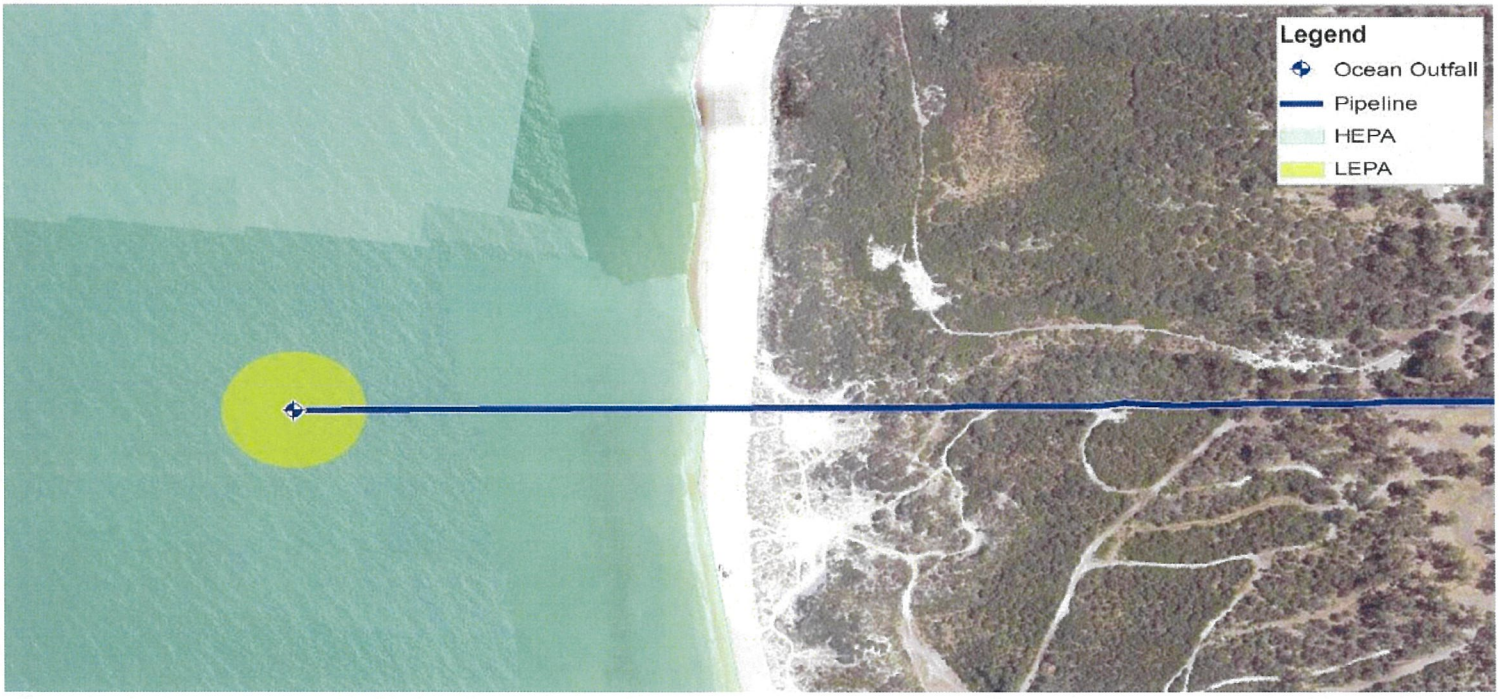
Albemarle Marine Discharge Outfall

Discharge Monitoring and Management Plan (DMMP)

South-West Industrial Water Services Pty Ltd

08 September 2026



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Acronyms and Abbreviations

Abbreviation	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Governments
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
As	Arsenic
Cd	Cadmium
COC	Chain of Custody
Cr	Chromium
CTD	Conductivity Temperature Depth profiler
Cu	Copper
DMMP	Discharge Monitoring and Management Plan
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
EV	Environmental Value
HEPA	High Ecological Protection Area
Hg	Mercury
ISQG	Interim Sediment Quality Guideline
km	kilometres
KSIA	Kemerton Strategic Industrial Area
L	Liter
LEP	Level of Ecological Protection
LEPA	Low Ecological Protection Area
LoR	Limit of Reporting
m	Meter
mg	Milligrams
MEPA	Moderate Ecological Protection Area
NATA	National Association of Testing Authorities
NH_4^+	Ammonium
Ni	Nickel
NO_X	Inorganic Oxidised Nitrogen
NTU	Nephlometric Units

Abbreviation	Definition
Pb	Lead
PO_4^{3-}	Phosphate
PSU	Practical Salinity Units
QA/QC	Quality Assurance/ Quality Control
RPD	Relative Percentage Difference
RO	Reverse Osmosis
SDS	Safety Data Sheet
sec	Second
SSDP	Southern Seawater Desalination Plant
TBA	To Be Advised
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP	Total Phosphorus
UM3	Update Merge 3
WA	Western Australia
WET	Whole Effluent Testing
$\Delta S_{HEPA-LEPA}$	Salinity difference at HEPA-LEPA boundary site relative to the reference site
µg	Micrograms

How to use this DMMP: This plan should be read as a practical pathway from environmental criteria to monitoring, assessment and response. Section 3 defines the environmental quality framework and compliance criteria; Section 4 sets out where, when and how samples and measurements are collected; Section 5 explains how monitoring results are assessed and what actions are required if EQG or EQS criteria are not met; and Section 6 sets out review and reporting obligations.

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1. Introduction

1.1 The Harvey Water KSIA Project

Harvey Water supplies non-potable water to rural areas in the south-west region primarily for agricultural industry use. Water is drawn under license from Waroona, Drakesbrook, Logue Brook, Harvey and Wellington Dams, and the Wokalup pipe head. Water is piped under gravity pressure through 495 kilometres (km) of closed pipelines and 256 km of open channels to its customers (Harvey Water 2020).

As part of expansion, Harvey Water constructed enabling infrastructure at the Kemerton Strategic Industrial Area (KSIA), Western Australia (WA) to provide wastewater disposal services to customers established in the KSIA. This enabling infrastructure consists of a pipeline, ~12 km in length, which transfers wastewater from the KSIA to the Indian Ocean. The pipeline route and ocean outfall are shown in Figure 1.1, which lies 3.3 km west of Parkfield, and ~3 km south of Binningup, WA (see Table 1.1**Error! Reference source not found.** for coordinates). The outfall is buried and extends ~350 meters (m) from the shoreline, where it will emerge from the seabed. The outfall lies on the seabed in ~8 m water depth.

The KSIA pipeline and marine outfall became operational in October 2022.

Table 1.1 Location of the KSIA outfall

	Easting	Northing	Geodetic Reference
KSIA outfall location	115.678997	-33.175668	GDA94, MGA Zone 50

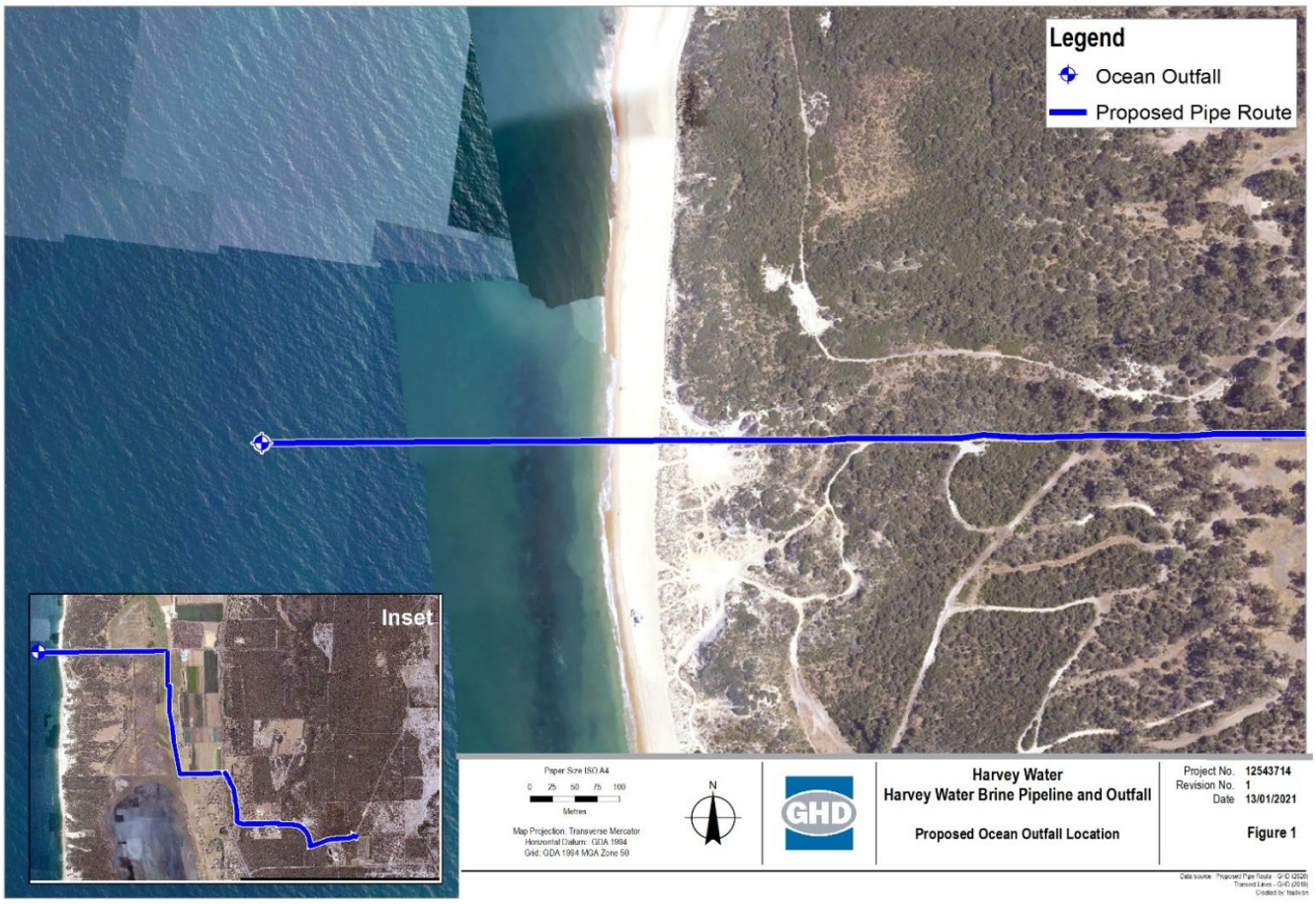

Figure 1.1 Wastewater pipeline and ocean outfall location

1.2 Document purpose

This document, the Discharge Monitoring and Management Plan (DMMP), describes the monitoring and management methodology and requirements to ensure that wastewater discharges via the outfall into the marine environment meet regulatory requirements. This version of the DMMP (Rev2.1) is an update of the March 2022 (Rev1) version.

2. Existing marine environment

2.1 Bathymetry

The KSIA pipeline traverses a simple offshore bathymetry that is oriented approximately north-south with the absence of an offshore limestone ridge (Figure 2.1). Hence, the nearshore waters are fully exposed to offshore wind, wave and current influences.

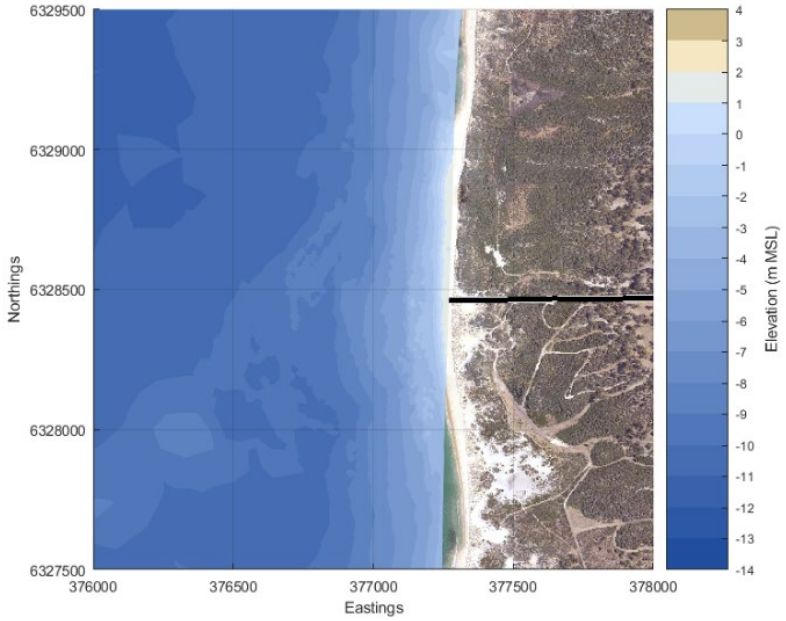

Figure 2.1 Bathymetry in locale of KSIA pipeline outfall (2021)

2.2 Oceanography

Tides along the coastline have a maximum tidal range of 1.2 m (difference between highest and lowest astronomical tides) (GHD,2021a).

The wave climate of the wider Binningup region is dominated by swell and wind waves (Oceanica 2008). Waves from the open waters to the west and north-west are less affected by shoaling and refraction. Wind waves from these directions are generated by low pressure systems and associated cold fronts that are common in winter. Concurrent swells from these directions may combine with wind waves to generate higher resultant waves.

Summer winds are predominantly from the southwest (afternoons) to east (mornings) with lower winds typically during April (GHD 2021a). Peak wind speeds typically occur during winter from the west (GHD 2021a). Winds are a dominant factor in the dispersion of brine discharge from the Southern Seawater Desalination Plant (SSDP) at nearby Binningup (KBR 2008, Oceanica 2008). Measured currents at the nearby SSDP site were below 0.15 m/s for 95% of the time (UWA 2008).

2.3 Temperature, salinity and turbidity

Temperature and salinity measurements of the SSDP baseline data from CTD profiling, several seaglider (autonomous underwater vehicle) deployments, and conductivity sensors at fixed heights documented:

Salinity of ~34.5 PSU in winter-spring to ~36.5 PSU in summer.

Water temperature of ~15°C in winter-spring to ~24°C in summer-autumn.

SSDP baseline measurements of turbidity and dissolved oxygen ranged from ~1-4 NTU and ~6.5-8.5 mg/L, respectively.

2.4 Water quality

SSDP baseline monitoring site BY-5000S is near the KSIA pipeline outlet. Mean annual background levels of nutrients at this site are summarised in Table 2.1.

Table 2.1 Mean annual background nutrient levels at site BY-5000S (KBR 2008) and default guideline values

	NH_4^+ (µg/L)	NO_X (µg/L)	TN (µg/L)	PO_4^{3-} (µg/L)	TP (µg/L)
ANZECC & ARMCANZ (2000)	5	5	230	5	20
ANZG (2018)	-	2.6 (spr)-7.5 (win) (NO_3^-)	-	5.9 (spr)-16.5 (win)	-
BY-5000S	8	6	88	4	9

Oil and grease and total petroleum hydrocarbons were below the limits of reporting (LoR) over the SSDP baseline monitoring period (KBR 2008). Heavy metals and metalloids were below the ANZECC & AMRCANZ (2000) 99% species protection level except for chromium (IV) and lead in winter, and copper in autumn and winter (KBR 2008).

2.5 Benthic communities and habitats

A 15 November 2019 benthic habitat survey identified habitat types, dominant species and potential sensitive habitats/species in the vicinity of the pipeline and outlet (GHD 2021b). The two major substrate types were unconsolidated sand and consolidated reef/hard rock/boulders. Reef types included low relief (<1 m) dominated by algae, and low/moderate relief (1-3 m) with mixed algal and epifauna assemblages. Reef structure and assemblages changed with distance from shore, where sandy patches became more frequent. A summary of the benthic organisms identified include:

Seagrass was dominated by *Amphibolic spp.* in the nearshore waters (with macroalgae) but not observed in the offshore transects (including the outlet location) (Figure 2.2). Seagrass density and coverage were considered insufficient to constitute seagrass meadows.

Few macroalgae species could be identified to species level, though high diversity and abundance was evident ranging from filamentous to large canopy forming morphologies with moderate to dense coverage (Figure 2.3). Large macroalgae (e.g. *Ecklonia spp*.) dominated the nearshore waters with generally a reduction in size with distance offshore.

Epifauna were mostly on consolidated substrate with <30% coverage due to relatively high macroalgal density.

Sponges were the dominant benthic macro-organism and appeared relatively diverse, ranging from encrusting to erect forms.

The sea tulip (*Pyura spp*.), a sessile ascidian, was also observed regularly.

2.6 Primary and secondary contact

The nearshore marine waters in the vicinity of the KSIA pipeline and outlet are used for a range of human activities that involve primary and secondary contact including, but not limited to, swimming and wading at beaches, recreational boating, paddle craft and fishing.

2.7 Fisheries

Fisheries in the proximal coastal waters to the KSIA outlet include:

Recreational and commercial fishers for crabbing, handheld line fishing and beach seining for whitebait and herring.

WA State Fisheries that operate within or immediately adjacent to the project area include the blue swimmer crab and the whitebait fishery. The key areas in the region that used by commercial fishers include from Forest Beach to Binningup.

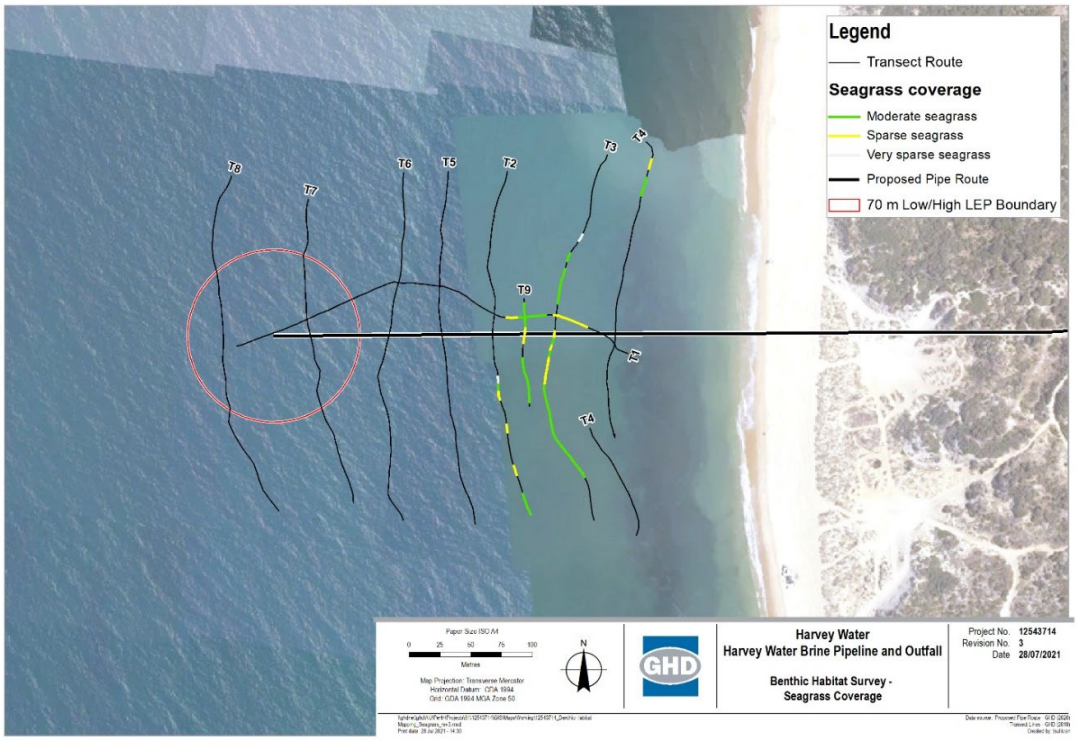

Figure 2.2 Seagrass distribution along underwater video survey transects lines (actual) on 15 November 2019 (GHD 2021b)

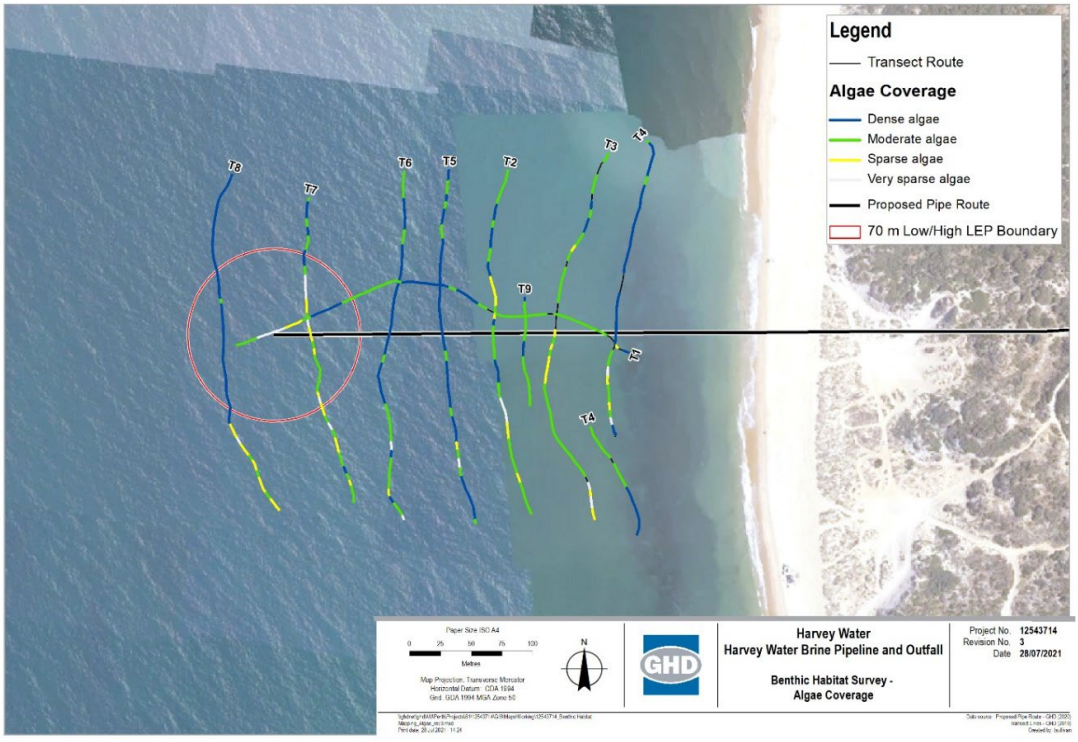

Figure 2.3 Macroalgae distribution along the underwater video survey transects lines (actual) on 15 November 2019 (GHD 2021b)

2.8 Marine fauna

Though the Whale Shark, Great White Shark, Grey Nurse Shark and Mackerel Shark are listed or protected fish potentially found within the project area, all are unlikely to be present except the Great White Shark sporadically, particularly during periods of whale migration.

Though the Loggerhead Turtle, Green Turtle, Leatherback Turtle and Flatback Turtle are listed or protected marine reptiles potentially found within the vicinity of the KSIA pipeline and outlet, all are unlikely to be present.

The Australian Sea Lion is the only listed or protected pinniped potentially found within the vicinity of the KSIA pipeline and outlet, though it is unlikely to be present as there are no proximal breeding colonies, haul-out sites or foraging areas.

The Pygmy Blue Whale, Southern Right Whale, Humpback Whale, Bryde's Whale, Pygmy Right Whale, Killer Whale, Dusky Dolphin and Spinner Dolphin are listed or protected cetaceans potentially found within the vicinity of the KSIA pipeline and outlet, the occurrence of these species is:

Unlikely for the Pygmy Blue Whale, Bryde's Whale, Pygmy Right Whale, Killer Whale and Dusky Dolphin.

Likely for the Southern Right Whale during winter and Humpback Whale during summer in the deeper waters.

3. Environmental quality plan

3.1 Environmental Protection Act 1986

The Environmental Protection Authority (EPA) exercises its powers under the *Environmental Protection Act 1986* (Government of Western Australia 2020). Section 44 (2) establishes that the EPA must make references to key environmental factors when assessing the potential environmental impacts of a referred proposal.

Environmental factors are those parts of the environment that may be impacted by an aspect of a proposal or scheme. The EPA has 14 environmental factors, organised into five themes: Sea, Land, Water, Air and People. The factors and objectives for sea are set out in Table 3.1. Of relevance to this DMMP is the factor marine environmental quality. This was the key EPA consideration around which the DMMP was designed.

Table 3.1 Environmental factors and objectives for theme 'Sea' (EPA 2020)

Theme	Factor	Objective
Sea	1. Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.
	2. Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.
	3. Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected.
	4. Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained.

3.1.1 Marine environmental quality

Environmental quality refers to the level of contaminants in water, sediments or biota or to changes in the physical or chemical properties of waters and sediments relative to a natural state. In the context of marine water quality, emissions or discharges that can cause water quality deterioration are the key considerations. For the KSIA outfall discharge, potential impacts to water quality are monitored and managed as per this DMMP.

3.1.2 Coastal processes

No effect on the coastal processes was caused by the project as horizontal directional drilling of the marine segment of the KSIA pipeline was below the supra- and inter- tidal regions of the shoreline to occur.

3.1.3 Benthic communities and habitats

The KSIA outfall discharge is buoyant and does not impact benthic communities and habitats. Direct and indirect impacts in the vicinity of the outlet where the KSIA pipeline emerges from construction activities were unlikely to have occurred as evidenced by the pre- and post- construction surveys of the benthic communities and habitats carried out in accordance with the Construction Environmental Management Plan.

3.1.4 Marine fauna

No or negligible effects on marine fauna have been caused through operations of the project. Direct (collision with vessel) or indirect (construction noise) impacts in the vicinity of the outlet where the KSIA pipeline emerged were not known to occur during construction of the outlet. Standard controls to prevent (collision) and mitigate (underwater noise) potential marine fauna impacts were implemented during the short-term and minor outlet construction activities.

3.2 Environmental quality management framework

This DMMP adopts the EPA (2016) Environmental Quality Management Framework (EQMF) for Western Australian marine waters as illustrated in Figure 3.1.

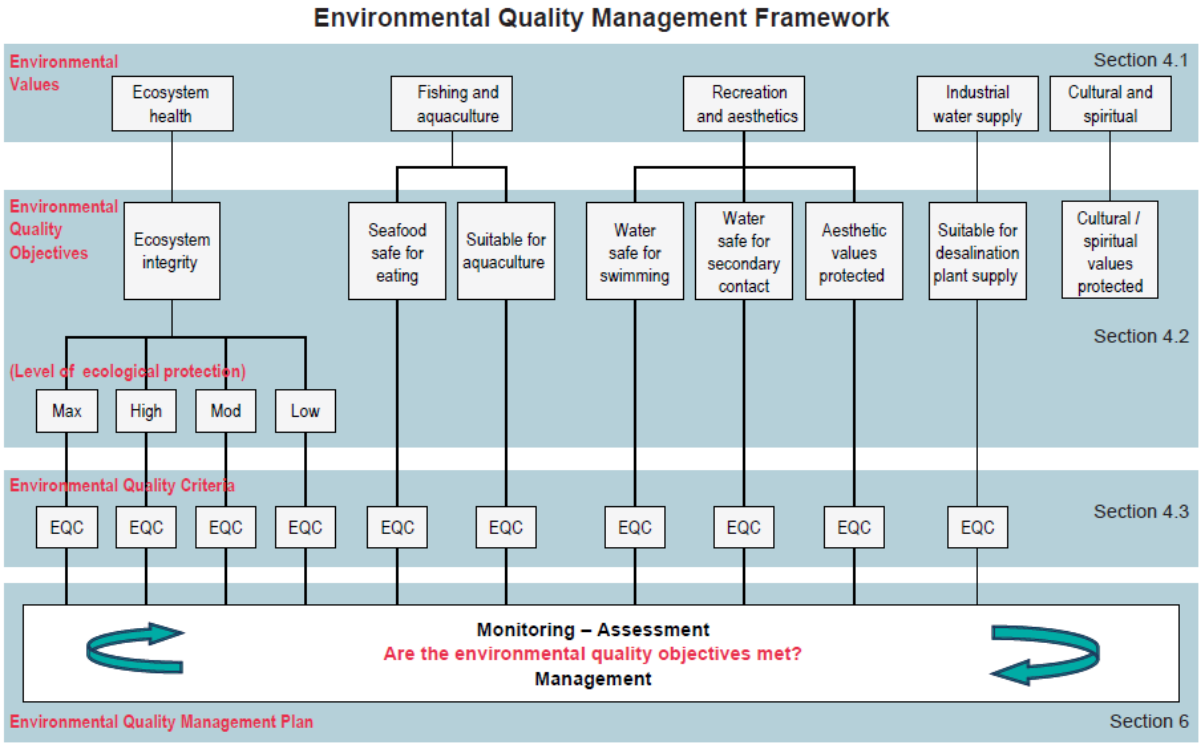

Figure 3.1 EQMF for Cockburn Sound (EPA 2016)

The key elements of the EQMF are Environmental Values (EVs), Environmental Quality Objectives (EQOs) and Environmental Quality Criteria (EQC) as described in Table 3.2.

Table 3.2 Framework for target setting

Element	Description
Environmental Value (EV)	Establish a broad area of ecological or social importance to the stakeholders
Environmental Quality Objective (EQO)	Specify the stakeholder aspirations for specific management objectives for each Value
Environmental Quality Criteria (EQC)	Benchmarks that indicate level of performance in meeting objectives as monitored outputs or measured inputs

3.2.1 Environmental values and objectives

EVs and EQOs identified for the KSIA pipeline outfall are summarised in Table 3.3. This Environmental Quality Plan (EQP) explicitly delineates spatial areas of varying ecological protection, specifically for the EV of Ecosystem Health and the EQO of Maintenance of Ecosystem Integrity. All other relevant EVs (Fishing and Aquaculture, Recreation and Aesthetics, Cultural and Spiritual, Industrial Water Supply) are protected everywhere outside of the Low Ecological Protection Area (LEPA, refer to Section 3.2.3).

Table 3.3 EVs and EQOs for coastal waters in vicinity of KSIA pipeline outfall

EVs	EQOs and Descriptions
Ecosystem Health	Maintenance of ecosystem integrity Marine ecosystem integrity is considered in terms of structure (e.g. the biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles) to an appropriate level.
Fishing and Aquaculture	Maintenance of seafood safe for human consumption Seafood is safe for human consumption when collected.
Recreation and Aesthetics	Maintenance of primary contact recreation values Primary contact recreation (e.g. swimming) is safe to undertake.
	Maintenance of secondary contact recreation values Secondary contact recreation (e.g. boating) is safe to undertake.
	Maintenance of aesthetic values The aesthetic values are protected.
Cultural and Spiritual	Cultural and spiritual values of the marine environment are protected Indigenous cultural and spiritual values are not compromised.
Industrial Water Supply	Maintenance of water quality for industrial use Water quality is suitable for *potential future* industrial use.

3.2.2 Environmental quality criteria

While EQOs are qualitative with narrative descriptions, whereas EQC are quantitative and provide a basis to measure environmental quality performance. EQC define the limits of acceptable change to environmental quality (expressed narratively as the EQOs), whereby EQC compliance assumes EQO achievement. The two types of EQC are:

Environmental Quality Guideline (EQG): Threshold numerical value(s) or narrative statement(s) when satisfied indicate a high degree of certainty that the associated EQO is achieved. If not satisfied, then assessment against an environmental quality standard(s) (EQS) is triggered because of uncertainty as to whether the associated EQO has been achieved.

Environmental Quality Standard (EQS): Threshold numerical value(s) or narrative statement(s) when not satisfied indicate a significant risk that the associated EQO is not achieved, and with continued EQS exceedance a management response is triggered.

EQG and EQS use indicators closer to the pressure and response ends of the pressure-response relation, respectively. The conceptual framework for applying EQC is illustrated in Figure 3.2.

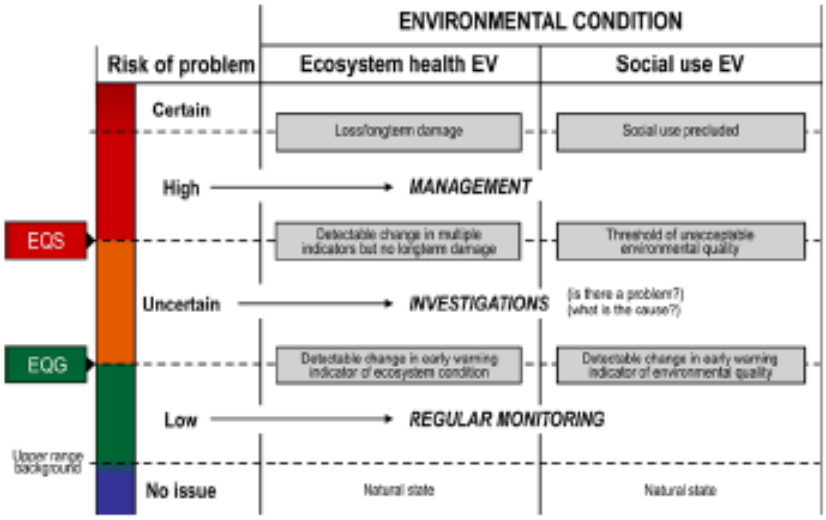

Figure 3.2 Conceptual diagram showing relation between two types of EQC (EQG and EQS shown on left) and associated environmental condition (shown on the right) (EPA 2016)

3.2.3 Levels of ecological protection for the ecosystem health environmental value

Four levels of ecological protection (LEPs) can be spatially applied to represent the minimum acceptable level of Marine Environmental Quality to be achieved through management:

Maximum LEP Area (Maximum Ecological Protection Area): Allowance for no changes in the quality of water, sediment or biota (e.g. no changes in contaminant concentrations with no resultant detectable changes beyond natural variation in the diversity of species and biological communities, ecosystem processes and abundance/biomass of marine life).

High LEP Area (High Ecological Protection Area or HEPA): Allowance for small changes in the quality of water, sediment or biota (e.g. small changes in contaminant concentrations with no resultant detectable changes beyond natural variation in the diversity of species and biological communities, ecosystem processes and abundance/biomass of marine life).

Moderate LEP Area (Moderate Ecological Protection Area or MEPA): Allowance for moderate changes in the quality of water, sediment and biota (e.g. moderate changes in contaminant concentrations that cause small changes beyond natural variation in ecosystem processes and abundance/biomass of marine life, but no detectable changes from the natural diversity of species and biological communities).

Low LEP Area (Low Ecological Protection Area or LEPA): Allowance for large changes in the quality of water, sediment and biota (e.g. large changes in contaminant concentrations causing large changes beyond natural variation in the natural diversity of species and biological communities, rates of ecosystem processes and abundance/biomass of marine life, but which do not result in bioaccumulation/ biomagnification in near-by high ecological protection areas).[1]

As described in EPA (2017), ANZECC (2000) (now ANZG (2018)) recognises and provides guidelines for three of the four LEP types (noting no change allowed in Maximum Ecological Protection Area) that are the basis for the EGQs, namely:

Undisturbed (i.e. HEPA) where:

Recommended 99% species protection guideline trigger levels for toxicant in waters.

Interim Sediment Quality Guideline (ISQG) -low guideline trigger levels for toxicants in sediments.

The 80th percentile and/or 20th percentile of the data distribution for a suitable relatively unmodified reference site for the physical and chemical stressors or the default guideline trigger value provided.

Slightly to moderately disturbed (i.e. MEPA) where:

Recommended 90% species protection guideline trigger levels for toxicant in waters.

ISQG-low guideline trigger levels for toxicants in sediments.

The 95th percentile and/or 5th percentile of the data distribution for a suitable relatively unmodified reference site for the physical and chemical stressors.

Highly disturbed (i.e. LEPA) where:

For toxicants with potential to adversely bioaccumulate or biomagnify, the recommended 80% species protection guideline trigger levels for toxicant in waters.

3.3 EQMF implementation

3.3.1 Contaminants of concern

As part of the environmental approvals, contaminants of concern in the wastewater were identified along with estimates of their concentrations GHD (2021a). Subsequently, wastewater monitoring since the onset of operations has included periods of discharge via the outfall (monthly December 2022-September 2023, February & May 2024) and no outlet discharge when wastewater was transferred to a waste facility due to poor water quality (July-October 2024 with weekly to fortnightly measurements). The GHD (2021a) estimates and subsequent maximum

[1] The fourth category of LEP, namely 'Low', in the Western Australia context generally only occurs in the immediate region of outfalls (e.g. wastewater or desalination) such as the KSIA pipeline outfall.

concentrations of monitoring measurements of wastewater samples that were discharged to the marine environment are summarised in Table 3.4. One analyte was removed in this DMMP update, namely sodium molybdate, because molybdate is measured.[2]

No other discharges are expected to be discharged into the pipeline other than the RO plant (operated by Harvey Water on behalf of MARBL Lithium). Any future additional client discharges into the pipeline will be directly from their treatment plant and are to be monitored in line with this DMMP. For each new industry that discharges into the pipeline, contaminants of concern in Table 3.4 will be updated accordingly in future updates of the DMMP.

Table 3.4 GHD (2021a) estimated and 2022-2024 maximum (minimum for salinity and pH) measurements of wastewater concentrations and sampling dates of contaminants of concern that were discharged via the outlet

Analyte	Units	Max Estimated $C_{Outfall}$ for DMMP Rev1	Max Measured $C_{Outfall}$ for DMMP Rev 2.4	Max Sampling Date for Updated DMMP Rev2.4 Max $C_{Outfall}$	Contaminant of Concern Status
pH	unitless	8.51	7.2	10 August 2023	Contaminant of Concern
Nitrate	mg/L	2.8	3.2	10 August 2023	Contaminant of Concern
Salinity (S)	PSU	11.93[3]	2.3	10 August 2023	Contaminant of Concern
Sodium Molybdate	mg/L	152.7[4]	Not Measured	Not Measured	Removed, molybdate monitored
THPS (Biocide)	mg/L	381.7[4]	1.1	29 August 2023	Contaminant of Concern
Phosphonates (PBTC)	mg/L	77.4[4]	56	12 February 2024	Contaminant of Concern
Phosphonates (HEDP)	mg/L	77.4[4]	0.05	LoR for all measurements	Contaminant of Concern
Polyacrylate	mg/L	2.9[4]	0.1	LoR for all measurements	Contaminant of Concern
Azole	mg/L	38.2[4]	0.9	17 June 2024	Contaminant of Concern
Molybdate	mg/L	119.1[4]	40	12 February 2024	Contaminant of Concern

3.3.2 Pressure-response considerations

Pressure-response considerations for operational activities for the KSIA outlet are summarised in this sub-section.

3.3.2.1 Pressure: increased nutrients

The discharge from the KSIA outlet can potentially stimulate phytoplankton growth that can cause shading (decreases in water clarity) and potentially impact benthic primary producers (EQO Maintenance of Ecosystem Integrity) and increase visual blight (EQO Maintenance of Aesthetic Quality). The combination of a buoyant plume, and rapid dispersion of nutrients and algal levels, occurs in this open nearshore environment so that there is a negligible risk to benthic primary producers within the HEPA.

3.3.2.2 Pressure: increased toxicants

Operations can potentially result in toxicant levels that may lead to increased risks to primary and secondary recreational contact, tainting of seafood, and impacts to marine organisms. The monitoring in this DMMP has been designed to demonstrate that potential toxicant impacts to marine organisms are limited to within the LEPA. Further, the environmental performance criteria for marine organisms are more stringent than those for primary contact values (e.g. As, Cd, Cr, Cu, Pb, Hg, Ni).

3.3.2.3 Pressure: increased microbiological contaminants

No microbiological contaminants are discharged via the outfall, so there are no concomitant risks to primary and secondary recreation and tainting of seafood.

[2] Met DMMP Rev1 Section 6.1.1 (Initial implementation) commitment to finalise 'process chemical' analytes (or analogues).
[3] Salinity (PSU, or ppt) is calculated from the TDS concentration
[4] Outlet concentration is estimated to be 7.7x the reverse osmosis (RO) feed water concentration and assuming process chemicals in the feed water are conserved in wastewater as described in GHD (2021a).

3.3.3 Environmental quality criteria

3.3.3.1 HEPA EQGs

Four EQGs evaluate whether impacts from wastewater discharge to the marine environment are limited within the LEPA, which are defined next. After each monitoring round, compliance with all four EQGs is determined in a compliance assessment table that is reproduced in Appendix B.

3.3.3.1.1 EQG 1

EQG 1: *The concentration of each toxicant in the wastewater stream prior to discharge is below the level to achieve 99% species protection (95% for cobalt) (ANZG 2018) at the HEPA/LEPA boundary.*

The allowable levels in the wastewater discharge via the outlet are determined with the following equation:

$C_O = D \times (C_t - C_a) + C_a$

where:

C_O = Allowable upper limit of outlet concentration to achieve EQG 1 as a function of wastewater discharge and the resultant near-field dilution of the centreline of the plume.

D = 208 fold dilution factor based on the plume centreline dilution for Stage 1 peak flowrate of 15 l/s.

C_t = Target toxicant concentration to achieve a 99% species protection level (95% for cobalt).

C_a = Ambient marine concentration of toxicant from baseline monitoring, or if unavailable from Table 12 of DoE (2004) (Appendix B).

Appendix A describes the methodology to estimate the dilution factor (D) to apply to EQG1 (and EQG 2).

Appendix B summarises the metals/metalloids toxicant monitoring data of the wastewater, the ambient seawater metals/metalloids concentrations, the dilution factor (D), and the compliance of metals/metalloids with EQG 1.

3.3.3.1.2 EQG 2

EQG 2: *The salinity differential in marine waters at the LEPA/HEPA boundary and the reference site is 0.25 PSU or less.*

EQG 2 will be revised as the 20th percentile of different seasons of the natural background when a cumulative two-year baseline period is acquired at the site (EPA 2016). Other data from nearby operations (e.g. Binningup wastewater treatment plant) are suitable to serve as background data. Given the low wastewater discharge rates to date (Appendix A), the need for a seasonal temporal granularity in salinity EQG is not required currently.

3.3.3.1.3 EQG 3

EQG 3: *The number of dilutions between the outlet and the LEPA/HEPA boundary is > 208x.*

The number of dilutions of the wastewater stream with ambient marine waters to achieve a 99% species protection level will be determined via whole effluent testing (WET) with eight marine species on two occasions during the first two months of operation of a substantive change in the wastewater stream (ie. addition of waste stream). The maximum dilution of these two WET tests will be adopted as the EQG 3 value.

3.3.3.1.4 EQG 4

EQG 4: *The concentration of each process chemical (or analogue) in the wastewater stream prior to discharge is below the concentration that was WET tested in EQG 3.*

Direct measurement of concentrations of known process chemicals in the wastewater stream(s) will be targeted during routine monitoring. If not possible or reliable to measure directly, then suitable analogue analytes of process chemicals will be measured during routine monitoring (e.g. molybdate instead of sodium molybdate).

3.3.3.2 HEPA EQS

EQS: *The number of dilutions with ambient marine waters required to meet a 99% species protection level as determined through WET testing of eight species of the wastewater stream to the outlet will be less than the calculated dilution at the HEPA-LEPA boundary.*

An EQG non-compliance at the HEPA-LEPA boundary will trigger evaluation of the EQS based on WET testing of eight species of a wastewater stream sample to determine the number of dilutions with ambient marine waters required to meet a 99% species protection level. This will be compared to the calculated dilution at the HEPA-LEPA boundary. If dilution at the HEPA-LEPA boundary is less than the required safe dilutions, then the EQS is exceeded and identification of the problem wastewater stream and associated management actions is triggered.

3.3.4 LEPA spatial extent

The EQO for Maintenance of Ecosystem Integrity requires the spatial classification of two LEPs in the immediate locale of the KSIA outlet, namely:

The LEPA in a confined area surrounding the outlet with a permitted reduction in Marine Environmental Quality. For marine areas adjacent to wastewater discharges, EPA (2016) recommends establishment of a LEPA that encompasses the 'zone of initial dilution'. Discharged water from the KSIA outfall may temporarily alter salinity and water quality from background levels. The LEPA for the KSIA outlet has been defined with consideration of the GHD (2021a) modelling of the outlet discharge over a range of moderate to long-term projected wastewater flow rates (Appendix C). A **70 m radius around the outlet** has been established as the LEPA for compliance monitoring purposes, which is aligned with typical LEPA sizes for marine areas adjacent to wastewater discharges (EPA 2016). Outside of this area, the HEPA EQGs are predicted to be achieved (Appendix C).

The HEPA covers all the proximal coastal waters outside of the LEPA in the vicinity of the KSIA outlet.

Figure 3.3 illustrates the spatial configuration of the LEPA as a 70 m radius of the outlet with as surrounding marine water classification as HEPA.

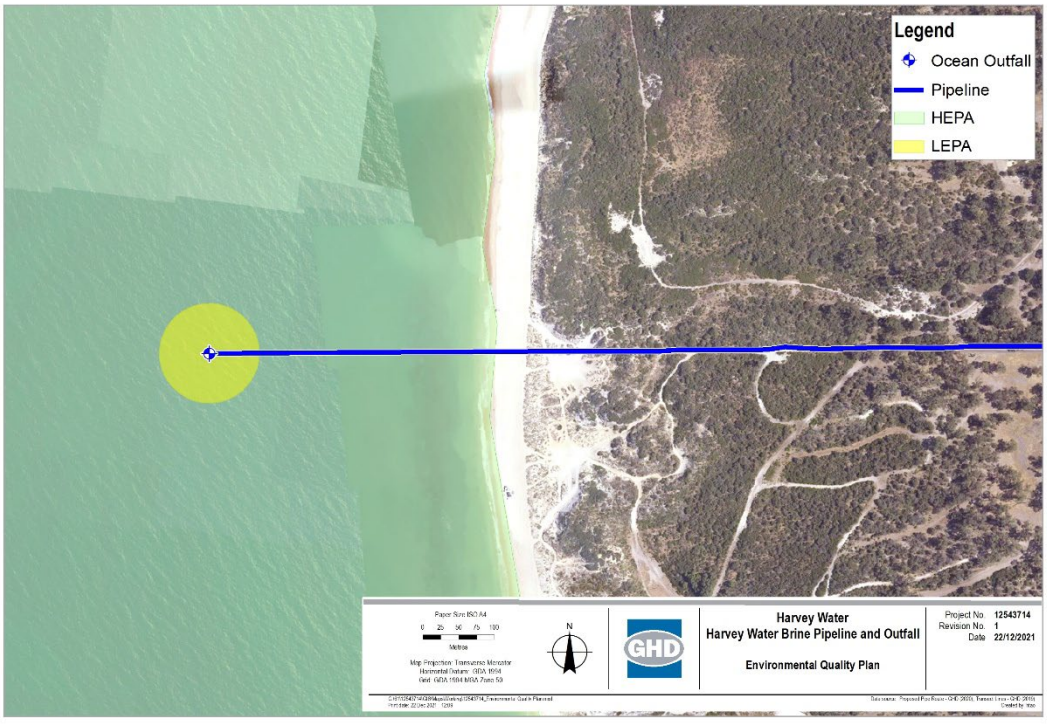

Figure 3.3 Spatial representation of the Environmental Quality Plan

4. Monitoring

This section describes the routine monitoring to verify whether the EQGs for the EQOs are met.

4.1 Sites

4.1.1 Marine

A schematic representation of the marine monitoring sites is illustrated in Figure 4.1. Marine monitoring sites are established by first confirming the survey conditions and current direction, then placing reference, LEPA and HEPA-LEPA boundary sites relative to the prevailing current.

The procedure to establish monitoring sites during a survey is:

Undertake the survey during neap tides with low to moderate current speeds, as elevated currents during spring tides may result in different near-field mixing conditions (Appendix A).

Deploy a drogue at the outlet location and determine the surface current direction and speed.

Establish monitoring sites relative to the prevailing current direction. For example, if the current is to the south, establish the following sites:

Two reference sites 500 m to the north and south of the KSIA outlet.

One LEPA site approximately 25 m south of the KSIA outlet along the prevailing current direction.

The LEPA site should be beyond the zone of initial dilution, which is expected to extend up to approximately 10 m from the outlet, as shown in Figure 4.1.

Three sites at 70 m from the KSIA outlet on the HEPA-LEPA boundary of which:

One site is directly south along the prevailing current direction.

Two sites 15 m to either side of the site directly south.

As illustrated in Figure 4.1 for a northerly current (as determined by a drogue deployment) the one LEPA site and the three HEPA-LEPA boundary sites would be placed to the north of the outlet.

4.1.2 Wastewater

Sampling sites of the wastewater stream are to be collected at the following locations:

The wastewater tank with the Albermarle and Harvey Water wastewater streams at the start of KSIA pipeline prior to the outlet after inputs from all the individual waste streams.

Each individual user wastewater stream immediately prior to discharge into the KSIA pipeline.

If multiple wastewater stream inputs into the KSIA pipeline, a sample prior to discharge via the outlet well downstream of the final source

4.2 Samples

4.2.1 Marine

The following samples at marine monitoring sites are to be collected during each survey:

Two surface water samples will be collected at 0.5 m below the surface at each monitoring site. This depth is consistent with EPA (2017) specifications to monitor buoyant plumes for comparison to EQGs. One sample is to be analysed by the laboratory(s), and the second sample is to be evaluated in the event an EQG non-compliance(s) needs to be confirmed.

At one monitoring site an additional sample will be collected for QA/QC (i.e. a replicate) (Section 4.6.1). The replicate sample site will be recorded but not reported to the laboratory.

Field sampling, transport and storage procedures will follow EPA (2005) protocols.

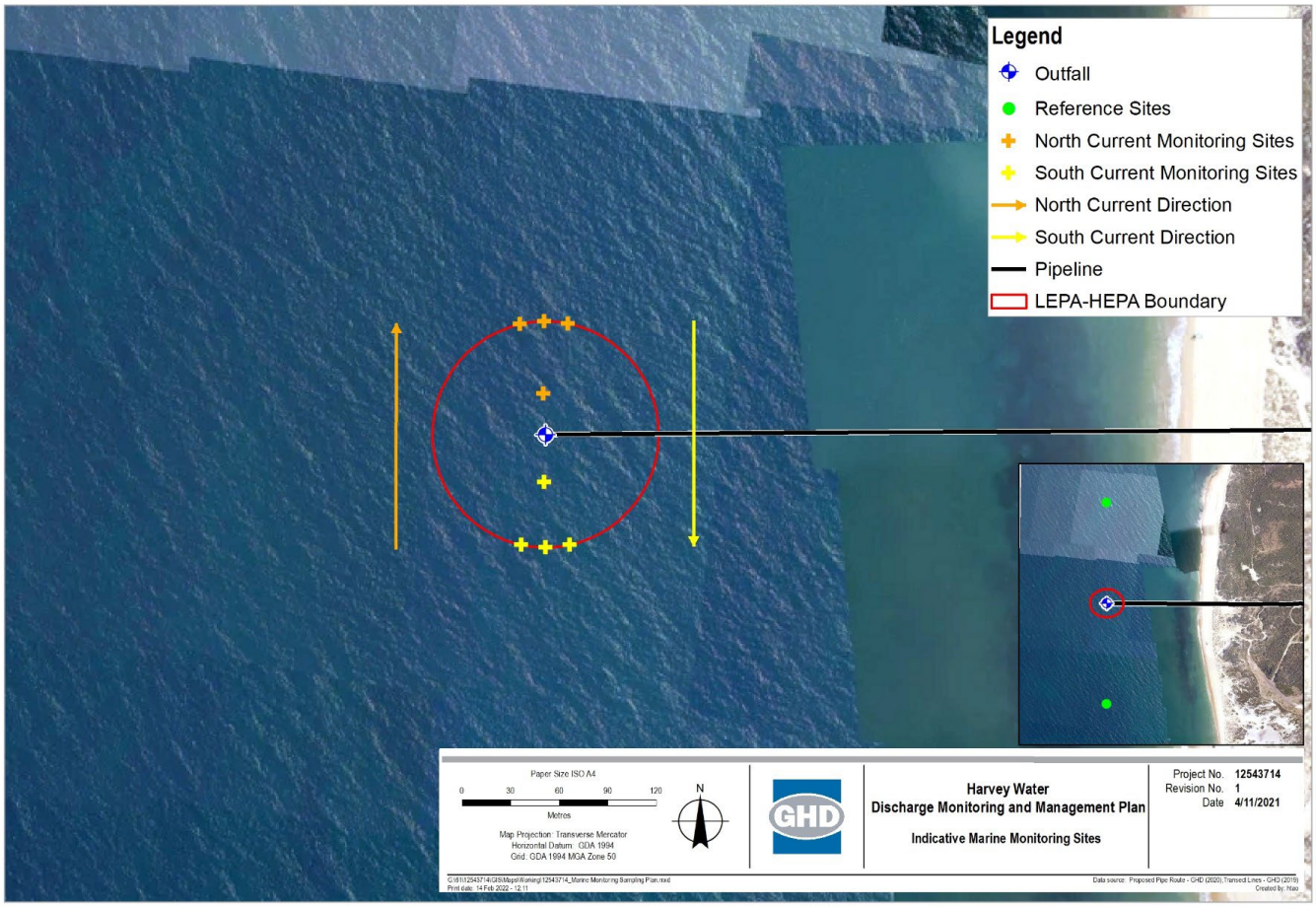

Figure 4.1 Indicative marine monitoring sites

4.2.2 Wastewater streams

Sample collection at the wastewater stream sites will be as follows:

Two wastewater stream samples will be collected at each site (i.e. each individual waste stream). One sample is analysed by the laboratory(s), and the second sample is evaluated in the event an EQG non-compliance(s) that needs to be confirmed.

For the wastewater stream prior to discharge to the outlet (and after the individual wastewater stream inputs) a sufficiently large sample to carry out WET testing will be collected and stored in the event confirmation of an EQG exceedance. The sample for potential WET testing should be kept refrigerated, in the dark, and filled in the container with no head space to maintain volatile contaminants in solution.

Field sampling procedures, transport and storage procedures will follow Department of Water Field Sampling Guidelines (Government of Western Australia 2009).

4.3 Measurements

4.3.1 Vertical CTD profiles through the water column of marine waters

A conductivity-temperature-depth (CTD) profiler (or similar) will be used to collect water profiles through the water column of temperature and salinity at <1 m depth intervals at each station. In addition, the CTD will collect continuous measurements at ~0.5 m below the surface at each marine monitoring site for at least 10 seconds to allow accurate characterisation of the salinity to allow robust calculations of the salinity at the HEPA-LEPA boundary.

4.3.2 Field temperature measurement(s) of wastewater sample(s)

In situ water temperature(s) of the wastewater stream(s) will be measured to an accuracy of 0.1°C to serve as inputs to near-field modelling to predict the number of dilutions of the wastewater plume in the marine environment if there is an EQG(s) or EQS exceedance(s).

4.3.3 Marine and wastewater samples: laboratory analysis

Marine water and wastewater stream(s) samples will be sent to a NATA certified laboratory(s) for analysis of analytes shown in Table 4.1. LoRs are stipulated to for the wastewater stream(s) and marine waters to allow evaluation of EQG and/or EQS compliance.

Table 4.1 Analytes, limits of reporting (LoRs), whether to collect wastewater or marine samples, and if analytes are evaluated for QA/QC

Analyte	Wastewater LoR (Intertek)	Seawater LoR (MAFRL)	Seawater	Wastewater	QA/QC
EQG 1. *The concentration of each toxicant in the wastewater stream prior to discharge is below the level to achieve 99% species protection (95% for cobalt) (ANZG 2018) at the HEPA/LEPA boundary.*					
Dissolved V	0.001 mg/L	0.0003 mg/L	Yes	Yes	Yes[5]
Dissolved Cr (VI)	0.005 mg/L	0.002 mg/L			
Dissolved Cr (III)	0.002 mg/L				
Dissolved Cr	0.001 mg/L	0.0002 mg/L			
Dissolved Co	0.001 mg/L	0.00005 mg/L			
Dissolved Ni	0.001 mg/L	0.0003 mg/L			
Dissolved Cu	0.001 mg/L	0.0002 mg/L			
Dissolved Zn	0.001 mg/L	0.001 mg/L			
Dissolved Ag	0.001 mg/L	0.0001 mg/L			
Dissolved Cd	0.0001 mg/L	0.0001 mg/L			
Dissolved Pb	0.001 mg/L	0.0001 mg/L			
Dissolved Hg	0.00005 mg/L	0.0001 mg/L			
EQG 2. *The salinity differential in marine waters at the LEPA/HEPA boundary and the reference site is 0.25 PSU or less.*					
Salinity	10 mg/L (~0.01 PSU)	0.1 PSU (~100 mg/L)	Yes	Yes	Yes
EQG 3. *The number of dilutions between the outlet and the LEPA/HEPA boundary is greater than 208.*					
Salinity	10 mg/L (~0.01 PSU)	0.1 PSU (~100 mg/L)	Yes	Yes	Yes
EQG 4. *The concentration of each process chemical (or analogue) in the wastewater stream prior to discharge is below the concentration that was WET tested.*					
Process chemicals[6]					
THPS (Biocide)	0.1 mg/L	-	No	Yes	Yes[5]
Phosphonates (PBTC)	0.05 mg/L	-			
Phosphonates (HEDP)	0.05 mg/L	-			
Polyacrylate	0.1 mg/L	-			
Azole	0.1 mg/L	-			
Molybdate	1 mg/L	-			

4.3.4 WET testing

Any WET testing is to be undertaken on wastewater samples with at least eight marine toxicity tests on at least eight different species and at least four (4) taxa to allow estimates of the 99% species protection level via species

[5] Second sample collected, both samples reported as averages. Relative percentage differences of both measurements to be reported.
[6] Process treatment chemicals (or analogues) and LoRs to be advised.

sensitivity distribution (SSD) statistics. The number of dilutions with ambient seawater to achieve a 99% species protection level is a key factor in the EQC framework to account for uncertainty in the additive (synergistic) effects of process chemicals and other potential contaminants in the wastewater stream on the marine environment. Additionally, WET testing is used to establish EQG numeric dilution criterion at the HEPA/LEPA boundary for EQG 3. Chemical analyses of the wastewater and background ambient marine waters are to be undertaken for analytes in Table 4.1 to check compliance with numeric criterion for EQG 4. Specifications of the eight species WET tests that are in line with ANZG (2018) guidance are summarised in Table 4.2.[7]

Table 4.2 WET toxicity tests

Ecotoxicity Test	Test Species
72-hour Microalgal Growth Bioassay	*Isochrysis galbana*
72-hour Microalgal Growth Bioassay	*Nitzschia Closterium*
72-hour Macroalgal Zoospore Germination Bioassay	*Ecklonia radiata*
5–7-day Copepod Larval Development Bioassay	*Gladioferens imparipes*
72-hour Sea Urchin Larval Development Bioassay	*Echinometra mathaei*
1 hour Sea Urchin Fertilisation Bioassay	*Echinometra mathaei*
48-hour Mollusc Larval Development Bioassay	*Mytilus edulis*
15-minute Acute Microtox Bioassay	*Vibrio fischeri*
7-day Fish Larval Development test	*Seriola lalandi*

Three of the eight species tests that are rapid (≤2 days) are to be used to identify a problematic individual wastewater stream(s) in the event of an EQS non-compliance. Note that the proposal is currently for only one wastewater stream, so a rapid ecotoxicity assessment based on three toxicity tests will not be necessary in the near term.

4.4 Schedules

The monitoring program consists of two schedules:

Schedule 1: To be implemented if there is a substantive change in wastewater quality (i.e. new wastewater stream or change in process chemicals).

Schedule 2: Routine monitoring procedure.

4.4.1 Schedule 1 (new wastewater stream or change in process chemicals)

Schedule 1 is illustrated schematically in Figure 4.2, which is comprised of the following procedure if there is a substantive change in wastewater quality (e.g. new wastewater stream or change in process chemicals):

- Determine 99% species protection level based on a species sensitivity distribution WET testing from at least eight toxicity tests and concentrations of contaminants of concern of wastewater stream samples during weeks 1 (WET_1) and 5 (WET_2).
- Verify GHD (2021) dilution predictions in the LEPA with CTD transects. Refer to Appendix D for preliminary summary of CTD verification procedure of GHD (2021a) dilution predictions during weeks 1 and 5.
- Carry out laboratory measurements of wastewater samples of the analytes in Section 4.3.3 on two occasions per week over the initial 8 weeks following the change to wastewater quality to allow characterisation of the chemical composition of each individual wastewater stream and the comingled wastewater stream prior to conveyance to the outlet. Additionally, the following analytes are to be monitored for the first 4 weeks (8 sampling rounds) to determine if additional contaminants of concern are to be incorporated into the DMMP:
- Full suite of metals and metalloids.
- Nutrients: TP, TN, FRP, NO_X, NH_X.
- Total recoverable hydrocarbons, BTEX and PAHs.

[7] Met DMMP Rev1 Section 6.1.1 (Initial implementation) commitment to finalise list of WET test species.

- Process chemicals used in the processes generating the waste streams (e.g. biocides, anti-corrosive chemicals).
- Evaluate the environmental performance of the comingled wastewater discharge via Schedule 2 incorporating the recent WET testing for EQG 3 and EQG 4.

4.4.2 Schedule 2 (routine monitoring and management)

Schedule 2 is illustrated schematically in Figure 4.3, which is comprised of the following procedure:

Evaluation compliance of the four EQGs for the monitoring round:

If an EQG non-compliance, then carry out EQS evaluation via WET testing of comingled wastewater sample to confirm if sufficient dilutions are estimated at the HEPA-LEPA boundary.

If EQS non-compliance, then compare individual waste stream chemical concentrations to identify contaminant source. Note for the current proposal there is only one wastewater stream, so this step would be skipped.

Carry out management actions until EQG compliance achieved.

4.4.3 Routine monitoring schedule

Routine monitoring to occur on a:

Monthly frequency. A reduction in the frequency of monitoring (e.g. monthly to quarterly) after two years can be requested of DWER through submission of monitoring data, a report of previous monitoring that supports a reduction in sampling frequency, and a revised DMMP.

Monthly monitoring will be carried over the first year after incorporation of a new wastewater stream. A reduction in the frequency of monitoring (e.g. monthly to quarterly) after one year can be requested to DWER through submission of monitoring data, a report of the previous monitoring that supports a reduction in sampling frequency, and a revised DMMP.

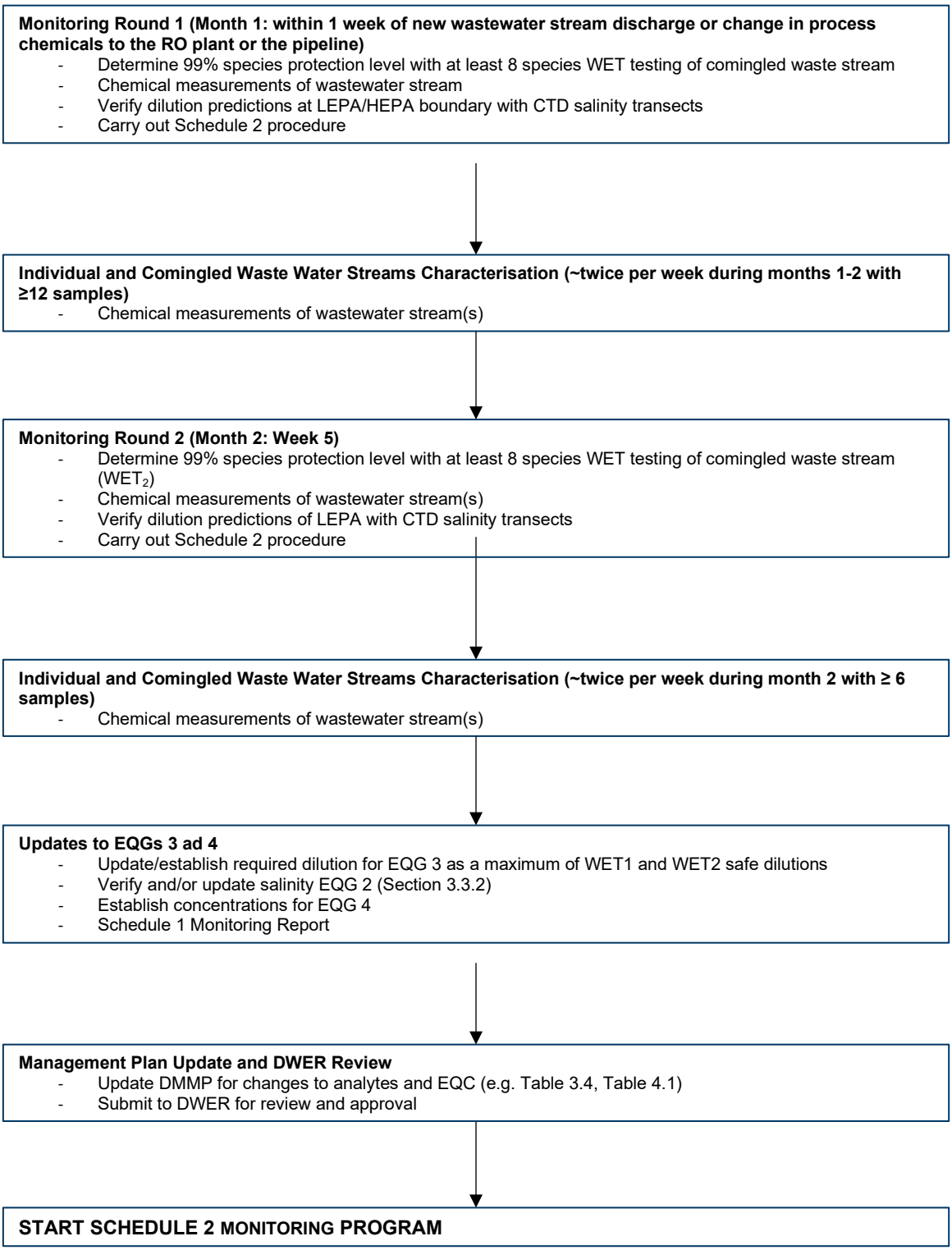

Figure 4.2 Schedule 1 monitoring program: start-up operations or new wastewater stream addition

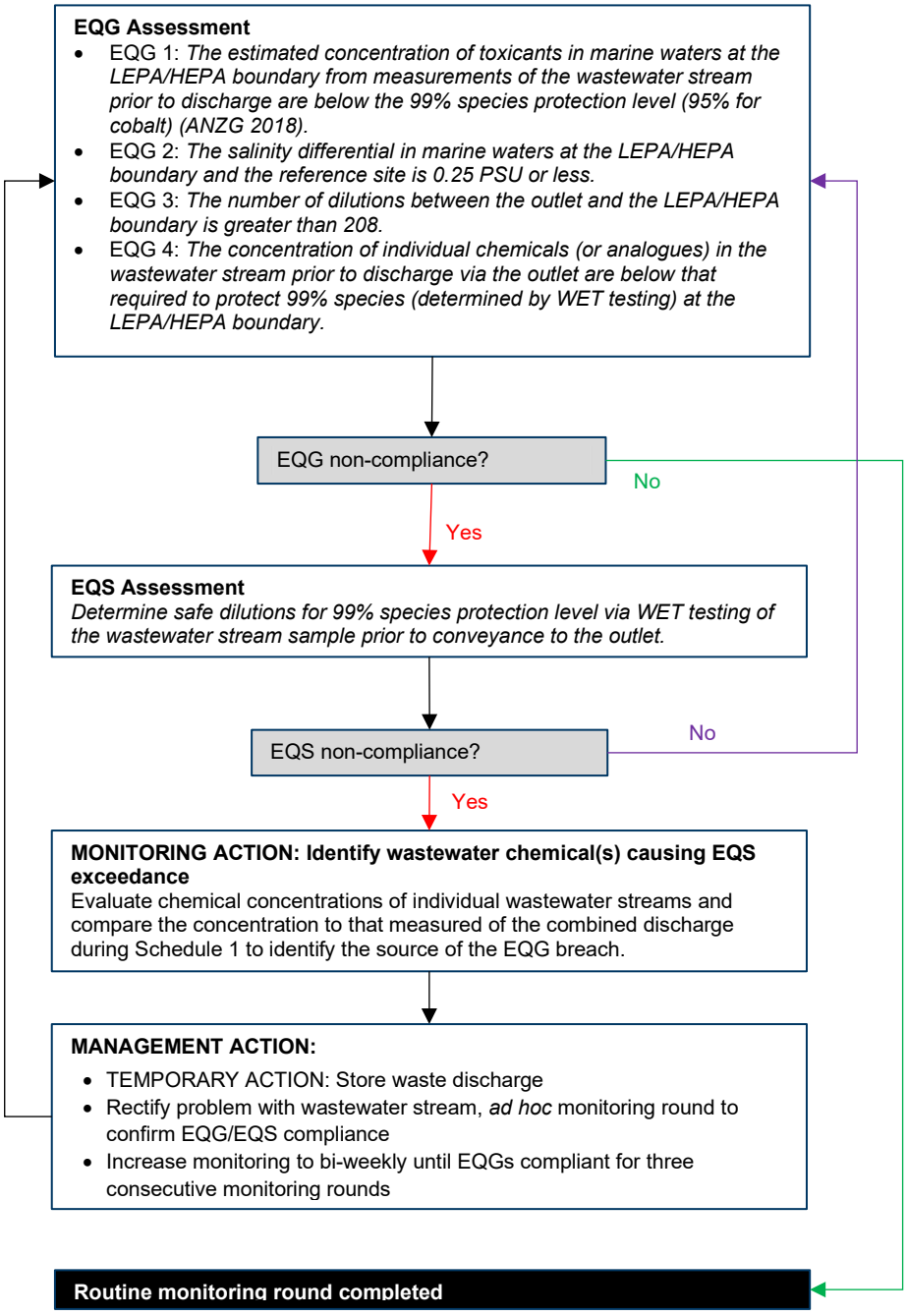

Figure 4.3 Schedule 2: routine monitoring program

4.5 Data collection and recording

4.5.1 Field measurements

4.5.1.1 Marine sites

Field profiles of temperature and salinity at each site as per Section 4.3.1 will be stored internally by the CTD (or similar sonde) logger where the operator is to periodically check that measurements are successfully recorded.

Characterisation of the water quality of undisturbed surface waters is a key requirement of the KSIA outlet monitoring program. Disturbance of the surface waters by the monitoring vessel can bias results, particularly at the HEPA-LEPA boundary. To minimise this effect as far as reasonably practicable, the vessel will move at a 'very slow' speed to minimise disturbance to the surface of the seawater, where permitted by navigational safety.

4.5.1.2 Wastewater sites

Field measurements of temperature at each site as per Section 4.3.2 will be recorded in a field book.

4.5.1.3 Data storage

At the end of the field monitoring activities, field measurement data will be downloaded from the CTD for marine monitoring and transcribed from a field book for the wastewater temperature onto a laptop as soon as practicable to minimise the risk of data loss. It is recommended that this data is regularly backed up to an external storage device, servers and/or the cloud to minimise the risk of data loss.

4.5.2 Water samples

Water samples are to be collected as specified in Sections 4.1 and 4.2, and dispensed into laboratory provided bottles. Sampling of marine waters at 0.5 m below the surface and wastewater will be in accordance with EPA (2005) and Government of Western Australia (2009), respectively. Samples will be carefully packaged in the field in a chilled thermal box (e.g. esky or similar) to minimise transient temperature effects during transit. Chain of custody (COC) documentation will be completed for all samples as per Government of Western Australia (2009).

4.6 Quality assurance and quality control (QA/QC)

4.6.1 Field QA/QC

The CTD is to be in calibration for temperature and salinity prior to use.

The replicate marine water sample (Section 4.2.1) will be analysed by the laboratory(s) for the analytes specified in Table 4.1. QA/QC of the replicate water sample will be based on acceptable relative percentage difference (RPD), nominally <50%.

4.6.2 Laboratory QA/QC

QA/QC testing of water samples will be undertaken in accordance with NATA accreditation and include testing of laboratory control samples, method blanks, matrix spikes, laboratory duplicates and surrogate recovery outliers (where applicable).

5. Assessment and management

Monitoring results are to be assessed to determine whether the EQOs are achieved, and thereby the EVs of the surrounding waters of the KSIA outlet are protected. Assessment of the monitoring results are to be evaluated as outlined in Schedule 1 (new wastewater stream or change in process chemical) and Schedule 2 (routine monitoring and management) in Sections 4.4.1 and 4.4.2, respectively.

Step	Assessment question	Outcome
1. EQG compliance	Do monitoring results meet EQGs 1-4?	If yes, complete the monitoring round. If no, proceed to EQS assessment.
2. EQS assessment	Does WET testing or dilution assessment confirm that the EQS is met?	If yes, complete the monitoring round. If no, identify the source stream and management response.
3. Source and response	Which wastewater stream or operational change is the likely cause?	Implement temporary controls, corrective actions, notification and reporting as required.

5.1 EQG compliance

Evaluation of EQGs 1-4 for compliance (Section 3.3.3) are to be carried out following receipt of laboratory measurements. If EQGs are met, then the monitoring round is completed. The EQGs are defined in Section 3.3.3.1.

5.2 EQS Assessment

If an EQG(s) are non-compliant then evaluate EQS. If EQS met, then monitoring round completed. The EQS is defined in Section 3.3.3.2:

5.3 Identification of problematic wastewater stream(s)

Only one wastewater stream is discharged to the system currently via the RO plant operated by Harvey Water. This assessment step becomes necessary as additional wastewater streams are incorporated into the KSIA pipeline.

5.4 Management

The key management actions following EQS non-compliance and identification of the problematic individual wastewater stream are:

Implement temporary measures that may include:

Store wastewater discharge.

Corrective management actions include, but are not limited to:

Amendment to chemicals and/or dosing concentrations.

Changes to operational protocols/procedures.

Changes to operations and maintenance activities.

Modification of the outlet (e.g. incorporation of a diffuser).

6. Review and reporting

6.1 DWER review and approval

The DMMP will at a minimum be updated with each addition of a new wastewater stream or new process chemicals to the pipeline.

The DMMP may also be updated following annual reviews (Section 6.4).

All updates to the DMMP will be submitted to DWER for review and approval prior to implementation.

6.2 Reporting on EQS exceedances

In the event of an EQS non-compliance, DWER will be notified within two (2) days of identification of the exceedance with the following information:

Which EQG exceeded.

Monitoring data at the HEPA-LEPA boundary, reference sites and wastewater stream.

Identification of the potential cause of the exceedance.

The proposed management response.

A follow-up report will be provided to DWER within one (1) month with the following information:

Corrective actions to meet EQC at the HEPA-LEPA boundary.

All monitoring data collected since the exceedance including demonstration that corrective management has been effective.

6.3 Schedule 1 monitoring report

At the completion of a Schedule 1 monitoring program, a report will be submitted to DWER within two months that includes:

A summary of all monitoring results of marine waters and the wastewater stream(s).

Verification of the modelling predictions about near-field mixing and the appropriateness of the LEPA spatial extent.

A summary of the EQGs compliance.

A summary of the WET test(s) and the EQS compliance.

An overview of the environmental performance of the outlet discharge at the HEPA-LEPA boundary.

6.4 Annual review

On an annual basis the DMMP will undergo a review by 1 February to maintain continual improvement with consideration of the following:

Appropriateness of the EVs, EQOs, LEPs and EQC.

New threats to Marine Environmental Quality from potential future waste streams and other activities/proposal in proximity to outlet.

Lessons learned from past monitoring and management actions.

Review of the EQC as additional data is accrued of the wastewater stream(s) and marine waters.

Proposed updates to the DMMP (if any) for submission to and review by DWER.

6.5 Schedule 2 annual report

At the completion of each calendar year for the Schedule 2 monitoring program, an annual report will be submitted to the DWER by 1 March that includes:

A summary of all monitoring results of marine waters and the wastewater stream(s).

An overview of the environmental performance of the outlet discharge at the HEPA-LEPA boundary.

A summary of the annual review of the DMMP.

Documentation of any management actions undertaken over the previous year and that may be extending into the next annual reporting period.

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Appendices

Appendix A

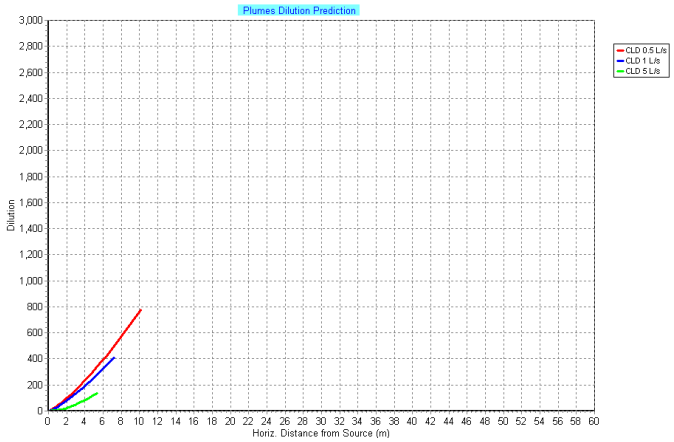
Estimates of plume centre-line dilution as a function of wastewater discharge rate

Near-field modelling with UM3 was undertaken for wastewater discharge rates of 0.5, 1 and 5 L/s in the same manner as GHD (2021a) for 5, 15 and 72 L/s. Substantially lower wastewater discharge rates have occurred over the October 2022-June 2024 period (0.17-1.13 L/s in Table A.1) than anticipated in GHD (2021a) (5-72 L/s).

Table A.1 n Average monthly wastewater discharge via the outlet

Start Date	End Date	Monthly Average (L/s)
9/10/2022	10/24/2022	0.29
10/24/2022	11/24/2022	0.39
11/24/2022	12/22/2022	0.36
12/22/2022	1/24/2023	0.32
1/24/2023	2/24/2023	0.30
2/24/2023	3/24/2023	0.41
3/24/2023	4/28/2023	0.17
4/28/2023	5/31/2023	0.40
5/31/2023	6/21/2023	0.52
6/21/2023	7/28/2023	0.52
7/28/2023	8/31/2023	0.52
8/31/2023	9/27/2023	0.48
9/27/2023	10/27/2023	0.62
10/27/2023	11/29/2023	0.57
11/29/2023	12/19/2023	1.13
12/19/2023	1/31/2024	0.46
1/31/2024	2/27/2024	0.66
2/27/2024	3/28/2024	0.60
3/28/2024	4/26/2024	0.72
4/26/2024	5/28/2024	0.85
5/28/2024	6/26/2024	0.83

The predicted number of dilutions of the plume centreline with the UM3 near-field model with an ambient marine current speed of 0.05 m/s for wastewater discharges of 0.5, 1 and 5 L/s were 775, 405 and 135, respectively (left panel of Figure A.1) at distances of 5, 7 and 10 m from the outlet, respectively. The predicted plume centreline dilutions with an ambient current speed 0.15 m/s were considerably higher for wastewater discharges of 0.5, 1 and 5 L/s at ~2,550, ~1,300 and ~333, respectively, though near-field mixing occurs over considerably longer distances from the outlet of 57, 41 and 23 m, respectively.



https://projectsportal..com/sites/sp01_08/harveywaterwaterqual/ProjectDocs/Analysis/Updated Near-Field

Modelling/2024-08-16_HarveryWaterOutputRev3_0pt15CurrentSpeeddil4.bmp

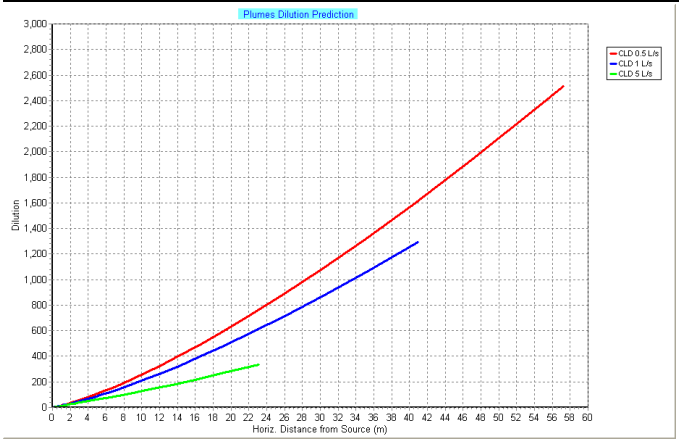


Figure A.1 ***Predicted centreline dilution of wastewater plume for discharges of 0.5, 1 and 5 L/s with marine ambient current speeds of 0.05 (left) and 0.15 (right) m/s***

A power regression of the predicted plume centreline dilution as a function of wastewater discharge explained ~99-100% of the variability for both ambient current speeds of 0.05 m/s and 0.15 m/s (Figure A.2). The relation for a 0.05 m/s ambient current speed was adopted to assess EQG compliance in Appendix B as a conservative measure because it estimates much lower near-field dilution than the 0.15 m/s ambient current speed case and the predicted near-field mixing distance from the outlet of 5-10 m is much shorter than to the LEPA-HEPA boundary at 70 m.

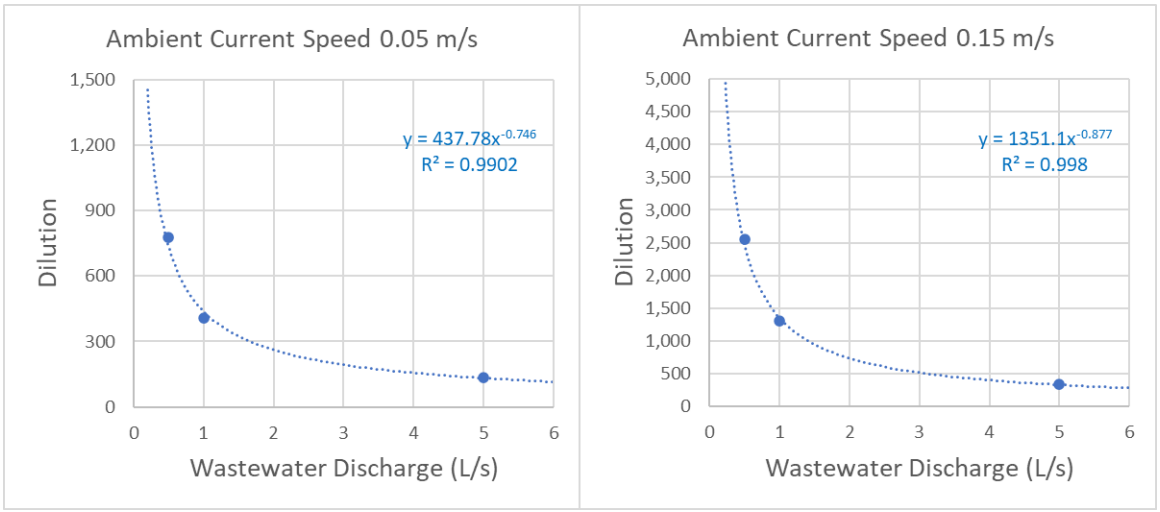


Figure A.2 ***Power regression relation of number of centreline plume dilutions versus wastewater discharge for ambient marine current speeds of 0.05 (left) and 0.15 (right) m/s***

Appendix B

Wastewater compliance assessment table

Table B.2 DMMP compliance assessment table: wastewater monitoring data, EQG compliance and WET testing results

Parameter	Units	EQG 1 Input Parameters		EQG				Routine Wastewater Tank Monitoring																				WET Tests				EQG Assessment
		99% LSP (95% LSP for Co)	Ambient Seawater	EQG 1: Upper Allowable Wastewater Concentrations to meet 99% LSP (95% for Co)	EQG 2: Near-Field Model Plume Centerline Dilution Estimate	EQG 3: WET Test Dilution Requirement at LEPA-HEPA (WET Test #3)	EQG 4: WET Test #3 Production Chemical Concentrations	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Gap Months 11-14 (Lapse in Monitoring)	Month 15	Month 17	Month 18	Month 19	Month 20	Gap Months 21-32 (No Discharge)	Month 33	Month 34	Month 35	Month 36	Month 37	Month 38	Month 39	Month 40	Pre-Commissioning (WET Test #1)	Commissioning (WET Test #2)	Commissioning (WET Test #3)	Normal Ops. Model (WET Test #5)	
								22-Dec-22	16-Jan-23	28-Feb-23	20-Mar-23	28-Apr-23	16-May-23	27-Jun-23	10-Aug-23	29-Aug-23	12-Sep-23		12-Feb-24	7-May-24	20-May-24	17-Jun-24	3-Jul-24		5-Aug-25	1-Sep-25	15-Oct-25	19-Nov-25	10-Dec-25	21-Jan-26	18-Feb-26	17-Mar-26	6-Jul-22	4-Oct-22	11-Nov-22	15-Jul-25	
Monthly Wastewater Discharge and Dilution Estimates																																				
Wastewater Discharge	L/s							0.36	0.32	0.41	0.41	0.17	0.40	0.52	0.52	0.52	0.48		0.66	0.85	0.85	0.83	0.20		0.36	0.38	0.24	0.14	0.10	0.22	0.05	0.04	NA	NA	NA	NA	
Near-Field Wastewater Dilution								934	1020	853	853	1630	862	712	711	711	757		594	494	494	504	1454		938	901	1269	1898	2439	1355	4091	4832	No Flow	No Flow	No Flow	No Flow	
EQG 1: The concentration of each toxicant in the wastewater stream prior to discharge is below the level to achieve 99% species protection (95% for cobalt) (ANZG 2018) at the HEPA/LEPA boundary.																																				
Nitrate (NO_3)	mg/L	0.7	0.1	See table below for concentrations				2	0.78	0.019	0.19	0.77	1.4	1.4	3.2	1.4	1.5		0.26	0.42	0.63	0.87	0.3		2.1	1.6	2.1	0.077	1.3	1.2	1.3	1.7	0.91	0.59	0.91	1.6	Only one EQG 1 non-compliance (NC) for Zn on 20 May 2024 with brine concentration of 2 mg/L ~25% greater than the allowable concentration of 1.6 mg/L
pH	-																		7.93			7.09	7.63		8.4		7.98	8.01	8.29	8.41	8.4	8.5	8.36	8.24	8.27	8.08	
Vanadium (V)	mg/L	0.05	0.002					0.003	0.002	0.004	0.006	0.002	0.002	0.002	0.004	0.002	0.003		0.013	0.011	0.034	0.011	0.02		0.013	0.009	0.008	0.009	0.007	0.0055	0.0045	0.003	0.002	0.002	0.002	0.011	
Cr (IV)	mg/L	0.00014	0.000025					0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.005	0.005	0.005		0.005	0.005	0.005	0.005	0.005		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.001	0.001	0.001	0.005	
Cr (III)	mg/L	0.0077	0.000025					0.001	0.001	0.006	0.007	0.002	0.001	0.005	0.007	0.005	0.005		0.005	0.005	0.005	0.005	0.005		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.001	0.001	0.001	0.005	
Chromium (Cr)	mg/L	0.0044	0.0002					0.009	0.002	0.006	0.007	0.003	0.004	0.005	0.007	0.003	0.003		0.002	0.002	0.002	0.006	0.013		0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.002	0.005	0.002	0.002	
Cobalt (Co)	mg/L	0.001	0.00001					0.001	0.001	0.001	0.004	0.002	0.002	0.002	0.002	0.002	0.001		0.005	0.004	0.007	0.002	0.006		0.007	0.009	0.004	0.002	0.003	0.004	0.003	0.001	0.001	0.001	0.001	0.009	
Nickel (Ni)	mg/L	0.007	0.001					0.011	0.007	0.007	0.012	0.007	0.007	0.015	0.01	0.006	0.005		0.005	0.003	0.009	0.004	0.007		0.003	0.019	0.003	0.003	0.003	0.002	0.002	0.001	0.008	0.006	0.008	0.002	
Copper (Cu)	mg/L	0.0003	0.00008					0.009	0.007	0.01	0.01	0.01	0.008	0.01	0.015	0.008	0.009		0.027	0.01	0.041	0.013	0.026		0.022	0.019	0.009	0.008	0.004	0.005	0.005	0.002	0.008	0.006	0.008	0.008	
Zinc (Zn)	mg/L	0.0033	0.00015					0.11	0.14	0.087	0.1	0.16	0.071	0.19	0.16	0.17	0.033		0.057	0.066	2	0.055	0.2		0.039	0.049	0.061	0.22	0.062	0.084	0.13	0.006	0.17	0.23	0.17	0.013	
Silver (Ag)	mg/L	0.0008	0.0000007					0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001		0.005	0.001	0.001	0.001	0.001		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Cadmium (Cd)	mg/L	0.0007	0.000005					0.009	0.0081	0.0056	0.007	0.0026	0.0025	0.0021	0.0034	0.0014	0.0018		0.0086	0.0017	0.004	0.0019	0.0022		0.0023	0.0012	0.0008	0.0004	0.0008	0.0002	0.0003	0.0001	0.0014	0.0012	0.0014	0.012	
Lead (Pb)	mg/L	0.0022	0.00002					0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001		0.005	0.001	0.003	0.001	0.004		0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.006	0.001	0.006	0.001	
Mercury (Hg)	mg/L	0.0001	0.0000004					0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005		0.00005	0.00005	0.00014	0.00005	0.00005		0.00005	0.00009	0.00005	0.0005	0.00026	0.0005	0.0005	0.00005	0.00005	0.00005	0.00005	0.00005	
EQG 1: Allowable EQG 1 Wastewater Tank Concentrations																																				
Nitrate (NO_3)	mg/L			Allowable wastewater concentrations to meet EQG 1				561	612	512	512	978	517	427	427	427	454		357	296	296	303	873		563	541	762	1139	1464	813	2455	2899	No Flow	No Flow	No Flow	No Flow	
Vanadium (V)	mg/L							44.8	48.9	41.0	41.0	78.3	41.4	34.2	34.1	34.1	36.4		28.5	23.7	23.7	24.2	69.8		45.0	43.3	60.9	91.1	117.1	65.0	196.4	231.9	No Flow	No Flow	No Flow	No Flow	
Cr (IV)	mg/L							0.107	0.117	0.098	0.098	0.188	0.099	0.082	0.082	0.082	0.087		0.068	0.057	0.057	0.058	0.167		0.108	0.104	0.146	0.218	0.281	0.156	0.470	0.556	No Flow	No Flow	No Flow	No Flow	
Cr (III)	mg/L							7.2	7.8	6.5	6.5	12.5	6.6	5.5	5.5	5.5	5.8		4.6	3.8	3.8	3.9	11.2		7.2	6.9	9.7	14.6	18.7	10.4	31.4	37.1	No Flow	No Flow	No Flow	No Flow	
Chromium (Cr)	mg/L							3.9	4.3	3.6	3.6	6.8	3.6	3.0	3.0	3.0	3.2		2.5	2.1	2.1	2.1	6.1		3.9	3.8	5.3	8.0	10.2	5.7	17.2	20.3	No Flow	No Flow	No Flow	No Flow	
Cobalt (Co)	mg/L							0.92	1.01	0.84	0.84	1.61	0.85	0.70	0.70	0.70	0.75		0.59	0.49	0.49	0.50	1.44		0.93	0.89	1.26	1.88	2.41	1.34	4.05	4.78	No Flow	No Flow	No Flow	No Flow	
Nickel (Ni)	mg/L							5.6	6.1	5.1	5.1	9.8	5.2	4.3	4.3	4.3	4.5		3.6	3.0	3.0	3.0	8.7		5.6	5.4	7.6	11.4	14.6	8.1	24.5	29.0	No Flow	No Flow	No Flow	No Flow	
Copper (Cu)	mg/L							0.21	0.22	0.19	0.19	0.36	0.19	0.16	0.16	0.16	0.17		0.13	0.11	0.11	0.11	0.32		0.21	0.20	0.28	0.42	0.54	0.30	0.90	1.06	No Flow	No Flow	No Flow	No Flow	
Zinc (Zn)	mg/L							2.9	3.2	2.7	2.7	5.1	2.7	2.2	2.2	2.2	2.4		1.9	1.6	1.6	1.6	4.6		3.0	2.8	4.0	6.0	7.7	4.3	12.9	15.2	No Flow	No Flow	No Flow	No Flow	
Silver (Ag)	mg/L							0.75	0.81	0.68	0.68	1.30	0.69	0.57	0.57	0.57	0.61		0.47	0.39	0.39	0.40	1.16		0.75	0.72	1.01	1.52	1.95	1.08	3.27	3.86	No Flow	No Flow	No Flow	No Flow	
Cadmium (Cd)	mg/L							0.65	0.71	0.59	0.59	1.13	0.60	0.49	0.49	0.49	0.53		0.41	0.34	0.34	0.35	1.01		0.65	0.63	0.88	1.32	1.70	0.94	2.84	3.36	No Flow	No Flow	No Flow	No Flow	
Lead (Pb)	mg/L							2.0	2.2	1.9	1.9	3.6	1.9	1.6	1.6	1.6	1.7		1.3	1.1	1.1	1.1	3.2		2.0	2.0	2.8	4.1	5.3	3.0	8.9	10.5	No Flow	No Flow	No Flow	No Flow	
Mercury (Hg)	mg/L							0.093	0.102	0.085	0.085	0.162	0.086	0.071	0.071	0.071	0.075		0.059	0.049	0.049	0.050	0.145		0.093	0.090	0.126	0.189	0.243	0.135	0.407	0.481	No Flow	No Flow	No Flow	No Flow	
EQG 2: The salinity differential in marine waters at the LEPA/HEPA boundary and the reference site is 0.25 PSU or less.																																				
Salinity of Outfall Discharge	psu				Dilution to maintain <0.25 psu needs to be lower than near-field brine dilution			5.9	7	4.6	5.5	4.6	4.7	3.7	2.3				6.2		3.5		3.3	2.8	2.5	1.9	2.5	2.7		3.1	4.6	5.8	5.4	2.3	Dilution requirement to maintain <0.25 psu decrease in salinity at the LEPA-HEPA boundary has been always met on the basis of the near-field plume dilution estimates.
	Dilution to maintain <0.25 psu drop in seawater							116	112	122	118	122	121	125	131				115		126		127	129	130	132	130	129	140	128	122	117	118	131	
EQG 3: The number of dilutions between the outlet and the LEPA-HEPA boundary is greater than 208.																																				
Near-Field Wastewater Dilution	# of Dilutions					208		934	1020	853	853	1630	862	712	711	711	757		594	494	494	504	1454		938	901	1269	1898	2439	1355	4091	4832	79	65	126	208	No EQG 3 NCs Intertek dilution estimates for PC99 on basis of Burriloz (WET Tests #1, #2 & #3) and SSDTools (WET Test #5)
EQG 4: The concentration of each process chemical (or analogue) in the wastewater stream prior to discharge is below the concentration that was WET tested in EGG 3.																																				
THPS (Biocide)	mg/L						0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.66	0.3	1.1	0.1		0.9	0.4	0.2	0.6	2.5		0.3	0.1	0.2	0.2	0.1	0.2	0.28	0.1	1.5	0.1	0.4	0.1	- NCs of THPS frequent due to low criterion, but between 0.1-0.3 mg/L since Aug-25 - Only 1 NC of PBTC & HEDP in Aug-25 - No NCs of polyacrylate, azole and molybdate sincc Aug-25
Phosphonates (PBTC)	mg/L						62.5	0.05	0.05	0.05	0.05	0.05	0.05	1.28	1.52	24	28		56	10	13	30	11		102.2	45.4	13.6	9.1	11.4	4	15.9	11.4	0.05	0.05	0.05	62.5	
Phosphonates (HEDP)	mg/L						23.9	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.05	0.05	0.05		39.1	17.4	5.2	3.5	4.3	2.3	6.1	4.3	0.05	0.05	0.05	23.9	
Polyacrylate	mg/L						0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1		0.01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Azole	mg/L						0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		0.4	0.1	0.3	0.9	1.7		0.01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Molybdate	mg/L						10	11	8	11	12	9	8	10	3.1	9.2	10.6		40	5	14	7	7		8	4	3	1	2	2	1	1	3	2	4	10	
Other Analytes Tracked, No EGQ (Adopt EQG4 Approach for Tracking)																																				
TRH (C10-C36)	mg/L						3.16	3.58	1.25	0.33	1.45	0.63	0.62	0.49	1.55	0.25	0.25		1.08	1.02	4.52	3.47	6.33		2.40	0.35	0.58	0.26	0.45	0.32	0.37	0.31	0.71	0.34	0.25	3.16	Other analytes that are tracked
TPH (C9-C40)	mg/L						3.22	3.62	1.25	0.32	1.51	0.70	0.68	0.47	1.90	0.25	0.25		1.12	1.08	4.57	3.52	6.37		2.48	0.40	0.63	0.27	0.53	0.38	0.40	0.34	0.66	0.37	0.25	3.22	
TRH C_{10}-C_{14}	µg/L						75	76	50	68	170	51	60	68	100	50	50		68	92	56	56	75		140	50	50	50	50	50	57	54	380	50	50	75	
TRH C_{15}-C_{28}	µg/L						3000	3400	1100	160	1000	370	460	320	770	100	100		710	700	4300	3200	6000		1900	200	310	110	300	170	210	160	230	190	100	3000	
TRH C_{29}-C_{36}	µg/L						110	100	100	100	280	210	100	100	680	100	100		300	230	160	210	250		360	100	220	100	100	100	100	100	100	100	100	110	
TRH $>C_{10}$-C_{16}	µg/L						50	120	54	63	210	59	62	50	170	50	50		78	130	170	620	170		71	50	50	50	50	50	56	50	300	50	50	50	
TRH $>C_{16}$-C_{34}	µg/L						3100	3400	1100	160	1200	530	520	320	1200	100	100		920	850	4300	2800	6100		2200	250	480	120	380	230	240	190	260	220	100	3100	
TRH $>C_{34}$-C_{40}	µg/L						100	100	100	100	100	110	100	100	530	100	100		120	100	100	100	100		210	100	100	100	100	100	100	100	100	100	100	100	
Phosphonates (ATMP)	mg/L						23.1																		27.8	16.8	5	3.4	4.2	1.2	5.9	4.2	25			23.1	

Appendix C

(2021) basis of LEPA spatial extent

To define the spatial extent of the LEPA surrounding the KSIA outfall during the approval phase of the project, modelling was undertaken for three flow rates that included stage 1 moderate flow (5 L sec^{-1}), stage 1 peak design flow (15 L sec^{-1}) and stage 2 peak design flow (72 L sec^{-1}) (GHD, 2021a).

Near-field dilution of the ocean outfall wastewater plume was simulated with Update Merge 3 (UM3). To predict additional dilution due to natural mixing processes beyond the near-field zone, a far-field assessment with the three-dimensional (3D) MIKE3 FM (flexible mesh) hydrodynamic model was used to simulate wind and tide-induced currents.

The dilution factors to define the edge of the mixing zone were calculated with the following formula:

$$D = \frac{C_O - C_A}{C_T - C_A}$$

where:

D = Target dilution factor to achieve EQG

C_O = Outlet concentration

C_T = Target concentration to achieve the EQG

C_A = Ambient (background) concentration

At the time of the modelling assessment, no site-specific ambient data at the outfall site was available, therefore dilution targets were calculated with assumed ambient concentrations based on professional judgement.

Concentrations for each analyte (Table C.3) were provided by Harvey Water. For the water treatment chemicals, concentrations were given for the feedwater to the reverse osmosis (RO) plant, outlet concentrations were estimated as follows:

Treatment chemicals were assumed to be conserved (i.e. does not degrade or transform) throughout the RO process and within the wastewater holding tanks and discharge pipe. This assumption is very conservative, as these chemicals are highly reactive.

The entire mass of a chemical is assumed to be removed from the RO product water and transmitted entirely to the wastewater stream and discharged through the outlet. The concentration in the RO feed water (provided by Harvey Water) was therefore assumed to increase in the wastewater discharge proportionally to the ratio of RO feedwater wastewater flow rates (a factor of 7.7).

The calculated dilution targets for the analytes of concern are summarised in Table C.3.

The most stringent dilution target is **92-fold** for salinity, so achieving this dilution of the wastewater plume at the HEPA-LEPA boundary will ensure adequate dilution of all other parameters to meet the EQGs or analytes of concern in Table 3.4. As the wastewater salinity is approximately one third of seawater, upon discharge from the outlet it forms a buoyant plume that rises to the surface.

Table C.3 Summary of water quality data and dilution calculations GHD (2021a)

Parameter	Units	C_O	C_T	C_A	D
Nitrate	mg/L	2.8	0.70	0.0025[8]	4
Boron	mg/L	2.0	5.10	NA	NA[9]
Salinity	PSU	11.93[10]	34.75[11]	35[11]	92
Water Treatment Chemicals					
Sodium Molybdate	mg/L	152.7[12]	50 (*Acohs, 2014*)	0	3

[8] Ambient concentration assumed to be 50% of the ANZECC & ARMCANZ (2000) default guideline trigger value for physical and chemical stressors (not toxicants) in inshore marine waters of south-west Australia.

[9] Outlet concentration below mixing zone criterion – no dilution required.

[10] Salinity (PSU, or ppt) is calculated from the TDS concentration.

[11] LEPA salinity target of 34.75 PSU represents a salinity change of 0.25 PSU from ambient (ambient assumed to be 35 PSU, which is standard for marine water in south-west Australia).

[12] Outlet concentration is estimated as 7.7 x the RO feedwater concentration as described in bullet-point two of this appendix.

Parameter	Units	C_O	C_T	C_A	D
THPS (Biocide)	mg/L	381.7[12]	15 (*Frayne, 2017*)	0	25
Phosphonates (PBTC)	mg/L	77.4[12]	33.3 (*NM&C Co., 2015*)	0	2
Phosphonates (HEDP)	mg/L	77.4[12]	3 (*SPE Chemicals, 2020*)	0	26
Polyacrylate	mg/L	2.9[12]	100 (*Recyc PHP, 2020*)	0	No dilution required
Azole	mg/L	38.2[12]	100 (*Ibis Water, 2019*)	0	No dilution required
Molybdate	mg/L	119.1[12]	41 (*HACH, 2017*)	0	3
Colour Legend:					
ANZECC & ARMCANZ (2000) Low reliability trigger value for marine waters.					
Conservative mixing zone target of <0.25 PSU change from ambient conditions.					
Lowest toxic concentration reported in the SDS.					

The near-field and far-field dispersion modelling were used to predict the spatial extent that a 92-fold dilution occurs over a range of flow rates from 5 L sec^{-1} (estimate of initial flow rate upon commissioning) to 72 L sec^{-1} (estimate of potential maximum flow rate in future) from the KSIA outfall to inform the size of the LEPA on the basis of the salinity EQG.

Near field modelling predicted that the buoyant plume reaches the sea surface at a horizontal distance of 6-9 m from the outlet, so the near-field zone is estimated to be within 10 m of the discharge point. The average plume dilution (i.e. average dilution across the plume width) at the end of the near-field zone was 480-fold for the stage 1 moderate flow rate (5 L sec^{-1}), 197-fold for the stage-1 peak flow rate (15 L sec^{-1}) and 58-fold for the stage 2 peak flow rate (72 L sec^{-1}). The plume centreline dilution (i.e. lowest dilution in the centre of the plume centre where a lower degree of mixing with ambient waters occurs) was 137-fold, 75-fold and 28-fold for the stage 1 moderate, stage 1 peak and stage 2 peak flow rates, respectively. The stage 1 moderate flow rate of 5 L sec^{-1} is predicted to achieve the target dilution of 92-fold near the outlet (i.e. within 5 m) for both the average and centreline plume dilution. The average plume dilution for the stage 1 peak flow (15 L sec^{-1}) was predicted to meet the 92-fold dilution target; however, the centreline of the plume is predicted to require additional far-field dilution to achieve the dilution target to meet the HEPA EQG for salinity. Both the average and centreline plume dilution are predicted to not meet the 92-fold dilution target in the near-field for the state 2 peak flow rate of 72 L sec^{-1}, thereby additional far-field dilution is required to meet the HEPA EQG for salinity.

Far-field modelling with MIKE3 FM predicts that the 92-fold dilution target (i.e. achievement of the HEPA salinity EQG) for the stage 1 peak flow of 15 L sec^{-1} will be achieved within ~20 m of the outlet for summer and winter conditions (Figure A.1). In contrast the substantially higher stage 2 peak discharge of 72 L sec^{-1} is predicted to extend up to 100 m from the outlet for the summer case to meet the HEPA salinity EQG requirement of a 92-fold dilution (Figure C.3).

Based on the far-field predictions a **70 m radius around the outlet** is recommended as the LEPA. This aligns with typical LEPA sizing for marine areas adjacent to wastewater discharges as outlined in the technical guidance (*EPA, 2016c*). Marine waters outside of the 70 m radius around the outlet (i.e. the LEPA) are to be classified as HEPA. Further rationale for a 70 m radius around the outlet as the spatial extent of the LEPA includes:

Ability to accommodate potential future changes in wastewater quality relative to those evaluated in this assessment that may require greater dilution (e.g. future waste streams from additional users of the marine outfall pipe).

In the event a stage 2 peak discharge of 72 L sec^{-1}, the 92-fold dilution requirement is predicted to not be met within 70 m of the outlet with the current single discharge nozzle. It is recommended that a second outlet (or nozzle) spaced approximately 10-20 m to the west of the stage 1 outlet to meet a 92-fold dilution requirement.

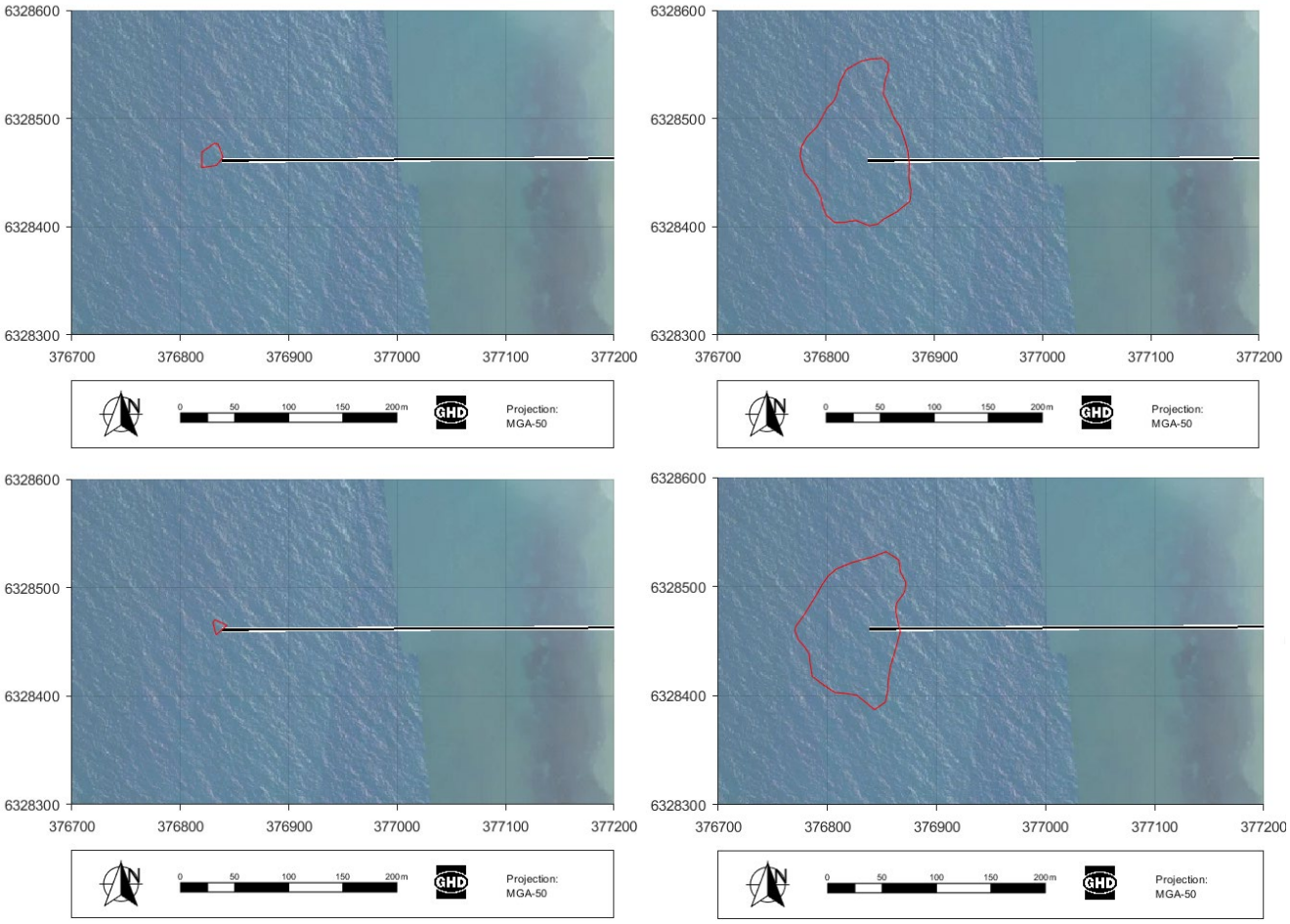


Figure C.3 ***Maximum predicted extent to achieve a dilution of 92-fold or greater for the summer simulation (top) and winter simulation (bottom) for Stage 1 peak flow of 15 L sec^{-1} (left) and Stage 2 peak flow of 72 L sec^{-1} (right) (GHD, 2021a)***

Appendix D

CTD verification procedure of GHD (2021a)

LEPA predictions

The following procedure is recommended to verify the GHD (2021a) predictions of the spatial extent of water quality degradation from the proposed KSIA outlet waters:

This procedure is to be carried out in addition to a routine monitoring survey as specified in Section 4.

Additionally, CTD profiles through the water column will be acquired as follows:

Directly over the outlet.

At 10 m intervals along transects from the outlet locations towards each of the three down-current sites at the LEPA-HEPA boundary that are established as per Section 4.1.1. Because the discharge is a buoyant plume, particular attention to proper surface CTD measurements is imperative.

Salinity is the primary tracer. Calculate the dilution of the wastewater with marine waters using the following formula:

$$D_{iz} = \frac{S_O - S_A}{S_{iz} - S_A}$$

where:

D_{iz} = Dilution estimates at CTD measurement at transect site I and depth z

S_O = Outlet salinity (measured as per Section 4.3.2)

S_{iz} = Transect site salinity (measured as per Section 4.3.1)

S_A = Ambient (background) salinity (measured as per Section 4.3.2 at the reference sites)

Assess whether dilution (D) greater than the EQG requirements at the HEPA-LEPA boundary as stipulated in Appendix C.

Reporting:

If the field verification of the model predictions is satisfactory (i.e. accurate or conservative) then report in the Schedule 2 Annual Report (Section 6.5).

If the field verification of the model predictions of dilution is unsatisfactory, then notify DWER of non-compliance within two (2) days and provide a non-compliance report within one (1) month as per EQS exceedance reporting specifications in Section 6.2.

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