LIFE Integrated Projects 2016

Optimising the implementation of the 2nd RBMP in the Malta River Basin District

LIFE 16 IPE MT 008

Action A.6:

Consultancy on Contaminants of Emerging Concern: Monitoring Strategy

Report drawn up by

and

ERA Tender Ref: GF/Admin/39/18

Consultancy on Contaminants of Emerging Concern: Monitoring Strategy & Programme

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June 2020

ECOSERV REPORT REFERENCE: 047-20_R

Version 2.2: June 2020

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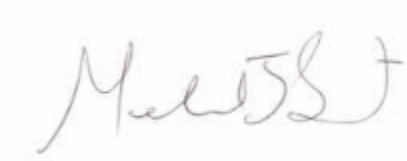

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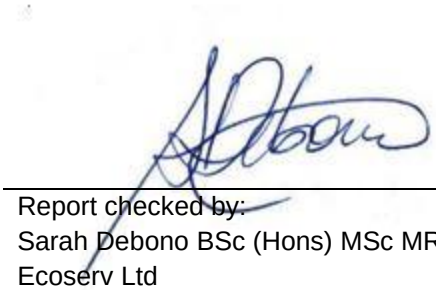

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Introduction

1. The Water Framework Directive (WFD) requires that good chemical status of surface waters and groundwaters is achieved by all member states of the European Union, providing a list of priority substances that are to be monitored and managed, and Environmental Quality Standards that are to be attained. These contaminants are listed in the relevant EU legislation, in particular the EU Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC).

2. The European Commission has also established a watch list of substances that is to be evaluated and monitored, to address the risks posed by chemicals arising from various anthropogenic activities. The WFD, through the Directive on Environmental Quality Standards (Directive 2008/105/EC), also requires consideration of 'Contaminants of Emerging Concern', a term used to describe compounds previously not considered or known to be significant with respect to the environmental health of the various water bodies.

3. The Environment and Resources Authority (ERA) has commissioned[1] Ecoserv Ltd., in collaboration with @econsulting, to develop a Monitoring Strategy for Contaminants of Emerging Concern (CEC) In four (4) Water Categories. This study is part of a project funded by the LIFE Programme under the Project Policy Area LIFE Integrated Project Environment contributing to the achievement of the objectives of the Water Framework Directive. The Project's reference and title are LIFE 16 IPE MT 008: *Optimising the implementation of the 2nd RBMP in the Malta River Basin District*, specifically *Action A.6 - Development of a monitoring strategy for contaminants of emerging concern.* The Work Plan for the process employed in the development of this monitoring strategy is presented in Annex 01 (Ecoserv Ltd and eConsulting 2019a)[2].

[1] Through award of tender GF/Admin/39/18.
[2] Ecoserv Report Reference: 090-19

4. This report is one of the deliverables highlighted within the tender dossier within article 24:

'The contractor shall develop a monitoring strategy and programme for the assessment of the contaminants of emerging concern identified in Activity 1 in the four (4) water categories. The monitoring framework shall be applied at a national level and shall cater for LIFE 16 IPE MT008 concrete action C.18. For this purpose, the monitoring strategy and programme shall address the need for:

(i) a two-year screening monitoring exercise and
(ii) an investigative monitoring programme on the basis of the screening monitoring exercise

In order to develop the monitoring strategy and programme the contractor shall undertake a thorough scientific literature review on each contaminants of emerging concern to identify minimum performance criteria[3] and analytical methods to be applied when monitoring the selected contaminants of emerging concern in each of the four (4) water categories. The contractors shall communicate with accredited laboratories to ensure that selected minimum performance criteria/analytical methods can be applied in practice. All efforts shall be made to identify minimum performance criteria for each of the selected contaminants of emerging concern. Should such performance criteria not be available, the contractor shall provide documentary evidence that alternative analytical methods were explored.

The monitoring strategy and programme will also elaborate on the sampling methodologies, the monitoring network (including monitoring stations) and monitoring frequencies. Any additional supporting parameters required to be monitored alongside the contaminants of emerging concern to aid in the interpretation of results shall also be identified.

In selecting the representative monitoring stations when designing the monitoring network, the use patterns and possible occurrence of the substance shall be taken into account such that the selection of the monitoring sites are representative. When considering the monitoring site per water category, a spectrum of at least two sites; one representing a highly impacted water body in terms of pressures present; and the second monitoring station located in a water body less impacted by significant pressures and hence representative of relatively better quality waters; should be selected. The location of these two sites considered to be at opposing ends of the pressure spectrum, would enable a better determination of potential sources should any contaminants be found to

[3] *Minimum performance criteria are defined as the limit of quantification (LoQ) and measurement of uncertainty.*

be of concern following the execution of the actual monitoring exercise to be undertaken following the completion of this project.

By Month 11, the contractor shall submit a monitoring strategy and programme for the contaminants of emerging concern identified in Result 1b for each of the four (4) water categories including:

(i) minimum performance criteria and/or analytical methods that should be employed by laboratories when analysing the concentration of contaminants in each water category;
(ii) gaps and uncertainties in analytical methods and associated alternatives;
(iii) monitoring network including monitoring stations in ED_1950_UTM_Zone_33N WKID: 23033 Authority: EPSG;
(iv) description and justification of the design of the monitoring network in relation to the use patterns and possible occurrence of the contaminant;
(v) the environmental matrices in which monitoring is to be undertaken as justified on the basis of the characteristics of the contaminants of emerging concern; and
(vi) sampling methodologies including any required treatment and preservation of samples.

5. This report is intended to satisfy tender requirements by providing a monitoring strategy and programme indicating:

- monitoring points to be adopted for the water bodies in each of the four water categories;
- a two-year screening monitoring exercise for the selected CECs, including an investigative component;
- a description of the sampling methodologies;
- performance criteria for sample analysis; and
- gaps and uncertainties in monitoring.

Receptor Water Bodies for CEC monitoring: location and monitoring frequency

6. A review of anthropogenic sources of pollution affecting water bodies was carried out as part of the report dated December 2019[4] '*Consultancy on Contaminants of Emerging Concern: Identification and Shortlisting'* (see Ecoserv Ltd and eConsulting, 2019b). This report documents the research carried out to shortlist materials used by a range of activities that may be considered as sources of CECs, and this monitoring programme is to be read in conjunction with the rationale of the shortlisting study.

7. The water bodies present in the Maltese islands are documented in detail within the *2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021* (2015) by ERA & SEWCU. It is not the purpose of this report to replicate these findings; however, the presence of CECs in these water bodies was also considered in December 2019 *Consultancy on Contaminants of Emerging Concern: Identification and Shortlisting*.

8. This study also documented possible pollution pathways from potential sources of pollution to receptor bodies that are likely in the local context. Existing water quality monitoring data from the various water bodies were also reviewed to identify aspects of the receptor water bodies or the pollution pathways that were relevant to the identification, behaviour and detection of CECs. The following points are held to be critical:

    - Urban, industrial and rural uses are expected to generate different profiles of CECs, which tend to overlap or combine in the local context, given geographic proximity;
    - pollutants of different varieties have accumulated and/or persisted in the various water bodies (as indicated in the monitoring programmes reviewed, insofar as this data allows such interpretation) in terms of spatial and/or temporal variation in pollution levels; and
    - pollution pathways require further investigation in terms of pollutant mobility and persistence, though groundwater data indicates that the sewerage network may constitute a significant conduit for transfer of pollutants.

[4] Ecoserv Report Reference: 214-19_R

9. The following is a list of water bodies that have been considered as receptors of the CECs, which require investigation:

- **coastal surface waters** as defined in the Water Framework Directive;

- **inland and transitional surface waters** as defined in the Water Framework Directive, with a particular emphasis on watercourses;

- **rainwater runoff** which in the local context consists of rainfall that is not absorbed by soils, but that is collected on the surface of saturated or impermeable areas, and eventually joins a flow of water that may or may not be channelled into a storm water collection system;

- **groundwater** as analysed in detail in the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021, which describes the three main typologies of groundwater bodies found within the Maltese context:

    i. Sea-level groundwater bodies developed in the Lower Coralline Limestone formation and take the form of freshwater lenses floating over seawater and referred locally as mean-sea-level aquifers (MSLAs). These are ubiquitous and occur extensively at sea level in Malta, Gozo and Comino.
    ii. Unconfined (phreatic) perched groundwater bodies sustained in the Upper Coralline Limestone formation perched over the Blue Clay formation. Perched aquifers are completely absent in central and eastern Malta where the UCL and the clay aquitard have been completely eroded. These aquifers occur in western Malta and in Gozo, on the sea-level aquifers.
    iii. Coastal groundwater bodies occurring in depressed valley areas within the Upper Coralline Limestone formation where the clay lies below sea level and freshwater is laterally bounded at its contact with seawater. These small aquifer systems occur at Pwales, Mellieha and Marfa.

- **sewage waters,** which include wastewaters arising from domestic and industrial discharges; and

- **new water** i.e. reclaimed water, a recent innovation managed by the Water Services Corporation, where wastewater collected through the urban wastewater sewerage system is treated to secondary treatment standards as required by the Urban Waste Water Treatment Directive, Instead of being discharged to sea, this water is further treated using ultrafiltration, reverse osmosis and advanced oxidation processes to produce a high quality reclaimed water suitable for agriculture and managed aquifer recharge.

10. In summary, the following monitoring network is deemed to be the minimum required to satisfy the requirement of having a national monitoring strategy:

A. **Groundwater**: representation of groundwater bodies in Malta would require:

- sea level groundwater - rural type reference point for Malta
- sea level groundwater - rural type reference point for Gozo
- sea level groundwater - urban type reference point for Malta
- sea level groundwater - urban type reference point for Gozo
- perched groundwater - Malta west
- perched groundwater - Gozo
- coastal groundwater - Pwales, Mellieha, and Marfa

B. **surface water - runoff**: surface water runoff in rural areas should be adequately represented by the water quality in watercourses; however, runoff from significant urban catchments is considered critical to understand its role in pollution pathways;

C. **surface water – watercourses**: representation of inland surface water bodies would require:

- a watercourse in Malta having a rural catchment;
- a watercourse in Malta having an urban catchment;
- a **transitional** watercourse; and
- a watercourse in Gozo.

D. **surface waters coastal:** representation of coastal water bodies would require:

- a monitoring point in the immediate proximity of a sewage treatment plant discharge/overflow; and
- a control point off the north of Gozo, where the main current direction would be from the north, and terrestrial influence would be limited.

E. **sewage monitoring points:** representation of sewage waters as a source of CECs would involve:

- a monitoring point from an agglomeration having a catchment of industrial character; and
- a monitoring point from an agglomeration having a residential character.

F. **new waters:** a monitoring point at point of production.

11. The monitoring points summarised above are given clearer definition in the following sections below. It is pertinent to note that these monitoring points are to be considered as the minimal extent for a comprehensive overview. It may be considered desirable to expand the range of testing further, e.g. to include more coastal monitoring points in ports and bays, or to provide a greater coverage in terms of monitoring points for groundwater or the sewerage network. However, in the interests of optimising information return on the investment in monitoring, it is preferable to establish a clear baseline, and then introducing an investigative element depending on the results attained (see section on investigative monitoring).

12. The selection of monitoring points was carried out in collaboration with the Environment & Resources Authority and the Energy & Water Agency, in an iterative manner. This considered the criteria highlighted above, monitoring points and monitoring data already used for other projects, and the selection of points (based on expert judgement) where the probability of encountering CECs is highest. A summary of the monitoring points identified in the following sections is provided in Annex 03 for ease of reference.

Monitoring Points & Frequency - Groundwater

13. The most recent and comprehensive data on groundwater monitoring was that undertaken as part of a surveillance monitoring exercise carried out in 2016, arising from the requirements of the Water Framework Directive. Findings of note were:

    - Chloride and sodium levels typically associated with saline intrusions or discharges of brine reverse osmosis plants;
    - Nitrate pollution typically associated with agricultural fertilisers;
    - Frequent occurrences of orthophosphates, boron, and zinc, and occasional detection of other metals; and
    - Occasional detection of various trihalomethanes, flame retardants, plasticisers, pesticides and pharmaceuticals.

14. Review of the available data indicated that barring nitrate and saline intrusion, substances detected were usually at low concentrations. However, it is important to note that at the source of the contamination, such substances were probably at higher concentrations, and were diluted by unknown and variable orders of magnitude before being detected in the groundwater.

15. Given that data availability for evaluation of longer terms trends is limited, the use of common monitoring points utilised in that survey is recommended, to assist in trend determination. To attain reasonable representation over the national territory, the following monitoring points are recommended as a minimum:

    - sea level groundwater - rural type reference point for Malta
    - sea level groundwater - rural type reference point for Gozo
    - sea level groundwater - urban type reference point for Malta
    - sea level groundwater - urban type reference point for Gozo
    - perched groundwater - Malta west
    - perched groundwater - Gozo
    - coastal groundwater - Pwales

    Recommended locations for monitoring are provided in Table 1 overleaf.

Table 1: groundwater monitoring stations (dataset provided by Energy and Water Agency)

Station Name	Groundwater body and context	Area/Locality	Eastings	Northings
Fiddien Station	Malta Mean Sea Level **Rural**	Rabat (Malta)	443796	3971842
Ġnien Borehole	Malta Mean Sea Level **Urban**	Ħal Luqa (Malta) L/O	454413	3968012
San Katald Borehole	Gozo Mean Sea Level Rural	Għarb (Gozo)	428579	3991805
Għattuq Borehole	Gozo Mean Sea Level Urban	Rabat (Gozo)	432451	3989603
Victoria Station, Rabat, GZ	Gozo Perched	Rabat (Gozo)	431197	3988565
Bahrija	Malta West (Rabat Dingli Perched)	Bahrija	440640	3972667
Pwales Station	Pwales Coastal	Pwales	440640	3972667

16. **Monitoring Frequency**: the recommended minimum frequency for monitoring is quarterly (i.e. every three months, four times per year), to detect seasonal variations in use of potential CECs, and concentration/dilution of such substances. This is to persist for the two-year screening monitoring required by the Terms of Reference, to establish the baseline for subsequent investigative monitoring.

17. **Sampling**: the borehole sampling point will require purging to ensure that the water collected is representative of the water body at the location represented by the monitoring station. In this regard, a pump is run for an appropriate period of time, and a minimum of two replicate samples collected in appropriate sample containers. The samples should be refrigerated prior to dispatch for laboratory analysis. Sample collection should be undertaken by personnel having experience in sampling techniques.

    Although there are basic standards for sample treatment and preservation, this is closely linked to the analytical method that the contracted analytic laboratories would apply. Two labs testing for a particular analyte might have different requirements of sample preservation and treatment. Sample treatment and preservation must be carried out as specified by the contracted laboratories.

Monitoring Points – Inland Surface Waters (Watercourses & Transitional Waters)

18. The previous report reviewed available data on the extent of contamination on inland surface waters collected through Ecoserv (2012), where inland surface and transitional waters across the islands were surveyed to evaluate the presence of priority substances and other specified pollutants. The previous report also considered the baseline surveys for physico-chemical parameters in inland surface waters as documented by AIS Environmental (2014).

19. Substances consistent in behaviour with CECs were detected in the survey conducted by Ecoserv (2012), where the plasticiser di(2-ethylhexyl) phthalate (DEHP), occurred in all the 60 samples monitored, reflecting the ubiquitous nature of contamination from plastic origin. Other contaminants of note recorded in a limited number of samples included:

    - Fluoranthene, a PAH commonly encountered as a combustion product, and also from coal tar products;
    - dichloromethane (an industrial solvent); and
    - mercury.

20. The following monitoring points are being recommended:

    - **Wied il-Luq** to represent a watercourse having a rural catchment;
    - **Wied is-Sewda** at a point capturing waters from Qormi, to represent a watercourse having an urban catchment;
    - **Is-Salini** to represent a transitional water; and
    - **Wied il-Lunzjata** to represent a catchment in Gozo.

    Although a set of coordinates are recommended, a site visit is required for familiarisation and to evaluate the point of sampling, to verify availability of water, and safety of access. This should be managed by the parties contracted to carry out sampling, where variations may be introduced (and justified) on the basis of changing circumstances prevalent at the site.

21. Transitional waters are considered to be intermediate in character between fresh and saline waters; although the chemistry of transitional waters is expected to have specific peculiarities, the major factor to consider here is dilution as pollutants transit between different media. In this regard, given that these waters are very limited in geographic scale and strongly influenced by site specific considerations, monitoring data from watercourses is expected to be more significant; more emphasis on monitoring of watercourses is deemed a more suitable approach.

22. **Monitoring Frequency**: the recommended minimum frequency for monitoring is during the wet season biannually, one during the beginning of the rainy season and another near the end. This is required to detect seasonal variations in use of potential CECs, and concentration/dilution of such substances. This is to persist for the two-year screening monitoring required by the Terms of Reference, to establish the baseline for subsequent investigative monitoring.

23. **Sampling methodology**: a sampling cup (material to be used will depend on the intended analysis) mounted on a rod should be used to collect composite replicate samples (minimum of two samples) from the water body, with the collected water being transferred to appropriate sample glass containers. A composite sample is here envisaged as a series of volumes collected from the same point that are then combined. This would serve to compensate for any concentration change with flow. Sample collection should be undertaken by personnel having experience in sampling techniques.

    The samples should be refrigerated at 4-10^{0}C prior to dispatch for laboratory analysis. Although there are basic standards for sample treatment and preservation, this is closely linked to the analytical method that the contracted analytic laboratories would apply. Two labs testing for a particular analyte might have different requirements of sample preservation and treatment. Sample treatment and preservation must be carried out as specified by the contracted laboratories.

Monitoring Points – Inland Surface Waters (Surface Water Runoff)

24. Runoff or storm waters generated via precipitation are expected to contribute significantly to movement of CECs. Data available on pollutants in storm waters are those of SCE (2018), who evaluated the water quality of storm waters captured by the National Flood Relief Project Infrastructure, which captured waters arising from urban areas. Their findings indicated that:

- Most metals, such as chromium, manganese, copper, lead and nickel were partitioned in the sediment fraction, where these occurred in appreciable amounts;
- Water quality was affected mainly by PAHs, and DEHP, and
- Other substances tested for were absent, including:
    a. the solvent Hexachlorobutadiene
    b. the fungicides Quinoxyfen and Hexachlorobenzene (the latter being banned), the miticide Dicofol and the insecticides Hexachlorocyclohexane, Heptachlor & Endosulfan (not permitted for local use), and the herbicide Trifluralin
    c. Pentachlorobenzene (banned)
    d. Nonylphenol,
    e. Sum of Polybrominated diphenyl ethers (PBDE)
    f. Chloroalkanes (C10-13)
    g. Perfluorooctane sulfonic acid (PFOS)
    h. Hexabromocyclododecane (HBCDD)
    i. TBTs

25. **Monitoring points:** it is recommended that the monitoring points selected recapitulate those used for SCE (2018) to allow monitoring results to be compared. In this regard, monitoring is recommended to focus upon samples (minimum two replicate samples per sampling point) collected from the National Flood Relief Project inlet points (sedimentators) associated with Birkirkara/Msida/Gzira catchments, which should provide an indication of the CECs transported within stormwater runoff.

    Although a set of coordinates are recommended, a site visit is required for familiarisation and to evaluate the point of sampling, to verify availability of water, and safety of access. This should be managed by the parties contracted to carry out sampling, where variations may be introduced (and justified) on the basis of changing circumstances prevalent at the site.

26. **Sampling:** a sampling cup (material to be used will depend on the intended analysis) laboratories mounted on a rod should be used to collect composite replicate samples (minimum of two samples) from the water body, with the collected water being transferred to appropriate sample glass containers. A composite sample is here envisaged as a series of volumes collected from the same point that are then combined. This would serve to compensate for any concentration change with flow. Sample collection should be undertaken by personnel having experience in sampling techniques.

    The samples should be refrigerated at 4-10^{0}C prior to dispatch for laboratory analysis. Although there are basic standards for sample treatment and preservation, this is closely linked to the analytical method that the contracted analytic laboratories would apply. Two labs testing for a particular analyte might have different requirements of sample preservation and treatment. Sample treatment (possibility including filtration) and preservation must be carried out as specified by the contracted laboratories.

27. **Monitoring Frequency**: the recommended minimum frequency for monitoring is during the wet season biannually, one during the beginning of the rainy season and another near the end. This is required to detect seasonal variations in use of potential CECs, and concentration/dilution of such substances. This is to persist for the two-year screening monitoring required by the Terms of Reference, to establish the baseline for subsequent investigative monitoring.

Monitoring Points – Marine Surface Waters

28. The presence of CECs in Maltese waters has been studied as part of the ERA study *Chemical monitoring of Watch List substances in the Maltese Islands*, which screened various CECs[5] at:

- a point at the northernmost end of Gozo (San Dimitri Point), and
- another outside the Ta' Barkat Urban Waste Water Treatment Plant.

The only CEC detected was Imidacloprid (a neonicotinoid) at the northernmost end of the island of Gozo, a result which was surprising given that the nature of the monitoring site in terms of depth and exposure to the currents, as well as the distance from potential sources of the substance.

29. **Monitoring points:** the continued use of the above monitoring stations is recommended, to enable comparability with datasets collected previously from this site, with the addition of another point at **Xemxija Bay**.

30. **Sampling:** a Van Dorn sampler should be used to collect a composite sample (minimum of two replicate samples) from the water body at a depth of 1 metre, with the sample collected being in appropriate sample containers. The samples should be are refrigerated at 4-10^{0}C prior to dispatch for analysis.

Although there are basic standards for sample treatment and preservation, this is closely linked to the analytical method that the contracted analytic laboratories would apply. Two labs testing for a particular analyte might have different requirements of sample preservation and treatment. Sample treatment and preservation must be carried out as specified by the contracted laboratories.

31. **Monitoring Frequency**: the recommended minimum frequency for monitoring is quarterly (i.e. every three months, four times per year), to detect seasonal variations in use of potential CECs, and concentration/dilution of such substances. This is to persist for the two-year screening monitoring required by the Terms of Reference, to establish the baseline for subsequent investigative monitoring.

[5] Other contaminants are included in this monitoring exercise which include erythromycin, the five neonicotinoids, oxadiazon and tri-allate ,17-Alpha-ethinylestradiol (EE2), 17-Beta-estradiol (E2), Estrone (E1), Diclofenac, 2,6-Ditert-butyl-4-Methylphenol, 2-Ethylhexyl 4-methoxycinnamate, Clarithromycin, Azithromycin & Methiocarb

Monitoring Points – Sewage and New Waters

32. Sewerage networks are managed by the Water Services Corporation, which is responsible for their maintenance, upgrading and general management. Sewerage networks are organised in agglomerations; although these are primarily associated with urban areas and uses, these also transect rural areas. New waters are the product of a project carried out by the Water Services Corporation, where sewage waters are treated for eventual use in agriculture or recharge of aquifers.

33. **Monitoring Points:** monitoring is recommended at the following points:

- a monitoring point from an agglomeration having a catchment of industrial character, where Hal Far would provide an agglomeration that is distinct from residential uses;
- a monitoring point from an agglomeration having a residential character, where the Birkirkara area would constitute an urban area relatively free from industrial effluent; and
- sample outputs from new waters.

34. **Monitoring Frequency**: the recommended minimum frequency for monitoring of both sewage and new waters is quarterly (i.e. every three months, four times per year), to detect seasonal variations in use of potential CECs, and concentration/dilution of such substances. This is to persist for the two-year screening monitoring required by the Terms of Reference, to establish the baseline for subsequent investigative monitoring.

35. **Sampling**: a composite sample (minimum of two replicate samples) should be collected as may be recommended by the Water Services Corporation as the entity responsible for the sewerage network, with the sample collected being in appropriate sample containers. The samples should be are refrigerated at 4-10^{0}C prior to dispatch for analysis. Sample collection should be undertaken by personnel having experience in sampling techniques.

Although there are basic standards for sample treatment and preservation, this is closely linked to the analytical method that the contracted analytic laboratories would apply. Two labs testing for a particular analyte might have different requirements of sample preservation and treatment. Sample treatment and preservation must be carried out as specified by the contracted laboratories.

CECs in surveillance monitoring

Consideration of CEC monitoring parameters

36. CECs of anthropogenic origin are expected to originate from the wide variety of materials used by human activities. A review of uses and associated potential sources of CECs are provided in December 2019 *Consultancy on Contaminants of Emerging Concern: Identification and Shortlisting* (see Ecoserv Ltd and eConsulting, 2019). This section of the current report should be read in conjunction with the latter 2019 review.

37. The previous report highlighted the significance of exchange of potential CECs between different water bodies. An understanding of the extent to which this happens is considered to be essential if an understanding of the behaviours of CECs in the local context is to be understood. The following sections refine further on the shortlisting exercise, to establish a list of compounds that are suitable for a screening exercise (surveillance monitoring).

38. **Gaps and Uncertainties**: the CECs shortlisted previously had made reference to monitoring data from other countries as presented within the NORMAN network, which clearly demonstrate that such testing for CECs is viable. The methodology for selection of the substances for evaluation in the first report focussed on substances for which there were no gaps and uncertainties in evaluation, and where there were demonstrated volumes of data from other member states in the water matrix[6]. Use characterisation is considered in the selection methodology described above, but given weighting in this final selection to ensure local relevance. In the report referenced above, substances for which there were gaps and uncertainties were given a lower priority rating and not included in the first round of evaluation.

[6] Given the focus on the water matrix, although some degree of partitioning in sediments is to be expected, exclusive partitioning of the pollutant in other media should not be a risk.

39. Given the intention to commission this monitoring via tender, a further exercise has been carried out to ask a range of laboratories as to the services offered with respect to monitoring of the various compounds. As is typically noted within such studies, none of the laboratories approached provide a comprehensive service; for commercial reasons, such laboratories only analyse for those materials for which there is a predicted throughput of samples for analysis. Consequently, samples collected will need to be of a volume that is sufficient to be shared between different laboratories which will be evaluating different parameters.

40. Accreditation of laboratories to the following standard is considered essential: ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. However, accreditation to the individual substances may not be possible to satisfy comprehensively even though this may be desirable. This may change in the future as commercial laboratories continue expanding their range of services to include novel parameters.

41. A further consideration was the requirement that the monitoring programme be issued to tender. Over 10 reputable laboratories were consulted to ensure that the parameters selected were available on a commercial basis. The selection of the parameters initially selected as part of the shortlisting exercise, in December 2019 *Consultancy on Contaminants of Emerging Concern: Identification and Shortlisting* was necessarily constrained by this requirement.

Parameters adopted in different water bodies

42. The initial review of potential CECs considered the range of different uses and the manner in which these may be segregated in different water bodies, depending on patterns of use. However, although it was noted that certain patterns emerged from the monitoring data, data points (such as the presence of Imidacloprid in coastal waters to the north of Gozo) are unexpected, and may be indicative of circumstances that are not predictable on the basis of available information. Furthermore, an investigation of the context of the varying monitoring points highlights that the distinction between urban and rural contexts is not clear cut, and that cross-contamination is expected. Given this context, it is recommended that monitoring during the surveillance period share all parameters across all monitoring stations. This would then be varied during the investigative phase.

43. A list of parameters recommended for inclusion in the surveillance monitoring phase is presented in Table 2 overleaf, with a rational presented for each parameter. In the case of groundwater, interpretation of monitoring data would be facilitated if the parameters in Annex 02 were to be included. This data would allow evaluation of the water quality at the specific monitoring point, so as to determine whether specific linkages can be established with particular source of pollution, particularly from sewage.

44. Typical methodologies available currently in commercial laboratories are provided, in so far as this has been possible in the time available. It should be noted that alternative methodologies may be available, as methodology may be dependent on the exact nature of analytical equipment available, and a flexible approach is recommended here. Expansion of this range of substances may be possible, if during the monitoring phase laboratories are shown that a sufficient throughput of samples would justify this inclusion as a commercial service. Limits of detection are also provided, though these are to be considered provisional, given that matrixing effects from the actual samples collected may have an effect on the actual implementation.

45. The compounds presented in the following lists are those which are highlighted during the original shortlisting exercise as conforming to Action 1 – Priority Monitoring, modified on the basis of additional information to promote relevance to the local context. Furthermore, the list has been streamlined to focus upon those compounds where it is likely that monitoring services will be available.

46. **Tentatively Identified Compounds**: the shortlisting exercise is based on examination of available data to develop a plausible list of compounds. However, the limitations of the available data require that an element of ground truthing be carried out to investigate the extent to which the predictions are correct. In this regard, it is useful to request laboratories to carry out a Tentatively Identified Compound test, whereby mass spectrographic libraries are used to highlight the presence of compounds whose presence was unpredicted. This may highlight the presence of chemicals that may qualify as CECs upon further evaluation.

Table 1: CECs selected for surveillance monitoring. Data on methodology and LoD are those which are currently confirmed as being commercially available in laboratories.

Parameter/Type	Comment	Methodology	LoD
Nutraceutical			
Acesulpham k	Sweetener widespread in various formulations and considered a useful indicator of the presence of excreted material.		
Pharmaceutical			
Carbamazepine	Pharmaceutical consumed locally with the highest order of magnitude, detected in circa 25% of boreholes surveyed during surveillance monitoring.	W-PHALMS02 - Pharmaceutical Compounds	0.05ug/l
Beta-estradiol (50-28-2)	Common constituent in oral contraceptives.	W-STELMS01 - Estrogenic Compounds	1 ng/l
Atenolol	Pharmaceutical consumed in similar (though lesser) order of magnitude to Carbamazepine	HPLC	0.001ug/L
Sulfamethoxazole	Common antibiotic used	US EPA 1694	0.01 ug/l
Veterinary Pharmaceuticals or substances used in animal husbandry			
P- Chloro-M-Cresol	Constituent in disinfectant used in animal husbandry.	GC-MS	0.5ug/l
Amoxicillin	Antibiotic commonly used in animal husbandry in multiples species		
Fipronil	Insecticde commonly used in poutry	LC/MS/MS, US EPA 535, US EPA 1694	0.05ug/l

Parameter/Type	Comment	Methodology	LoD
Agriculture			
1,2,4-trimethyl benzene	Common pesticide propellants	GCMS-modified USEPA 8260	3ug/l
cyclohexanone	Common pesticide propellants	GCMS-modified USEPA 8260	100ug/l
N-methyl-2-pyrolidone	Common pesticide propellants; CMR rated	GCMS-modified USEPA 8270	100ug/l
propan-1,2-diol	Common pesticide propellants	LCMS	10ug/l
EDTA	Common chelating agent in fertilisers	GC/MS, EN ISO 16588	0.5mg/l
Pesticides			
Azoxystrobin		Pesticides by GCMS (W-PESLMS02LL)	0.01ug/l
Chlorpyrifos-methyl		GCMS	0.01ug/l
Deltamethrin		GCMS - modified USEPA 8270 on DCM extract	100ug/l
Dimethomorph		Pesticides by GCMS (W-PESLMS02LL)	0.01ug/l
Glyphosate		LC-MS	0.1ug/l
Propamocarb		Pesticides by GCMS (W-PESLMS02LL)	0.03ug/l
Imidacloprid		Pesticides by GCMS (W-PESLMS02LL)	0.01ug/l

Parameter/Type	Comment	Methodology	LoD
Industry			
tert-butyl methyl ether; MTBE; 2-methoxy-2-methylpropane		GCMS modified USEPA 8260	0.1-2ug/l
Triisobutylphosphate		GC/MS	0.01ug/l
Methylbenzotriazole		LC/MS/MS, US EPA 535, US EPA 1694	0.03ug/l
Benzotriazole		LC/MS/MS, US EPA 535, US EPA 1694	0.03ug/l
DEHP		GC/MS, US EPA 8061A	0.6ug/l
Chemicals used widely in residential context			
Aniline		GCMS - modified USEPA 8270 on DCM extract	10 ug/l
Styrene		GCMS - modified USEPA 8260	2ug/l
Triphenyl phosphate		GCMS - modified USEPA 8270 on DCM extract	100ug/l
Bisphenol A		GCMS - modified USEPA 8270 on DCM extract	100ug/l
diethyl phthalate (DEP)		GC/MS	5ug/l

- **Tentatively Identified Compounds test**

Strategy for Investigative Monitoring

47. The December 2019 *Consultancy on Contaminants of Emerging Concern: Identification and Shortlisting* involved consideration of the pollution sources and potential pathways related to candidate CECs These substances were assigned into action categories following the methodology described in Dulio et al. (2013).

48. Review of the available data on water quality pollution highlighted the need to gain further understanding as to how pollutant loads behave in the local context, in terms of their dispersion through the water bodies, particularly since there is the probability that CECs discharged may be rapidly diluted to the point where their concentration would be below the limits of quantification. A typical example are the data collected on Acesulpham K and Carbamazepine from groundwater; a meaningful monitoring programme on emerging CECs will need to address the following issues:

    - Whether these substances are detected in other water bodies;
    - The extent to which CECs move between water bodies (e.g. from wastewaters to groundwater) as may be implied by different concentration loads; and
    - Whether similar CECs (in terms of chemical properties and/or origins) display the same behaviours when discharged at equivalent rates.

49. Furthermore, CECs may only be of significance in a localised area (e.g. particular catchment areas), or may not be as easily dispersed given their specific chemical behaviour (e.g. tendency to partition into another environmental medium, or rate of degradability).

50. The limited baseline data available indicates that shortlists for monitoring need to focus on priorities for regular monitoring (Category 1 substances – see below for further definition). The shortlist developed for the first report was refined further in the previous section to provide a basis for the initial screening, to develop an understanding of the behaviour of CECs in the local water bodies, and the associated pollution pathways.

51. An iterative approach is necessary during investigations into occurrence of CECs, if the behaviour of CECs in the different water matrices is to be understood. The baseline surveillance study is intended to highlight basic patterns of occurrence and provide insight into the pollution pathways. The results of the baseline studies are essential to direct further monitoring effort. Although the risks posed by CECs have importance, it is equally critical to understand the range of potential CECs, the pollution pathways followed, and the extent to which dilution will determine whether a potential CEC is actually detectable or otherwise.

52. **Variation in spatial extent of CECs**: further investigative monitoring of CECs would be possible by extending surveys of detected CECs to determine geographic range, i.e. by investigating the presence of detected CECs in other water bodies, such as from boreholes surrounding those where contamination is detected, or other watercourses. The scope of this exercise would be to attempt to triangulate potential sources of CECs, to evaluate scope for practical abatement measures.

53. **Range of CECs**: review of the list of CECs to eliminate candidates not detected, and identify other plausible CECs. The shortlist report may be used as a reference to identify other substances, likely to be in the same use class, that may be following common pollution pathways. This would be done by:

    - reviewing data collected by TIC testing;
    - searching for substances detected in sewage waters and water runoff; and
    - searching for substances in the same use class (e.g. pharmaceuticals), having less prevalent use, to determine when extent of use at a national level becomes significant.

54. **Evaluation scope for studies on specific water bodies and/or catchments**: the scope of this exercise would be to attempt to refine further on the understanding of potential sources of CECs in the immediate proximity to water bodies determined to be of particular risk, and develop monitoring measures that are specific to the requirements of the water body. Land use surveys would be of particular use for the development of specific monitoring approaches.

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Annex 01: Workplan

ERA Tender Ref: GF/Admin/39/18

Consultancy on Contaminants of Emerging Concern:
Work Plan

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June 2019

ECOSERV REPORT REFERENCE: 090-19

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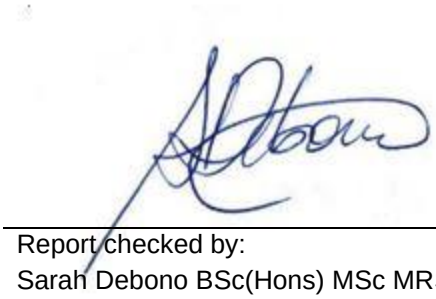

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Introduction

55. The term ‘emerging contaminants’ is generally used to refer to compounds previously not considered or known to be significant with respect to the environmental health of the various environmental media. The WFD (Water Framework Directive) requires that good chemical status of surface waterbodies is achieved by all member states of the European Union, providing a list of priority substances that are to be monitored and managed, and Environmental Quality Standards that are to be attained. In this regard, the European Commission is establishing a watch list of substances that is to be evaluated and monitored, to address the risks posed by chemicals arising from various anthropogenic activities.

56. The Environment and Resources Authority (ERA) has commissioned Ecoserv Ltd., in collaboration with @econsulting, through award of tender GF/Admin/39/18, to develop a Monitoring Strategy for Contaminants of Emerging Concern (CEC) In four (4) Water Categories. This study is part of a project funded by the LIFE Programme under the Project Policy Area LIFE Integrated Project Environment contributing to the achievement of the objectives of the Water Framework Directive. The Project’s reference and title are LIFE 16 IPE MT 008: *Optimising the implementation of the 2nd RBMP in the Malta River Basin District*, specifically *Action A.6 - Development of a monitoring strategy for contaminants of emerging concern.*

57. This report is one of the deliverables highlighted within the tender dossier within article 24:

    ‘A work plan outlining the approach to be adopted by the contractors to identify the indicator parameters (or contaminants of emerging concern) including stakeholders to be involved, data sources and methodologies to be employed in gathering the required data and information (to be delivered by Month 1 from the signature of the contract and formally approved by ERA).’

    This report is intended to satisfy tender requirements by:

    - Providing an outline of methodology to be employed;
    - List stakeholders to be involved; and
    - List data to be collected as required background material and project context.

58. Many emerging contaminants are unregulated, and in various cases unrecognized. Detection of such substances depends upon an understanding of the sources of the contaminants and the pathways through which the contaminants are introduced into the various environmental media.

59. It is understood that these terms of reference are to consider the following (amongst others):

    a. **contaminants pertaining to agriculture** – besides the typical pollutants such as pesticides and fertilizers, there is the need to consider other potential sources such as natural toxins, veterinary medicines, hormones and their metabolites, as well as residues or transformation products of man-made chemicals used in agriculture, ranging from plastics to disinfection products. Biological contaminants, such as bacteria and viruses, should also be considered.
    b. **contaminants pertaining to industry** – these include the wide range of chemicals used by industry as raw materials, together with the wastes and fugitive emissions that may eventually contaminate water bodies. An understanding of how local industries manage on-site waters and potential contamination pathways is key.
    c. **contaminants pertaining to medicine** – these include the wide range of substances emerging mainly from the pharmaceutical industry, as well as the biological materials (such as bacteria and viruses) that have the potential to contaminate water bodies.
    d. **contaminants pertaining to personal care products** – these are chemicals involved in the formulation of such products, including substances such as parabens, synthetic preservatives, phthalates, surfactants and fragrances. Microplastics is another area where further consideration is required.

60. It is also understood that, as highlighted in the Terms of Reference, the emerging contaminants shall be evaluated in the following categories of water bodies:

- **surface waters** as defined in the Water Framework Directive, and include the coastal, transitional and inland surface waters. Surface waters are analysed in detail in the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021. All surface water bodies have been listed and characterized as per Water Framework Directive Article 5 Summary Reports for Surface Waters, which lists the various bodies and describes them in terms of geographic location and size. Data on catchment is also provided, together with a list of risks and pressures that affect these water bodies;
- **rainwater runoff** which in the local context consists of rainfall that is not absorbed by soils, but that is collected on the surface of saturated or impermeable areas, and eventually joins a flow of water that may or may not be channelled into a storm water collection system;
- **groundwater** as analysed in detail in the 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015 – 2021, which describes the three main typologies of groundwater bodies found within the Maltese context:

  iv. Sea-level groundwater bodies developed in the Lower Coralline Limestone formation and take the form of freshwater lenses floating over seawater and referred locally as mean-sea-level aquifers (MSLAs). These are ubiquitous and occur extensively at sea level in Malta, Gozo and Comino.
  v. Unconfined (phreatic) perched groundwater bodies sustained in the Upper Coralline Limestone formation perched over the Blue Clay formation. The perched aquifers overlie, in western Malta and in Gozo, the sea-level aquifers. Perched aquifers are completely absent in central and eastern Malta where the UCL and the clay aquitard have been completely eroded.
  vi. Coastal groundwater bodies occurring in depressed valley areas within the Upper Coralline Limestone formation where the clay lies below sea level and freshwater is laterally bounded at its contact with seawater. These small aquifer systems occur at Pwales, Mellieha and Marfa.

- **new water** i.e. polished water following urban waste water treatment; the latter is a recent innovation managed by the Water Services Corporation, where water collected through the urban wastewaters collection system, and treated using reverse osmosis to be brought to a standard where it can be put to alternative use, mainly in the agricultural context or aquifer recharge.

61. The above is only a cursory overview that would need to be amplified further. Other sources that require consideration are – amongst others – urban infrastructure (including the road network), domestic water mis/management, and waste treatment. It is also critical to consider different scenarios which may result in generation or mobilization of contaminants of emerging concern:

- Chemicals for which analytical methods are available, where reference values are available, but have not necessarily been studied locally;
- Chemicals used historically, but are only now being recognized as contaminants of emerging concern;
- Chemicals that are regularly used in industry, but where risks of pollution have not been systematically mapped, or are still in the process of being recognized;
- Chemicals that have a seasonal use;
- Whether chemicals are persistent, or have different rates of degradation, of whether the degradation products pose a risk in their own right.

The overview of selected sectors above already highlights that the contaminants of concern that are shortlisted for monitoring will need to be classified according to:

- Individual chemicals e.g. specific pesticides or pharmaceuticals
- Chemical family or group e.g. parabens, phthalates, etc.
- Origin or taxonomic affinity in the case of contaminants of biological origin

Each of the sectors highlighted above is associated with various processes that tend to be sector specific (e.g. processes related to animal husbandry in agriculture; processes related to handling of chemicals in industry). High level mapping of material flows will be carried out to establish the potential linkages between the various sectors, and sector specific processes, to define linkages between sources of potential pollutants (and where possible, potential by-products) and the receptor water bodies.

Methodology

62. **Outline of the methodology to be employed**: the identification of contaminants of emerging concern shall follow the process highlighted in the NORMAN prioritisation framework for emerging substances, as highlighted in Dulio V, von der Ohe PC (2013) *NORMAN prioritisation framework for emerging substances.* NORMAN Association, Verneuil-en-Halatte. ISBN 978-2-9545254-0-2 17. The first step required involves the definition of an initial list of candidate substances as indicated below.

63. Deriving an initial list for candidate substances for prioritisation shall include:

    A. A top down approach where data mining in the literature is carried out to identify specific contaminants that have been highlighted elsewhere, and that should be considered in the local context. In this regard, reference shall be made to various databases, the scientific literature, and in particular the data held by the NORMAN network, which is active in the field of exchange of information on emerging environmental substances of concern.
    B. Consideration of data collected from relevant stakeholders.
    C. A review of high-level material flows of materials currently present and handled within Malta, to identify plausible sources of contamination, and assess the possibility of their role with respect to emission or leaching of contaminants of emerging concern.

    This combined approach is considered essential given that datasets are incomplete, the number of potential substances too large for systematic examination in certain circumstances (e.g. pharmaceuticals and the resultant metabolites), and others (such as flame retardants) emanate from a range of products (such as furniture, electronics) are not included in any systematic database.

64. Further prioritisation will follow the methodology described in Dulio *et al.* (2013), where the substances are assigned into action categories as defined within the same paper, followed by ranking of the substances within each action category, to generate a final shortlist for review. Should any deviations from this methodology be found to be necessary, these will be described and justified as appropriate. However, the overall criteria for selection will consider:

- Known presence or absence of potential CECs in the Maltese context (i.e. through production and/or use, and usage patterns), based on data collected, and expert judgement in the absence of data; and
- The environmental and health hazard risks posed by the various substances, in relation to the indicated, expected or potential abundance of the substance occurrence, making reference to data emanating from the requirements of Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation).

Knowledge of by-products of parent compounds must be based on data held in the NORMAN network. Alternatively, data in the literature (i.e. case histories with comparable scenarios) will be used where available.

65. Environmental and health risk assessment will require assessment of CEC candidates to their status as actual or potential substances of very high concern (SVHCs):

- Substances meeting the criteria for classification as carcinogenic, mutagenic or toxic for reproduction (CMR) category 1A or 1B in accordance with the CLP Regulation.
- Substances which are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) according to REACH Annex XIII.
- Substances on a case-by-case basis, that cause an equivalent level of concern as CMR or PBT/vPvB substances.

Assessment will also require an evaluation of the known behaviour of the various substances in the natural environment, to determine the extent of significance of the presence of that substance, and to facilitate their ranking and prioritisation.

66. In parallel, monitoring data and other available literature regarding water quality will then be reviewed to provide a context to the list generated above, to highlight existing pollution pathways that may be followed by the CECs that are identified in the above exercise. This data would include those datasets and reports held by the following:

- Environment and Resources Authority
- Water Services Corporation
- Malta Resources Authority

This data should include data collected through monitoring exercises, as well as relevant data collected through permitting, and/or other projects.

67. The above exercise will be used to identify potential pollution pathways that would affect water bodies, and evaluate the levels of risk posed by contaminants to the various water resources. This would in turn generate a shortlist of chemical parameters for each water body, that would consist of the most likely CECs that should be investigated with priority.

Stakeholders & Timeline

68. **Stakeholders:** The main entities involved in the importation, regulation or monitoring of substances that may contain contaminants of emerging concern are:

- **Customs Department**: importation data, list of chemical and products imported into Malta
- **Malta Competition and Consumer Affairs Authority**: the competent authority responsible for the REACH directive (on chemicals), cosmetics, pesticides and fertilizers
- **Water Services Corporation**: holds data on drinking water quality, data on sewerage (treatment and chemical composition)
- **Energy and Water Agency**: holds data on priority pollutants in groundwater bodies
- **Pesticides Control Board**: holds data on pesticide use
- **Agriculture Department**: holds data on fertilizer use
- **Veterinary Regulation Directorate**: holds data on chemical and pharmaceutical use in animal husbandry
- **Department of Environmental Health**: data on communicable diseases resulting from vectors of disease that are water-borne
- **Medicines Authority**: data on pharmaceuticals used in Malta
- **National Antibiotic Committee**: holds data on antibiotic use in Malta
- **Environment and Resources Authority**: holds data on wastes and environmental permits
- **Ministry for Transport, Infrastructure and Capital Projects**: holds data on urban runoff.

The above all contribute data to the National Statistics Office.

69. The above exercise is projected to follow the timeline indicated below:

Item	Description	Month (from signing contract*)										
		1	2	3	4	5	6	7	8	9	10	11
1	Finalization of workplan – submission to ERA (Result 1a)**											
2	Desk study on contaminants of emerging concern											
3	Collection of data from authorities											
4	Consultation meetings with authorities to discuss data gaps and identify concerns											
5	Risk assessment											
6	Shortlisting of selected chemicals of concern											
7	Report on shortlisted chemicals – submission to ERA (Result 1b)											
8	Collection of data on required laboratory & sampling techniques, and consideration of feasibility											
9	Report on the proposed monitoring strategy and programme for the contaminants of emerging concern – submission to ERA (Result 2)											
10	Finalisation of Report / clarification of any outstanding comments.											

* Contract signed in May 2019
**Workplan approved 30th July 2019

Annex 02: additional parameters for groundwater, to assist in data interpretation

GROUNDWATER

BASIC PARAMETERS

Turbidity N.T.U.
Conductivity µScm-1
Temperature (on site) ◦C
pH
Total Hardness mg/L
Calcium Hardness mg/L
Magnesium mg/L CaCO3
Calcium mg/L Ca
Magnesium mg/L Mg
Chlorides mg/L
Nitrates mg/L
Bicarbonate mg/L
Hydrogen Sulphide µg/L
Total Alkalinity mg/L
Dissolved Oxygen mg/L
Total Dissolved Solids mg/L
Potassium mg/L
Sodium mg/L
Ammonia mg/L
Flourides mg/L
Iron mg/L
Silica mg/L
Nitrites mg/L
Total Phosphorus mg/L
Orthophosphates mg/L
Sulphates mg/L
Boron mg/L
Copper µg/L
Zinc µg/L
Arsenic µg/L
Lead µg/L
Aluminium µg/L
Chromium µg/L

Manganese µg/L
Nickel µg/L
Selenium µg/L
Cadmium µg/L
Antimony µg/L
Mercury µg/L
TOC mg/L
TOTAL COLIFORMS
E.coli
FAECAL STREPTOCOCCI
TOTAL BACTERIAL COUNT
TOTAL BACTERIAL COUNT

Annex 03: Recommended Monitoring Points

The following table consists of a summary of the recommended monitoring points. Although a set of coordinates are provided, a site visit is required to evaluate each point of sampling, to verify availability of water, and safety of access. This should be managed by the parties contracted to carry out sampling, where variations may be introduced (and justified) on the basis of changing circumstances prevalent at the site. All coordinates (barring those in italics) are as provided by the competent authorities, and their interpretation must consider sampling requirements as specified in the respective sections of this report.

Inland surface Waters (watercourses and transitional water bodies)

Site name	**UTM**	
	Eastings	Northings
Wied il-Luq	445813	3968424
Wied is-Sewda	*451547*	*3971346*
Wied il-Lunzjata	430913	3988663
Is-Salini	447807	3978025

Coastal Waters

Site name	**UTM**	
	Eastings	Northings
Off San Dimitri Point, Gozo	425781.39	3992303.97
Off Ta' Barkat STP, Xghajra, MT	459773.32	3971568.53
Xemxija Bay	444923.19	3978627.44

Surface runoff

National Flood Relief Project inlet points (sedimentators) associated with Birkirkara/Msida/Gzira catchments

Sewage and new waters

- a monitoring point from an agglomeration having a catchment of industrial character, where Hal Far would provide an agglomeration that is distinct from residential uses;
- a monitoring point from an agglomeration having a residential character, where the Birkirkara area would constitute an urban area relatively free from industrial effluent
- from point of generation of new waters

Groundwater

Site name	**Groundwater Body**	**UTM**	
		Eastings	Northings
Fiddien Station, Rabat, MT	Malta Mean Sea Level	443796	3971842
Ġnien Borehole, Luqa	Malta Mean Sea Level	454413	3968012
San Katald Borehole, Gharb	Gozo Mean Sea Level	428573.003	3991812.79
Għattuq Borehole, Rabat, GZ	Gozo Mean Sea Level	432451	3989603
Bahrija spring	Rabat Dingli Perched	440640.88	3972667.855
Victoria Station, Rabat, GZ	Victoria_Kercem Perched	431197.11	3988565.173
Pwales station	Pwales Coastal	440640.88	3972667.855