

BEFORE THE ENVIRONMENT COURT  
I MUA I TE KOOTI TAIAO O AOTEAROA

IN THE MATTER of the Resource Management Act 1991  
AND  
IN THE MATTER of an appeal under section 120 of the Act  
BETWEEN THE MANUKAU HARBOUR  
RESTORATION SOCIETY  
INCORPORATED  
ENV-2018-AKL-00002  
Appellant  
AND AUCKLAND COUNCIL  
Respondent  
AND WATERCARE SERVICES LIMITED  
Applicant

Environment Judge J A Smith sitting alone under s 279 of the Act  
IN CHAMBERS at Auckland

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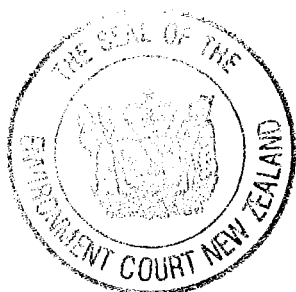
CONSENT ORDER

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[A] Under s 279(1)(b) of the Resource Management Act 1991, the Environment Court, by consent, orders that:

- (1) the appeal is allowed subject to the amendments set out in **Schedule A** and **Schedule B** to this order.
- (2) the appeal is otherwise dismissed.

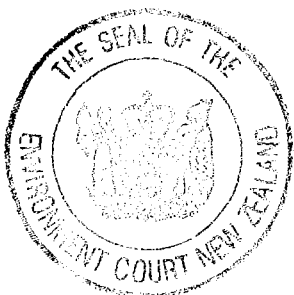
[B] Under s 285 of the Resource Management Act 1991, there is no order as to costs.



## REASONS

### Introduction

- [1] This appeal concerns a decision of the respondent made on 5 December 2017 to grant resource consents for the discharge of treated wastewater into the Waiuku Estuary, in the south Manukau Harbour, and for the construction of a new sub-surface/submerged pipeline and outfall structure to convey and diffuse the wastewater into the coastal marine area.
- [2] The Appellant appealed the conditions of consent.
- [3] The parties have agreed to resolve the appeal by making certain changes to the conditions of consent and draft Receiving Environment Monitoring Plan (REMP) approved by the respondent. The general purpose of the agreed changes is to enhance certain monitoring and reporting requirements, and to better facilitate the Community Liason Group (CLG) to undertake its functions.
- [4] The key changes are as follows:
- (a) Conditions 6 and 7(d) - amendments to require the provision of draft reports to the CLG in electronic format and to require that the reports be hosted on Watercare's website or an alternative information sharing web application.
  - (b) Condition 7(e) - amendments to require Watercare to make the authors of the Receiving Environment Monitoring Report (REM Report), the Monitoring and Technology Review Report (MTRR) and the Emerging Contaminants Risk Assessment (ECRA) available to the CLG upon request.
  - (c) Condition 8 - amendments to require Watercare to provide the minutes of CLG meetings to members of the CLG in electronic format unless specified otherwise and to host the minutes on its website or an alternative information sharing web application. Where actions are proposed by Watercare to respond to suggestions or issues, the minutes



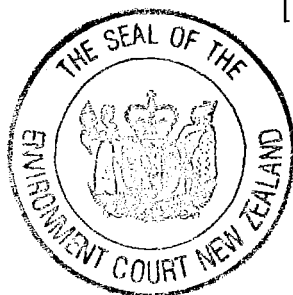
shall include the ongoing status of those actions, including whether they have been completed.

- (d) Condition 8A - new condition to require peer reviewer(s) appointed by the Council to attend the CLG meeting to consider the draft REM Report, MTRR and ECRA and contribute to the CLG's understanding of those draft reports including answering any questions from the CLG.
- (e) Conditions 10(b) and 26 - amendments to require Watercare to monitor and record the daily rainfall.
- (f) Conditions 11, 29 and 34 - amendments to require independent suitably qualified persons to be engaged to prepare the MTRR, REM Report and ECRA.
- (g) Condition 12(e) - amendments to expressly require the MTRR to address industrial re-use options.
- (h) Condition 13 - amendments to enhance the review condition by linking it to more than minor (rather than significant) effects and options identified in MTRR.
- (i) Condition 27 and draft REMP - amendments to enhance the REMP, including phytoplankton monitoring, enhanced heavy metals monitoring, dissolved oxygen monitoring and measurement of Redox Potential Discontinuity.

[5] In making this order the Court has read and considered the appeal and the memorandum of the parties dated 12 June 2018.

[6] Mr Gary Whyborn has given notice of an intention to become a party under s 274 of the Act and has signed the memorandum of the parties requesting this order.

[7] No other person has given notice of an intention to become a party under section 274.



[8] The Court is making this order under s 279(1)(b) of the Act, such order being by consent, rather than representing a decision or determination on the merits pursuant to s 279. The Court understands for present purposes that:

- (a) All parties to the proceedings have executed the memorandum requesting this order;
- (b) All parties are satisfied that all matters proposed for the Court's endorsement fall within the Court's jurisdiction, and conform to relevant requirements and objectives of the Resource Management Act, including in particular Part 2.

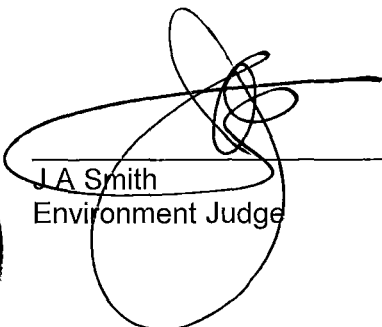
[9] Therefore, the Court orders, by consent, that resource consents are granted to Watercare Services Limited to construct a pipeline and outfall structure (including disturbance of the seabed, use and occupation of the coastal marine area) and to discharge treated wastewater to the Waiuku Estuary subject to:

- (a) The conditions of consent being amended as set out in **Schedule A** (additions shown in underlining and deletions shown in ~~strikethrough~~); and
- (b) The draft Receiving Environment Monitoring Plan being amended as set out in **Schedule B** (additions shown in underlining and deletions shown in ~~strikethrough~~).

[10] The appeal is otherwise dismissed.

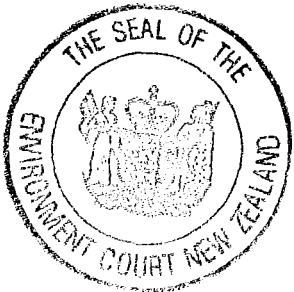
[11] There is no order as to costs.

DATED at Auckland this 27<sup>th</sup> day of June 2018

  
J.A. Smith  
Environment Judge



SCHEDULE A  
AMENDED CONDITIONS OF CONSENT

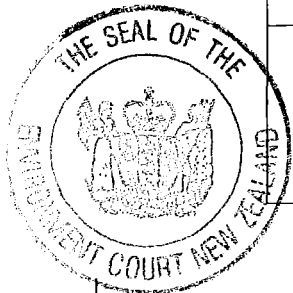


## General conditions

Consent Holder	Watercare Services Limited
Consent Duration	These consents will expire 35 years from the date the consents commence
Lapse Period	Eight years
Location	Waiuku Channel, adjacent to the Clarks Beach Golf Course
Consent Numbers	CST60082600 and CST60082302

### General Summary of Management and Monitoring Plan Requirements

Plan Type	Timing	Condition #
Receiving Environment Monitoring Programme	At least two years prior to the commencement of the treated wastewater discharge	<u>28</u>
Receiving Environment Monitoring Report	No later than two years following the commencement of the treated wastewater discharge and subsequently at five yearly intervals thereafter.	<u>2829</u>
Annual Performance Report	By 30 September for each year of operation of the WWTP	10
Operations and Management Plan	No later than six months following the commencement of the treated wastewater discharge	<u>31</u>
Monitoring and Technology Review Report	No later than 5 years following the commencement of these consents and then at Years 10, 15, 20, 25 and 30.	11

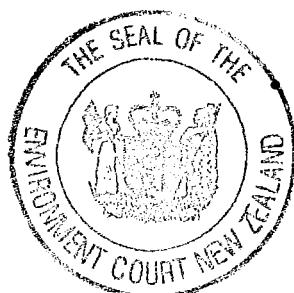


Emerging Contaminants Risk Assessment	By 30 September 2022 and subsequently at five yearly intervals thereafter.	<u>34</u>
Offshore Outfall Construction Management Plan	No later than 30 working days prior to the commencement of the construction of the offshore outfall pipeline and <u>diffuser</u> .	<u>3637</u>
Drilling Fluid Management Plan	No later than 30 working days prior to commencement of the construction of the offshore outfall pipeline and diffuser	<u>3940</u>
Offshore Outfall Inspection Report	Every five years from the commencement of the treated wastewater discharge and subsequently at five yearly intervals thereafter.	<u>5152</u>

**Table 1: General Summary of Management and Monitoring Plan Requirements**

**Conditions applying to both coastal permit CST60082600 and coastal permit CST60082302**

1. The wastewater treatment process at the WWTP and physical discharge facilities shall be designed, operated and maintained, and receiving environment monitoring shall be, in general accordance with the information provided with the application, and all referenced by the Council as consent numbers CST60082600 and CST60082302 as follows:
  - (a) Volume One: Assessment of Environmental Effects report, titled "Southwest Sub-regional Wastewater Treatment Plant Discharge to the Waiuku Estuary", prepared by Watercare Services Limited, dated 30 June 2016.
  - (b) Volume Two: Supporting Documents:
    - Report titled "Assessment of Ecological Effects on the Receiving Environment from the Discharge of Treated Wastewater from a Combined Clarks Beach, Waiuku and Kingseat WWTP", prepared by Mark James, Mike Stewart, Ngaire Phillips and Jim Cooke (Aquatic Environmental Sciences Ltd and Streamlined Environmental Limited), dated May 2016;
    - Report titled "Southwest Sub-Regional Wastewater Treatment Plant Application – Assessment of the Sensitivity of the Receiving Environment of the South-West Manukau Harbour to Predicted Contaminants", prepared by Mark James, Mal Green and John Oldman (Aquatic Environmental Sciences Ltd and Streamlined Environmental Limited), dated February 2016;





- Report titled “Stakeholder Report”, prepared by MWH New Zealand Limited, dated June 2016; and
- Report titled “Southwest Sub-Regional Wastewater Servicing Project - Assessment of Alternatives Report”, prepared by MWH New Zealand Limited, dated 29 June 2016.

(c) Further documents provided post-lodgement:

- Section 92 Response (1) titled “Watercare Response to S92 Request for Further Information Request”, prepared by Tanvir Bhamji of Watercare Services Limited, dated 20 April 2017;
- Document titled “Draft Receiving Environment Monitoring Programme”, prepared by Watercare Services Limited, dated 11 June 2017;
- Section 92 Response (2) titled “Watercare Response to S92 Request for Further Information Request”, prepared by Tanvir Bhamji of Watercare Services Limited, dated 18 August 2017; and
- Email regarding the construction methodology from Tanvir Bhamji of Watercare Services Limited dated 29 August 2017.

In the event of any conflict between the documents listed above and the conditions of this consent, the conditions shall prevail.

2. Under section 125 of the RMA, these consents lapse eight years after the date they are granted unless, before the lapse date:
  - (a) The consents are given effect to; or
  - (b) The Council extends the period after which the consent lapse.
3. The consent holder shall pay the Council an initial consent compliance monitoring charge of \$1,200 inclusive of GST, plus any further monitoring charge or charges to recover the actual and reasonable costs incurred to ensure compliance with the conditions attached to this consent/s.

**Advice note:**

*The initial monitoring deposit is to cover the cost of inspecting the site, carrying out tests, reviewing conditions, updating files, etc., all being work to ensure compliance with the resource consent. In order to recover actual and reasonable costs, monitoring of conditions, in excess of those covered by the deposit, shall be charged at the relevant hourly rate applicable at the time. The consent holder will be advised of the further monitoring charge. Only after all conditions of the resource consent have been met, will the Council issue a letter confirming compliance on request of the consent holder.*

4. The agents of the Auckland Council shall be permitted to have access to the WWTP and discharge facilities at all reasonable times for the purpose of carrying out monitoring procedures, inspections, surveys, investigations, tests, measurements or take samples while adhering to the consent holder's health and safety policies.

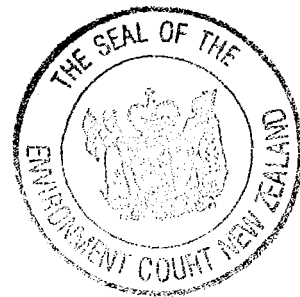
**Consultative Community Liaison Group**

5. No later than six months after the commencement of these consents, the consent holder



shall invite stakeholders including, but not limited to, one representative each from Te Ara Rangatu o Te Iwi o Ngati Te Ata Waiohua, Ngati Tamaoho Trust, Te Akitai o Waiohua, Te Ahiwaru (Makaurau Marae), Te Kawerau a Maki, the Manukau Harbour Restoration Society, the Ornithological Society of New Zealand Inc (BirdsNZ), and the Auckland Regional Public Health Service to establish, in association with the consent holder, a Consultative-Community Liaison Group. A general invitation shall be made by way of public notice in the Franklin Country News and the Post (Franklin & North Waikato) and on the consent holder's website.

6. The consent holder shall provide reasonable organisation and administrative support to facilitate the development and on-going role of this Consultative-Community Liaison Group for the duration of the consent. The Consultative-Group-Community Liaison Group and the Auckland Council Team Leader – Southern Monitoring or delegate shall be invited to meet at least six-monthly to exercise the functions set out in Condition 7. Upon agreement with the Consultative-Community Liaison Group and the Auckland Council's Team Leader – Southern Monitoring, the meeting frequency may be reduced. All reports shall be provided to the Consultative-Community Liaison Group in electronic format unless specified otherwise and be hosted on the consent holder's website or an alternative information sharing web application.
7. The functions of the Consultative-Community Liaison Group shall include, but not be limited to, the following matters:
  - (a) Reviewing the performance of the WWTP and discharge facilities in relation to the quality of the treated wastewater discharge and compliance with the consent conditions;
  - (b) Reviewing the results of monitoring and the associated assessment of monitoring information carried out in accordance with the conditions of these consents;
  - (c) Receiving and commenting on the following documents:
    - i. Receiving Environment Monitoring Programme and Receiving Environment Monitoring Report;
    - ii. Annual Performance Report;
    - iii. Offshore Outfall Construction Management Plan;
    - iv. Operations and Management Plan;
    - v. Offshore Outfall Inspection Report;
    - vi. Monitoring and Technology Review Report;
    - vii. Emerging Contaminants Risk Assessment; and
    - viii. Complaints Register.
  - (d) The consent holder shall provide the Draft Receiving Environment Monitoring Programme, Draft Operations and Management Plan, and Draft Emerging



Contaminants Risk Assessment to the Community Liaison Group for comment prior to being submitted to the Council's Team Leader – Southern Monitoring for certification.

(e) The consent holder shall make the authors of the Receiving Environment Monitoring Report, the Monitoring and Technology Review Report and the Emerging Contaminants Risk Assessment available to the Community Liaison Group, upon request.

~~(d)~~(f) Making suggestions to the consent holder and/or Auckland Council as to any practical physical measures and other initiatives further needed to address actual or potential adverse effects of the treated wastewater discharge;

~~(e)~~(g) Making suggestions as to any additional investigations the consent holder might undertake in respect of actual or potential adverse effects of the treated wastewater discharge; and

~~(f)~~(h) Considering any other issues of concern to the Consultative Community Liaison Group relating to the WWTP treated wastewater discharge.

Any comments or suggestions provided for under (c), ~~(df)~~ or ~~(eg)~~ above shall be provided to the consent holder and Auckland Council within 60-30 working days of any meeting of the Community Liaison Group or within such other timeframe as agreed by the Group.

8. The consent holder shall provide minutes of each Consultative Community Liaison Group meeting to the Auckland Council and the members of the Consultative Community Liaison Group within four weeks-60 working days of each meeting in electronic format unless specified otherwise and be hosted on the consent holder's website or an alternative information sharing web application. The minutes shall include:

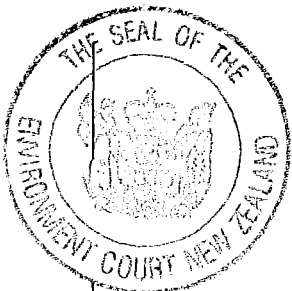
(a) A record of discussions and attendance at the meeting;

(b) A record of any suggestions provided or issues raised by the members of the Consultative Community Liaison Group including:

i. What actions are proposed by the consent holder to respond to suggestions made or issues raised by the Consultative Community Liaison Group as they relate to the functions of the Consultative Community Liaison Group as set out in Condition 7; and

ii. Where no actions are proposed to respond to suggestions or issues, the reasons why not.

iii. Where actions are proposed by the consent holder to respond to suggestions or issues, the ongoing status of those actions, including whether they have been completed.



### **Peer Reviewer**

8A. A Peer Reviewer(s), who is suitably qualified and knowledgeable in the following fields:

- i. Operation of wastewater treatment plants and assessment of alternative wastewater technologies;
- ii. Wastewater chemistry (including emerging contaminants) and marine water quality;
- iii. Marine ecology.

shall be appointed and briefed by the Council's Team Leader - Southern Monitoring.

The functions of the Peer Reviewer(s) shall be:

- i. To attend the meeting of the Community Liaison Group held to consider the draft versions of the Receiving Environment Monitoring Report, the Monitoring and Technology Review Report and the Emerging Contaminants Risk Assessment provided to the Community Liaison Group for comment, in order to contribute to the Community Liaison Group's understanding of those draft reports; and
- ii. To advise the Council on the certification of the reports and assessment in (i) above as required by Conditions 30, 11, and 34 respectively.

In performing function (i) above, the Peer Reviewer(s) will summarise to the Community Liaison Group the key conclusions in the draft reports, comment on the adequacy of the information contained in those reports, and inform the Group of any issues arising, and answer any questions.

The Consent Holder shall provide the Peer Reviewer(s) with all records, plans, designs and other information that the Peer Reviewer(s) requires to be able to carry out its functions.

All costs related to the appointment of the Peer Reviewer(s) shall be borne by the consent holder.

### **Advice note**

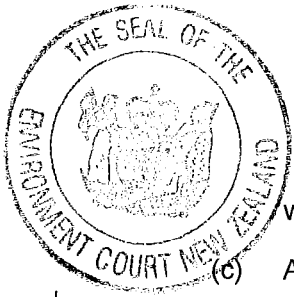
The role of the Peer Reviewer(s) described in Condition 8A does not extend to the Peer Reviewer(s) acting in a professional advisory capacity to the Community Liaison Group.

### **Complaint Reporting and Processes**

9. All complaints received by the consent holder about the treated wastewater discharge shall be logged immediately in the WWTP Complaints Register. The Register shall record:

- (a) The date, time, location, duration and nature of the alleged event/incident;
- (b) Name, phone number and address of the complainant unless the complainant





wishes to remain anonymous;

- (c) Any remedial action taken by the consent holder in response to the complaint and when it was undertaken, and if no remedial action was considered necessary by the consent holder, the reasons for taking no remedial action;
- (d) The possible cause of the relevant event/ incident that lead to the complaint;
- (e) The weather conditions at the time of the relevant event/ incident including estimates of wind direction, wind strength, temperature and cloud cover;
- (f) The date and name of the person making the entry; and
- (g) Details of any complaints received that may indicate non-compliance with the conditions of these consents shall be provided to the Council's Team Leader - Southern Monitoring within 24 hours of receipt of the complaint or on the next working day. All other complaints shall be included in the Annual Performance Report required by Condition 10.

### Reporting

10. An Annual Performance Report shall be submitted by the consent holder to the Council's Team Leader - Southern Monitoring and the ~~Consultative~~ Community Liaison Group as per Condition 7 by September 30 of each year in which the treated wastewater discharge is occurring. The report shall:
- (a) Collate, analyse and interpret the monitoring results required by the conditions of these consents for the previous year from 1 July to 30 June;
- (b) Report the calculated Average Dry Weather Flow (ADWF) and rainfall data for the previous year from 1 July to 30 June;
- (c) Include comment on WWTP performance in relation to the quality of the treated wastewater discharge and any significant trends in changes in the discharge volume and/or the discharge quality ~~standards~~ over time;
- (d) Comment on compliance with each consent condition and evaluate against the Auckland Council's standard compliance scoring protocol; and
- (e) Identify any actions required and submit a timetable to rectify any non-compliance.

### Monitoring and Technology Review Report

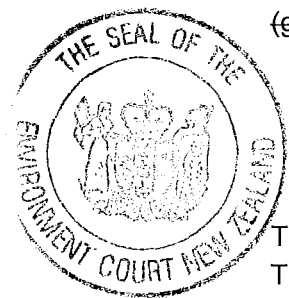
11. The consent holder shall engage an independent suitably qualified person to prepare and submit a Monitoring and Technology Review Report to the Council's Team Leader – Southern Monitoring by the 5<sup>th</sup>, 10<sup>th</sup>, 15<sup>th</sup>, 20<sup>th</sup>, 25<sup>th</sup> and 30<sup>th</sup> anniversaries of the commencement of these consents. The Review Report shall be provided to the ~~Consultative~~ Community Liaison Group as per Condition 7, with a request for comments to be provided to the consent holder and Auckland Council within 60 working days. After receiving comments from the ~~Consultative~~ Community Liaison Group (or in the case that no comments are forthcoming, after 60 working days), the Report shall be submitted to the Team Leader – Southern Monitoring for certification it has been produced in

accordance with the requirements of these conditions.

12. The Monitoring and Technology Review Report shall include the following:

- (a) An assessment of ongoing compliance with the requirements of these resource consents particularly in relation to any reported non-compliance with consent conditions;
- (b) An assessment of compliance/consistency with any relevant national or regional water quality policies, environmental standards or guidelines in effect at the time;
- (c) An assessment of the results of the consent holder's monitoring undertaken in accordance with these consents, including the adequacy and scope of such monitoring;
- ~~(d)~~—A summary of any residual actual or potential adverse effects of the treated wastewater discharge, particularly effects of the treated wastewater ~~(e)(d)~~ discharge on total nitrogen and total phosphorus concentrations in the receiving environment and the relationship of total nitrogen and total phosphorus to limiting algal growth, irrespective of whether the discharge complies with the conditions of these consents;
- ~~(f)(e)~~ An outline of significant technological changes and advances in relation to wastewater management, inflow reduction, treatment, discharge and beneficial reuse technologies (including Managed Aquifer Recharge) that could be of relevance for possible future use in the South-west Sub-regional Wastewater Scheme treatment and discharge facilities. Specific information shall be included on ~~actions the consent holder has investigated for wastewater reuse and the results of those investigations along with discharge volume reduction that has been achieved since the commencement of these consents, when assessed on a per domestic connection equivalent basis; and:~~
  - i. options the consent holder has investigated for wastewater reduction and/or reuse, including Managed Aquifer Recharge and industrial re-use, and any actions taken as a result of those investigations; and
  - ii. any discharge volume reduction that has been achieved as a result of those actions, since the commencement of these consents, when assessed on a per domestic connection equivalent basis, as reported by the discharge monitoring in Condition 25.
- ~~(g)(f)~~ An assessment of whether any newly available technology option/s or combination of options identified through (e) above represent the Best Practicable Option (**BPO**) to minimise the potential and actual adverse effects of the treated wastewater discharge and whether the consent holder intends to adopt that BPO and incorporate such technologies.

Those matters listed in 12(a) to (d) shall not be required in the Monitoring and Technology Review Report until after the discharge of treated wastewater has commenced.



13. The conditions of these consents may be reviewed by the Council's Team Leader - Southern Monitoring pursuant to section 128 of the RMA, by giving notice pursuant to section 129, on the fifth anniversary of the commencement of the discharge of treated wastewater and subsequently at five yearly intervals thereafter in order:

- (a) To deal with any ~~significant~~ adverse effect on the environment arising from the exercise of the consent, which is more than minor, which was not foreseen at the time the application was considered and which is appropriate to deal with at the time of review, including more than minor adverse effects of the treated wastewater discharge on receiving water quality, shellfish quality and marine ecology, identified in the Receiving Environment Monitoring Report under Condition 29; or,
- (b) To consider developments in technology and management practices that would enable practical reductions in the discharge of contaminants, in particular where any technology option/s identified through Condition 12(e) represent the BPO in Condition 12(f) to minimise the potential and actual adverse effects of the treated wastewater discharge; or
- (c) To alter the monitoring requirements, including requiring further monitoring, or increasing or reducing the frequency of monitoring.

13A. The conditions of these consents may be reviewed by the Council's Team Leader - Southern Monitoring pursuant to section 128 of the RMA, by giving notice pursuant to section 129, on 30 June 2032, being six months prior to the expiry of the discharge permit for the Mangere Wastewater Treatment Plant in order:

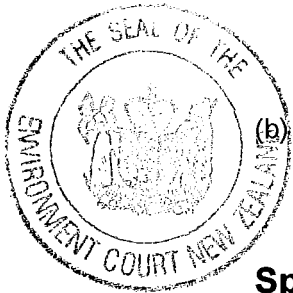
- (a) To consider the effects on the environment arising from the exercise of this consent in combination with the proposed effects on the environment of any replacement consent that may be sought for the discharges into the Manukau Harbour of the Mangere Wastewater Treatment Plant, which are appropriate to deal with at the time of review;
- (b) To alter the contaminant discharge limits, monitoring requirements (including requiring further monitoring), or increasing or reducing the frequency of monitoring.

### **Specific conditions – coastal permit CST60082600**

14. The treated wastewater compliance monitoring point for the purpose of monitoring compliance with Conditions 15 and 16 shall be at the point immediately following the UV disinfection system at the WWTP at or about grid reference 5879106N and 1753497E (NZTM).

#### **Discharge Limits**

15. The consent holder shall ensure that the quality of the treated wastewater at the treated wastewater compliance monitoring point does not exceed the limits as set out in Table 2.



Parameter	Unit	Laboratory Detection Limit	Median Limit	92nd Percentile Limit
Carbonaceous Biochemical Oxygen Demand (cBOD <sub>5</sub> )	mg/L	0.5	5	20
Total Suspended Solids (TSS)	mg/L	0.2	5	20
Total Ammoniacal Nitrogen (NH <sub>4</sub> -N)	mg/L	0.4	2	15
Total Nitrogen (TN)	mg/L	0.01	5	20

**Table 2: Treated Wastewater Quality Discharge Limits**

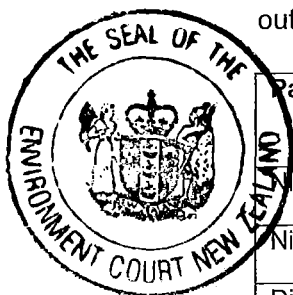
For the purposes of this condition, to determine compliance with median limits no more than 12 samples out of any 24 consecutive weekly samples shall exceed the specified limit. To determine compliance with the 92nd percentile limit, no more than two samples out of any 24 consecutive weekly samples shall exceed the specified limit.

- The consent holder shall ensure that a validated UV dose of 35 mWs/cm<sup>2</sup> is delivered by the UV disinfection facility for 99% of the time (calculated on the basis of a 15-minute average) over each calendar month.

**Treated Wastewater Monitoring (Immediately After UV Disinfection)**

- The consent holder shall take 24 hour flow proportioned samples of the treated wastewater on a weekly basis from the treated wastewater compliance monitoring point, for the purposes of determining compliance with Condition 15 and monitoring under Conditions 19 and 20.
- All wastewater quality analyses shall be undertaken by an IANZ accredited or equivalent laboratory. All methods used shall be appropriate for the wastewater analyses undertaken.
- The consent holder shall take 24 hour flow proportioned samples (taken in accordance with Condition 17) of the treated wastewater on a weekly basis from the treated wastewater compliance monitoring point and analyse for the parameters set out in Table 3.

Parameter	Unit	Laboratory Detection Limit
Nitrite-Nitrogen (NO <sub>2</sub> -N)	mg/L	0.002
Nitrate-Nitrogen (NO <sub>3</sub> -N)	mg/L	0.02
Dissolved Reactive Phosphorus (DRP)	mg/L	0.005
Total Phosphorus (TP)	mg/L	0.005
Temperature	Degrees Celsius	N/A
Electrical Conductivity	µS/cm	5.0



pH	unit	0.1
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**Table 3: Treated Wastewater Quality Monitoring**

20. The consent holder shall monitor on a three-monthly basis (by grab samples) the treated wastewater at the treated wastewater monitoring compliance point for the parameters set out in Table 4 below for two years following commencement of the discharge of treated wastewater. After two years of monitoring the frequency of monitoring shall be reduced to 6 monthly (by grab samples) for the duration of the consent.

Parameter	Unit	Laboratory Detection Limit
Arsenic (Total)	mg/L	0.0001
Cadmium (Total)	mg/L	0.00005
Chromium (Total)	mg/L	0.0005
Copper (Total)	mg/L	0.0002
Lead (Total)	mg/L	0.0001
Nickel (Total)	mg/L	0.0001
Zinc (Total)	mg/L	0.001

**Table 4: Treated Wastewater Detection Parameters**

**Treated Wastewater Monitoring (After Tidal Holding Facility and Prior to Discharge)**

21. The consent holder shall take a 24 hour flow proportioned sample of the treated wastewater on a weekly basis from a point after the tidal holding facility at the Clarks Beach site and prior to discharge to the coastal marine area and analyse for the parameters set out in Table 5.

Parameter	Unit	Laboratory Detection Limit
Carbonaceous Biochemical Oxygen Demand (cBOD <sub>5</sub> )	mg/L	0.5
Total Suspended Solids (TSS)	mg/L	0.2
Total Ammoniacal Nitrogen (NH <sub>4</sub> -N)	mg/L	0.4
Total Nitrogen (TN)	mg/L	0.01
Nitrite-Nitrogen (NO <sub>2</sub> -N)	mg/L	0.002







Nitrate-Nitrogen (NO <sub>3</sub> -N)	mg/L	0.02
Dissolved Reactive Phosphorus (DRP)	mg/L	0.005
Total Phosphorus (TP)	mg/L	0.005
Temperature	Degrees Celsius	N/A
Electrical Conductivity	µS/cm	5.0
pH	unit	0.1

**Table 5: Treated Wastewater Quality Monitoring – After Tidal Holding Facility and Prior to Discharge to the Coastal Marine Area**

**Discharge Volume**

22. The discharge shall not exceed a maximum volume of 20,250m<sup>3</sup> of treated wastewater per day, with a maximum flow rate of 727.5 litres per second (calculated as an average over each tidal discharge cycle) and average dry weather flow (**ADWF**) of 6,750m<sup>3</sup> per day.

**Discharge Location**

23. The discharge location shall be in the Waiuku Channel at or about grid reference 5887800N and 1750600E (NZTM).

**Discharge Timing**

24. The discharge of treated wastewater at the discharge location shall not commence until one hour after any high tide and ~~may last for a period of up to four~~ must cease no later than five hours after any high tide.

**Discharge Monitoring**

25. The consent holder shall monitor the flow rate of treated wastewater leaving the tidal holding facility at the Clarks Beach site (prior to the discharge location) and shall record the total daily discharge volume. The discharge volume meters must be maintained to ensure an accuracy of plus or minus 5 percent.

**Rainfall Monitoring**

26. The consent holder shall monitor and record the daily rainfall in millimetres (mm) at the Waiuku WWTP site.

**Receiving Environment Monitoring Programme**

- ~~26-27.~~ The consent holder shall prepare a Receiving Environment Monitoring Programme (REMP) as follows:

- (a) Prior to monitoring commencing the REMP shall be submitted to the Council's

Team Leader – Southern Monitoring for certification that it has been produced in accordance with the requirements of these conditions. The REMP shall be in general accordance with the requirements listed in (b)(i) to (xii) below and the Draft Receiving Environment Monitoring Programme, a copy of which is attached as **Appendix One**. The certified REMP shall also be provided to the ~~Consultative~~ Community Liaison Group by the consent holder.

- (b) The purpose of the REMP is to detect and delineate any obvious temporal trends in Manukau Harbour water quality, shellfish quality and marine ecology related to the discharge of wastewater from the WWTP. The REMP shall include/address:
- i. Coastal water quality monitoring (initially from 10 sites);
  - ii. Diurnal measurements of dissolved oxygen (at one site);
  - iii. Phytoplankton monitoring (initially 4 sites);
  - iv. Shellfish monitoring for microbial contaminants (initially from four sites);
  - v. Benthic ecology monitoring (initially from nine sites and reef ecology from one site);
  - vi. Shellfish monitoring (initially from six sites for scallops, five sites for cockles and five sites for oysters);
  - vii. A procedure for modifying the REMP;
  - viii. Records of comments received from the ~~Consultative~~ Community Liaison Group;
  - ix. Spatial and temporal extent of the key biogenic habitats (scallop beds, sponge gardens, horse mussel beds, seaweed forests) within 1km from the proposed outfall;
  - x. Benthic community (fauna and flora) abundance and diversity;
  - xi. Sediment quality analysis (heavy metals, grain size, organic content, anoxic layer/redox potential);
  - xii. Spatial and temporal extent of algal blooms;
  - xiii. Suitability of kaimoana species for harvesting and human consumption. This shall include species, size and number of samples to monitor; and
  - xiv. Reporting procedures.



Monitoring design for the above aspects is to include the number of samples, spacing of sample stations in relation to the position of the outfall, frequency of sampling, methodology and reporting. The monitoring programme should be designed to deliver ecologically meaningful results and be statistically robust enough to detect potential changes to those matters listed above.

27-28. As a minimum, for two years prior to and two years following commencement of the



discharge of treated wastewater to the Waiuku Channel as authorised by this resource consent, the consent holder shall undertake the monitoring in accordance with the REMP as described in Condition ~~26-27~~ and shall provide a ~~summary data~~ report to the Auckland Council on an annual basis for the first three years of implementing the REMP (prior to the preparation of the Receiving Environment Monitoring Report as per Condition 29). The ~~summary data~~ report shall provide all the raw data collected and a summary interpretation of the results of the REMP.

~~28-29.~~ On completion of two years of receiving environment monitoring following commencement of the treated wastewater discharge, and every five years thereafter, the consent holder shall engage ~~a~~ an independent suitably qualified person to prepare a Receiving Environment Monitoring Report. The Receiving Environment Monitoring Report shall as a minimum:

- (a) Summarise the results of the REMP against relevant standards and/or guidelines;
- (b) Critically assess any significant trends in the results of the receiving environment monitoring;
- (c) Assess any significant adverse effects of the treated wastewater discharge on receiving water quality, shellfish quality and marine ecology, irrespective of whether the discharge complies with the conditions of this consent; and
- (d) Recommend that the frequency of sampling and/or number of sites specified in Condition ~~26-27~~ be maintained, increased or reduced as appropriate.

~~29-30.~~ The consent holder shall provide the Receiving Environment Monitoring Report to the Council's Team Leader – Southern Monitoring for certification that the report meets the requirements of Condition ~~289~~, and that any recommendations under Condition ~~289~~(d) accord with the purpose of the REMP as stated in Condition ~~26(b)27(b)~~. If they do accord with that purpose, certification of the report constitutes acceptance of the recommendations, and the REMP shall be amended accordingly. The Receiving Environment Monitoring Report shall also be provided to the ~~Consultative Community Liaison~~ Group as per Condition 7.

### **Operations and Management Plan**

~~30-31.~~ Within six months of the commencement of the discharge of treated wastewater, the consent holder shall prepare an Operations and Management Plan (OMP). The objective of the OMP is to provide a framework for the operation and management of the WWTP and discharge facilities to ensure compliance with the conditions of consent. The OMP shall be submitted to the Council's Team Leader – Southern Monitoring for certification that it is consistent with the requirements of this condition and Condition 34 management of the WWTP and discharge facilities to ensure compliance with the conditions of consent. The OMP shall be submitted to the Council's Team Leader – Southern Monitoring for certification that it is consistent with the requirements of this condition and Condition 32. The OMP shall be reviewed and updated every three years by the consent holder and as required as a result of any significant changes in WWTP and discharge facilities' operation or management that could affect the quality and

quantity of the discharge to the coastal marine area. An electronic copy of the OMP shall be provided to the Council's Team Leader – Southern Monitoring within 10 working days of a request to do so.

31.32. As a minimum, the OMP shall include:

- (a) An overview description of the WWTP and discharge facilities;
- (b) A description and schedule of the routine inspection, monitoring and maintenance procedures to be undertaken to ensure operation of the WWTP and discharge facilities, complies with this consent;
- (c) A description of the sampling location/s and methodology for sampling the treated wastewater discharge;
- (d) A schedule of the critical aspects of the WWTP and the detailed response and contingency plans to remedy any possible variations from normal plant operation that could potentially affect discharge quality;

Details of contingency plans and procedures to address a critical power or equipment failure at the WWTP;

Procedures for recording routine maintenance and all major repairs that are undertaken; and

- (g) The consent holders chain of command, responsibility and notification protocols.

32.33. Any improvement or review of the OMP shall be consistent with the objective of the OMP and submitted to the Council's Team Leader – Southern Monitoring for certification.

### Emerging Contaminants

33.34. The consent holder shall engage ~~a~~ an independent suitably qualified person to undertake an Emerging Contaminants Risk Assessment (ECRA) by 30 September 2022 and five yearly intervals thereafter. The ECRA as a minimum include:

- (a) A review of the state of knowledge of emerging contaminants relevant to the WWTP since the commencement of these consents or the previous ECRA;
- (b) Consideration of whether additional samples are required for the purposes of the ECRA;
- (c) Measurement of emerging contaminants if determined necessary and the results of any samples collected;
- (d) An assessment of the risks to the environment from emerging contaminants in the treated wastewater discharged from the WWTP;
- (e) The ECRA shall be forwarded to the Council (Team Leader – Southern Monitoring) by 30 September of each year that it is required for certification that it meets the requirements of (a) to (d) above.

## Specific conditions – coastal permit CST60082302

### Outfall and Diffuser Location

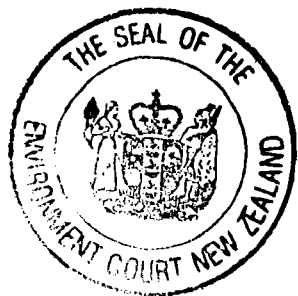
~~34.~~35. The outfall and diffuser structure shall be located in the Waiuku Channel at or about co-ordinates 5887800N and 1750600E (NZTM).

~~35.~~36. The diffuser structure shall be a 40 port diffuser outfall pipeline, or an alternative outfall structure providing, as a minimum, an equivalent dilution factor as presented in the AEE, to the satisfaction of the Council's Team Leader – Southern Monitoring.

### Offshore Outfall Construction Management Plan

~~36.~~37. No later than 30 working days prior to the commencement of construction the consent holder shall prepare an Offshore Outfall Construction Management Plan (**OOCMP**) for the construction of the offshore outfall pipeline and diffuser structure within the coastal marine area and submit the OOCMP to the Council's Team Leader – Southern Monitoring for certification it has been produced in accordance with the requirements of this condition. No later than 30 working days prior to providing the OOCMP to the Council, the OOCMP shall be provided to the ~~Consultative~~ Community Liaison Group for review and comment, as per Condition 7. The objective of the OOCMP is to confirm the detailed construction methodology for the outfall/diffuser and the measures proposed to mitigate potential adverse effects during construction. The OOCMP shall include:

- (a) Pipeline(s) profile and diffuser structure and design concept;
- (b) Type of construction method being adopted and material types;
- (c) Method of backfilling and the nature of trench backfill material, including that the material is free from contaminants and sized to prevent scour and remobilisation;
- (d) Threshold levels for total suspended solids in the water column, monitoring and response procedures, and methods to remedy disturbance resulting from the construction works;
- (e) Hydrostatic and any other testing of the pipeline(s);
- (f) The proposed timeframe for construction (including contingency);
- (g) Contingency plans in case of discharges to the coastal marine area;
- (h) Site management; including details of:
  - i. Site access;
  - ii. Signage during the construction works;
  - iii. Methods to be used to minimise the need for cleaning, refuelling, maintenance and storage of equipment and machinery in the coastal marine area;



- iv. Procedures for cleaning, refuelling, maintenance or storage of equipment or machinery in any part of the coastal marine area if this is required, and measures to avoid discharges of contaminants during cleaning, refuelling, and maintenance activities in the coastal marine area; and
- v. Site clean-up following completion of the construction works.
  - (i) Identification of all construction access points to the coastal marine area and along the foreshore;
  - (j) Health and safety and access matters relating to general public accessing and using the coastal marine area and along the foreshore;
  - (k) Minimisation as far as is reasonably practical the footprint of the disturbed area;
  - (l) A vegetation restoration and maintenance programme including an inter-tidal shoreline restoration plan (only required if the inter-tidal rock platform is cut and disturbed);
  - (m) Measures proposed to minimise disruption to water related recreational activities (including boating) in the vicinity of the construction activities; and
  - (n) Measures to minimise underwater noise effects during construction.

The consent holder shall ensure that the outfall construction is undertaken generally in accordance with the OOCMP.

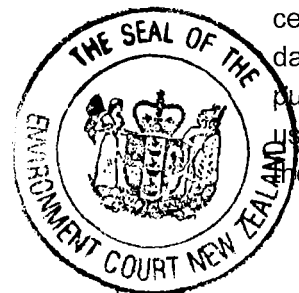
#### **Notifications**

~~37-38.~~ The consent holder shall notify the Council's Team Leader – Southern Monitoring in writing of the date of the proposed commencement of works at least 10 working days prior to the proposed start date.

~~38-39.~~ The Harbourmaster's Office (Auckland Transport Harbourmasters Office, HarbourMaster@aucklandtransport.govt.nz or Private Bag 92250, Auckland 1142) shall be notified by the consent holder in writing at least 10 working days prior to construction activity commencing in the coastal marine area.

#### **Construction Management – Horizontal Directional Drilling**

~~39-40.~~ A Drilling Fluid Management Plan shall be prepared by an appropriately qualified person and submitted to the Council's Team Leader – Southern Monitoring for certification that it meets the purpose stated in this condition no later than 30 working days prior to commencement of construction activities in the coastal marine area. The purpose of the Drilling Fluid Management Plan is to demonstrate how drilling fluid will be used, stored and disposed of in a manner designed to prevent unlawful discharges into the environment.



### **Construction Reporting**

~~40.41.~~ During installation of the off-shore outfall pipeline and diffuser, the consent holder shall provide monthly reports to the Council's Team Leader – Southern Monitoring regarding details of the monitoring undertaken to demonstrate the activities are in accordance with the OOCMP.

~~41.42.~~ In the event of the detection of any system failure of the offshore outfall and diffuser structure while under construction or in operation, the Council's Team Leader – Southern Monitoring shall be notified within 24 hours of such a system failure and provided with details of:

- (a) The nature of any failure including effects; and
- (b) Any remedial works to be carried out.

### **Erosion within the Coastal Marine Area**

~~42.43.~~ All practicable measures shall be undertaken to ensure that the construction of the offshore outfall and diffuser does not exacerbate erosion within the coastal marine area.

~~43.44.~~ In the event of erosion occurring as a direct result of the construction or operation of the offshore outfall and diffuser, the consent holder shall, in consultation with the Council's Team Leader – Southern Monitoring, undertake all practicable measures to remedy any damages caused and minimise the potential for future erosion.

### **Completion of Works**

~~44.45.~~ The consent holder shall, within one month following the completion of works, remove all temporary structures from the coastal marine area and shall ensure that all disturbed areas are returned to a state generally consistent with the surrounding seabed and foreshore, to the satisfaction of the Council's Team Leader - Southern Monitoring.

~~45.46.~~ The Council's Team Leader – Southern Monitoring shall be notified in writing of the date of completion of the works, within one week of the completion date.

~~46.47.~~ Within one month of the completion of the proposed works, a complete set of "as built" plans shall be supplied to the Council's Team Leader - Southern Monitoring.

~~47.48.~~ The consent holder shall remove the existing redundant outfall at the Waiuku WWTP and associated structures located within the coastal marine area within 12 months of the operation of the WWTP.

### **Use and Occupation**

~~48.49.~~ The use of the offshore outfall pipeline and the diffuser structure, which may include any temporary structures associated with the installation, repair and maintenance of the offshore outfall pipeline and diffuser structure, shall be limited to the conveyance and discharge of treated wastewater

~~49.50.~~ The right to occupy part of the common marine and coastal area shall be limited to the area constructed under this permit and temporary staging works identified in the documents listed in Condition 1.



50-51. The right to occupy part of the common marine and coastal area with constructed structures under this permit shall not be an exclusive right.

#### **Offshore Outfall Inspection Report**

51-52. The consent holder shall provide to the Council's Team Leader – Southern Monitoring and the ~~Consultative~~ Community Liaison Group, as per Condition 7, every five years from the commencement of the treated wastewater discharge a report prepared by a suitably qualified and experienced person(s) to demonstrate that the offshore outfall and diffuser structure is:

- (a) In sound repair and the diffuser ports are clear of any significant marine growths and that there are no significant losses occurring from the system; and
- (b) The offshore outfall pipeline is not exposed above the seabed floor other than the diffuser structure.

In the event that the consent holder is aware that the offshore outfall pipeline is identified as having become exposed (other than the diffuser section that is designed to be exposed), either as a result of an inspection carried out or at any other time, the Council's Team Leader – Southern Monitoring and The Harbourmaster's Office (Auckland Transport Harbourmasters Office, Private Bag 92250, Auckland, 1142 or HarbourMaster@aucklandtransport.govt.nz) shall be notified immediately and provided with a report providing an assessment of effects and any proposed remediation or risk management to be undertaken within 10 working days.

#### **As-built Plans to Council and Chief Hydrographer**

52-53. Within twenty (20) working days of the completion of the construction works, the consent holder shall supply a copy of the 'as built' plans to the Council's Team Leader – Southern Monitoring and the New Zealand Hydrographic Authority (Land Information New Zealand, Private Box 5501, Wellington 6011 or customersupport@linz.govt.nz). The 'as built' plans shall include a location plan, a plan which shows the area of occupation, outfall dimensions, and cross sections.

#### **Maintenance Requirements**

53-54. The structures permitted to occupy part of the common marine and coastal area by this consent shall be maintained in a good and sound condition, and any repairs that are necessary shall be made, subject to obtaining any necessary resource consents.







## Definitions and Abbreviations

Term	Definition
Average Dry Weather Flow	The flow averaged over a year using only flows calculated on those days defined as a 'dry day'.
<u>Consultative Community Liaison Group</u>	A group to be formed between the consent holder and stakeholders for on-going involvement throughout the resource consent term.
Discharge Facilities	The tidal storage basin at the existing Clarks Beach Wastewater Treatment Plant site and the proposed offshore outfall and diffuser structure located in the Waiuku Channel off the existing Clarks Beach Golf Course.
Discharge Location	The location of the treated wastewater discharge to the Coastal Marine Area of the Waiuku Channel.
Dry Day	A day when the flow in the wastewater network is indicative of a dry weather period. A dry day is defined as a day with fourteen preceding days including the dry day of 25mm or less of total rainfall. Using this definition, a dry day requires fourteen preceding consecutive days and the dry day itself to have a total rainfall of 25mm or less, to be defined a 'dry day'.
Treated Wastewater Compliance Monitoring Point	The point immediately following the UV disinfection system located within the WWTP site.
Validated Dose	The Ultraviolet (UV) dose reported by the UV system shall be a biosimetrically validated UV dose, established according to the procedures described in the US EPA UV Disinfection Guidance Manual, 2006. Biosimetric work should have been conducted with a multiple test organisms (minimum two) and would include the sensitivity of the target organism within the dose prediction equation. The validated UV dose shall be reported utilising the predicted sensitivity of MS2 bacteriophage within the dose prediction equation and shall be limited, where appropriate, to the boundaries of validation envelope.
Council	Auckland Council
ADWF	Average Dry Weather Flow
BPO	Best Practicable Option
DO	Dissolved Oxygen
DRP	Dissolved Reactive Phosphorus
NH <sub>4</sub> -N	Total Ammoniacal Nitrogen
OMP	Operations and Management Plan
OOCMP	Offshore Outfall Construction Management Plan
RMA	Resource Management Act 1991
TIN	Total Inorganic Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WWTP	The future Waiuku Wastewater Treatment Plant

## Advice notes

Any reference to number of days within this decision refers to working days as defined in section 2 of the RMA.

For the purpose of compliance with the conditions of consent, "the Council" refers to the Council's monitoring inspector unless otherwise specified.

For more information on the resource consent process with Auckland Council see the Council's website [www.aucklandcouncil.govt.nz](http://www.aucklandcouncil.govt.nz). General information on resource consents, including making an application to vary or cancel consent conditions can be found on the Ministry for the Environment's website: [www.mfe.govt.nz](http://www.mfe.govt.nz).

The consent holder is responsible for obtaining all other necessary consents, permits, and licences, including those under the Building Act 2004, and the Heritage New Zealand Pouhere Taonga Act 2014. This consent does not remove the need to comply with all other applicable Acts (including the Property Law Act 2007 and the Health and Safety in Employment Act 1992), regulations, relevant Bylaws, and rules of law. This consent does not constitute building consent approval. Please check whether a building consent is required under the Building Act 2004.

Compliance with the consent conditions will be monitored by the Council in accordance with section 35(d) of the RMA. This will typically include site visits to verify compliance (or non-compliance) and documentation (site notes and photographs) of the activity established under the consents. In order to recover actual and reasonable costs, inspections will be charged at the relevant hourly rate applicable at the time.

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SCHEDULE B

AMENDED DRAFT RECEIVING ENVIRONMENT MONITORING PLAN





# **SOUTHWEST SUBREGIONAL WASTEWATER TREATMENT PLANT**

## **DRAFT RECEIVING ENVIRONMENT MONITORING PROGRAMME**

Updated 14<sup>6</sup>th June 2018<sup>7</sup>



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# 1 Purpose of Draft Receiving Environment Monitoring Programme

The purpose of this Draft Receiving Environment Monitoring Programme is to provide a draft version of the monitoring programme proposed to meet the requirements of the Watercare suggested condition 25 of the consent conditions for the South-West Sub-Regional Wastewater Treatment Plant Discharge to the Waiuku Channel.

This Draft Receiving Environment Monitoring Programme sets out to further detail the monitoring programme to meet the requirements of suggested condition ~~25~~27(b). The frequency of sampling and/or number of monitoring sites specified in this document may be reviewed through the Receiving Environment Monitoring Report process (see conditions 29(d) and 30 of the consent).

## 2 Water Quality of Receiving Environment

Like many of our estuaries the Manukau Harbour and Waiuku Estuary are under growing pressure from coastal and land activities and deteriorating water quality. The upper Waiuku Estuary has "Poor" water quality, lower Waiuku Estuary "Fair" to "Poor" water quality and the Manukau Harbour around Clarks Beach also "Fair" to "Poor" water quality based on data from the Auckland Council sites. The Waiuku Estuary is classified as "Degraded 1" which means water quality must be improved and the Manukau Harbour as "Degraded 2" which means it must at least be maintained. These classifications come from the Auckland Unitary Plan.

It is important that the monitoring programme includes monitoring of water quality in the receiving environment to ensure that standards and guidelines and coastal policies are met and to ascertain if any changes in water quality can be attributed to the discharge from the Wastewater Treatment Plant (WWTP) at the Clarks Beach discharge point. It is recommended that water quality be measured at sites in a transect up the estuary and one out into the South-west Manukau Harbour as shown in Figure 2-1. Indicative site co-ordinates are provided in Appendix A. The transect sites will be sampled monthly at falling mid-tide and for at least two years prior to the upgrade commencement of the treated wastewater discharge from the new Wastewater Treatment Plant (WWTP), and all sites and parameters for two years after the new plant is installed commencement of the discharge, then reviewed for sites and frequency (see consent conditions 29(d) and 30).

The surveys will be integrated with the existing Auckland Council (AC) monitoring at Clarks Beach and in the Waiuku Basin which are sampled monthly and provide long term trends.

### 2.1 General Water Quality Monitoring

The following sites will be monitored for general water quality:

- 50 m upstream and downstream of the discharge point (WQ3 and WQ4);
- 250 m upstream and downstream of the discharge point (WQ2 and WQ5);
- 1 km upstream and downstream of the discharge point (WQ1 and WQ6);
- 3 km out into the south-west Manukau Harbour (WQ7);
- Sites at Clarks Beach (CB) and Waiuku Town basin (WU) (presently monitored by Auckland Council); and
- A site off the Whatapaka Marae (WQ8).

The following parameters will be measured at the above sites:



- TSS, salinity, turbidity, DO, Temperature, pH and conductivity
- Nutrients (NH<sub>4</sub>-N, TIN, TN, TP, DRP)
- Enterococci, FC
- Chlorophyll a<sub>2</sub>

## **2.2 Phytoplankton Monitoring**

The following sites will be monitored for phytoplankton at the same time as the general water quality monitoring described in Section 2.1 above:

- 250 m upstream and downstream of the discharge point (WQ2 and WQ5);
- 3 km out into the south-west Manukau Harbour (WQ7);
- Site at Clarks Beach (CB) (presently monitored by Auckland Council); and

The following parameters will be measured at the above sites:

- Presence, or not, of harmful algal species;
- Cyanobacteria if present to species level; and
- The three numerically dominant phytoplankton species.

Samples shall be taken at in the top 1m of the water column.

~~After two years sampling the results will be reviewed and the sampling programme design reconsidered with a view to reducing the number of sites long term.~~



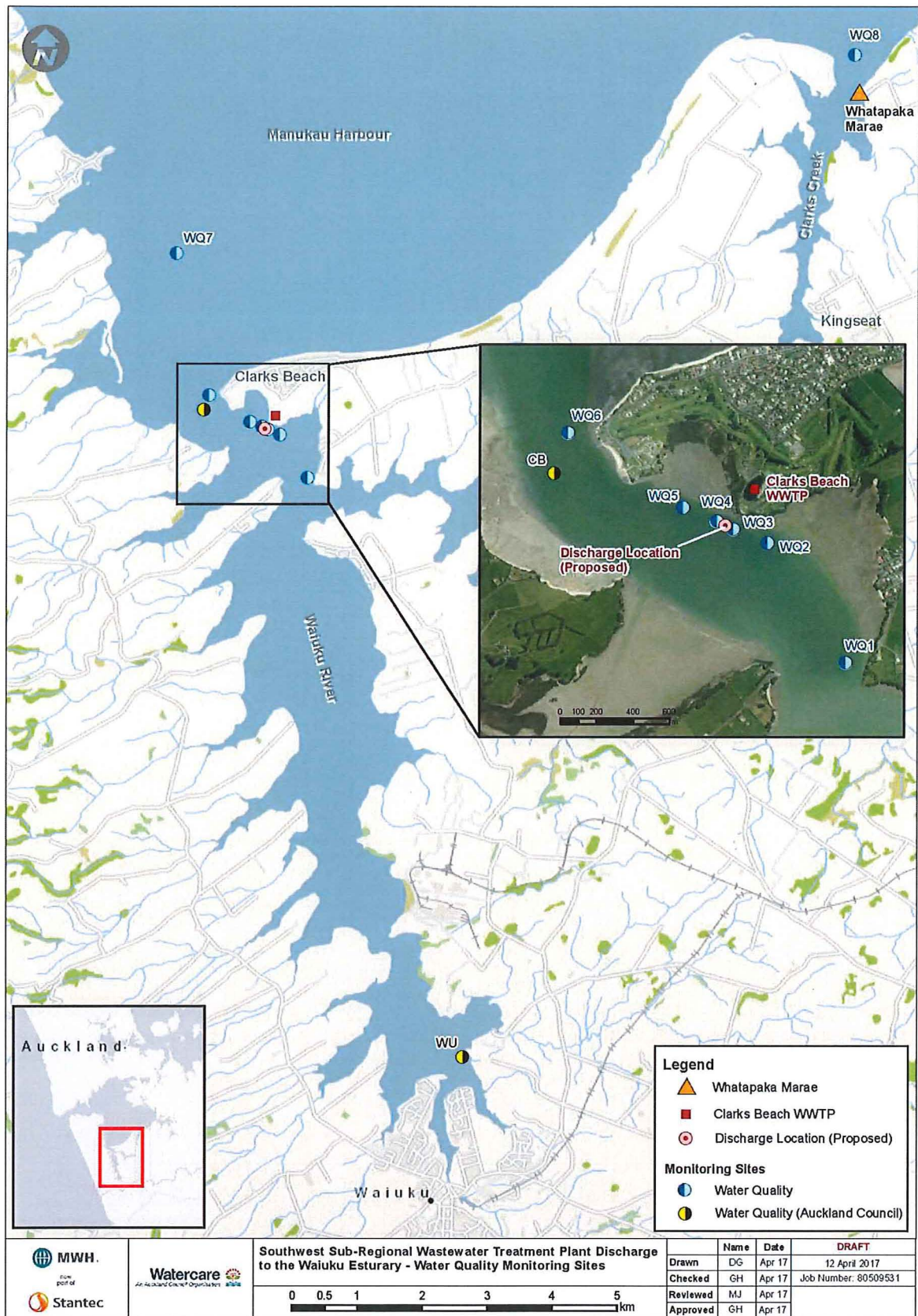


Figure 2-1: Indicative Sites for Water Quality





### 3 Shellfish Monitoring for Microbial Contaminants

Shellfish flesh monitoring for viruses will be advisory only, not constrained by a 'standard'. This is because there can be factors other than treated wastewater impingement that can cause viral shellfish contamination—for example storm runoff.

Shellfish will be sampled on 5 occasions per year for two years, for human enteroviruses, human noroviruses, enterococci and faecal coliforms, from four sites that could be impinged. Two of these will be conducted after prolonged dry weather (no significant rainfall in the preceding fortnight) and the other three shortly after significant rainfall (greater than 15 mm (tentative) over the preceding 24 hours). There will need to be a minimum of 20 shellfish from each site on each occasion

~~After two years sampling the results will be reviewed and the sampling programme design reconsidered.~~

Figure 3-1 shows the location of the four indicative sites. Site co-ordinates are provided in Appendix A.



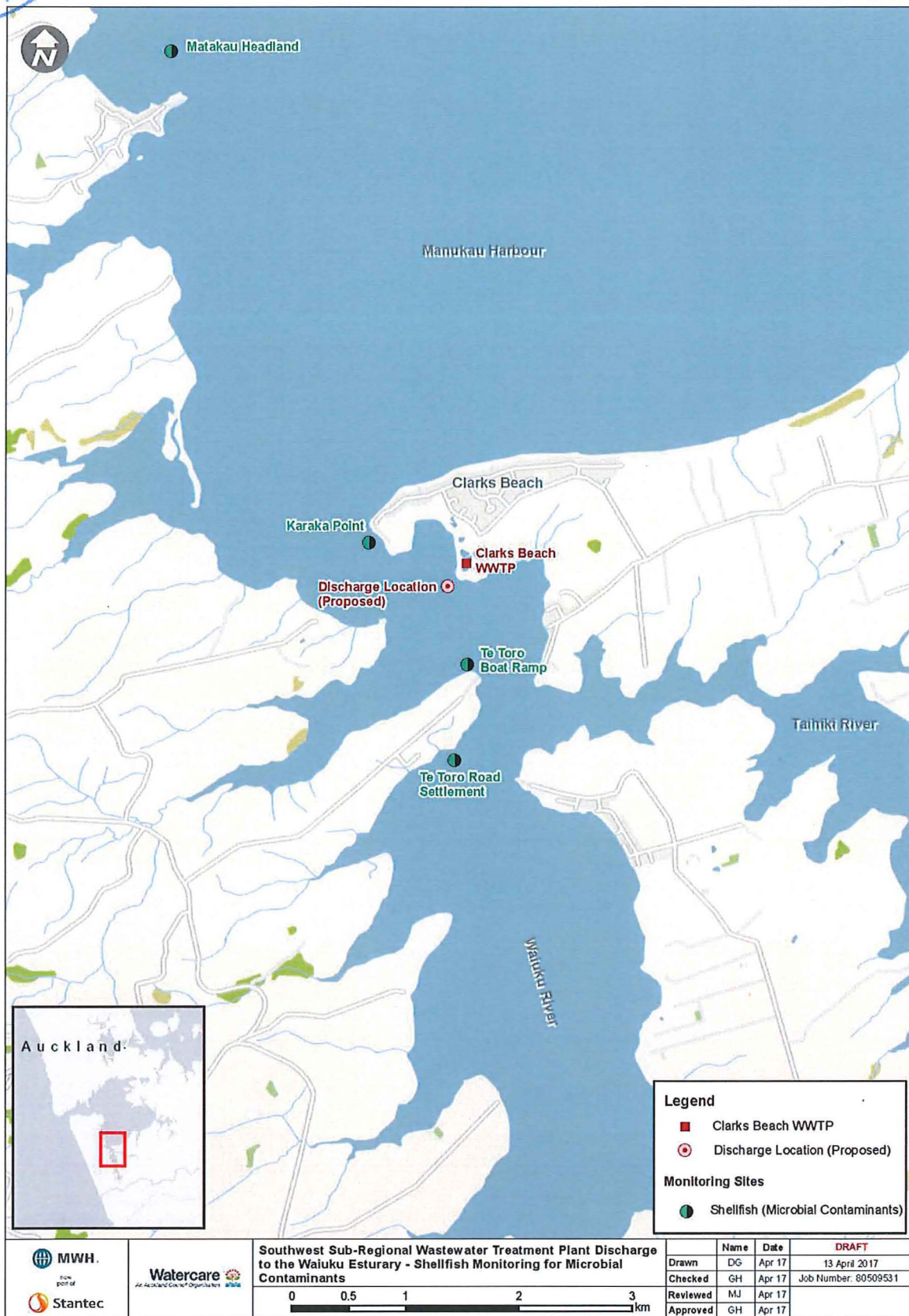


Figure 3-1: Indicative Sites for Shellfish Monitoring for Microbial Contaminants

## 4 Marine Benthic Ecology

Currently there is no regular ecological monitoring conducted in the Waiuku River estuary. The only routine sampling is the (oyster) consent monitoring associated with the Steelworks works (Bioresarches 2014). The Auckland Council Regional Sediment Chemistry Monitoring Programme (RSCMP) occasionally samples from sites in the Waiuku River. The nearest regular ecological monitoring occurs at the Auckland Council's Clarks Beach site (CB).

Dependent on treatment level, wastewater can be elevated in nutrients and can result in elevated levels of primary production in micro- and macro-algae. Small increases in these (particularly benthic micro-algae) can result in increases in diversity of macrofaunal communities, while greater organic enrichment can result in lower diversity, changes in species abundance and changes in macrofaunal community composition. Increases in benthic micro-algae can also increase mud content of the sediment and thus concentrations of other contaminants. Finally increases in nutrients can result in decreases in seagrass coverage and condition. Any monitoring of discharge effects needs to combine components of benthic macrofauna, micro-algae, macro-algae and sediment characteristics. Due to the lack of remote assessment methods all but the macro-algae and seagrass need to be monitored at selected sites; vegetation monitoring can be conducted at these sites but also at a broader scale.

All sites and parameters will be monitored for at least two years prior to and after the treated wastewater discharge from the new WWTP is installed commences. After two years, the sampling programme design will be reconsidered in terms of frequency and number of sites but it is anticipated that the frequency of monitoring will reduced to annual once the seasonal component has been assessed.

### 4.1 Site-Scale Sampling

#### 4.1.1 Design

Modelling by McBride (2016) indicates that the area closest to, and in the immediate vicinity of, the discharge point to be at most risk (wastewater-viruses). Generally speaking, moving away from the point of discharge the risk diminishes. The monitoring proposed below is designed to complement existing Auckland Council monitoring; using similar procedures and timing. This will enable a contextualisation of newly collected monitoring data and will allow the detection of trends much sooner than would otherwise be the case. The monitoring sites proposed (Figure 4-1) cover a gradient from the WWTP, allowing impacts of anthropogenic disturbance and other environmental factors to be considered and partitioned (e.g. Ellis et al. 2000). Data from the Auckland Council CB site can be utilised as an 'outer' site in relation to the Clarks Beach WWTP<sup>1</sup>; a site where trends and long-term cycles in species and environmental variables are already established. Thus, over the first years of monitoring, the Auckland Council CB site can be used as both as an endpoint on a gradient of effect and a contextual point for behaviour of the macrobenthic community at new sites.

These proposed sites contain ecological communities that are suitable for monitoring i.e. include shellfish beds or collections of common estuarine species, and are composed of muddy-sands. Importantly these proposed sites are not highly degraded which would make the detection of further changes more difficult to determine (co-ordinates provided in Appendix 1):

Glenbrook Beach

Mid-shore, flat beach, typical estuarine habitat (~2.1km up the Waiuku River estuary from the discharge point).

<sup>1</sup> However it is also demonstrating subtle signs of enrichment (Greenfield et al. 2015), control sites can be difficult to establish.



Waiau Bay	Mid-shore, embayment, cockle presence (~500m to the east (across the estuary) of the discharge point).
Ohiku Creek	Mid-shore, sandy plain at mouth of the estuary, typical estuarine habitat with presence of mud crabs (~650m, opposite discharge point).
Site 50 m from discharge point	Important to measure effects along gradient including near discharge point.
Site 250 m from discharge point	Important to measure effects along gradient including near discharge point.
Karaka point	Typical estuarine habitat on the mid-shore (beyond the white sand), popular beach (~800m from discharge point), indicated to be at high risk from modelling work.
Lower Clarks Beach (LCB)	Typical estuarine habitat, cockle presence, on the outer Clarks Beach sandflat (mid-shore, ~2 km from discharge point).
Clarks Beach (CB)	Auckland Council monitoring site.
Clarks Beach East	Site identified as important for bird habitat.



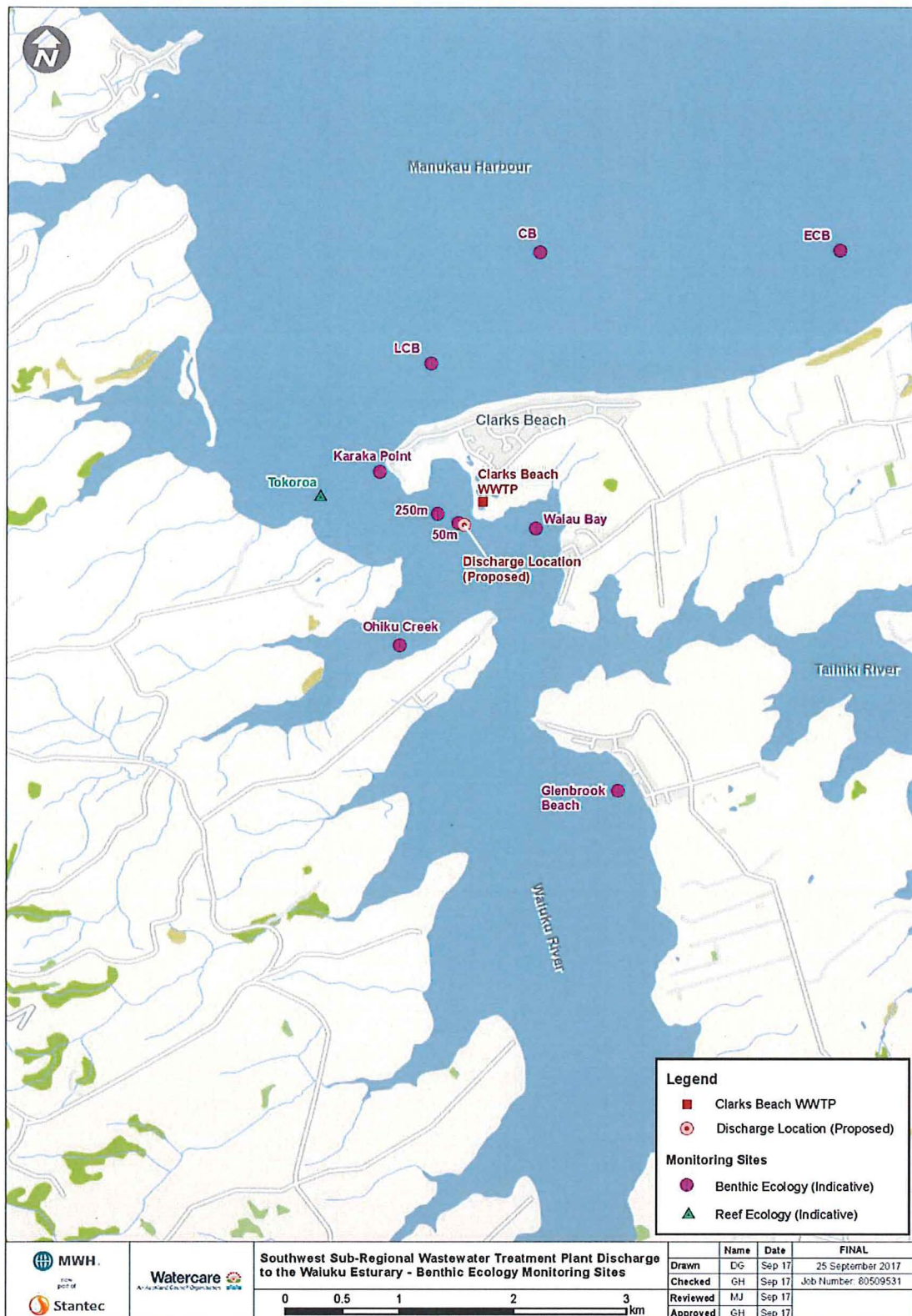


Figure 4-1: Indicative Sites for Benthic Ecology Monitoring



Six-times annually (February, April, June, August, October and December) except for the Glenbrook Beach and Middle Clarks Beach sites which will be sampled annually. Samples will be collected for:

- Macrofauna (12 cores, 13 cm dia, 15 cm deep), from a 6000-9000 m<sup>2</sup> site area.
- Micro-algal biomass as sediment Chlorophyll a content, one composite sample per site.
- Sediment organic content (AFDW), Redox Potential Discontinuity (RPD) and grain size, one composite sample per site.
- Site photos and observations.

~~After two years~~ Two years after the commencement of the treated wastewater discharge from the WWTP, the frequency and number of sites will be reviewed and consideration given to reducing frequency at least for the middle Clarks Beach and Glenbrook sites to annual surveys.

Sampling three-times annually for:

- The presence of macro-algae across the monitoring site using aerial photography and digital analysis. Conducted at least quarterly if the presence of macro-algae becomes high e.g. if >20% of the area contains macro-algal coverage.
- Additional sediment samples for TOC, TP and TN<sup>2</sup>.

~~Annual sampling~~ Sampling every two years for:

- Sediment heavy metal contaminant samples: total recoverable copper, zinc ~~and lead annually, 5, lead, arsenic, cadmium, chromium, nickel and mercury. Five replicates per site from within the monitored area (Annually in October, 3 analysed, 2 kept as reference samples). Five yearly sampling for arsenic, cadmium, chromium, nickel and mercury from within the monitoring sites<sup>3</sup>.~~
- Organic contaminants. Annual sampling for polycyclic aromatic hydrocarbons (PAHs) from within the monitoring sites. To be collected during a month when TOC samples are also collected.

As part of the REMP Monitoring Programme, Watercare will fund a study consisting of DO monitoring three times per year (two during blooms<sup>3</sup> and one during a non-bloom period) as follows over each of these years:

- At least one year before commencement of the new WWTP discharge, as a baseline;
- No later than two years after commencement of the discharge; and
- No later than five years after commencement of the discharge.

Measurements of DO are to be taken on a calm night at a minimum of every two hours over a 24 hour period using appropriate technology at the Auckland Council Clark's Beach site. One sampling run in each of these years shall be a vertical DO sampling taken during an algal bloom. The other samples are to be a one off grab sample.

<sup>2</sup> Measures of sediment total nitrogen and total phosphorus content have been advocated and implemented in monitoring programmes in the South Island where enrichment and eutrophication have been problematic (Robertson et al. 2002). The use of the TP and TN as useful indicator in the North Island is not well established and results have been variable e.g. (McCartain & Hewitt 2016, Parks et al. 2016). TP and TN samples could be collected and assessed for their variability and validity as a useful metric. Over time, if their validity remains unproven these should be discontinued.

<sup>3</sup> Although these might not be directly from the WWTP, they will help to partition out possible influences and sources of stress on benthic communities.

<sup>3</sup> Blooms in these circumstances means a sustained (1-2 month) increase in chlorophyll a concentration at times blooms normally occur including winter.



If there is no algal bloom in any of the years specified above, then DO monitoring will be undertaken in the following year.

Details on tests and detection limits are provided in Appendix 2, procedures should follow Mills & Williamson (2014).

## 4.1.2 Methods

### Sites and sampling

- Each monitoring site will be ~6000-9000 m<sup>2</sup> of relatively uniform habitat on the mid-shore. Each site will be divided into 12 equal sectors, with one macrofaunal core collected from a random location within each sector.
- Adjacent to every second macrofaunal core, two small sediment cores (2 cm deep, 2 cm diameter) will be collected, one to determine grain size and organic content and the other for chlorophyll *a* analysis (each 'final' sample is the composite of 6 pooled cores). Cores will be frozen and kept in the dark. RPD to be measured at each site on each occasion (six times annually in February, April, June, August October and December).
- Contaminant sample collection will follow the procedures of the Regional Sediment Chemistry Monitoring Programme (RSCMP) (Mills et al. 2012).
- Macrofaunal core samples will not be positioned within a 5 m radius of each other or of any samples collected in the preceding 12 months. This will preclude the localised modification of populations by previous sampling events and limit the influence of spatial autocorrelation.
- Macrofaunal cores will be sieved over a 500 µm mesh and the fauna retained preserved with 70% isopropyl alcohol and stained with 2% Rose Bengal prior to identification.
- Post identification - common bivalves e.g. *Austrovenus stutchburyi*, *Paphies australis* and *Macomona liliiana* will be measured (longest shell dimension; mm) and put into size classes <5 mm, 5-10 mm, 10-15 mm, 15-20 mm, 20-30 mm, 30-40 mm, 40-50 mm and >50 mm).
- During each visit, digital photos will be collected and notes on site appearances will be taken e.g. presence of birds, plants, micro-algal blooms and epifaunal species.

### Macrofauna:

- Sorting and identification procedures will follow the standardised methods used by NIWA, many Regional Councils and other agencies, outlined in Hewitt et al. (2014)
- Macrofaunal community data will be used to calculate health indices developed in the Auckland Region (see Appendix 3 for details).
  - Benthic Health Model for Mud (BHMmud) as per Hewitt & Ellis (2010).
  - Benthic Health Model for heavy metals (BHMmetals) as per Anderson et al. (2006).
  - Trophic Based Index (TBI) for Functional Redundancy as per Lohrer and Rodil (2011).
  - Combined Health Index as per Hewitt et al. (2012), outlined in Appendix B.
- Trial the use of Benthic Health Model for nutrients and organic enrichment (BHMnutrients, developed in Tauranga, Ellis et al. 2015).

### Chlorophyll a:

- Within one month, the sediment sample is freeze dried, weighed, then homogenised and a subsample (~0.5 g) taken for analysis. Chlorophyll *a* is extracted by boiling the sediment in 90% ethanol, and the extract processed using a spectrophotometer (Sartory, 1982).

### Ash-free dry weight:



- Approximately 5 g of sediment will be placed in a dry, pre-weighed tray. The sample will be dried at 60°C until a constant weight is achieved (the sample is weighed after ~ 40 hr and then again after 48 hr). The sample is ashed for 5.5 hr at 400°C (Mook and Hoskin 1982) and reweighed.

#### Grain-size:

- Prior to analysis, the samples will be homogenised and a subsample of approximately 5 g of sediment taken. Samples will be digested in 6% hydrogen peroxide until all organic matter is removed, and sampled by wet sieving and pipette analysis (Gatehouse 1971). Pipette analysis will be used to separate the <63 µm fraction into >3.9 mm and <3.9 mm. All fractions need to be dried at 60°C until a constant weight is achieved (fractions are weighed at ~ 40 hr and then again at 48 hr).
- The results of the grain size analyses will be presented as percentage composition of gravel/shell hash (>2 mm), coarse sand (500–2000 µm), medium sand (250–500 µm), fine sand (62.5–500 µm), silt (3.9–62.5 µm) and clay (<3.9 µm). Mud content is calculated as the sum of the silt and clay content.

#### Macro-algae

- Each monitoring site (~6000-9000 m<sup>2</sup>) will be divided into 6 zones, with 3-5 random quadrats within each zone. Each quadrat will be photographed vertically from above, and the digital images used to estimate the mean coverage of macro-algae (visual estimates or digital estimate using suitable graphics software). Collectively the quadrats can be used to estimate the percentage coverage across the site.

#### Contaminants:

- Analysis of contaminants will follow the recommendations of the Regional Sediment Chemistry Monitoring Programme (RSCMP) (Mills et al. 2012).

## 4.2 Vegetation Mapping

Monitoring will include an assessment of macro-algae coverage across sites near to the WWTP (See above) and also further afield across the wider intertidal areas:

- RGBI ortho-imagery<sup>4</sup> at a 0.3 m GSD pixel resolution or greater, will be collected across the southern harbour. Images will be collected at the time of low water (ideally spring low water, 0.1 to 0.5m) when the sand and mudflats are exposed.
- Aerial images to be used for vegetation mapping - principally nuisance red algae (*Gracilaria* spp.), nuisance sea lettuce (*Ulva lactuca*) and seagrass (*Zostera muelleri*), using manual or automated methods in ARC-GIS. See Townsend et al. (2016) for details on vegetation mapping<sup>5</sup>.
- Within the first 2 years of the treated wastewater discharge commencing, seasonal variation in vegetation coverage will be explored to determine if there are specific time periods that have lower or higher coverage.
- After 2 years of the treated wastewater discharge commencing, vegetation mapping will be conducted every five years.
- Vegetation coverage between years will be compared across a standardised area; to prevent anomalies attributable to differences in total area surveyed.

<sup>4</sup>Spatial resolution of imagery, +0.4 m at a 95% confidence level, and natural RGB colour of 24-bit (3 x 8 bits per band for red, blue and green).

<sup>5</sup> Assessment of mangrove expansion could also have some value here, could be combined with AC efforts.





- Changes over time can be considered e.g. increase in *Gracilaria* spp. coverage, decreases in seagrass, in relation to the nutrient budget of the catchment and the relative and potentially increasing contribution from the WWTP.

### 4.3 Monitoring of Shellfish in the Vicinity of the Clarks Beach Discharge

The following surveys will be carried out for 2 years after the treated wastewater discharge commences and then reviewed to assess if the frequency and all sites are required for long-term monitoring (e.g. reduce sites to those close to the discharge). The potential microbial contamination of shellfish has already been covered above and these surveys are focussed on the distribution and abundance patterns to ascertain if the discharge is having any effects on the populations.

Shellfish sampling should be designed to ensure that the sampling does not compromise local populations of shellfish through sampling effort and removing excessive numbers of shellfish.

#### 4.3.1 Scallops

Scallops are present throughout the Waiuku River Channel and are found both north and south of Clarks Beach. Scallops were abundant within the vicinity of the WWTP, although principally not of legal size for harvesting during the survey of Townsend et al. (2016) (See Figure 31 in that report). Monitoring of scallops could include:

- Twice-yearly surveying at sites in the Waiuku River Channel e.g. Sites 5, 18, 3, 2, 1, and 19 from Townsend et al. (2016) (Figure 2, co-ordinates in Appendix 2).
- Sampling 6 months apart, at suitable points e.g. pre and post harvesting season.
- Surveying using a recreational scallop dredge (64.5 cm mouth width), 1 tow per site.
- Tows of approximately 100 m, standardised towing direction and speed (relative to tidal conditions).
- Scallops to be photographed with scale, facilitating sizing and enumeration, the majority of scallops returned immediately at the site of collection.
- Scallops from each site to be collected, put on ice, and the flesh analysed for:
  - Condition Index (ratio of dry tissue weight to shell weight)
  - Levels of contaminants relevant to the catchment i.e. copper, lead, arsenic and zinc, organics.

#### 4.3.2 Cockles

Cockles (*Austrovenus stutchburyi*) are present on the intertidal flats of Waiuku River and on the outer Manukau Harbour flats (Townsend et al. 2016, Greenfield et al. 2015). Monitoring of cockles will include:

- Twice-yearly, quantitative surveying of cockle populations e.g. 12 macrobenthic cores (13cm dia), collected across a defined areas of intertidal habitat<sup>6</sup>, sieved on a 500 µm mesh. Survey timed to include juvenile recruitment peaks and a period post juvenile mortality. Local sites known to have beds are<sup>7</sup> (co-ordinates provided in Appendix 2)
  - Matakawau Point
  - Rangiriri Spit
  - Southern shore of Te Toro Point



<sup>6</sup> This will allow direct comparison with surveying done at Waiau Bay

<sup>7</sup> These extent ~5km North and South of the WWTP

- Pukewhau Creek
- Waipipi Creek
- Analysis of populations (abundance) and size spectra.
- Annual mapping of the extent of cockle habitat at the above localities by examining location of samples and density.
- Twice-yearly sampling of cockles (as above for scallops).

### 4.3.3 Oysters

Oysters are present on the intertidal flats of Waiuku River and the outer Awhitu Peninsula. In some localities distinct oyster beds are formed. In other places, oysters are present on rocky reef but are below a density where they are classified as oyster beds. Bioresarches Ltd. have been undertaking long-term consent monitoring for New Zealand Steel Ltd. They have recorded a decline in the abundance of oysters since 1995 (including their control site in the Taihiki River near to the WWTP) and suspect this to be caused by a naturally occurring oyster virus, increased sedimentation and the expansion of mangroves (Bioresarches 2014). They have had to move a number of their monitoring sites due to a low abundance of oysters. Monitoring of oysters will include:

- Establishing areas of oyster reef suitable for repeated surveying. Potential sites to be identified from:
  - A site in Ngahere Bay and potentially multiple sites around the rocky-reef of Waiau Bay (if viable).
  - A site opposite Ngahere Bay on the rocky-reef.
  - A site in the large oyster reef on the southern shore of Te Toro Point.
  - A site at the entrance of the Taihiki River
  - A site on the oyster reef adjacent to Clarks Beach
  - A site close to the Needles
  - A site near Tahuna marae
- A baseline survey conducted for oysters, analysing flesh for the same parameters as scallops above:
  - Condition Index (as above)
  - Other contaminants relevant to the catchment i.e. copper, zinc and lead, arsenic and organic contaminants (PAHs).
- A suitable sampling frequency can be derived depending on the current levels of contaminants and the abundance of oysters at the localities. This frequency can be increased if there are concerns over specific contaminants.

### 4.3.4 Kai mMoana

At least two kai moana sites will be surveyed at Tokoroa Point and in the Taihiki River area. Details are yet to be finalised but the surveys will focus on species important for iwi.



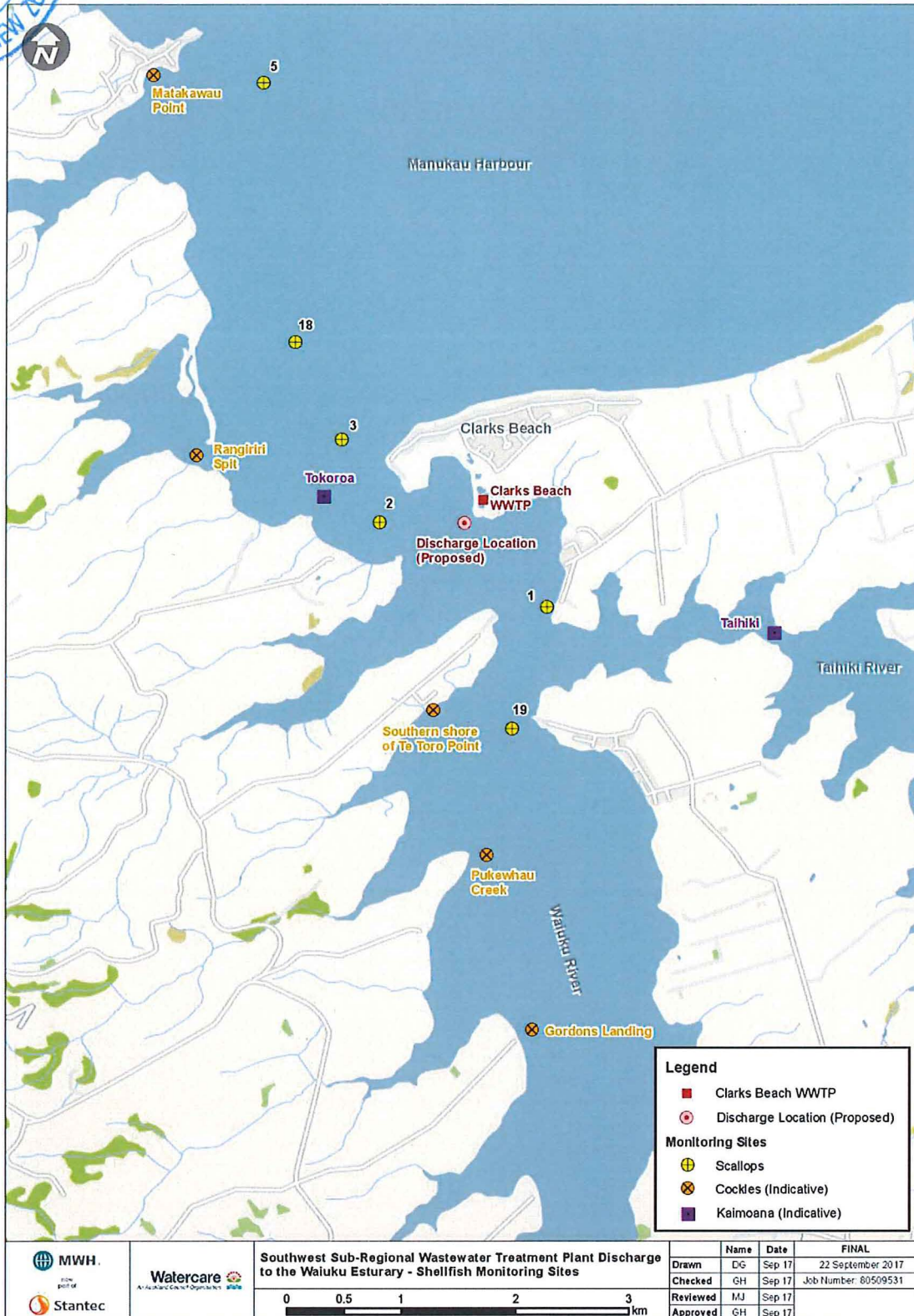


Figure 4-2: Indicative Sites for Shellfish Monitoring<sup>8</sup>

<sup>8</sup> Note – sites for oysters will need to be confirmed in the field.

### **Attributing Effects to the Discharge of Treated Wastewater**

There are multiple sources of stress in Manukau Harbour. The Waiuku River and intertidal flats already show impacts of land-use changes that have resulted in sedimentation and a predominance of mud across the estuary. Heavy metals contaminants are elevated at a number of sites and high levels of nutrients have resulted in the presence of nuisance macroalgae. The monitoring outlined in the sections above focuses on the condition of the species, communities and habitats in the vicinity of the WWTP. However, linking changes in the condition of benthic systems specifically to WWTP activities requires a well-focussed sampling design, an understanding of natural spatial and temporal dynamics and statistical analyses that partition variation along gradients in effects. Long-term monitoring of benthic communities, likely environmental drivers and stressors specifically associated with waste water discharge along a gradient away from the discharge provides a strong foundation for recording changes and being able to attribute them to the WWTP discharge (if they occur), rather than other catchment activities, natural temporal dynamics or marine influences. In the short-term this is only made possible by the existence of some Auckland Council monitoring in the Clarks Beach area.

## **5 Reef eEcology**

Following discussion with Ngati te Ata a reef site will be monitored at Tokoroa Point. Reef sampling is yet to be finalised but is likely to involve:

- a) Four replicate permanently marked reef sites at which photoquadrats will be established (at least 6).
- b) At least one permanent transect will be marked (5-20 m long) along the reef with 1 m<sup>2</sup> quadrats sampled along the transect at regular intervals.

At each location the reef habitat will be assessed for invertebrates, cover of seaweed and algae and a description of the habitat.

## **6 Procedure for Modifying the Monitoring Programme**

To be completed in final version of Monitoring Programme.

## **7 Records of Consultation with the Consultative Group**

To be completed following consultation.



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## Appendices

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**Appendix A**

**Co-ordinates for Sampling Sites**

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Monitoring Map	Site	Description	Location Coordinates (NZTM)	
			X	Y
WQ Monitoring Sites	<b>WQ Monitoring Sites</b>			
	WQ8	Off from Whatapaka Marae	1759645.701	5893505.607
	WQ7	3 km north of proposed discharge location	1749232.579	5890470.234
	WQ1	1 km south of proposed discharge location	1751258.242	5887047.192
	WQ6	1 km north of proposed discharge location	1749736.332	5888304.06
	WQ5	250 m north of proposed discharge location	1750369.03	5887895.67
	WQ2	250 m south of proposed discharge location	1750830.97	5887704.328
	WQ4	50 m north of proposed discharge location	1750554.759	5887821.288
	WQ3	50 m south of proposed discharge location	1750645.242	5887778.71
	CB	Clarks Beach site	1749651	5888082
WU	Town Basin (Sandspit) site in Waiuku	1753690	5878187	
Microbial Shellfish	<b>Shellfish Health Monitoring (Microbial contaminants)</b>			
	Karaka Point		1749904.048	5888183.602
	Te Toro Road Settlement		1750659.159	5886274.512
	Te Toro Boat Ramp		1750771.936	5887115.98
	Matakau Headland		1748155	5892485
Benthic Ecology	<b>Benthic Ecology</b>			
	Glenbrook Beach		1751959.84	5885477.901
	Ohiku Creek		1750038.014	5886747.916
	Waiiau Bay		1751236.15	5887770.572
	50m	50 m northwest of proposed discharge location	1750547.132	5887817.68
	250m	250 m northwest of proposed discharge location	1750368.823	5887898.476
	Karaka Point		1749862.16	5888262.305
	LCB		1750308.492	5889209.66
	CB		1751262.009	5890177.037
	ECB		1753893.787	5890191.025
	<b>Reef Ecology</b>			
Tokoroa		1749340.572	5888060.439	
Shellfish Monitoring	<b>Scallops</b>			
	1		1751323.205	5887067.434
	2		1749860.746	5887807.211
	3		1749521.431	5888529.271
	5		1748831.723	5891630.512
	18		1749115.089	5889375.507
	19		1751021.358	5886005.112
	<b>Cockles</b>			
	Matakawau Point		1747870.873	5891693.283
	Rangiriri Spit		1748251.601	5888389.745
	Southern shore of Te Toro Point		1750332.755	5886167.808
	Pukewhau Creek		1750799.014	5884902.895



Gordons Landing	1751199.279	5883379.313
Kaimoana		
Tokoroa	1749370.276	5888028.657
Taihiki	1753318.892	5886838.227

FINAL



**Appendix B Tests and Detection Limits for  
Nutrients and Metals**

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## Nutrients

	Method or Reference	Detection limit
Ammoniacal Nitrogen (as N)	Ref: APHA (2012) Colorimetry/Discrete Analyser	0.4 mg/L
Nitrate (as N)	Ion Chromatography (0.45 µm Filtered)	0.02 mg/L
Nitrite (as N)	APHA (2012) 4500-NO2-B (modified)	0.002 mg/L
Total Nitrogen (as N)	Persulphate Digestion and Flow Analysis	0.010 mg/L
Dissolved reactive phosphorus	TBC	0.005 mg/L
Total phosphorus (as P)	TBC	0.005 mg/L
Total suspended solids	TBC	0.2 mg/L
Chlorophyll a	TBC	0.0006 mg/L

## Sediments

Sample Type: Sediment		
Test	Method Description	Default Detection Limit
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt
Polycyclic Aromatic Hydrocarbons Trace in Soil	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on dried sample	0.002 - 0.010 mg/kg dry wt
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-
Total Recoverable Copper	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O <sub>2</sub> ), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt



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## C.1 Traits-Based Index (TBI)

Organisms can be categorised according to characteristics (traits) that are likely to reflect ecosystem function (i.e., their feeding mode, degree of mobility, position in the sediment column, body size, body shape, capacity to create tubes/pits/mounds, etc.). During 2010 and 2011, an index based on these biological traits was created (van Houte-Howes and Lohrer 2010) and improved (Lohrer and Rodil 2011). The index is based on seven broad trait categories (living position, sediment topography feature created, direction of sediment particle movement, degree of mobility, feeding behaviour, body size, body shape and body hardness). Specifically the richness of taxa exhibiting seven particular traits: living in the top 2 cm of sediment, having an erect structure or tube, moving sediment around within the top 2 cm, being sedentary or only moving within a fixed tube, being a suspension feeder, being of medium size, or being worm shaped. Values of this index range from 0-1, with values close to 0 indicating low levels of functional redundancy and highly degraded sites. Values closest to 1 indicate high levels of functional redundancy, which is indicative of healthy areas (high functional redundancy tends to increase the inherent resistance and resilience in the face of environmental changes, (Hewitt et al. 2012)). The index has been refined (Hewitt et al. 2012) with the SUMmax parameter modified to allow the metric to be applied to a wider range of sites and those sampled with differing numbers of replicates (Lohrer and Rodil 2011).

## C.2 Benthic Health Models

The original benthic health model (BHMmetals) was developed by Auckland Regional Council, Marti Anderson (Massey University, then at Auckland University) and Simon Thrush (University of Auckland, then at NIWA) and Judi Hewitt (NIWA), to determine the health of macrofaunal communities relative to storm-water contaminants. The model is based on a multivariate analysis of the variation in macrofaunal community composition related to total sediment copper, lead and zinc concentrations, extracted from the 500  $\mu\text{m}$  fraction of the sediment (Anderson et al. 2006). In 2010-2011, another model was developed, this time to determine health relative to sediment mud content (BHMmud, Hewitt & Ellis 2010). At the time of the development of this model it was determined that, while there was some crossover between community compositions found in response to high mud and high contaminants, the two effects could still be separated. Both models are based on the community composition observed at 84 intertidal sites in the Auckland Region between 2002 and 2005. The sites are within tidal creeks, estuaries or harbours, but do not include exposed beaches. They cover a range of contaminant concentrations and mud content. The models use Canonical Analysis of Principal Coordinates (CAP, Anderson & Willis 2003) of square root transformed Bray-Curtis dissimilarities to extract variation related to a single environmental variable and produce a score of community composition related to that variable. For the metal model, the concentrations of the three metals have been used in a Principle Component Analysis to create a single axis (PC1) that explains >90% of the variability in contaminant differences between the sites. For the mud model, the % mud content of sediment at the time of sampling is used.

The macrofaunal community composition of sites and sampling times not in the models are compared to model data (using the "add new samples" routine in CAP, *PerMANOVA add-on*, Primer E). The samples are then allotted to five different groups related to health (see Table 2).

## C.3 Combined Indices

Hewitt et al. (2012) recommended the use of the three indices above (TBI index, BHMmud score (CAPmud) and BHMmetals score (CAPmetals)) to provide a complementary assessment of health. Average health values are determined for each site in the following way:

1. If the CAPmud score is  $\leq -0.12$ , the site is allocated to Mud group 1 (Table 1), and the combined Health score is calculated as the average CAPmetals and CAPmud group values. The TBI is



not used in the combined score in this case, as it does not work well when mud content is extremely low (Hewitt et al. 2012).

2. If the CAPmetals score is  $\geq 0.10$ , the site is allocated to group 4 or 5, and the combined Health score is equal to the TBI group value. At this level of contaminants, the TBI score itself fully reflects health.
3. Otherwise, Health is the average of the CAPmetals, CAPmud and TBI group values.

Health scores, "x", are then translated as  $x \leq 0.2$  "extremely good";  $0.2 < x \leq 0.4$  "good";  $0.4 < x \leq 0.6$  "moderate";  $0.6 < x \leq 0.8$  "poor" and  $x > 0.8$  "unhealthy with low resilience". It is important to recognise that the health scores are from particular sites within each estuary, and do not necessarily represent the health status of the estuary as a whole. There may be locations in each estuary that are significantly healthier, or less healthy, than the monitored sites.

**Table 1: Conversion of CAPmetals and CAPmud scores into health groups (1 is least healthy).**

Group	CAPmetals		CAPmud		TBI	
	Cutoff	value	Cutoff	value	Cutoff	value
1	-0.164	0.2	-0.12	0.2	0.4	0.33
2	-0.0667	0.4	-0.05	0.4	0.3	0.67
3	0.0234	0.6	0.02	0.6		1.0
4	0.10	0.8	0.10	0.8		
5		1.0		1.0		

Cut off point is equal or less than. These groups are then converted (along with TBI scores) into values of similar scale (0-1) that run in the same direction (higher values indicating more degraded conditions), to facilitate their combination into overall health scores.

