

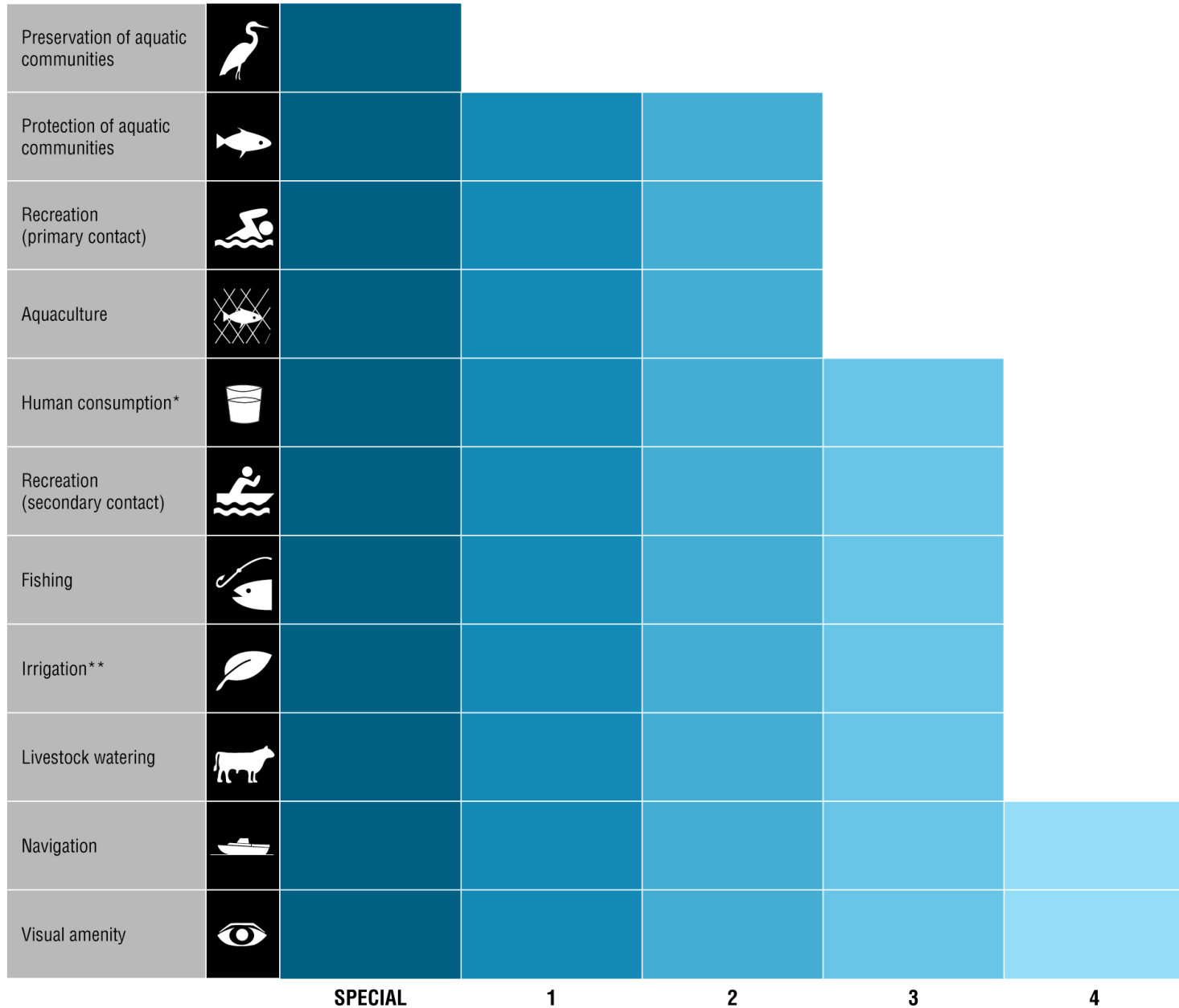
WATER QUALITY STANDARDS AND INDICES

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Compendium of Water Quality Regulatory Frameworks: Which Water for Which Use?

USES OF SURFACE FRESHWATER



SPECIAL

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CLASSES OF SURFACE FRESHWATER BODIES

HISTORY OF NATIONAL WATER QUALITY STANDARDS (NWQS)

- The Department of Environment (DOE) initiated an extensive program on the Development of Water Quality Criteria and Standards for Malaysia in 1985.
- The study was carried out in phases (Phase I – IV).
- It was established the beneficial uses that should be focused on;
 - domestic water supply
 - fisheries and aquatic propagation
 - livestock drinking
 - recreation
 - agricultural use

HISTORY OF NATIONAL WATER QUALITY STANDARDS (NWQS)

- Phase I of the study involved the review of over 120 physico-chemical and biological parameters from international and local literature for the prescribed beneficial uses.
- The initial phase of the study recommended a set of Interim National Water Quality Standards (INWQS) which defined six classes (I, IIA, IIB, III, IV and V) to be referred to for classification of rivers or river segments into classes of quality based on descending order.

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	μ S/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000) ^a	5000 (20000) ^a	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

National Water Quality Standards For Malaysia

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III*	IV	V
Al	mg/l		-	(0.06)	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	-	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pd	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	

NWQS – BENEFICIAL USES

CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

HOW DOES THE NWQS COMPARE TO INTERNATIONAL STANDARDS? - DRINKING WATER QUALITY CRITERIA

Parameter	NWQS Class II	US EPA MCL	WHO
Arsenic	0.05	0.01	0.01
Lead	-	0.015	0.01
Nitrate (as N)	7	10	11
Mercury	0.001	0.002	0.001
Cadmium	0.01	0.005	0.003

NWQS VS MOH DRINKING WATER QUALITY

PARAMETER (ALL IN MG/L)	CLASS IIA NWQS (WATER SUPPLY II – CONVENTIONAL TREATMENT REQUIRED)	MOH (RECOMMENDED RAW WATER QUALITY CRITERIA)
BOD	1 - 3	< 6
NH ₃ -N	0.1 - 0.3	< 1.5
TSS	25 - 50	-
NO ₃ -N	< 7	< 10
PO ₄ ³⁻	< 0.2	-
LEAD	< 0.05	< 0.05
ARSENIC	< 0.05	< 0.01
CADMIUM	< 0.01	< 0.003
NICKEL	< 0.05	-
MERCURY	< 0.001	< 0.001

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National Recommended Aquatic Life Criteria table

Aquatic Life Criteria

Pollutant (P = Priority Pollutant)	CAS Number	Freshwater CMC ¹	Freshwater CCC ²	Saltwater CMC ¹	Saltwater CCC ²	Publication Year	Notes
		(acute) (µg/L)	(chronic) (µg/L)	(acute) (µg/L)	(chronic) (µg/L)		
Acrolein (P)	107028	3ug/L	3ug/L	—	—	2009	
Aesthetic Qualities	—	—	—	—	—	1986	See Quality Criteria for Water, 1986 ("Gold Book") for narrative statement.
Aldrin (P)	309002	3.0	—	1.3	—	1980	These criteria are based on the 1980 criteria which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines . If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

US EPA

Pollutant	CAS Number	Human Health for the consumption of Water + Organism (µg/L)	Human Health for the consumption of Organism Only (µg/L)	Publication Year	Notes
Acenaphthene (P)	83329	70	90	2015	The criterion for organoleptic (taste and odor) effects may be more stringent. See National Recommended Water Quality Criteria - Organoleptic Effects .
Acrolein (P)	107028	3	400	2015	
Acrylonitrile (P)	107131	0.061	7.0	2015	This criterion is based on carcinogenicity of 10^{-6} risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10^{-5} , move the decimal point in the recommended criterion one place to the right).
Aldrin (P)	309002	0.00000077	0.00000077	2015	This criterion is based on carcinogenicity of 10^{-6} risk. Alternate risk levels may be obtained by moving the decimal point (e.g., for a risk level of 10^{-5} , move the decimal point in the recommended criterion one place to the right).
alpha-Hexachlorocyclohexane (HCH) (P)	319846	0.00036	0.00039	2015	
alpha-Endosulfan (P)	959988	20	30	2015	
Anthracene (P)	120127	300	400	2015	

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WATER QUALITY INDEX (WQI)

- ▶ A Water Quality Index (WQI) ascribes quality value to an aggregate set of measured parameters.
- ▶ It usually consists of sub-index values assigned to each pre-identified parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined into the final index. The sub-index value is also sometimes referred to as the Q-value.
- ▶ The purpose of the WQI is to summarize large amounts of water quality data for a specific river into simple terms (i.e. one number and a statement such as “good”).
- ▶ This makes it easily understandable for communities in the watershed and for watershed management.

DOE-WQI

- ▶ The DOE-WQI is an opinion-poll formula – a panel of experts is consulted on the choice of parameters and on the weight age to each parameter.
- ▶ The parameters that were chosen ; Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), Ammoniacal Nitrogen (NH₃-N) and pH.
- ▶ Calculations are performed not on the parameters themselves but on their sub-indices.
- ▶ The sub-indices are named SIDO, SIBOD, SICOD, SIAN, SISS and SIPH respectively.

DOE-WQI

The Best Fit Equations used for the estimation of the 6 sub index values :

Subindex for DO (in % saturation): SIDO

$$\begin{aligned} \text{SIDO} &= 0 && \text{for } x \leq 8 \% \\ &= 100 && \text{for } x \geq 92 \% \\ &= -0.395 + 0.030x^2 - 0.00020x^3 && \text{for } 8 \% < x < 92 \% \end{aligned}$$

Subindex for BOD : SIBOD

$$\begin{aligned} \text{SIBOD} &= 100.4 - 4.23x && \text{for } x \leq 5 \\ &= 108e^{-0.055x} - 0.1x && \text{for } x > 5 \end{aligned}$$

Subindex for COD : SICOD

$$\begin{aligned} \text{SICOD} &= -1.33x + 99.1 && \text{for } x \leq 20 \\ &= 103e^{-0.0157x} - 0.04x && \text{for } x > 20 \end{aligned}$$

DOE-WQI

Subindex for AN : SIAN

$$\begin{aligned} \text{SIAN} &= 100.5 - 105x \\ &= 94e^{-0.573x} - 5|x-2| \end{aligned}$$

$$\begin{aligned} &\text{for } x \leq 0.3 \\ &\text{for } 0.3 < x < 4 \end{aligned}$$

Subindex for SS : SISS

$$\begin{aligned} \text{SISS} &= 97.5e^{-0.00676x} + 0.05x \\ &= 71e^{-0.0016x} - 0.015x \\ &= 0 \end{aligned}$$

$$\begin{aligned} &\text{for } x \leq 100 \\ &\text{for } 100 < x < 1000 \\ &\text{for } x \geq 1000 \end{aligned}$$

Subindex for pH : SIPH

$$\begin{aligned} \text{SIPH} &= 17.2 - 17.2x + 5.02x^2 \\ &= -242 + 95.5x - 6.67x^2 \\ &= 181 + 82.4x - 6.05x^2 \\ &= 536 - 77.0x + 2.76x^2 \end{aligned}$$

$$\begin{aligned} &\text{for } x < 5.5 \\ &\text{for } 5.5 \leq x < 7 \\ &\text{for } 7 \leq x < 8.75 \\ &\text{for } x \geq 8.75 \end{aligned}$$

Note : x = concentration in mg/l for all parameters except DO (in %DO_{sat}) and pH

DOE-WQI

Once the sub indices have been calculated (file has build-in formulae for water quality index calculation incorporated into the Excel spreadsheet), the DOE-Water Quality Index can be calculated:

$$\text{DOE-WQI} = 0.22 * \text{SIDO} + 0.19 * \text{SIBOD} + 0.16 * \text{SICOD} + 0.15 * \text{SLAN} + 0.16 * \text{SISS} + 0.12 * \text{SIPH}$$

*Note: * indicates multiplication, where the multipliers are the weight ages for the corresponding parameters with a total value of 1*

WQI CLASSIFICATION

DOE Water Quality Index Classification

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7	6 – 7	5 – 6	< 5	> 5
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)		< 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

DOE Water Quality Classification Based On Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH ₃ -N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59

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LIMITATIONS OF DOE-WQI

- ▶ Consists of only 6 physico-chemical parameters : DO, BOD, COD, TSS, pH and NH₃-N.
- ▶ Based on **aggregated, opinion-poll approach**; essentially the **sub-indices are “averaged”**; which can be misrepresentative.
- ▶ **Doesn't include bacteria or heavy metals in the benchmarking.**
- ▶ Other than water quality, no information given of other stream conditions.
- ▶ **Frequency and amplitude** not accounted for, or averaged.



W1 Sg. Kimanis
DOE-WQI : Class II, Clean
Lowest Sub-index : TSS,
Class III, Polluted
CCME WQI : Marginal



W1 Sg. Papar

DOE-WQI : Class II, Clean

Lowest Sub-index : TSS, Class IV,
Polluted

CCME WQI : Marginal



W1 Sg. Sembulan

DOE-WQI : Class II, Clean

Lowest Sub-index : BOD, Class IV,
Polluted

CCME WQI : Marginal

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W2 Sg. Sembulan

DOE-WQI : Class II, Slightly
Polluted

Lowest Sub-index : COD, Class
III

CCME WQI : Marginal

Comparison of Benchmarking Methods

River	Station ID	DOE-WQI			DOE-WQI Lowest Sub-index				CCME-WQI (Class IIB)*	
		Index	Class	Status	Lowest Sub-index	Parameter	Lowest Sub-index Class	Status	Index	Status
Sg. Kinabatangan	W1	85	II	Clean	55	TSS (100 mg/L)	III	Polluted	87	Good
Sg. Kinabatangan	W2	86	II	Clean	55	TSS (135 mg/L)	III	Polluted	81	Good
Sg. Kinabatangan	W3	80	II	Slightly Polluted	38	TSS (319 mg/L)	V	Polluted	63	Marginal
Sg. Kimanis	W1	85	II	Clean	56	TSS (127 mg/L)	III	Polluted	62	Marginal
Sg. Kimanis	W2	92	I	Clean	90	TSS (13 mg/L)	I	Clean	95	Excellent
Sg. Papar	W1	86	II	Clean	54	TSS (150 mg/L)	IV	Polluted	48	Marginal
Sg. Papar	W2	91	II	Clean	81	TSS (30 mg/L)	II	Clean	95	Excellent
Sg. Sembulan	W1	83	II	Clean	66	BOD (9 mg/L)	IV	Polluted	54	Marginal
Sg. Sembulan	W2	80	II	Slightly Polluted	53	COD (40 mg/L)	III	-	52	Marginal
Sg. Sembulan*	W1	-	-	-	-	-	-	-	86	Good
Sg. Sembulan*	W2	-	-	-	-	-	-	-	86	Good

*Sg. Sembulan CCME-WQI Class III target

CCME WQI

The Canadian WQI is based on 3 set criteria ;

- 1.The number of variables whose objectives are not met,
(Scope)
- 2.The frequency with which the objectives are not met,
(Frequency) and;
- 3.The amount by which the objectives are not met,
(Amplitude).

CCME WQI

F1 (Scope) represents the percentage of variables that do not meet their objectives at least once during the time period under consideration (“failed variables”), relative to the total number of variables measured:

$$F_1 = \left(\frac{\text{Number of failed variables}}{\text{Total number of variables}} \right) \times 100$$

F2 (Frequency) represents the percentage of individual tests that do not meet objectives (“failed tests”):

$$F_2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. F3 is calculated in three steps.

CCME WQI

- ▶ The CCME Water Quality Index (CCME WQI)

$$CCMEWQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

CCME Water Quality Index Calculator 1.2

INTRODUCTION AND VITAL INFORMATION

This program uses the CCME Water Quality Index formula (version 1.2) to calculate water quality index values based upon user-defined guidelines for various water quality variables. For details on the formulation and interpreting WQI scores, see the [CCME WQI User's manual](#) and the [Technical report](#) (*click on yellow buttons to the right*). The program is composed of the following Excel worksheets:

Getting started: You're here!

Instructions: Important steps to follow to ensure the program functions properly.

Data: Input sheet for raw water quality data.

Note: Negative numbers are treated as missing data. Therefore, if your data set contains tests with values less than zeros you must set them to be at least zero.

Guidelines: Input sheet for up to 400 user-defined water quality objectives.

Tested Data: A colour-coded summary that identifies failed tests and categorizes excursions from objectives.

Output: Output sheet for the CCME WQI values plus other summary information.

Parameter Output: Output sheet for station parameter summary information.

Excursions: Histograms for the F_1 , F_2 , F_3 and CCME WQI values.

After all the pertinent data are entered, the program can be launched by a button imbedded in the "Guidelines" sheet. The next worksheet (Instructions) provides a detailed summary of each sheet and any information regarding format controls and conventions that are necessary to ensure the reliable operation of this program.

**CCME WQI
User's
Manual**
(click here)

**CCME WQI
Technical
Report**
(click here)

**Canadian
Environmental
Quality
Guidelines** *(click
here)*



CCME WQI

Once the CCME WQI value has been determined, water quality is ranked by relating it to one of the following categories:

Excellent: (CCME WQI Value 95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

Good: (CCME WQI Value 80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

CCME WQI

Fair: (CCME WQI Value 65-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal: (CCME WQI Value 45-64) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor: (CCME WQI Value 0 - 44) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

CCME WQI

Station No.	DOE-WQI	WQI (as per CWQI)
1K09	63 (Class III - Slightly Polluted)	39 (Poor)
1K14	46 (Class IV - Polluted)	33 (Poor)
1K15	63 (Class III - Slightly Polluted)	46 (Marginal)
1K18	78 (Class II - Slightly Polluted)	44 (Poor)
1K20	69 (Class III - Slightly Polluted)	39 (Poor)
1K23	64 (Class III - Slightly Polluted)	37 (Poor)
1K26	47 (Class IV - Polluted)	34 (Poor)
1K29	50 (Class IV - Polluted)	39 (Poor)
1K30	53 (Class III - Polluted)	36 (Poor)

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INDEXES IN OTHER COUNTRIES - AUSTRALIA

The index is broken into **5 parts**. It provides a summary of the extent of change from natural or ideal conditions for each of the parts:

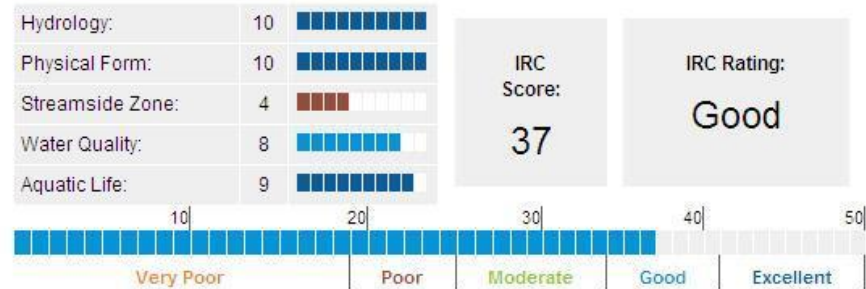
Index Part	Description
physical form	river bank and bed condition, presence of and access to physical habitat, artificial barriers
streamside zone	quality and quantity of streamside vegetation
hydrology	flow volume and seasonality of flow
water quality	key water quality indicators compared against Victorian Government environment protection policy water quality objectives
aquatic life	diversity of macro invertebrates

INDEXES IN OTHER COUNTRIES - AUSTRALIA

Index of River Condition - Middle and Upper Bunyip River

Whiskey Creek is a natural Reach in the Bunyip Basin and within the Western Port Catchment.

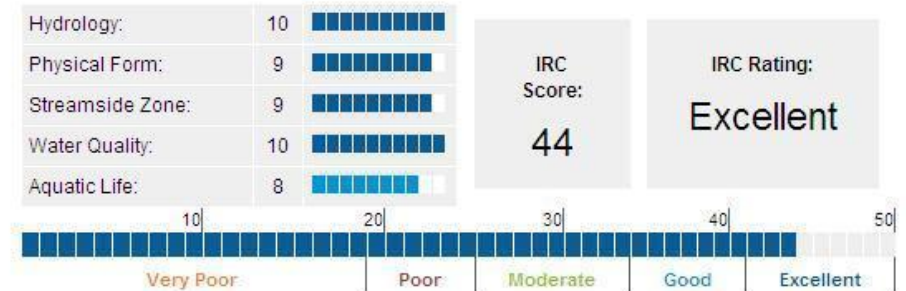
The latest Index of River Condition data for the Whiskey Creek Reach is for the 5 years to 30th June, 2004 and was compiled by Melbourne Water.



Index of River Condition - Watts River Source

New Chum Creek (upper) is a natural Reach in the Yarra Basin and within the Yarra Catchment.

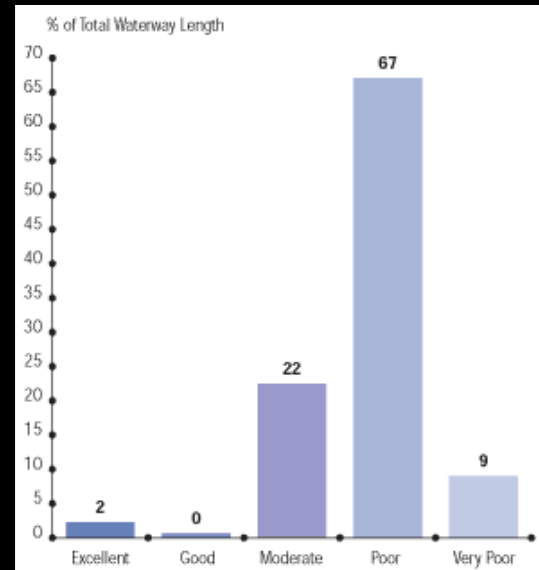
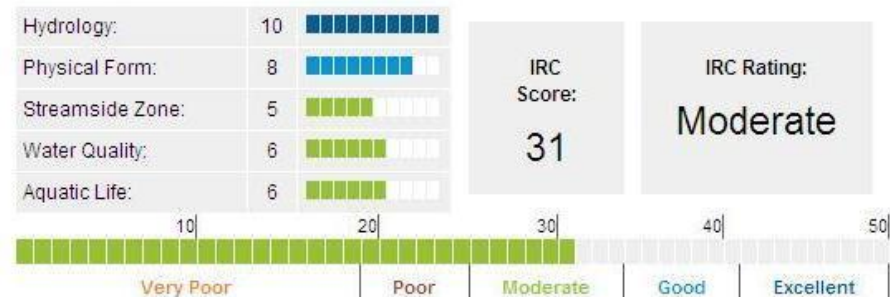
The latest Index of River Condition data for the New Chum Creek (upper) Reach is for the 5 years to 30th June, 2004 and was compiled by Melbourne Water.



Index of River Condition - Watts River Source

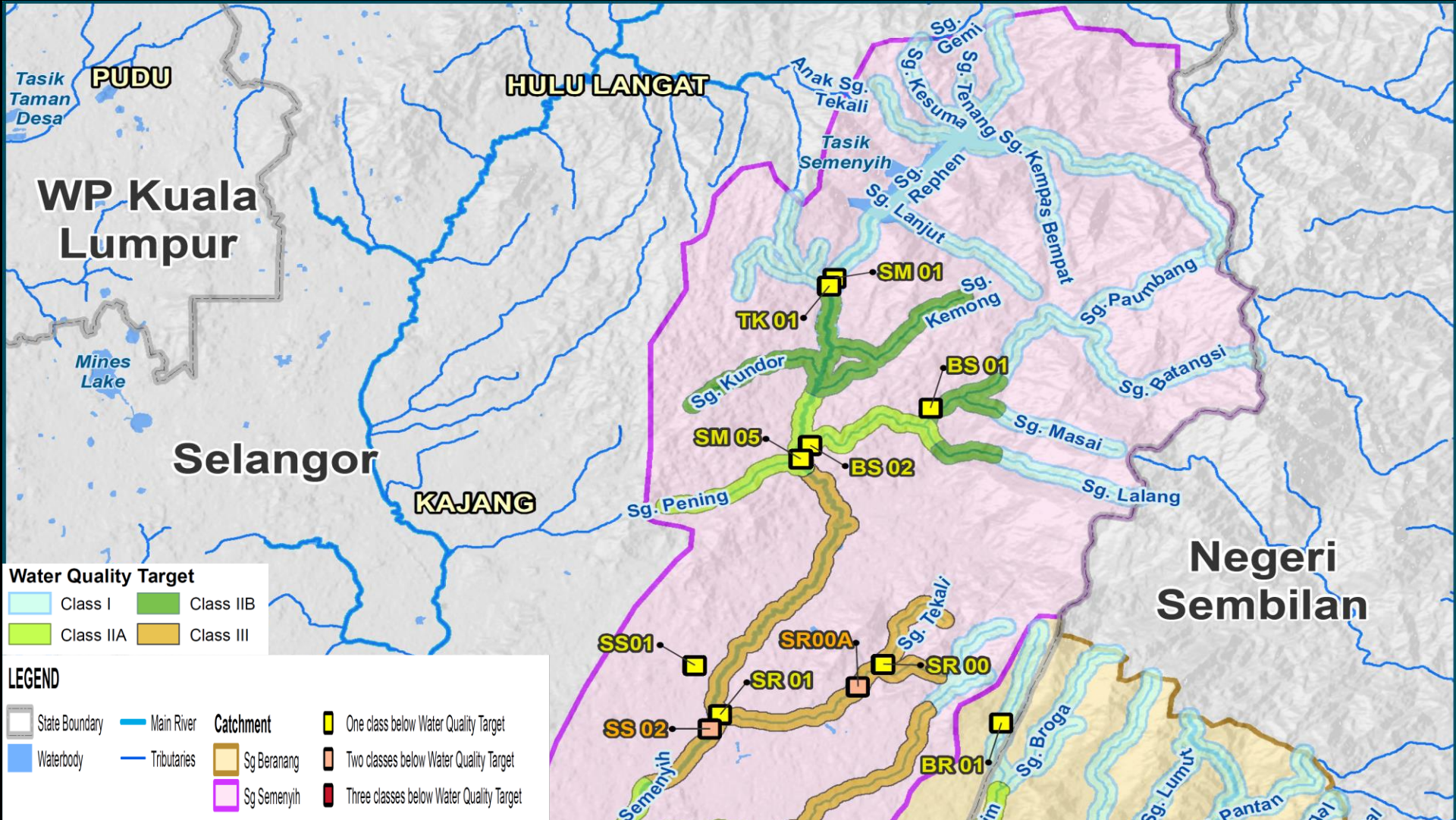
New Chum Creek (Lower) is a natural Reach in the Yarra Basin and within the Yarra Catchment.

The latest Index of River Condition data for the New Chum Creek (Lower) Reach is for the 5 years to 30th June, 2004 and was compiled by Melbourne Water.



TARGETS AND IMPAIRMENTS

WATER QUALITY IMPAIRMENTS

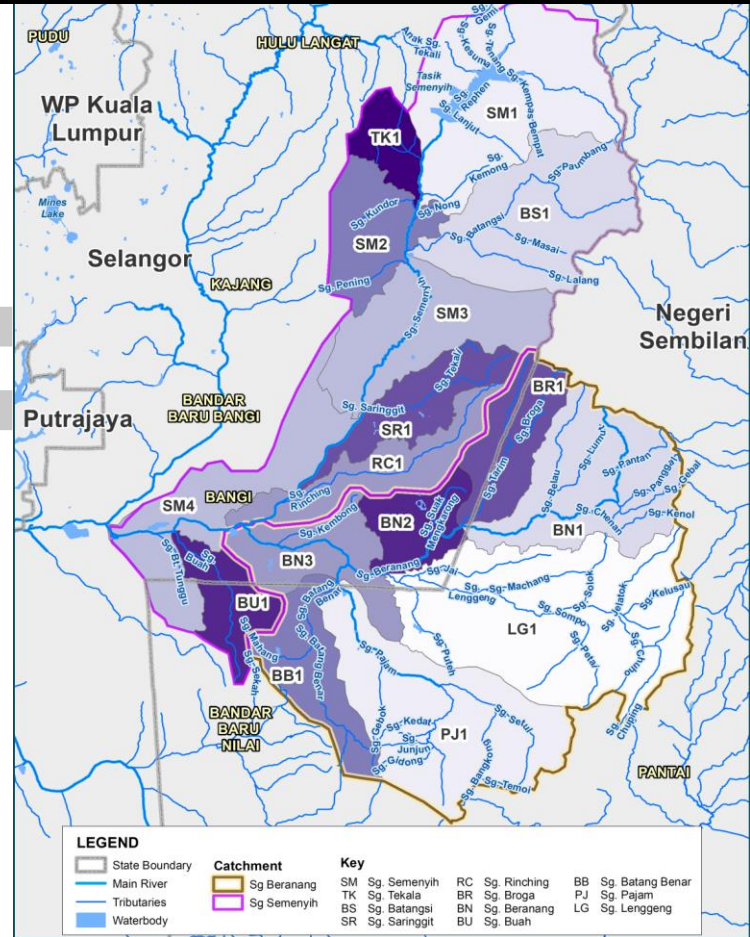


WATER QUALITY IMPAIRMENTS

Station	WQI	DO	BOD	COD	SS	AN
SM 01		-1				
SM 02	-1	-1				
SM 06				-1		
SM 08					-1	
SM 09					-1	
SM 10					-1	-1
SM 11					-1	
SM 14	-1	-1			-1	-1
TK 01	-1	-1				
RC 02						
BN 01	-1		-1	-1	-1	
BN 04		-1				
BR 01	-1	-1	-1	-1		
BR 02		-1				
LG 01	-1	-2			-1	
LG 02					-1	
PJ 03	-1	-2	-2	-2		

Water Quality Targets

 Class I	 Class II	 Class III
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MALAYSIAN MARINE WATER QUALITY STANDARDS (MMWQS)

PARAMETER ($\mu\text{g/l}$) unless otherwise stated	CLASSIFICATION					
	CLASS 1	CLASS 2	CLASS 3	INTERIM CLASS E1	INTERIM CLASS E2	INTERIM CLASS E3
	Sensitive Marine Habitats	Fisheries (including Mariculture)	Industry, Commercial Activities & Coastal Settlements	Estuaries		
				Coastal Plain	Lagoon	Complex Distributary Network
Dissolved Oxygen (mg/l)	>6.0	>5.0	>3.0	>5.0	>5.0	>5.0
Total Suspended Solids (mg/l)	25.0	50.0	100.0	30.0	30.0	30.0
Phosphate	5.0	75.0	670.0	100.0	180.0	180.0
Nitrate	10.0	60.0	700.0	200.0	570.0	430.0
Ammonia	35.0	50.0	320.0	5.0	10.0	10.0
Mercury	0.04	0.04	0.04	0.04	0.04	0.04
Cadmium	0.50	2.00	3.00	1.00	1.00	1.00
Chromium (VI)	0.14	10.00	20.00	10.00	10.00	10.00
Copper	1.30	2.90	8.00	1.00	1.00	1.00
Cyanide	2.00	7.00	14.00	5.00	5.00	5.00
Lead	2.20	8.50	12.00	1.30	2.00	2.00
Zinc	7.00	50.00	100.00	16.00	5.00	5.00
Arsenic (III)	1.00	3.00	3.00	3.00	1.00	1.00
Aluminium	27.00	27.00	55.00	27.00	27.00	27.00
TBT	0.001	0.010	0.050	0.002	0.002	0.002
PAH	100.0	200.0	1000.0	5.0	5.0	5.0
Total Phenol	1.0	10.0	100.0	10.0	10.0	10.0
Oil & Grease mg/l	0.01	0.14	5.00	1.00	1.00	1.00
Faecal Coliform (Cfu/100ml)	70	70	70	70	70	70
Temperature ($^{\circ}\text{C}$)	$\leq 2^{\circ}\text{C}$ increase over maximum ambient					
pH	6.5 - 9.0					
Marine litter	Free from marine litter					

MALAYSIAN MARINE WATER QUALITY STANDARDS (MMWQS)
SUPPLEMENTARY LIST
(Pesticide)

PESTICIDE TYPE	ACTIVE INGREDIENT	STANDARD ($\mu\text{g/l}$)
Herbicide	Atrazin	10
	Bentazone	5000
	2,4 D	200
	2,4 D (ester)	10
	Diuron	0.2
	Metolachlor	0.020
	Paraquat	0.6
	Carbaryl	5.7
	Chloropyrifos	0.011
	Dichlorvos	0.6
Insecticide	Dimethoate	1
	Malathion	0.6
	Temephos	0.0004

GUIDANCE NOTES

- i. The application of the MMWQS is based on a predetermined classification of the marine waters of interest.
- ii. The process of classification should not result in the application of a class of lower water quality compared to the existing ambient water quality.
- iii. In situations where there exists the possible application of more than one class, the more stringent class should take precedent.
- iv. In situations where the adjacent body of water is subjected to a more stringent water quality requirement compared to the waters of interest, then the class with the more stringent water quality requirement shall apply.
- v. Application of standards imposed in EIA approval conditions shall take precedent over any classification.
- vi. The proper and meaningful application of the MMWQS requires that the corresponding ambient data is generated by employing the appropriate standard methods of water sampling protocols, *in situ* measurements and analysis. Special considerations should be taken into account with respect to the application of Class E¹.
- vii. The analytical methodology² to be adopted for the determination of the respective MMWQS parameters is required to comply to the following criteria:
 - Represents a recognized standard method such as those published by APHA, USEPA or other equivalent sources.
 - Allows for a Level of Reporting (LoR) equal or less than the corresponding threshold value of the respective MMWQS parameter.
 - Conducted at a laboratory accredited for the respective MMWQS parameter.
- viii. Class R³
The *Standard Kebangsaan Kualiti Air Rekreasi Semulajadi dan Garispanduan bagi Pemantauan Air Rekreasi Semulajadi (Air Marin & Air Tawar)*², Ministry of Health, Malaysia, is applied in relation to recreational use of marine waters.
- ix. Application of standards related to pesticide residues as presented in the Supplementary List is most relevant in estuarine waters and waters in the vicinity of agricultural areas.

**²STANDARD KEBANGSAAN KUALITI AIR REKREASI SEMULAJADI
BAGI PARAMETER PRIMA**

NO.	Parameter	Unit	Standard	
			Marine Water	
			Primary Contact	Secondary Contact
Microbial				
1.	Enterococci	Count/100 ml	35 ^e	230 ^e
2.	Faecal Coliforms	Count/100 ml	100 ^b	1000 ^c
3.	Leptospira species	-	Not Detected	
Nuisance Algae				
4.	Cyanobacteria	Cyanobacteria Cells/ml	15000 ^e	15000 ^e
Physical and Chemical				
5.	pH	-	5.0 – 9.0 ^e	5.0 – 9.0 ^e
6.	Temperature	°C	15 – 35 ^e	15 – 35 ^e
Aesthetics				
7.	Colour	TCU	-	-
8.	Turbidity	NTU	-	-
9.	Dissolved oxygen (DO)	mg/l	-	-
10.	Total dissolved solid (TDS)	mg/l	1000 ^f	1000 ^f

^aASEAN

^bANZECC

^cPiawai Mutu Air Minum Kebangsaan, KKM

The MMWQI is calculated as follows:

$$\text{MMWQI}^* = q_{\text{DO}}^{0.18} \times q_{\text{FC}}^{0.19} \times q_{\text{NH}_3}^{0.15} \times q_{\text{NO}_3}^{0.16} \times q_{\text{PO}_4}^{0.17} \times q_{\text{TSS}}^{0.15}$$

Whereby,

q_{DO}	=	$-85.816 + 55.4768(\text{DO}) - 4.142(\text{DO}^2)$	When DO is < 3 mg/L, $q_{\text{DO}} = 10$ When DO is > 10 mg/L, $q_{\text{DO}} = 10$
q_{FC}	=	$100 \cdot \text{EXP}(-0.0001(\text{faecal coliform}))$	IF FC > 500 Faecal coliform count/100ml, $q_{\text{FC}} = 8$
q_{NH_3}	=	$100 \cdot \text{EXP}(-0.0001(\text{Total of Ammonia}))$	
q_{NO_3}	=	$94.8 \cdot \text{EXP}(-0.0001(\text{Nitrate}))$	
q_{PO_4}	=	$95.2 \cdot \text{EXP}(-0.0001(\text{Phosphate}))$	When PO ₄ > 900 µg/L, $q_{\text{PO}_4} = 10$
q_{TSS}	=	$95.8 \cdot \text{EXP}(-0.0001(\text{Total Suspended Solid}))$	When TSS > 100 mg/L, $q_{\text{TSS}} = 20$

*Salinity of the marine water quality data shall be higher than 10 ppt

MMWQI	CLASS
90 - 100	Excellent
80 - 89	Good
50 - 79	Moderate
0 - 49	Poor

THANK YOU

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