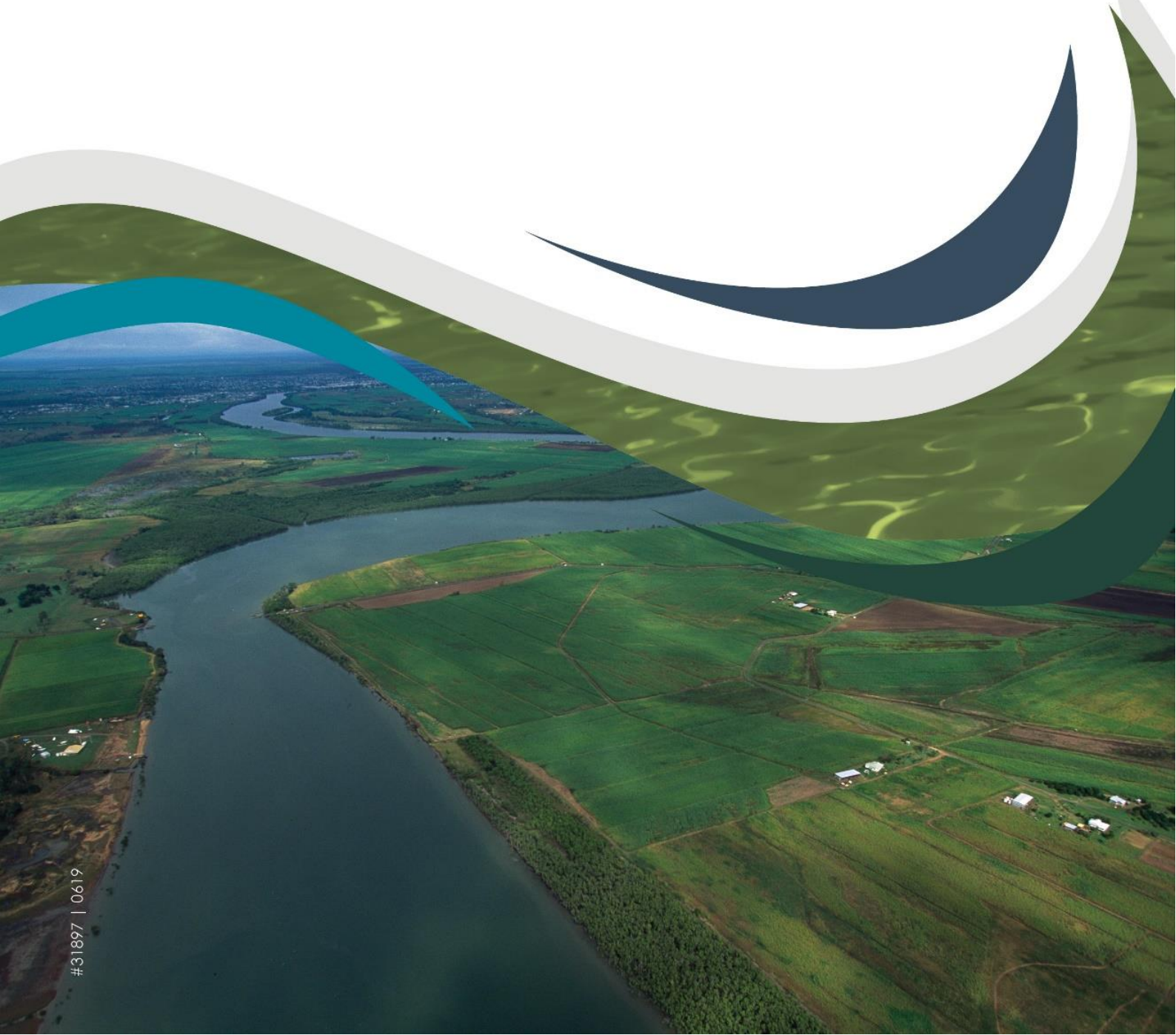
Australian Government

Queensland Government

Wetland Condition Methods

Reef Water Quality Report Card 2017 and 2018

Reef 2050 Water Quality Improvement Plan



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CONTENTS

CATCHMENT CONDITION – WETLAND CONDITION MONITORING METHODS

This report describes analysis methods used to produce the Reef Water Quality Report Card 2017 and 2018 wetland condition results. Within the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program the Wetland condition monitoring program aims to monitor progress towards the Reef 2050 Water Quality Improvement Plan (Reef 2050 WQIP*)*, improved wetland condition objective.

The program design is described in the Great Barrier Reef (GBR) catchments wetland monitoring pilot study: assessment methods and monitoring design (Tilden et al., 2015) and the proposed program analysis methods are set out in detail in The Great Barrier Reef catchments wetland monitoring program: analysis methods (Tilden and Vandergragt, 2017).

Methods

The analysis methods document referred to above (Tilden and Vandergragt, 2017) identified a number of activities to be carried out in 2017 and 2018. The aims were to:

- assess wetland condition and change in wetland condition in GBR freshwater floodplain wetlands
- examine sources of variance in data gathered with the program's wetland assessment tool.

Baseline data for pressure on wetland values and the state of wetland values were reported in 2016. The 2017 and 2018 analyses (covered by this report card) focussed on:

- Testing for change in wetland condition (pressure on environmental values and state of environmental values) between 2016 and 2018.
- Testing against precision criteria set in the program design phase to see if the assessment method yields sufficient power to detect change between two times with a sample of 40 wetlands. The criteria were a detectable difference of one point on the wetland assessment tool's 13-point scoring scale[1] with a <5% chance of Type 1 error (false detection of change) and a less than 20% chance of Type II error (failing to detect a change), which equates to a power of 80%.
- Examining interoperator variability as a source of variance in assessment data with a view to improving the precision of the instrument.

The test of interoperator variability is the first of a number of planned investigations to identify and quantify sources of uncertainty in the program's wetland data. Also of interest is the degree to which natural variability adds uncertainty that would mask changes or trends in wetland condition. The program's wetland assessment tool was designed to assess anthropogenic impacts while being unresponsive to natural variability. Sufficient data has not been collected as yet to test for natural variability. Activities are planned to research the effects of rainfall, climate zone (tropical versus subtropical) and wetland habitat type on wetland assessment scores, to see if natural variability has been factored out to an acceptable degree.

[1] On this scoring scale, 1 is the most pristine wetland condition (pressure or state), while 13 represents the most disturbed condition (pressure or state).

Progress with monitoring design

Table 1 shows the GBR wetland condition monitoring program sample design – an augmented serially alternating design comprising one panel[2] of 20 wetlands assessed every year and four panels of 20 assessed in alternate years following a pattern that repeats every eight years. The total sample size is 100 wetlands, comprising a spatially balanced random sample of wetlands selected using the GRTS[3] method. The sub-population sampled for the GBR-wide monitoring program is natural freshwater floodplain wetlands in high density assemblages.

By the end of 2018, 63 wetlands had been assessed at least once and 39 had been assessed twice, allowing us to test for change between the 2016 baseline and 2018, and also to establish whether precision criteria set in the design phase had been met.

Table 1. Panel design for the Great Barrier Reef catchments wetland monitoring program.

Panel	Year									
	2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
1	20	20	20	20	20	20	20	20	20	20
2	20		20						20	
3		20		20						20
4					20		20			
5						20		20		
Year total	40	40	40	40	40	40	40	40	40	40
Total sample	**40**	**60**	**60**	**60**	**80**	**100**	**100**	**100**	**100**	**100**

The discrepancy in the numbers of wetlands proposed to be assessed by the end of 2018 and those actually assessed had two sources. First, after the initial GRTS draw, an extra wetland from the Mackay Whitsunday region was added to the sample. This extra wetland was drawn from the original GRTS random sample following standard procedures. It was needed because the original sample of 40 wetlands (panels 1 and 2), designed to proportionally represent the whole GBR catchment by region, yielded only one wetland for Mackay Whitsunday due to the relatively small number of freshwater floodplain wetlands in that region. Second, two wetlands dropped out of the original panel 1 sample and were replaced from the GRTS random sample with two new ones from within the regions of the dropouts (Burdekin Dry Tropics and Mackay Whitsunday).

Data collection

Wetland assessment data was collected in two ways:

- desk top analysis based on imagery and spatial data using a range of data sets for 15 indicators primarily related to the pressure index
- field-based data collection methods for ten indicators primarily related to state.

[2] A panel is a group of wetlands with the same schedule of repeat assessments across years.
[3] Generalised Randomised Tessellation Stratified sampling

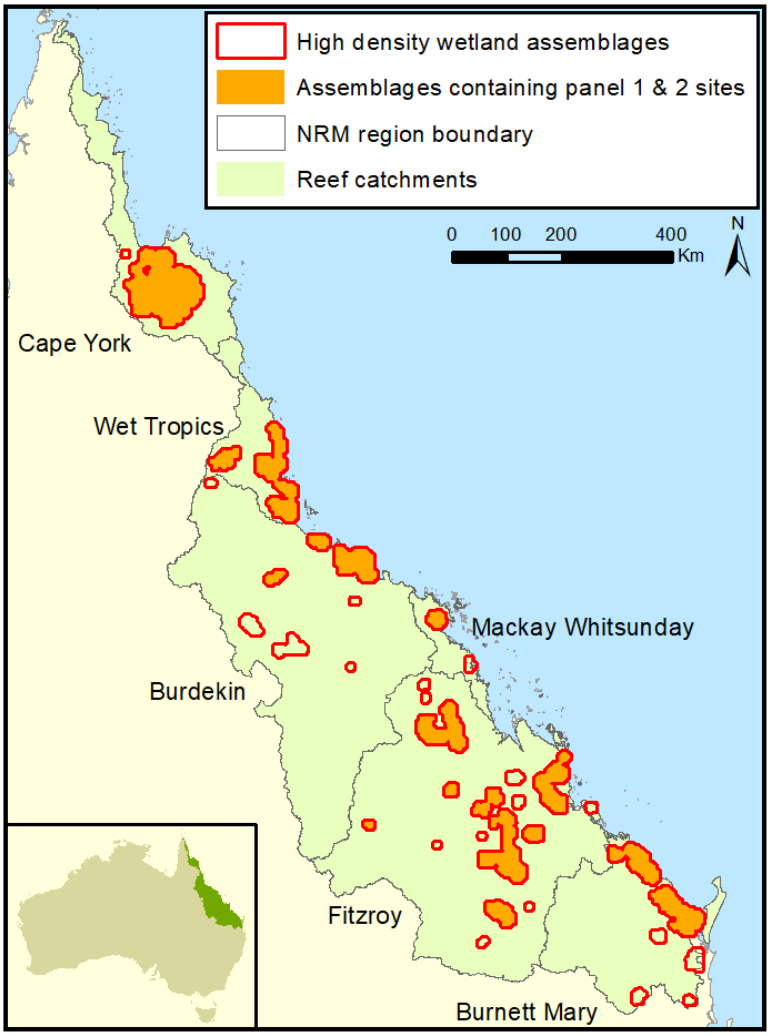

Figure 1. High density wetland assemblages containing panel 1 and panel 2 wetlands assessed in 2016 and 2018.

Calculating summary statistics

For each wetland, the assessment tool produces overall scores for **pressure** on wetland environmental values and the **state** of wetland environmental values (condition) plus scores on four wetland environmental value (WEV) sub-indices for both pressure and state. The WEV sub-indices are:

- biotic integrity: the biological health and diversity of the wetland's ecosystems
- local physical integrity: the wetland's natural physical state and integrity
- local hydrology: the wetland's natural hydrological cycle
- connectivity: the natural interaction of the wetland with other ecosystems including other wetlands.

The status and change assessment for 2018 focussed on the 39 freshwater floodplain wetlands in the GBR catchments that had been assessed at least twice. Descriptive parametric and non-parametric statistics, were calculated. Mean and variance of scores for overall wetland pressure and state were used to characterise the level of anthropogenic disturbance to GBR natural freshwater floodplain wetlands in 2018, along with the mean and variance per WEV for pressure and state. Norman (2010) summarises work supporting the use of parametric statistics on aggregated ordinal data.

Scoring scales for individual wetland and GBR-wide assessments

Generating the GBR scale wetland condition Pressure and State scores is a five step process. It starts with indicator scoring at the individual wetland scale then steps through to calculating wetland scale WEV scores and overall Pressure and State grades. GBR-wide grades for the four WEVs (*biotic integrity*, *local physical integrity*, *local hydrology* and *connectivity for pressure and state respectively) and the overall* GBR-wide State and Pressure report card grading are then calculated. These steps, score classes and cut-off values are summarised in 2 to 5.

Table 2. Scores per indicator: Individual indicators (pressure and state) are assessed on ordinal scales with scores generally ranging from one to five.

Condition	Very low pressure/Very good state	Low pressure/ Good state	Moderate pressure/ Moderate state	High pressure/ Poor state	Very high pressure/ Very poor state
Indicator scores (individual wetlands)	1	2	3	4	5

Table 3. Scores per WEV: The indicator scores are aggregated and converted into sub-index numeric scores for each of the four WEVs per wetland : *biotic integrity*, *local physical integrity*, *local hydrology* and *connectivity for both pressure and state respectively*.

WEV sub-index cutoff values	≤1.53	>1.53 to ≤2.33	>2.33 to ≤3.13	>3.1 to ≤3.93	>3.93

Table 4. Overall wetland pressure and state scores: The four WEV pressure scores and the four WEV state scores are then aggregated to generate an overall numeric pressure and state (OP and OS) score per wetland corresponding to a 13 point grading scale as shown below.

Aggregated overall pressure and state cut-off values	≤1.27	>1.27 to ≤1.53	>1.53 to ≤1.8	>1.8 to ≤2.07	>2.07 to ≤2.33	>2.33 to ≤2.6	>2.6 to ≤2.87	>2.87 to ≤3.13	>3.13 to ≤3.4	>3.4 to ≤3.67	>3.67 to ≤3.93	>3.93 to ≤4.2	>4.2
Pressure and state score classes (grades)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**

Table 5. GBR wide scores: At the GBR-wide scale individual WEV pressure and states scores and overall pressure and state scores are calculated by averaging the numeric values obtained from the individual wetlands. The GBR-wide pressure and state scores are then converted to the report card grades as shown below.

GBR scale WEV Sub-index Pressure and State report card grading

WEV subindex cutoffs (1–5 scale)	<1.5	≥1.5 to <2.5	≥2.5 to <3.5	≥3.5 to <4.5	≥4.5
Report Card grade	A	B	C	D	E

GBR scale State and Pressure report card grading

Index cutoffs (1–13 scale)	<2.5	≥2.5 to <5.5	≥5.5 to <8.5	≥8.5 to <11.5	≥11.5
Report Card grade	A	B	C	D	E

Baseline backcasting

Due to minor upgrades of the wetland assessment tool, the 2016 baseline statistics used to make comparisons in the Reef Water Quality Report Card 2017 and 2018 vary slightly from those used in Reef Water Quality Report Card 2016.

In particular, when the 2016 results were first reported, one indicator of pressure on 'local physical integrity' (modelled sediment supply) was non-discriminating. All wetlands had a score of one for this indicator, leading to an aggregated WEV2 grade of 'A'. Following a methods change, this indicator now discriminates across the range of wetland disturbance.

All 2018 comparisons between summary statistics for 2016 and 2018 use the 2016 backcast results for index and sub-index scores (pressure and state).

Assessments of change between 2016 and 2018

Tests for change between 2016 and 2018 analysed aggregated wetland assessment scores.

Paired-sample t-tests were used to test for any statistically significant differences in overall pressure and state scores and sub-index pressure and state scores between the 2016 and 2018 survey periods ($p \leq 0.05$). All assessments of change use the 2016 back-cast results. Test results are for the n = 39 wetlands that were surveyed in both 2016 and 2018.

All paired-sample t-tests were two-tailed and were performed using the 't.test' function from the 'stats' package in R (R Core Team, 2018).

Analysis by land use type

The aims of this analysis are to:

- determine if, in 2018, there were any significant differences in pressure or in state scores between wetlands surrounded by conservation land uses and those surrounded by other land use categories
- determine if land use intensity (LUI) in the wetland and the surrounding area affects change in scores between 2016 and 2018.

All analysis used data from the n = 39 wetlands surveyed in both 2016 and 2018. Data were aggregated pressure and state scores (i.e. scores between one and 13 for the overall pressure and state of wetlands; scores between one to five for the individual pressure and state WEVs).

To test for differences in condition between wetlands within conservation land uses and wetlands surrounded by all other land uses, Mann-Whitney U tests were performed on 2018 data only. This test uses sample distributions instead of measures of central tendency to test for difference in populations. The null hypothesis is that 'there is no difference between score distributions attributable to land use type'.

To test the significance of changes in average scores by land use category between 2016 and 2018, we used paired-sample t-tests (two-tailed, $p \leq 0.05$, N = 16 for wetlands surrounded by conservation land use and N = 22 for wetlands surrounded by all other land uses). For each land use category comparisons between 2016 and 2018 were made at the overall pressure or state score level, as well for individual WEV pressure or state scores.

Non-response bias

The previous reef wetland condition report (2016) established that there was a non-response bias in the program's wetland assessment data related to the intensity of land use surrounding wetlands. Managers of wetlands surrounded by high intensity land uses such as cropping and manufacturing were less likely to agree to monitoring than managers of wetlands surrounded

by conservation land uses with intermediate acceptance rates for wetlands surrounded by land use of intermediate intensity.

Because a slightly different cohort of wetlands was assessed for the change analyses reported here, a new set of weights was calculated and applied to correct for the non-response bias. Using the method of Johnson (2008), weights were calculated by dividing the expected proportions of wetlands in each land use intensity class (high, moderate and low) by the observed proportions.

All aggregated scores for the pressure on wetland values and the state of wetland values were adjusted using the resulting weights and summary statistics were recalculated.

Both unadjusted and adjusted results are given in the 2018 wetland condition results report.

Power to detect change

As described earlier, paired-sample t-tests were used to test for changes in wetland pressure and state scores (both overall and per WEV) between 2016 and 2018.

The 'power.t.test' function from the 'stats' package in R (R Core Team, 2018) was used to to determine the minimum change in score that could be detected in these paired-sample t-tests, with a power of 0.80 and a significance level of $p = 0.05$, based on a sample size of $N = 39$ and the standard deviations of differences in scores recorded between 2016 and 2018.

Repeatability testing

Forty-one wetlands, comprising panels 1and 3 of the program sampling design, were assessed in 2017. In a repeatability study 11 of these wetlands were assessed twice. The two assessments were carried out on the same day to reduce other sources of extraneous variance among the repeat assessments. The assessment teams, each comprising two members, worked independently. The teams had similar levels of experience with the wetland assessment tool.

Data from the 11 repeat-assessment wetlands were examined using various descriptive and statistical techniques to gauge the contributions of individual indicators to interoperator variability in the wetland assessment tool. The aim is to minimise this source of variability.

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Glossary

Aggregated wetland assessment scores: The wetland assessment method uses scores at three levels – *indicators* are aggregated into four *sub-indices* based on wetland environmental values (WEVs). The WEV sub-indices are aggregated into two *indices*, overall pressure and overall state. The aggregation methods average the scores of indictors to derive sub-index scores, which are in turn averaged to derive index scores.

Augmented serially alternating design: A monitoring design consisting of a number of panels of sites (wetlands), where one panel is assessed every year (the augmented section of the design) and the remaining panels are assessed in different years on a regular and repeating schedule.

Baseline: A baseline is the initial collection of data used for comparison with subsequently acquired data. In the case of the wetland condition monitoring component of the Reef Report, baseline data for the 2018 wetland results reported here were collected in 2015 and 2016 and reported in the Reef Water Quality Report Card 2016.

DPSIR framework: A causal framework for describing the interaction between society and the environment. Driver, Presssure, State, Impact, Response.

Interoperator variability: Interoperator variability is the amount of variability between the results obtained by two or more observers examining the same material.

Natural wetlands: Natural wetlands are areas that existed as wetlands before European settlement and that still meet the definition of wetlands (whether modified or not) in current state-wide wetland mapping.

Non-response bias: A non-response bias occurs when randomly selected subjects (wetland managers) choose not to be involved in a study (wetland assessment), not at random, but in ways that are meaningful to the phenomenon under study.

Panel: A panel is a group of wetlands with the same schedule of repeat assessments across years.

Power (to detect an change): In statistical testing, Power = $(1 - \beta)$, where β is the probability of making a Type II error, that is failing to detect an effect.

Pressure: Under the DPSIR framework, pressure refers to human activities directly affecting the environment.

Repeatability: The closeness of agreement between results of successive measurements of the same subject (wetland) carried out under the same conditions of measurement. See interoperator variability.

Spatially balanced random sample: A random sample whose sample sites are more or less evenly dispersed over the extent of the population being studied.

State: Under the DPSIR framework, characteristics, at a particular time, of ecosystem processes and the organisms and habitats that define, support and/or adversely affect ecosystem environmental values.

Wetland condition: Under the Great Barrier Reef Wetland Condition Monitoring Program, wetland condition refers to the pressure on wetlands' natural environmental values and the state of those values under a Driver, Pressure, State, Impact, Response (DPSIR) conceptual framework.

Wetland environmental values: Wetland environmental values are individual physical and biological characteristics associated with a particular wetland that provide its ecological, social and economic benefits and are sometimes referred to as ecosystem services. The Wetland Condition Monitoring Program assesses wetland environmental values (WEVs), defined as:

- biotic integrity – the biological health and diversity of the wetland's ecosystems
- local physical integrity – the wetland's natural physical state and integrity
- local hydrology – the wetland's natural hydrological cycle
- connectivity – the natural interaction of the wetland with other ecosystems including other wetlands.