AN ASSESSMENT OF OPERATIONAL FIELD INSPECTION OF WET PONDS AND WETLANDS IN THE AUCKLAND REGION

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ABSTRACT

In the Auckland region, legacy Councils owned hundreds of constructed wet Ponds and wetlands used for management of urban stormwater. In order to effectively manage these devices it is acknowledged that it is vital to have current, accurate, and relevant asset information. The Auckland Council's new West and North Stormwater Operations Teams identified that the quality and completeness of this information for these assets was not sufficient to prioritise various maintenance actions. In 2011/12 Morphum Environmental was engaged to undertake survey of 126 Ponds/wetlands and report on condition by ranking in terms of priority for maintenance.

A methodology was developed for field inspection and included parameters adopted from Auckland Regional Council (ARC) Technical Publications 10 and from best practice standards. The method standardised the inspection criteria and a Multi-Criteria Analysis (MCA) tool was developed to rank each of the Ponds on 26 criteria. The parameters for inspection included standard design features, such as configuration, but also incorporated ecological components, such as aquatic weed infestation and the quality of riparian habitats.

A Pond Reporting Tool and Database (PRTD) forms part of the electronic deliverables associated with this project. The PRTD includes all data associated with the inspections recorded against asset identification numbers and can be used to view all pictures, videos, and data from the inspections. The results of these pilot study inspections were ranked to provide prioritisation using the MCA tool to be used in developing maintenance strategies.

This presents a method, procedure, and criteria to develop a single information repository for Pond and Wetland asset maintenance and to achieve operational optimisation in the wider Auckland Region.

KEYWORDS

Multi-Criteria Analysis, Operational Performance, Complex Assets

PRESENTER PROFILE

Damian Young is a Director of Morphum Environmental. He has been working in the areas of Pond design, assessment, and maintenance for the last 10 years across the Auckland Region. As an Environmental Engineer he has focused heavily on the performance and function of Ponds and how they meet their assumed design objectives.

1 INTRODUCTION

Stormwater Ponds are now common features of the urban landscape. They have been constructed to mitigate the adverse effects of development, to control flooding, and to improve water quality. This evolution has now reached an epoch where hundreds of Ponds are dotted throughout Auckland and increasingly in other parts of New Zealand.

Auckland Council (AC) has in excess of 430 Stormwater Pond and Wetland assets (referred to as Ponds in this paper) that have been inherited from legacy Councils. They form part of the essential infrastructure in the management of flooding and water quality.

They range in size from less than 200 m^2 to more than a 20,000 m^2 in surface area. These assets are complex in both their design and operational requirements. Many form part of the aesthetic value of the surrounding urban context being habitats for many plants and animals.

Ponds are designed to reduce flooding and accumulate tonnes of sediment, which often contains harmful contaminants that would otherwise negatively impact waterways and marine environments. In many ways they succeed in their design objectives but the information about these assets in terms of geometry, performance, and configuration is variable in quality and completeness. This makes effective management challenging and prioritisation of operational works difficult (ad hoc).

In 2011 and 2012 Morphum Environmental conducted a project for Auckland Council (AC) Stormwater to improve the quality of Pond operational and asset related data. The operations teams at the time had to quickly compile and disseminate a lot of information about their assets. In general, up to date Pond condition data (e.g. how full of sediment they might be, thus whether they require clean-out) was not available. This identified data gap forms the basis of an exercise to address the poor state and completeness of the data by designing and implementing field survey and running a prioritisation tool to present the relative data in terms of operational priority (e.g. Pond clean out, weed infestations, or safety issue, infrastructure conditions and embankment stability).

The sustainable and cost effective management of Ponds is a key area of concern to council operations and planning staff. However, much of the legacy data associated with the assets is limited, of poor quality, or does not meet the business needs of the asset managers. Additionally, capture and management of this data, for operation teams, has generally either been underfunded or lacked an information system to capture/manage the information flow.

The first stage of the study included a pilot assessment of 66 Ponds and wetlands in the former Waitakere City area. The design of the field assessment and reporting was trialled during this initial investigation. Then, in the former Rodney District Council area, a further 60 assets were inspected with an additional topographical GPS survey undertaken to determine geometry, level of service, and to calculate the Pond depth–storage relationships, using digital terrain models (DTM) in AutoCAD 3D. The overall study inspected 126 Ponds. This represents approximately 29% of the total asset base.

As these assets have many components such as outlets, inlets, weirs, and dam walls, the task of collating and recording core asset data was a challenge. Former legacy councils had been able to capture and store this data to varying degrees. However, core asset data is not available for a large proportion including; basic dimensions, catchment area, and even design purpose. Additionally, operational data such as inspection records, method, and maintenance prioritisation are either not available or in numerous formats. Consequently no central data repository exists for this extensive and critical asset base.

This paper documents the development of a data structure, associated assessment method populated by GPS survey, and processed using a bespoke prioritisation tool for the 126 Wetlands and Wet Ponds in the former Rodney (referred as North) and Waitakere (referred as West) areas in Auckland. It proposes and provides a standard for inspection and data structure for all Ponds within the Auckland Region.

1.1 Stormwater Ponds and Wetlands

Auckland Council has inherited Stormwater Ponds and Wetlands that form part of the stormwater management infrastructure system. Stormwater Ponds can be of three types: dry Ponds, wet Ponds, or wetlands.

Dry Ponds are engineered topographical depressions providing peak flow attenuation or reducing downstream channel erosion risk.

Wet Ponds (Photograph 1~~Photograph 1~~) have a permanent body of water, and depending on the specific design, can serve three primary purposes: reducing downstream flood potential, providing water quality treatment, and reducing downstream channel erosion (ARC TP10, 2003).

Wetlands (**Error! Reference source not found.**~~Photograph 2~~) can provide the same functions as wet Ponds but are usually shallower and planted with aquatic vegetation improving the treatment capacity and increasing the ecological value of the device.

There is generally, some confusion of the difference between wetlands and wet Ponds. Some guideline methods such as ARC TP10 provide clarity on this but, as-built Pond geometry often has varied adherence to these standards and they are all too often random and various in geometry. Consequently, some of these geometries encourage the growth of thriving wetland plant communities and hence can quite reasonably be viewed as a wetland not a wet Pond.

Photograph 1: Example of Wet Pond

Photograph 2: Example of a Wetland

1.2 Status of Information About Ponds and Wetlands

Recent work conducted by Auckland Council to combine and rationalise data related to Ponds Asset information across the Region has found it of varying quality and completeness. An example of the most complete dataset being former North Shore City

Council's Pond asset data which is shown in Table 2. Normal practice for the commissioning of a Pond, and a consenting requirement, is the preparation of a Pond Operations and Maintenance Plan. These plans have, for the most part, been used to populate asset records but when they have not been available data sources are unknown or not populated. In general the quality and completeness of the data was not sufficient to optimally manage the assets.

Operational Plans do not always include as-builts and the dimensions and performance of the Ponds 'as-built' vary from the details provided (i.e. what was built was not the same as the proposed plans). Many of the key dimensional details are simply not available e.g. spillway type and levels.

Additionally information related to operational details is often not available or patchy. This includes details of fencing, plantings, or access type which form the core details used by asset managers to prioritise maintenance works.

Performance related data is generally not available or is considered to be approximate only e.g. live storage volumes, extended detention volumes, and permanent storage volumes. Two areas of related data are clean out volume and sediment laboratory analytical results (e.g. metals, organochlorines, or polyaromatic hydrocarbons) which although often recorded are not compiled in a single location.

The need for a comprehensive rational data structure is highlighted by the pressure operational staff have been under to efficiently manage this large complex asset base. Consideration of the gaps and completeness of data, in junction with all the existing fit for purpose data, helped to define scope of works for the project.

1.3 Stages of Work Description and Scope

In order to successfully fulfil the aims of this project, the work was organised into two distinct phases. Phase one involved the survey of 66 Ponds in Waitakere with a focus solely on operational condition and reporting. Phase two used the method and data capture protocols from stage one, with a broadening of the scope to include GPS survey, to define geometry, as-built levels, and populate the development of CAD models to define depth-storage relationships for a further 60 Ponds in the North Area. The general workflow for inspection and reporting for all 126 Ponds is described below:

- Agreement on client requirements and definition of the information to gather and the attributes of the database;
- Prepare Data Capture Library and Forms;
- Desktop investigation to define client requirements, Pond locations, existing data and delivery format;
- Study of available as-built plans and current data;
- Field work including inspection, measurements, and topographical survey of the Ponds to confirm or complete data previously obtained through desktop study;
- Post processing of the field work data, development of the DTMs, CAD modelling, and completion of the database; and
- Reporting.

2 METHODOLOGY

No standard methodology was available to conduct the inspections and reporting for this project. The project team needed to design and commission a method with associated data capture protocols, forms, and techniques to meet the stated aims of the project, consider available standards and integrate existing data.

2.1 OVERVIEW OF INSPECTION METHOD AND DATA CAPTURE SCHEMA

The project phases were:

- Phase one involved the survey, operational condition, and reporting of 58 Ponds in Western Area. Additionally a Multi-criteria Analysis Tool (MCA) was designed and the data modelled using the criteria, with a supporting Pond Reporting Tool (PRT) developed.

- Phase two used the method, data capture protocols, and reporting from stage one, and included asset data validation using GPS survey, for 60 Ponds in the North.

Phase one involved the development of the condition inspection methodology based on inspection parameters adopted from Auckland Regional Council Technical Publications 10, and from best practice standards. A Multi-Criteria Analysis (MCA) was then designed reflecting function, design, sediment, vegetation, structure condition, health and safety, and aesthetics parameters. The subsequent weighted scoring system allows for ranking and prioritisation of maintenance works.

The data capture schema included a list of assessment options referred to as a pick list. The data pick list options have been selected to provide sufficient details to describe the condition or function of the assessed parameter, while also forming the basis for the scoring system that is subsequently used in the MCA and contained within the PRT.

The criteria which provide information on the function of the wet Pond are type, function, forebay, shape, and bathymetry. These criteria give an indication of the design purpose of the Pond and also the suitability of that design to fulfil its requirements. The criteria relating to condition are those describing sediment, vegetation, structure condition, access, and the requirement for maintenance.

The intention being that these criteria can be used to develop maintenance plans or actions for each Pond. Fencing is taken into consideration when determining the safety of a Pond and litter when considering aesthetics. Overall quality gives an indication of the general performance of the device based on all criteria and subjective considerations onsite.

While these criteria can be categorised to some extent, they often overlap. Failure in one area can often lead to poor performance in another. For this reason, all criteria should be considered when determining the performance and operational factors associated with each Pond. A full description of the condition inspection method is provided following.

2.2 PHASE ONE: CONDITION INSPECTION CRITERIA AND METHOD

The data capture schema was developed to provide a practical overview of the condition of each Pond with respect to function, maintenance, safety, aesthetics, and performance. The schema includes 26 inspection criteria adopted from ARC TP10 and based on experience. Each Pond was assigned ratings for its performance in these specific criteria. Further comments, recommendations, photo codes, and video codes were also recorded. The inspection criteria and parameters are detailed as follows:

Photos: Eight photos (minimum) are taken of each Pond. These are taken in sequence starting from North facing vantages, followed by East, South, and West to give an overall perspective of the Pond. Photos are also taken of the outlet, inlet, and the dominant landscape and aquatic vegetation.

Type: The type of stormwater device being inspected:

- Wet Pond – a permanent stormwater Pond that has a standing pool of water.
- Dry Pond – a permanent Pond that temporarily stores stormwater.
- Wetland – constructed, shallow water detention device with large amounts of hydrophytic vegetation.

Function: The primary function of the stormwater device:

- Water quality improvement – no extended detention capacity; primary function is sedimentation.
- Peak flow attenuation – the device has an extended detention capacity; primary function is to reduce flood flows downstream.
- Combined WQ improvement – the device has extended detention capacity and allows for sedimentation.

Forebay: A visual inspection of the forebay shows that it is:

- Inadequate – there is a forebay that is less than 15% of the volume of the main Pond.
- Adequate – the forebay is at least 15% of the volume of the main Pond.
- None – there is no forebay.

Shape: The shape that describes the dominant characteristics of the Pond perimeter, as inspected onsite and by aerial photography:

- Circular, Rectangular, Kidney, Oval, Other (specify in comments).

Bathymetry: A visual inspection of the Pond shows that it is:

- Not Banded – no bathymetry.
- Banded – banded bathymetry present in Pond.

Sediment: Sediment depth is gauged by using a measuring pole to probe at least four locations around the perimeter of the Pond. Depth of water is estimated when firm substrate is reached; the probe is then pushed further through the material until the natural ground surface is reached. The criteria are based on consenting thresholds:

- 50% or more, 15-50%, 15% or less, Trace, None.

Sediment Cleanout: These criteria are based on the sediment depth identified. Consideration may also be given to the susceptibility of the Pond to sedimentation and the potential rates.

- High – greater than 50% sediment
- High to Moderate – between 30-50% sediment
- Moderate – between 15-30% sediment
- Moderate to Low – less than 15% sediment; potentially high risk of sedimentation
- Low – less than 15% sediment; low risk of sedimentation

Vegetation volume: A visual estimation of the reduction in volume in the wet Pond due to vegetation:

- 50% or more, 15-50%, 15% or less, Trace, None.

Photograph 35: Showing Vegetation Volume

Photograph 46: Showing Depth of Accumulated Sediment

Vegetation intrusion: A visual estimation of the reduction in surface area in the wet Pond due to vegetation:

- 50% or more, 15-50%, 15% or less, Trace, None.

Asset Criteria: Several of the assessment criteria are covered by a similar set of ratings. These are **Embankment and Spillway, Service Structures*, Outlet Condition*, Inlet Condition, Fencing, Aesthetic Quality, Landscape Plants, Wetland Plants,** and **Overall Quality**. The available ratings are:

- Failing – the criteria is failing to meet its original design function at any level. Maintenance is required as soon as possible.
- Poor – the criteria is still maintaining its design performance, but to a reduced level. Maintenance will be required within 18 months to prevent the criteria from failing.

- Degraded – the criteria is performing the majority of its design function, however there are signs of degradation since it was installed. Assets meeting this level should be given monitoring priority to assess further degradation.

- Sound – the criteria is performing as per its design function and appears to be well established in its environment.

- Excellent – the criteria is performing as per its design function and is designed to a standard above the average for its kind.

(***Service Structures** include the service outlet, where **Outlet Condition** refers to where the flow is discharged into the receiving environment.)

Drain Valve Depth: The service outlet is inspected for a drain valve. These are required to drain the Pond during maintenance. These are recorded as:

- Depth in metres below the permanent water level of the standard service outlet. If multiple drain valves are present the depths are listed.

- None – no drain valve present.

- Unknown – the inspector could not gain visuals of inside the service outlet.

Photograph 5~~7~~: Showing Drain Valves

Photograph 6~~8~~: Showing Outlet Configuration

Maintenance Access: This refers to the ability to get plant and access to the places in the Pond in order to perform maintenance activities such as sediment removal and weed removal and vegetation management e.g. planting. These are:

- Excellent – the access is established and adequately sized to allow all potential maintenance activities.

- Sound – established access, may need to be enlarged for some activities.

- Degraded – the maintenance access has become degraded reducing its usability i.e. overgrown.

- Feasible; not established – maintenance access is possible but is not established.

- Topographical constraints – there are topographical conditions surrounding the Pond that make access difficult to establish.

- None.

Safety The safety of the device is evaluated based on fencing, drops over 1.5 m, benching, water depth, accessibility, and structures:

- Safe – no obvious or reasonable cause for concern.
- Not Safe – there are factors increasing the likelihood and/or severity of potential hazards to public or Pond users.

Litter Present: A visual inspection of the Pond and perimeter determines the extent of litter:

- None – none or minor amounts of litter present; not a nuisance.
- Present – there is noticeable litter in localised instances around the Pond.
- Widespread – there is noticeable litter around most of the Pond; moderate nuisance.
- Extensive – There is obvious litter in and surrounding the Pond; high visual nuisance.

Pest Vegetation: A visual inspection of the Pond and perimeter planting determines the extent of **Pest Plants** (terrestrial) and **Aquatic Pests**:

- None – none or minor amounts of pest vegetation present; not a nuisance.
- Present – there is noticeable pest vegetation in localised instances around the Pond.
- Widespread – there is noticeable pest vegetation around most of the Pond; moderate nuisance.
- Extensive – There is obvious pest vegetation in and surrounding the Pond; high nuisance.

Maintenance Required: This gives an indication of the maintenance priority that should be assigned to the Pond:

- Yes - urgent – maintenance is required as soon as possible to restore function to the device or prevent negative effects to property or the public.
- Yes - 18 months – maintenance is required within the given period to prevent the deterioration of the Pond to dysfunctional levels.
- No - standard – maintenance on the Pond should be carried out as per the standard maintenance schedule.

Fish Passage A basic assessment of fish passage is made based on obstructions such as drop heights and structures:

- Yes – some form of fish passage is provided for.
- No – not expected that fish could pass device.

- DNA – there is no upstream fish habitat, therefore not expected that fish would need to pass

2.3 PHASE ONE: MULTI-CRITERIA ANALYSIS TOOL

The Multi-Criteria Analysis tool was developed and used to assign a rank to each Pond based on its performance when inspected. Each of the pick list options for the inspection criteria were assigned a value based on a positive or negative performance in that criteria. Criteria were also assigned weightings depending on how important the criteria were considered to be to Pond performance. See Table 1~~Table 1~~ for pick list values and weightings. The weightings were assigned with a maintenance focus in mind in order to identify those which require works.

The option values and criteria weightings were then combined to generate a score for each criterion. The sum of these scores formed the overall MCA score which was then used to determine the rank of each Pond. This is a rank which takes into consideration all of the Pond aspects inspected and evaluated.

Table 1: Criteria and Pick List Scorings and Weightings

Criteria	**Score**						**Weighting**	**Weighting Factor**
Forebay	-1	0.75	1				10	4.5
Bathymetry	0	1					5	2.2
Sediment	1.5	0.5	0.1	-1			**25**	11.2
Cleanout	1	0.75	0.5	0.25	-1		10	4.5
Vegetation Volume	1	0.75	0.25	0.1	0		7	3.1
Vegetation Intrusion	1	0.75	0.25	0.1	0		7	3.1
Embank. / Spillway	1	0.75	0.5	0.25	-1	0	15	6.7
Service Structures	1	0.75	0.5	0.25	-1	0	7	3.1
Outlet Condition	1	0.75	0.5	0.25	-1	0	10	4.5
Inlet Condition	1	0.75	0.5	0.25	-1	0	10	4.5
Maintenance Access	1.5	1.15	1	0.75	0.25	-1	**12**	5.4
Fencing	1	0.75	0.5	0.25	-1	0.5	10	4.5
Safety	1	0					**20**	8.9
Aesthetic Quality	1	0.75	0.5	0.25	-1		10	4.5
Litter Present	1	0.75	0.25	-0.5			2.5	1.1
Landscape Plants	1	0.75	0.5	0.25	-1	1.5	7	3.1
Pest Plants	1	0.75	0.25	0			7	3.1
Wetland Plants	1	0.75	0.5	0.25	-1	0	7	3.1
Aquatic Pest	1	0.75	0.25	-1			7	3.1
Fish Passage	1	0					5	2.2
Maintenance Required	1	0.5	0				**15**	6.7
Overall Quality	1	0.75	0.5	0.25	-1		15	6.7
Totals	**20**	**15.15**	**8.1**	**-2.5**	**-8.8**		**223.5**	**100.0**

2.4 REPORTING TOOL

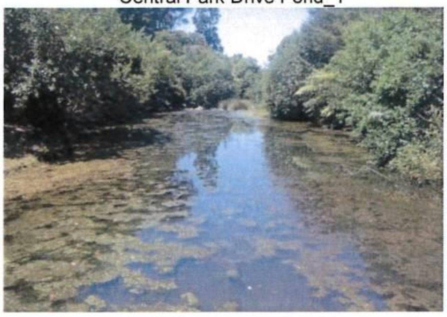
The results of the data collected are summarised in a one page report form generated by a reporting tool in the MCA Database, as shown in Figure 1~~Figure 1~~. This report includes hyperlinks to as-built plans, photographs, and videos related to each Pond. The system is designed in Microsoft Excel utilising macro tool functions.

MORPHUM ENVIRONMENTAL LTD

Overall Quality Ranking:	17. Central Park Drive Po	Inspection date:	18/01/2012
Treatment Device:	Central Park Drive Pond	UFI Number (GIS):	1010920
Adress:	3/ 133 CENTRAL PARK I	Device No.:	66

Central Park Drive Pond_1

Central Park Drive Pond_2



Central Park Drive Pond_3

Central Park Drive Pond_4

Criteria	Rating	Criteria	Rating
Type	Wet Pond	**Maintenance access**	Degraded
Function	Water Quality Improve...	**Fencing**	Failing
Forebay	None	**Safety**	Safe
Shape	Rectangular	**Aesthetic quality**	Sound
Bathymetry	Not Banded	**Litter**	None
Sediment	15% or less	**Landscape plants**	Excellent
Cleanout	Moderate - Low	**Pest plants**	None
Vegetation volume	15 to 50%	**Wetland plant**	None
Vegetation intrusion	15% or less	**Aquatic pests**	Extensive
Embankment / Spillway	Sound	**Fish passage**	DNA
Service structures	Sound	**Maint. required**	Yes - 18 Months
Outlet condition	Excellent	**Overall quality**	Degraded
Inlet condition	Sound	**Video code**	None
Drain valve depth	None	**Photos link**	4269 - 4295

Comments

Large numbers of Gambusia present in pond. Maintenance access is established on eastern side of pond but is overgrown and egress to the margins is very steep. There is a fence section missing on the Eastern end of the pond, closest to the road allowing access to the pond. Caprosma providing the primary vegetation cover. Sedimentation at ~15%.

Recommendations

Fix broken section of fence and clear surrounding dense vegetation to get access. Also clear access way. If operational works are undertaken for clean out, establish perimeter access for long reach digger.

Figure 1: Reporting Form

2.5 PHASE TWO: ASSET DATA VALIDATION AND CALCULATION

A list of asset feature attributes was established in collaboration with Auckland Council staff. Populating or updating the 32 items listed in Table 2~~Table 2~~ formed the central focus, and basis of the project methodology for asset data capture, of Phase two of this project. This involved a combination of desk top, field survey, and computer modelling as detailed in Section 2.6.

Table 2: Asset Feature Attributes Table

No.	Description	No.	Description
1	File Number	17	Maximum operating surface area(estimated)
2	Consent ID Number	18	Normal operating surface area
3	Pond ID from CMP	19	Normal max water depth
4	GIS Reference (Asset ID)	20	Live storage volume (forebay)
5	Stormwater Catchment	21	Live storage volume (main Pond)
6	Pond location (Address)	22	Water quality Pond volume.
7	NZ map reference	23	Detention aquatic storage 34.5mm over 24 hrs
8	Type of Pond	24	Extended Detention 50% (2ARI)
9	Top of Dam RL	25	Extended Detention 10% (10ARI)
10	Top of Spillway RL	26	Extended Detention 1% (1 ARI)
11	Toe of Dam RL	27	Forebay present Y/N
12	Height of the Dam	28	Spill way type and dimensions
13	Contributing Catchment area	29	Emergency Spillway type and dimensions
14	Maximum Pond length	30	Inlet types and dia/width
15	Maximum Pond width	31	Outlet types and dia/width
16	Normal operating surface area	32	Embankment dimensions and RL

2.6 PHASE TWO: DESKTOP STUDY

Auckland Council was consulted and all available information about the Northern Ponds was provided. Information was in the form of files containing hard-copies of consenting documents and electronic. In some instances, these files included construction or as-built plans. Existing information about each Pond varied from sparse to comprehensive.

For each of the paper records the Pond unique asset ID number was a critical piece of information used to search and summarise the data. This asset ID number was used to define or refer to each Pond to ensure consistency.

The desktop study sourced much of the information required to populate the Asset Feature Attributes Table outlined in Table 2~~Table 2~~. This was done prior to the site survey and inspection. Auckland Council GIS data was used to determine geographical attributes where possible. All scanned copy or other documents were then linked through PRT as described in 2.4.

2.7 PHASE TWO: ASSET DATA CAPTURE AND VALIDATION FOR FIELD SURVEYING

Following the desktop study, a comprehensive topographical survey of each Pond was completed using surveying instruments (GPS RTK). Structural elements such as inlet/outlet invert levels, pipe diameters, level of service outlet, emergency spillway, and top of embankment elevations were surveyed and/or measured to gain an overall understanding of each Pond's storage level and capacity. The definition of these levels was based on ARC TP10, as illustrated in Figure 2~~Figure 2~~ and chosen to reflect key levels for reporting.

For

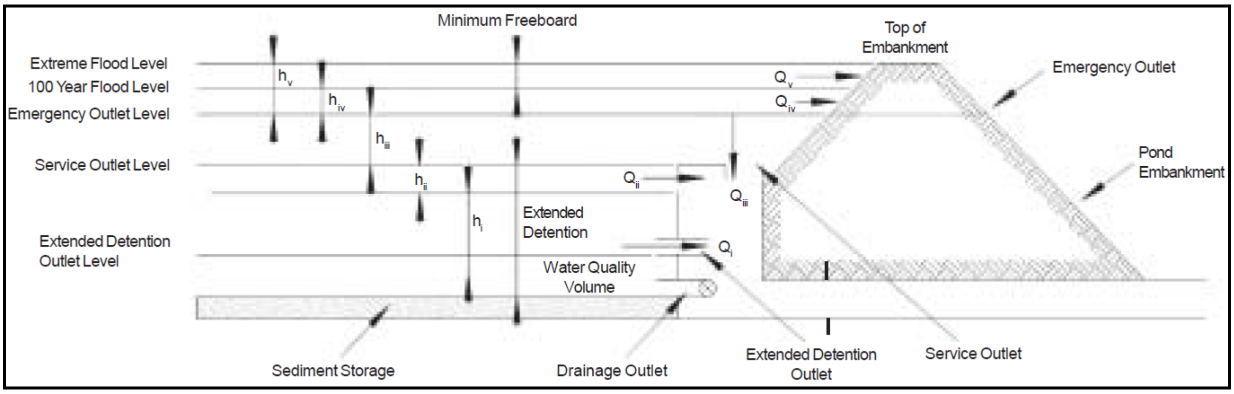
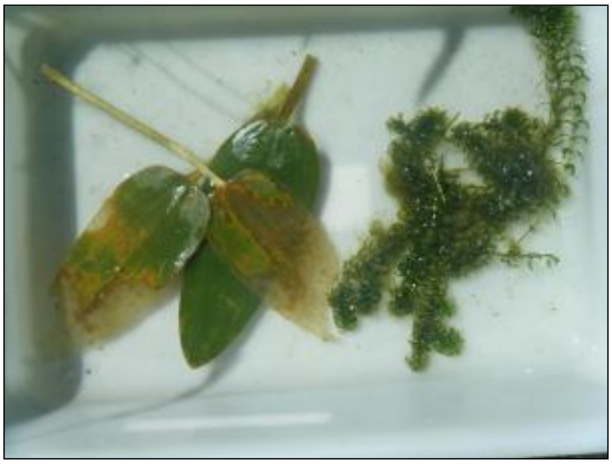


Figure 2: ARC TP10 Illustration of the Relevant Pond Levels



Photograph 7~~9~~: Showing Aquatic Vegetation Samples

Photograph 8~~10~~: Showing Engineer Conducting GPS Survey

As per the Phase one inspection method, additional relevant information was gathered during this surveying exercise: Pond type, presence of forebay, Pond bathymetry, existing fencing, aquatic weeds etc. were recorded to complete the database. Whilst on site, questionable record data tentatively filled in during the desktop study were verified and updated accordingly.

Pictures of the surveyed Ponds and associated ecological and structural details were taken. Some were included in the Inspection Database to present condition.

2.8 PHASE TWO: CALCULATION AND MODELLING

The modelling process was undertaken using AutoCAD Civil 3D (AutoCAD) to define the various storage volumes associated with specific water levels. These specific levels are:

- Bottom of Pond;
- Permanent water level;
- Level of service;
- Level of emergency spillway; and
- Level of top of embankment.

The bottom of Pond was defined by measuring the water depth at various points around the Pond perimeter (to provide a representative geometry) and estimating a mean water depth from levels at the outlet and measured depths from the perimeter. The depth of sediment is not included in the definition of the level of the bottom of the Pond.

The slope of the Pond banks was assumed to be uniform and defined from site observations.

The survey data was verified, imported into AutoCAD, and combined with local LiDAR (Light Detection and Ranging) data to create a three dimensional surface, or digital terrain model (DTM), as illustrated in Figure 3Figure 3.

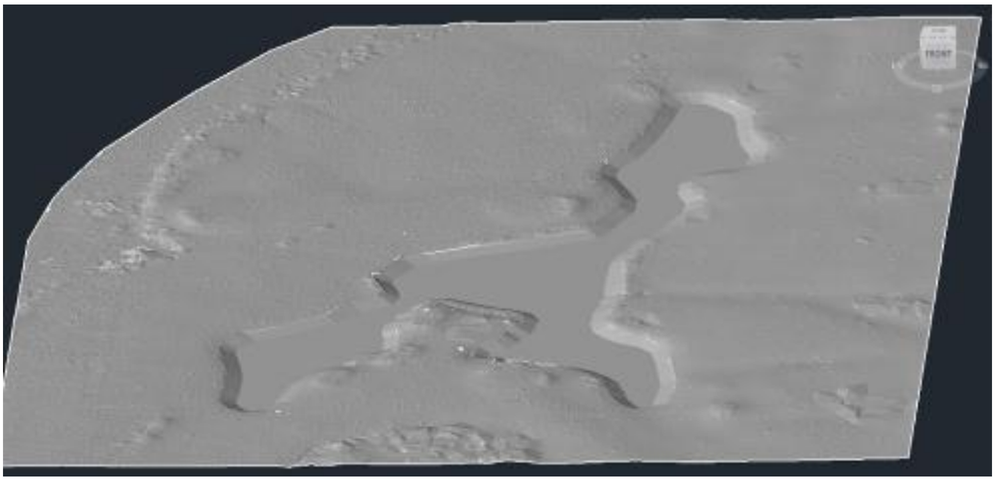


Figure 3: Existing Surface (Digital Terrain Model) of a Surveyed Pond (SWP062).

LiDAR data were processed and compared with GPS surveyed data to determine if the LiDAR could be used for the DTM generation. The LiDAR data often correlated strongly with the survey data but at times, for example where dense vegetation was present, the survey data was considered more reliable. In these cases the existing surface was created mainly using the survey data. The surveying equipment was calibrated daily using known points to ensure accurate and reliable data. Where no LiDAR data was available, the survey data constituted the basis of the modelling exercise.

The DTM was then combined with the five specific levels investigated to obtain the storage volumes from the bottom of the Pond to the specific level, and the related surface areas, as illustrated in Figure 4Figure 4.

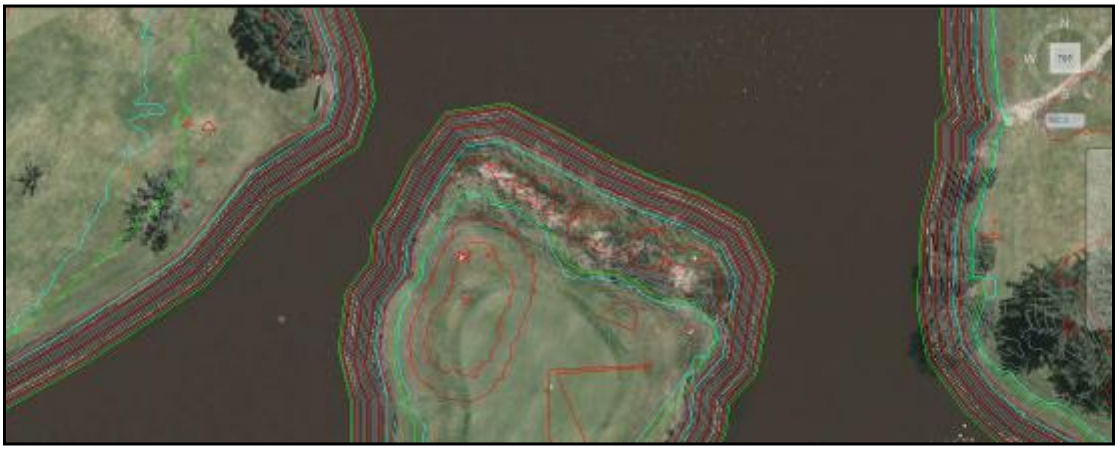


Figure 4: Digital Terrain Model and Investigated Levels of a Surveyed Pond (SWP062).

When the Pond outlet structure was a single stage weir, the level of service, permanent water level and emergency spillway were considered as being at the same elevation. Only the extreme, or top of embankment, water level was then calculated.

This exercise was conducted for all of the Ponds in the former Rodney District in the Northern area only

3 DISCUSSION OF RESULTS

The results of the project were delivered in report and database form. They included a summary of all findings, prioritisation of operational works, and the collated outputs from both project phases.

3.1 PHASE ONE CONDITION INSPECTION AND ASSSESSMENT

Table 3~~Table 3~~ presents the data summary for the Phase one condition inspection of the Ponds. Of particular note:

- 67% of the Ponds did not have a forebay,
- Urgent maintenance required on 12%,
- Drain valves were not present in 53% of cases,
- Aquatic Pests (Extensive or Widespread) were identified in 19% of the Ponds sampled,
- 57% had 15% or more sediment build up (of the water quality volume).

The field work undertaken for this project highlighted the necessity to follow ARC TP10 guidelines for the design of wet Ponds and wetlands to minimise any health and safety risk. Installing fences and/or a safety bench would maximise public safety.

Additionally information related to operational details is often not available or patchy. This includes details of fencing, plantings, or access type which form the core details used by asset managers to prioritise maintenance works. The accumulated details go some way to filling these gaps.

The current ARC TP10 design guidelines would also enhance the treatment potential of the devices. Furthermore the soon to be released GDO5 will provide further design features. For example, if fore bays or bathymetry were in place, treatment efficiency would increase.

Table 3: Summary Results from 126 Inspections

Item	North Total	West Total	% of Total
Inspected Wet Ponds	42	60	81%
Inspected Wetlands	7	5	9%
Inspected Dry Ponds	11	1	9%
Function of Ponds WQ	2	51	42%
Function of Ponds Peak Flow	16	1	13%
Function of Ponds WQ and Peak Flow	42	15	45%
Forebays Present Adequate	14	23	29%
Forebays Present Inadequate	1	4	4%
Forebays Present None	45	40	67%
Maintenance Access (Sound or Excellent) %	55	73	64%
Drain Valves Present %	51	43	47%

Item	North Total	West Total	% of Total
Sediment 50% or more	10	4	11%
Sediment 15-50%	29	30	46%
Vegetation Volume and Surface Intrusion 50% <	11	7	14%
Aquatic Pests (Extensive or Widespread) %	15	22	19%
Structure Condition Failing	0	1	1%
Structure Condition Poor	8	3	9%
Structure Condition Degraded	15	14	23%
Landscape Plants (Sound or Excellent) %	52	76	64%
Wetland Plants (Sound or Excellent) %	28	41	35%
Health and Safety Issues (Failing H and S)	17	4	17%
Fencing Failing	0	1	1%
Fencing Poor	0	6	5%
Fencing None	43	17	47%
Litter Present or Widespread %	48	43	46%
Aesthetic and Overall Quality (Failing)	3	3	5%
Maintenance Required Urgent	12	3	12%
Maintenance Required in 18 Months	20	29	39%
Maintenance Required Standard Cycle	28	31	46%

The information gathered in this study and supplementary database can be used to gauge the effectiveness of different Pond designs and features. These performance indicators can then be used for developing more efficient Pond design in the future.

The MCA ranking tool can be modified as required to suit the developing needs of the user. Weightings of each criterion can be adjusted to refine the ranking system to match any changes in the focus of the inspections, retrospectively or into the future. As more Pond data is collected, a greater basis for comparison will be established which will encourage development of the tool.

3.2 PHASE TWO ASSET DATA CAPTURE AND VALIDATION FOR FIELD SURVEYING

The survey and CAD modelling of the Pond's structural elements such as inlet/outlet invert levels, pipe diameters, level of service outlet, emergency spillway, and top of embankment elevations, was used to develop a better understanding of each Ponds storage level and capacity and to populate the missing key asset related data.

Overall the methodology, as implemented, provided sufficient details to do the complex CAD modelling associated with the project. Additionally, the missing asset related data was captured.

4 CONCLUSIONS

A Pond Reporting Tool and Database (PRTD) forms part of the electronic deliverables associated with this project. The PRTD includes all data associated with the inspections recorded against asset identification numbers and can be used to view all pictures, videos, and data from the inspections. The results of these pilot study inspections were ranked to provide a prioritisation tool to be used in developing maintenance strategies.

Maintenance of these devices is critical for their operational role. Monitoring should be planned in advance and regular site visits should be undertaken to obtain a better understanding of the function and maintenance requirements of Ponds and wetlands.

The presented inspection method, Multi-criteria Analysis Tool and supporting Pond Reporting Tool (PRT) is considered very useful. Elements of which would strengthen components of the AC Corporate Register. This would require update accordingly to include all relevant parameters to maximise consistency.

The sustainable and cost effective management of Ponds is a key area of concern to Council operations and planning staff. However, much of the legacy data associated with the assets is limited, of poor quality, or does not meet the business needs of the asset managers. This project demonstrates the method and benefit of an operational assessment and reporting structure. This forms the basis of an information system to capture and manage the information flow.

Riparian margin vegetation management and maintenance should not be underestimated as it provides an important function for these devices. Riparian vegetation can act as a safety fence if dense enough; it will provide shade to the Ponding water, regulating water temperatures and therefore water quality. Riparian vegetation also increases the ecological and amenity values of the body of water. Ponds and their riparian margin could be integrated in the management of ecological corridors.

There is currently no code of practice or standards applicable for Pond design. TP10 provides guidelines only, but it is under review and should soon be replaced by GD05.

This study forms the basis of a method, procedure, and criteria that has the potential to form a single information repository for Pond and Wetland asset maintenance and operational optimisation in the wider Auckland Region.

5 RECOMMENDATIONS

There appears to be a need to have a regional tool to manage all the Auckland Ponds. At time of writing moment 66 Western and 60 Northern Area Ponds were inspected according to Morphum Environmental methodology, as presented. These investigations could be carried out in other former TLAs of the Auckland Region. However, as it is a time consuming process, resources and timeframe should be adequately planned for.

It is considered that an evaluation of Pond design, at the consenting stage, through a multi criteria analysis would be beneficial. Critical design parameters should be set and used for Pond design approval/decline. This could be based on the Pond Reporting Tool presented, and further developed to evaluate Pond design requirements in terms of compliance.

Ponds located in catchments undergoing urban/residential development often show high total suspended sediment (TSS) loads. In these cases, Ponds are likely to contain significant volumes of sediment at the end of the contributing catchment development, reducing their future treatment capacity. Council may consider removing sediment from these devices once their contributing catchment is fully developed or near completion as many risk not meeting design or consenting requirements.

It considered prudent to consider that Pond maintenance should be the land developers responsibility for the first few years after completion to ensure adequate maintenance and the development of a balanced, healthy, and efficient device. In some instances during site visits it was observed that weeds dominated the riparian vegetation, or that no topsoil was placed on the re-contoured Pond banks reducing the chance for any vegetation establishment. The resource and money required to remedy these shortfalls are currently largely being borne by Council.

It's recommended for Council to consider sharing the cost of maintenance with developers and/or owners, further training building and/or earthworks contractors, and/or monitoring compliance with the Erosion and Sediment Control Plan more frequently.

Understanding Pond performance, functions, and ecosystems cannot be achieved without understanding the associated catchment and influence of Pond design. Ideally all the relevant information should be spatially presented to allow council and other decision makers to understand issues and opportunities potentially present around, upstream, and downstream of their assets. The key may be the development of an easily accessible, spatialised and multi-user information tool.

Recommendation for future works includes

- An exercise to define the capacity of Ponds to store the required Water Quality Volume ("WQV") and a comparison of the calculated treatment efficiency versus that recorded. The definition of the catchment boundaries would allow calculating these volumes and comparing them with inspection results. Catchment areas draining to the Ponds should be defined in GIS

- An assessment of current corporate Pond dataset and conduct a gap analysis to identify any inconsistencies, needs or information to be collected for Ponds.

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REFERENCES

Auckland Regional Council (2003) Guidelines for Stormwater Design in the Auckland Region, TP10.