learning (Csikszentmihalyi 1997; Hooper-Greenhill 2007; Shernoff et al. 2003). Understanding Streamwatch through the frame of flow helps ascertain if there is potential within citizen science to foster self-motivated learning, a key aspect of identity formation (Csikszentmihalyi 1997; Shernoff et al. 2003). It also satisfies the goal of the museum to act as a place of positive education and engagement (Hooper-Greenhill 2007).

Identity formation in this context is most easily understood as confidence; an individual's confidence in their own ability and a willingness to engage in discussions that are important to them (Falk & Dierking 2000; Hooper-Greenhill 2007). The presence of identify formation is important as it is one of the major goals of education delivered in a new museological space (Hooper-Greenhill 2007).

We're using the Streamwatch banner to validate what we do there, and to say "look, you know, council these are not local do-gooders meddling, there's some science behind this and you've haven't got it but we have."

- Citizen scientist

I probably feel I've been around the program long enough now to comment about how it's going.

-Citizen scientist

It was [taxonomical] training, but we still felt that we helped to sort some of the collections which could be used as a reference collection in the future.

-Citizen scientist

Confidence expresses itself in different ways; the above three experiences of citizen scientists are such examples. The first experience discusses being confident enough in Streamwatch as a program to use it to champion causes with council. They are proud of the scientific reputation and rigour associated with the program, and using it as a vehicle to engage in conversation with policy makers.

The second experience is discussing being able to contribute to conversations about the future of Streamwatch. This displays not only this citizen scientist's confidence in their understanding of the program and what it is aiming to achieve, but that they are confident enough to voice their personal opinions about it.

The third experience is confidence in their own ability to taxonomically classify specimens through the MicroVols program. This then transforms into pride as they posit that they are capable enough that their work could be good enough to help produce a research collection for the Museum.

Experiences that contribute to identity formation are necessary if Streamwatch is to be understood as complying with the goals of new museology; identity formation is a goal of education within a museum space employing new museological theory (Hooper-Greenhill 2007). There is evidence of this happening in Streamwatch, however further research is needed to fully explore the manifestation and role of confidence in citizen science programs.

Public Betterment

The environmental and educational benefits of Streamwatch are inherent to the nature of the program and arguably all citizen science programs. There is a basic level of training required for citizen scientists in order to ensure that their collected data is of a high enough quality, which often involves contextual information about the research topic. Streamwatch has shown that there is capacity to take this even further if these two facets are delivered in such a way to encourage flow. It can result in both peer-to-peer learning opportunities and activism within communities. These two outcomes can be considered to represent public betterment, one of the goals of new museology (Ross 2004). Working for the benefit of the public is a characteristic of citizen science: it is the public benefit of an act that makes it an act we undertake as citizens, for example rather than for self-interest, as employees (Irwin 1995).

> *And then the same people on the council say "well if it's polluted, why aren't there dead fish and frogs and things everywhere?" Well it's a stream, the fish are about 2 cm long on the outside, frogs are aerobic, they don't stay inside a muddy stream and try to breathe they hop out onto the bank.*
>
> *– Citizen scientist*

The above quote is an example of the awareness of biodiversity relevant to the health of an ecosystem participants displayed and demonstrates a Streamwatch citizen scientist

engaging in conversations in which they are trying to teach environmental information to others within their community. Specifically, this was a conversation with councillors; community decision makers. This citizen scientist was confident and active enough not only to engage in conversation with this group, but to correct them on their incorrect environmental assumptions. Facilitating programs where members of the community are able to access the resources to gain this skill set aligns with the museum's institutional goal of public betterment through education, while simultaneously increasing the reputation around Streamwatch and proving facets of its scientific rigour.

Not every individual will use a citizen scientist program in the same way; for example, some may not want to have anything to do with decision makers. The tacit goal of a museum is not to incite people to argue with policy makers, but rather to give them the skills, knowledge and confidence to engage in meaningful dialogue and stand up for what they think is important; public betterment as initiated by the public (Ross 2004)

Transparency

The new museological focus on transparency aims to foster relationships between the museum and individuals within communities (Crooke 2007), in line with meeting the museum's educational and community engagement goals. New museology is also a means through which the museum can relate to their scientific research, mission and responsibility. Transparency helps the museum achieve the larger tacit goal of public betterment, as it enables the community to better understand institutional motivations and actions (Hooper-Greenhill 2007; Rashman et al. 2009).

Transparency within the museum manifests in many different ways. One such way is in revealing the spectrum of tasks undertaken by a museum front and back of house. Certainly this level of transparency has been achieved by the Streamwatch program;

I gave all my children and grandchildren yearly passes to the Museum; I'm keen for them to know more about the organisation.

– Citizen scientist

Going through the back rooms, pulling open drawers and seeing various collections stuck with pins. You go, "wow! There's so much of it!" It's quite staggering.

– Citizen scientist

We have a scientific research element which is more behind the scenes...these programs help bridge the gap...people are visiting the exhibition when we have meetings days here, or using their volunteers card to go to an exhibition for volunteers' days, and then working behind the scenes doing an activity like MicroVols or then being out in the field collecting Streamwatch data.

– Program administrator

Interview responses show that Streamwatch has been successful in increasing the transparency around the scientific capability of the AM, but this can be taken even further. Citizen science has the potential to reveal the tacit goals of the museum to foster positive community engagement, among other things.

We've been surprised at how good the fit of Streamwatch is at the Australian Museum. The idea of what a museum is, is changing. It is more than just the static building that you go to for information. I think that the Museum, by doing programs like this, is changing.

– Citizen scientist

> *It's opened my eyes to just how much goes on at the Museum behind the scenes, that you never, and most people say the same thing, "Why would the Museum be interested in that?" And I say, "well, I wouldn't have thought that the Museum would be doing that either." But now we start to see what role they are playing and it's just marvellous.*
>
> *– Citizen scientist*

> *They're here, and they're making our Museum...well, maybe it's more citizen engagement, they're making our science that is sometimes complicated language, accessible to the everyday person. So they are expanding the scientific knowledge of the populace through their ability to interpret the science we present in a way that's understandable to the lay person.*
>
> *– Program administrator*

There is still an incredible amount of potential for Streamwatch to increase the transparency of the AM, even within its current cohort of citizen scientists;

> *I think that citizen science is an area that the Museum could more into, but I don't think that they must do that. It's only if it doesn't compromise the activities that are fundamental to what a museum is.*
>
> *– Citizen scientist*

It is imperative to realise that while citizen science can produce quality data, it can also be a vehicle through which the museum can achieve these goals of transparency, and its other tacit goals (Hooper-Greenhill 2007; Lynch 2013; Rashman, Withers & Hartley 2009; Tam 2012).

FEASIBILITY OF DUAL GOALS FOR CITIZEN SCIENCE

Streamwatch is often understood as a community engagement program, rather than a citizen science program. As per the interviews held with stakeholders, it was perceived that there was a disconnect between Sydney Water and the citizen scientists that resulted in no clear focus or goals for Streamwatch. Participants expressed their views that Streamwatch was being used to pursue a complex set of objectives, without the tensions between them being properly resolved.

> *In the early stages, the feedback communications and the obvious lack of interaction I supposed was a bit of a downer, but now that Streamwatch is being supported by the Museum, things have changed dramatically.*
>
> *- Citizen scientist*

> *Historically, Streamwatch was a one size fits all program...delivered as both a citizen science program, and an education program, as an outreach program, as a capacity building program...*
>
> *-Program administrator*

When the AM took over the administration of Streamwatch, they were focused on ensuring that it complied with their own science and engagement policies, while simultaneously ensuring a smooth transition by employing change management strategies[19]. From the outset, Streamwatch at the AM had the goals of producing high quality data and engaging with the citizen scientists in a meaningful way, in compliance with other museum programs.

[19] Strategies involved encouraging communications and conversations between AM staff and Streamwatch participants through evaluations, regular newsletters, information sessions and personable staff.

I think that's probably how Streamwatch came to the Museum: because of our strength in community outreach and our strength in volunteer programs. Most other organisations didn't have the capacity to meet those needs.

-Program administrator

Well we need to make Streamwatch fit in accordance to our science strategy and also make sure it fits the mandate of our citizen science policy

-Program administrator

Responses in this study have shown that Streamwatch is understood by stakeholders as a vehicle for public betterment, a service to community and a source of valuable data. They see that there is potential for programs like this to be both a citizen science and museum public program.

[I think it's important] to try and preserve something for the next generation, and to try and prevent increases in pollution and try to clean up pollution that is already there.

- Citizen scientist

I love the fact that so many people are willing to give up their time to contribute to science knowledge, but it's actually everyone's social responsibility to make sure they're involved in this program, or a citizen science program, or community engagement.

– Program administrator

> *I think that when you look at what we're doing, and what we've always been doing here...capacity building. ...there is an enormous capacity for the Museum to be actively out there and part of everybody's daily life in a way capacity building.*
>
> *– Program administrator*

The move to the AM, though initially not understood and part of larger anxieties about the future of the program for citizen scientists, is now retrospectively appreciated as something that has been beneficial both for Streamwatch and the AM.

> *If you are trying to create a database, where better to house it [than the AM]. You've got scientists there, you've got a reputation there, it's a good place for it.*
>
> *-Citizen scientist*

> *You couldn't [collect a similar data set] without having a big group of people doing it regularly... as a scientist you wouldn't be able do that, for years and years [Streamwatch is] adding on and adding to the actual collections [of the AM].*
>
> *-Program administrator*

As this case study of Streamwatch has established, it is possible for Streamwatch to function both as a citizen science program and as a museum public program. Streamwatch has developed in response to a particular set of circumstances however and its dual ability may not be achievable for all citizen science projects.

Narrative as a Way to Achieve Dual Goals for Citizen Science

An additional framework derived from the literature review will use responses from interviews to see if citizen science can function as a 'narrative' structure for museums.

Narrative, in this context, refers to the capacity of a program, exhibit or interaction to allow for different systems of meaning to occur, i.e. different interpretation and understanding of the exhibition to exist simultaneously and equally. The potential for this is important as it is one method through which a visitor can achieve 'flow'[20]. Citizen scientists experiencing flow is significant not only in terms of contributing to the 'success' of citizen science as a public program for museums, but because flow can be linked to narrative construction within the museum space. If interview participants indicate that they experience aspects of flow, a potential to use citizen science to increase engagement with communities has been revealed.

If citizen science easily fits within the museological frameworks of narrative and flow, it then has the potential to not only meet the goals of public programs, but satisfy the ethical responsibility of a museum to be transparent to its public (Gurian 2006). In addition, it strengthens the idea of citizen science as a vehicle through which a museum can discuss its research work and goals with communities: a more refined and specific goal for a public program where the public becomes part of and contributes to the story of a museum. Supported by evidence from a case study of Streamwatch, this thesis investigates the potential for citizen science programs to be re-framed as museum programs that align with new museology and foster positive behaviours and social inclusion within communities (Garcia 2012), while still functioning as a 'successful' citizen science program within its own right.

[20] 'Flow', as described by Csikszentmihalyi, is "*The metaphor...that many people have used to describe the sense of effortless action they feel in moments that stand out as the best in their lives*." (Csikszentmihalyi 1997, p. 44). It is a way to understand the intrinsic motivation of why people engage in activities and is a desirable experience for a museum visitor as the museum itself becomes a facilitator to achieving 'flow' and is linked with positive identity formation.

Anderson (1997) talks about the potential for narrative to link individual life stories together and create communities. Narrative, in this context is a framework through which an individual interprets, understands and denotes significance of experience and information to form a sense of identity that is responsive to both the self and others (Anderson 1997). Understanding experiences through the narrative framework has already been adopted as best practice by museums when thinking about how community navigate museum spaces (Ntzani 2015; Ross 2004). It creates a space sympathetic to the development of an individual's identity in relation to other people and the museum and for this reason helps position the museum as a rewardingly positive space. It accommodates different motivations for participation; supports social learning processes; encourages participation and individual goals; and is a way for museums to share the story of their institution, to increase transparency, and to increase capacity, in a variety of ways.

> *I have been so in awe of the capacity of some of our volunteers to develop their scientific discipline and passion...I think there are a lot of high quality amateur scientists out there that don't know that they are potential high calibre amateur scientists. There's a lot of Charles Darwin types out there that are yet to realise that.*
>
> *-Program Administrator*

> *It's so entrenched with the Museum's core research focus and core science that I don't feel like you can separate it anymore. And that was on purpose, that was the goal. To make it not a separate program but a component of what the Australian Museum does...to see those real links.*
>
> *-Program Administrator*

> *[Streamwatch has] really brought together the capacity of the Australian museum, in terms of community engagement and citizen science, about how much we're already doing and about how integrated Streamwatch had really become with the Australian Museum...if it wasn't for Streamwatch, there wouldn't be as much capacity for the invasive snails' app to get out there into the community.*
>
> *-Program Administrator*

Work is still required to refine the data of Streamwatch so it is of the same standard as the other scientific outputs of the AM, and able to be used by research scientists. Despite this, Streamwatch is a successful example of how public program, educational, volunteer and change management practices have been employed for a scientific cause. More than that, it is an example of how citizen science can help a museum achieve institutional goals of self-motivated learning, identity formation, public betterment and transparency. Moving forward, it is worth exploring the adoption of cultural programing methods (commonly employed in museum public and educational programming) to engage audiences with science in a different way. Using the narrative framework as a way to understand and anticipate the ways citizen scientists engage with a program could mean that programs are developed with dual goals. Programs capable of producing high quality data and facilitating positive experiences within the museum space.

CHAPTER 6 | CONCLUSION

This thesis has investigated the potential for citizen science to simultaneously satisfy the expectations of both a citizen science program and a museum embodying new museological theory. Through analysis of interviews with Streamwatch stakeholders about their experiences and expectations using the lenses of both citizen science and new museology, it has been ascertained that it is possible for a citizen science program to successfully achieve the outcomes of both kinds of program. This has revealed the potential to adopt traditional theoretical frameworks to extend the application and benefits of science engagement and education initiatives utilised by the museum. The small scope of the case study of Streamwatch has not provided enough data or evidence to claim this ability for every citizen science program, but it has shown that there is potential for citizen science programs to function as new museological public programs.

This study analysed citizen science and new museology at a theoretical level and demonstrated that there was potential for citizen science programs to further the community engagement goals of museums that have embraced new museology. Interviews with citizen scientists and program administrators of Streamwatch along with one external user, enabled the comparison of experiences and expectations with the program and its place within the AM.

This facilitated the exploration of citizen science as a vehicle through which museums can interact with sections of the community, fostering the co-creation and sharing of knowledge, and encouraging positive relationships between communities and their environments.

Based on findings from this study, recommendations are made for areas of further study to enhance understanding of how museums can best engage in citizen science—

specifically, recommendations on how to maximise the potential of citizen science programs to act as a narrative device for museums to increase organisational transparency.

The Australian Museum has already decided that citizen science and the museum space are a good fit, as is evident from the creation of the Australian Museum Centre for Citizen Science, and by the AM hosting the headquarters for the Australian Citizen Science association (Australian Museum 2015a). The complementary relationship between museum and citizen science makes sense from a financial and research perspective as government funding for both the public culture and science sectors, in Australia, have been and are being reduced. Citizen scientists are able to produce large data sets as volunteers, and can contribute valuable data that acts as a launch pad for further scientific research (Dickinson et al. 2010; Dickinson et al. 2012; Fore 2001) There is more to be gained from this partnership than efficient resource use for data production however; the ability for citizen science to embody new museological public program theories is growing.

Citizen science, by definition, needs to be producing data. The understanding of how data is used is shifting as it starts to get used not just by scientists for research, but by citizen scientists in response to community concerns. Marlow (1995) outlined the potential for citizen science to achieve this, but didn't offer a scaffold through which to implement and support this function of citizen science. There is sparse literature discussing the benefits of citizen science for museums; much grey literature being produced currently assumes the benefits of citizen science within the museum space, as can be seen in the strategic documentation of the AM.

The Streamwatch program, as hosted by the AM, is an example of how a citizen science program can be mutually designed to work well as a citizen science program while achieving museum goals. Quality assurance and control around the data is a necessity for citizen science,

and priority for the AM in the context of its position as a prominent scientific institution. In addition, from a citizen science perspective, ensuring positive and educational experiences for citizen scientists is a priority, just as it is a necessity for new museological public programs. A goal shared by some of the interviewed Streamwatch stakeholders (10 out of 17) was for the data to eventually contribute to longitudinal and baseline studies. However, the nature of the program and the change management required by the AM to address legacy issues with the data, citizen scientists, and not research scientists, are currently the main users of the data. This is both a success and a weakness of Streamwatch when understood purely as a citizen science program. When understood through the lens of new museology however, Streamwatch is seen as a success. The use of the data by citizen scientists to enact change in their local environment and community satisfies the tacit goals of a museum to foster positive learning, identity formation, public betterment and transparency (Falk & Dierking 2000; Dickinson et al. 2010; Fore 2001; Hooper-Greenhill 2007; Ross 2004).

The significance of communication with citizen scientists in administrating a program has been shown. The potential of museological best practice to create meaningful experience for all stakeholders of citizen science without ignoring the importance of data has also been revealed. It is important to note the unique circumstances of governance – the change of administrator being the most influential – surrounding Streamwatch which enabled this to happen; not every citizen science program would be able to achieve similar results. These benefits are of obvious significance to citizen science within the museum space, but benefits for the wider discipline of citizen science need to be explored. Best practice for how to emulate the success of Streamwatch in engaging its citizen scientists needs to be explored.

The museum can position itself as a facilitator of this function of citizen science data by supporting the building of data sets and then providing the framework and resources for citizen scientists to use data at a grassroots level. If the museum approached citizen science

proactively with this intent, it would assist the shift of the museum from a disseminator of knowledge to instead facilitating its use, in the spirit of new museological theory (Hudson 1998; Lloyd 2014; Ross 2004; Weil 1999).

Recognising that museums can be good hosts of citizen science programs raises the question of what best practice would be. Understanding Streamwatch in relation to Csikszentmihalyi's concept of 'flow', combined with looking at how the data produced is being used, has revealed the easy alignment of citizen science theory and new museology. Principals of best practice already exist for citizen science—see, for example, the ECSA's '*Ten principles of citizen science'* (2015)—but these haven't been developed specifically for the museum context. A framework for how to design and administer these programs in a way that fulfils the goals of both citizen science and new museological public programs needs to be developed and explored. One potential framework that could assist in bridging this gap is that of the narrative—understanding and creating spaces and experiences that allow for multiple systems of meaning to grow and exist. A narrative approach would encourage the sensitive design of programs to allow for these multiple experiences. When combined with the goal of citizen science to contribute data and knowledge to the scientific community, designing citizen science within a narrative framework is one way in which museums can achieve the dual goals of citizen science as a research output and as a form of community engagement.

FUTURE RESEARCH

The small scope of this study and the unique circumstances around the development and administration of Streamwatch limited the extent to which the potential of new museological frameworks could be applied to increasing opportunities for science engagement and education within the museum. What this study has done though, is reveal that this is a field rich in possibilities for further research. The outcomes of such research could

assist in the development of citizen science as a tool for meaningful community engagement within museums.

Citizen science is defined as members of the community actively contributing data and knowledge to assist with scientific research (Australian Museum 2015c; Citizen Science Association 2016; European Citizen Science Association 2016). The way this is achieved varies depending on community and program goals, among other factors. The variety of different citizen science programs that currently exist means that the way in which Streamwatch successfully met these duals goals cannot be replicated in every program. More research needs to be done into frameworks in order to support the delivery and administration of citizen science within the museum space and achieve the aforementioned dual goals. This needs to be done with attention and sensitivity towards the different types of citizen science programs, as well as the different defined outcomes.

Alongside the necessary consideration of the variety of ways in which citizen science can be delivered, is the examination of the variety of uses of the data produced by the programs. The Streamwatch case study revealed that data was not being used for research by scientists; it was being used by citizen scientists themselves for environmental activism and capacity building within the community. There is further need to explore this citizen use of the data, and investigate other uses of the data outside of traditional research applications. One area of particular note to museums is the use of data by local governments for environmental management. Deliberately setting out to support environmental management as well as or instead of research scientists, would expand the range of groups and organisations within the community whom the museum could support. The use of the data by environmental managers also aligns well with the museum goals of community building, and increasing the transparency of their work.

The broadening of the potential audience for the data does then lead to questions about how explicit the research question of a citizen science program needs to be. As Streamwatch has shown, a citizen science program can successfully exist with no delineated research question but rather a broader aim; in this instance, environmental monitoring. Further research is needed to understand how an aim, as opposed to a specific question, changes experience and expectations around citizen science. While this has the potential to align well with museum goals of community engagement, education and public betterment, the impact on the integrity of the program from a pure citizen science perspective needs to be understood.

The ability of citizen science to make the scientific work of a museum more accessible needs to be investigated further. The external user of Streamwatch said that one goal they wanted Streamwatch to achieve was '*to bring the data to life, make stories with it, and then communicate these stories'*. This idea of the stories of science is in line with current discussions in the field of science communication. In interviews concerning the 'Alan Alda Center for Communicating Science', Alan Alda discussed the power of stories to engage people with science (Grant & Lambert 2016). He reflects on the growing practice within science communication to personalise science, and make it accessible on a variety of levels to the everyday person. This is another instance where the application of cultural theory can be used to extend the experience of science engagement and education, and is an area that needs further exploration.

Further research concerning the intersections of citizen science and the museum space can add to understandings of how the museum can embody new museological practices when engaging with scientific content, and support the growth of scientific research outputs of museums.

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Appendix A- Macquarie University Human Research Ethics Committee (HREC (Human Sciences & Humanities)) letter of approval, reference no: 5201500216

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(Research)

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MACQUARIE University
SYDNEY·AUSTRALIA

15 October 2015

Dr Greg Walkerden
Department of Geography and Planning
Faculty of Arts
Macquarie University
NSW 2109

Dear Dr Walkerden

Reference No: 5201500216

Title: *Pathways to community engagement in museums through citizen science: examining expectations of Streamwatch*

Thank you for submitting the above application for ethical and scientific review. Your application was considered by the Macquarie University Human Research Ethics Committee (HREC (Human Sciences & Humanities)) at its meeting on 27 March 2015 at which further information was requested to be reviewed by the Ethics Secretariat.

The requested information was received with correspondence on 14 October 2015.

I am pleased to advise that ethical and scientific approval has been granted for this project to be conducted at:

- Macquarie University

This research meets the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007 – Updated March 2014) (the *National Statement*).

This letter constitutes ethical and scientific approval only.

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the *National Statement,* which is available at the following website:

http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research

2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol.

3. All adverse events, including events which might affect the continued ethical and scientific acceptability of the project, must be reported to the HREC within 72 hours.

4. Proposed changes to the protocol must be submitted to the Committee for approval before implementation.

It is the responsibility of the Chief investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Ethics Secretariat on 9850 4194 or by email ethics.secretariat@mq.edu.au

The HREC (Human Sciences and Humanities) Terms of Reference and Standard Operating Procedures are available from the Research Office website at:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics

The HREC (Human Sciences and Humanities) wishes you every success in your research.

Yours sincerely

Dr Karolyn White
Director, Research Ethics & Integrity,
Chair, Human Research Ethics Committee (Human Sciences and Humanities)

This HREC is constituted and operates in accordance with the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research* (2007) and the *CPMP/ICH Note for Guidance on Good Clinical Practice*.

Details of this approval are as follows:

Approval Date: 15 October 2015

The following documentation has been reviewed and approved by the HREC (Human Sciences & Humanities):

Documents reviewed	Version no.	Date
Macquarie University Ethics Application Form	2.3	July 2013
Correspondence from Dr Walkerden responding to the issues raised by the HREC (Human Sciences and Humanities)		Received 15/10/2015
MQ Participant Information and Consent Form (PICF)		
Streamwatch Experiences Study Demographics		
Streamwatch Experiences Study Interview Questions – Group 1 Citizen Scientists		
Streamwatch Experiences Study Interview Questions – Group 2 Program Administrators		
Streamwatch Experiences Study Interview Questions – Group 3 Research Scientist		
Research Participant Invitation		

The following documentation was noted by the HREC (Human Sciences & Humanities):

Documents noted	Date
Letter of support from the Australian Museum	11/03/2015

Appendix B- Participant Information and Consent Form

Department of Geography and Planning
Faculty of Arts
MACQUARIE UNIVERSITY NSW 2109

Researcher: Ellie Downing, Masters of Research Candidate
Email: ellie.downing@students.mq.edu.au
Supervisors Names: Dr. Greg Walkerden and Dr. Kirsty Davies
Supervisor emails: greg.walkerden@mq.edu.au and kirsty.davies@mq.edu.au

Interview Participant Information and Consent Form

Name of Project: **Pathways for museums to community engagement through citizen science. Examining the experiences of Streamwatch.**

Short name: **Streamwatch expectations and engagement study**

You are invited to participate in a study of the experience and expectations of the Streamwatch program, and contribute to knowledge surrounding the programs capacity to function as a form of community engagement. Participation will involve either a face-to-face interview, or a phone interview, lasting approximately 45 mins. We plan to record the interviews to help with transcription.

The purpose of the study is to better understand what the expectations of participants in Streamwatch are, what their experience of the program is, and if there is potential for similar programs run by museums to better facilitate the contributions of community members to scientific understanding and knowledge.

The study is being conducted by Ellie Downing, Masters of Research candidate of the Department of Geography and Planning at Macquarie University and is being conducted to meet the requirements of Masters of Research under the supervision of Dr. Greg Walkerden of the Department of Geography and Planning. His phone number is: 02 9850 7991, and his email is greg.walkerden@mq.edu.au. Dr. Kirsten Davies of the Department of Environmental Sciences is co-supervisor. Her phone number is 02 9850 8334 and her email is kirsty.davies@mq.edu.au.

If you decide to participate, you will be asked some questions about your experience of Streamwatch, and your expectations of the program by Ellie Downing. If you are willing, the interview will be recorded so that a transcription can be prepared. Recordings will be deleted once individuals have confirmed that the transcript is a true and accurate record of their views. Interviews will take place at a location convenient to the participant, e.g. a library or café local to the participant, or by phone or Skype.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Interview transcripts will only be available to the research team. The main risk to participants from being involved in this study is that if they were critical of the museum, and this became public knowledge, there might be unwelcome repercussions. The study's design addresses these risks in a number of ways:

(i) who is and is not participating in the study will remain confidential;
(ii) all interview transcripts will have potentially identifying details removed;
(iii) all participants will have the opportunity to check transcripts of interviews after de-identification has taken place; and

(iv) published material from interviews will be limited to selected quotations, and any text that is seen to have the potential to reveal the identity of an individual inadvertently will be altered and/or removed.

Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw consent at any time without having to give a reason and without consequence. You are free and encouraged to ask questions of the researchers at any time.

I, (*participant's name*)_____
have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Name of Project: Pathways to community engagement in museums through citizen science: examining expectations of Streamwatch.

Masters of Research Candidate: Ellie Downing, Department of Geography and Planning,
Faculty of Arts, Macquarie University.
Email: ellie.downing@students.mq.edu.au
Phone: 0405 610 683

Supervisors: Dr. Greg Walkerden, Department of Geography and Planning, Faculty of Arts, Macquarie University.
Email: greg.walkerden@mq.edu.au
Phone: 02 9850 7991

Dr. Kirsty Davies, Department of Environmental Studies, Faculty of Science
Macquarie University.
Email: kirsty.davies@mq.edu.au
Phone: 02 9850 8334

Participant's Name:_____
(Block letters)

Participant's Signature:_____ Date:_____

Investigator's Name:_____
(Block letters)

Investigator's Signature:_____ __ Date:_____

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

(cross out where necessary) INVESTIGATOR'S/PARTICIPANT'S COPY

Appendix C- Demographic questions

Streamwatch Experiences Study
Demographics

Please note that you do not have to respond to any of the following questions. You can withdraw from participating in this study at any time.

All responses are kept anonymous.

Please mark with a cross [X] the information that best describes you.

1. Gender: ☐Male ☐Female ☐ Other…_____

2. Age

☐18 – 19 years	☐40 – 44 years	☐65 – 69 years
☐20 – 24 years	☐45 - 49 years	☐70 – 74 years
☐25 – 29 years	☐50 – 54 years	☐74 – 79 years
☐30 – 34 years	☐55 – 59 years	☐80 – 84 years
☐35 – 39 years	☐60 – 64 years	☐85 and over

3. What is the main language spoken in your household? If there is more than one language, please list all languages spoken.

_____

4. Do you identify as Aboriginal or Torres Strait Islander? ☐Yes ☐No

5. Primary activity:

☐Student (school, TAFE, university, college etc)	☐Government employee	☐Retired citizen
☐Home maker and/or carer	☐Private enterprise employee	☐Looking for work
	☐Self employed	☐Other…_____

6. How long have you been involved with Streamwatch?

☐Not involved	☐3 to 5 years
☐1 year or less	☐6 to 10 years
☐1 to 2 years	☐more than 10 years

7. Which of the below best describes how you are/were involved in Streamwatch? You can select more than one answer…

☐Citizen Scientist – you are largely involved with the collection of data and/or administration of a specific Streamwatch site in a voluntary capacity.

☐Program administrator – you are largely involved with co-ordinating citizen science initiatives and/or involved with public programming within a museum context.

☐Research Scientist

☐Other… (please explain below)

8. If you are no longer part of the Streamwatch program, please explain briefly why you are no longer involved.

Appendix D- Interview questions

Streamwatch Experiences Study Interview Questions
Group 1 Citizen Scientists

Please note that you do not have to respond to any of the following questions. You can withdraw from participating in this study at any time. All responses are kept anonymous.

Question 1

Tell me about your involvement in Streamwatch.

Question 2

Could you tell me what it is about Streamwatch that makes your involvement and/or commitment to it worthwhile (if you find it is)?

Question 3 a)

Do you feel there has been adequate opportunity for you to be involved in the development of Streamwatch?

Question 3 b)

Would you like to be involved more in the development/planning of Streamwatch? Please explain your answer.

Question 4

What, if any, have been Streamwatch's successes? Please explain your answer.

Question 5

What, if any, have been Streamwatch's failures? Please explain your answer.

Question 6

What do you see as the role(s) of the data collected by the Streamwatch program?

Question 7

Can citizen science programs, such as Streamwatch, increase current levels of, community engagement for the Australian Museum?

Yes No Not sure *(Please choose one)*

Please expand on your response.

Question 8

Should the Australian Museum be offering other citizen science programs similar to Streamwatch? Why, or why not?

Question 9

If you could set three goals for Streamwatch to achieve over the next five years, what would they be?

Question 10

Is there anything else you would like to say regarding community engagement, citizen science and/or Streamwatch?

Thank you for your time and knowledge.

Streamwatch Experiences Study Interview Questions
Group 2 Program Administrators

Please note that you do not have to respond to any of the following questions. You can withdraw from participating in this study at any time. All responses are kept anonymous.

Question 1

Tell me about your involvement in Streamwatch.

Question 2

Could you tell me what it is about Streamwatch that makes your involvement and/or commitment to it worthwhile (if you find it is)?

Question 3

What is your understanding of why the Australian Museum decided to offer the Streamwatch program?

Question 4

What, if any, have been Streamwatch's successes? Please explain your answer.

Question 5

What, if any, have been Streamwatch's failures? Please explain your answer.

Question 6

What do you see as the role(s) of the data collected by the Streamwatch program?

Question 7

Can citizen science programs, such as Streamwatch, increase current levels of, community engagement for the Australian Museum?

Yes No Not sure *(Please choose one)*

Please expand on your response.

Question 8

Should the Australian Museum be offering other citizen science programs similar to Streamwatch? Why, or why not?

Question 9

If you could set three goals for Streamwatch to achieve over the next five years, what would they be?

Question 10

Is there anything else you would like to say regarding community engagement, citizen science and/or Streamwatch?

Thank you for your time and knowledge.

Streamwatch Experiences Study Interview Questions
Group 3 Research Scientist

Please note that you do not have to respond to any of the following questions. You can withdraw from participating in this study at any time. All responses are kept anonymous.

Question 1

Tell me about your involvement in Streamwatch.

Question 2

Could you tell me what it is about Streamwatch that makes your involvement and/or commitment to it worthwhile (if you find it is)?

Question 3

What do you see as the potential benefits of Streamwatch?

Question 4

What, if any, have been Streamwatch's successes? Please explain your answer.

Question 5

What, if any, have been Streamwatch's failures? Please explain your answer.

Question 6

What do you see as the role(s) of the data collected by the Streamwatch program?

Question 7

Can citizen science programs, such as Streamwatch, increase current levels of, community engagement for the Australian Museum?

Yes No Not sure *(Please choose one)*

Please expand on your response.

Question 8

Should the Australian Museum be offering other citizen science programs similar to Streamwatch? Why, or why not?

Question 9

If you could set three goals for Streamwatch to achieve over the next five years, what would they be?

Question 10

Is there anything else you would like to say regarding community engagement, citizen science and/or Streamwatch?

Thank you for your time and knowledge.