WATER QUALITY PROTECTION TECHNICAL NOTE

الدقم
Duqm
هيئة المنطقة الاقتصادية الخاصة
Special Economic Zone Authority

Environment Regulatory Department

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TABLE OF CONTENTS

List of Acronyms ..... **iii**

1 INTRODUCTION **4**

1.1 Objectives *4*

1.2 Project Information *4*

2 APPLICABLE STANDARDS **6**

2.1 National Standards *7*

2.1.1 RD 114/2001: Law for the Conservation of the Environment and Prevention of Pollution 7

2.1.2 RD 29/2000: Law of Protection of Water Resources 7

2.1.3 Omani Standard 8/2012: Unbottled Drinking Water 7

2.1.4 MD 145/1993: Regulations for Wastewater Reuse and Discharge 12

2.1.5 MD 421/1998: Regulations for Septic Tanks, Soak away Pits, and Holding Tanks 12

2.1.6 MD 200/2000: Regulations for Crushers, Quarries and Transport of Sand from Coast, Beaches and Wadis 12

2.1.7 RD 115/2001: Law on Protection of Potable Water Sources from Pollution 12

2.1.8 MD 79/2006 – Regulation specifying requirements of sub-surface reservoirs for storage of Hydrocarbons and hazardous materials 15

2.1.9 MD 12/2017 – Regulation amending MD 145/93 15

2.2 SEZAD Licenses *15*

2.3 International Standards *16*

2.3.1 Dutch Standards 16

3 ENVIRONMENTAL PERMITTING REQUIREMENTS **17**

3.1 Environmental Regulatory Procedure *17*

3.2 Environmental Impact Assessment (EIA) *17*

3.2.1 Construction Environmental Management Plan (CEMP) / Operational Environmental Management Plan (OEMP) / Decommissioning Environmental Management Plan 18

4 MONITORING AND ASSESSMENT METHODOLOGIES **19**

4.1 Monitoring Methodologies *19*

4.1.1 Baseline monitoring prior to Construction 19

4.1.2 Monitoring during Construction 21

4.1.3 Monitoring during Operation 21

4.1.4 Monitoring during Decommissioning 22

4.2 Assessment Methodology *26*

4.2.1 Identification of Exceedance 26

4.2.2 Impact Assessment 26

5 GENERAL POLLUTION PREVENTION GUIDANCE NOTES **27**

5.1 Construction and Decommissioning Pollution Prevention Guidelines *27*

5.1.1 Groundwater Quality Pollution Prevention Guidelines 27

5.1.2 Surface Water Quality Pollution Prevention Guidelines ... 28
5.2 Pollution Prevention Guidelines during Operation ... 29
5.2.1 Groundwater Quality Pollution Prevention Guidelines ... 29
5.2.2 Surface Water Quality Pollution Prevention Guidelines ... 29
5.2.3 Water Conservation Guidelines ... 30
5.3 Industry-Specific Best Management Practices ... 31
5.3.1 Petrochemical Industry ... 31
5.3.2 Limestone/Cement Industry ... 32
5.3.3 Fisheries Industry ... 33
5.3.4 Silica Sand/Glass, Metal Casting and Production Industry 34
5.3.5 Automotive Industry ... 36
5.3.6 Desalination Industry ... 36
5.3.7 Power Generation Industry ... 37
5.3.8 Infrastructure (Port, Harbour and Terminals, Airport, Gas Distribution Network) ... 38

References ... 41

List of Figures

Figure 1-1: SEZD Area ... 5

List of Tables

Table 2-1: Water Quality Legislations and Guidelines ... 6
Table 2-2: Organoleptic and inorganic Parameters as per OS 8/2012 ... 7
Table 2-3: The maximum level for health – related inorganic constituents 8
Table 2-4: Maximum limits for chemicals that are of health significance ... 8
Table 2-5: Maximum limits for Chemicals that are of Health Significance in Drinking Water ... 9
Table 2-6: Levels of radionuclides in drinking water ... 11
Table 2-7: Wastewater Standards as per RD 115/2001 and MD 145/1993 ... 13
Table 2-8: Standards for Wastewater Re-use based on Areas of Application as per RD 115/2001 and MD 145/1993 ... 14
Table 2-9: Standards for Discharge of Non-Household Liquid Waste into Sewage System as per RD 115/2001 ... 14
Table 4-1: Water Quality Parameters for Industrial Sources of Pollution Common to the SEZ Area (WMO, 2013) ... 24

List of Acronyms

BGL	Below Ground Level
BMP	Best Management Practices
CEMP	Construction Environmental Management Plan
DEMP	Decommissioning Environmental Management Plan
EIA	Environmental Impact Assessment
IDZ	Industrial Development Zone
MD	Ministerial Decree
MECA	Ministry of Environment and Climate Affairs
OEMP	Operational Environmental Management Plan
PPGN	Pollution Prevention Guidance Notes
QA/QC	Quality Assurance/ Quality Control
RD	Royal Decree
SEZ	Special Economic Zone
SEZAD	Special Economic Zone Authority of Duqm
WQPTN	Water Quality Protection Technical Note

1 Introduction

1.1 Objectives

The Water Quality Protection Technical Note (WQPTN) has been developed as part of a set of technical notes for the environmental requirements of the Special Economic Zone (SEZ) at Duqm. The WQPTN includes a description of the relevant national and international water quality related standards, the environmental permit requirements, methodologies for undertaking water monitoring and assessments, and relevant industry-specific pollution prevention guidelines.

The WQPTN is intended for future applicants whose proposed industries may adversely impact water quality during construction, operation and decommissioning phases of the Project. The purpose of this document is to set forth a comprehensive document that will ensure compliance with the required standards.

The related applications which might give rise to concerns regarding water quality will be assessed and reviewed by the Special Economic Zone Authority at Duqm (SEZAD) Environmental Regulatory Department with specific requirements detailed on a case by case basis.

1.2 Project Information

The SEZ at Duqm is an integrated economic development area that covers 2,000 square kilometres. The SEZ is located in the Wilayat of Duqm on the south-east coast of Oman. The coastline of Wilayat Duqm is approximately 170 km in length, with the northern boundary lying between Nafun and Sidera, and the southern boundary being approximately 120 km south of Ras al Madrakah. Ghubbat Al Hashish and Barr Al Hikman lie to the north of the Al Wusta Region and Ras al Madrakah in the south.

The SEZ is composed of zones that include the Duqm port, the ship dry dock, the oil refinery, the regional airport, the residential, commercial and tourism area, the logistic services area, fisheries area and the industrial zone.

This WQP Technical Note applies to industries in the SEZ area. Figure 1-1 specifies the boundaries of the SEZ as per RD 5/2016.

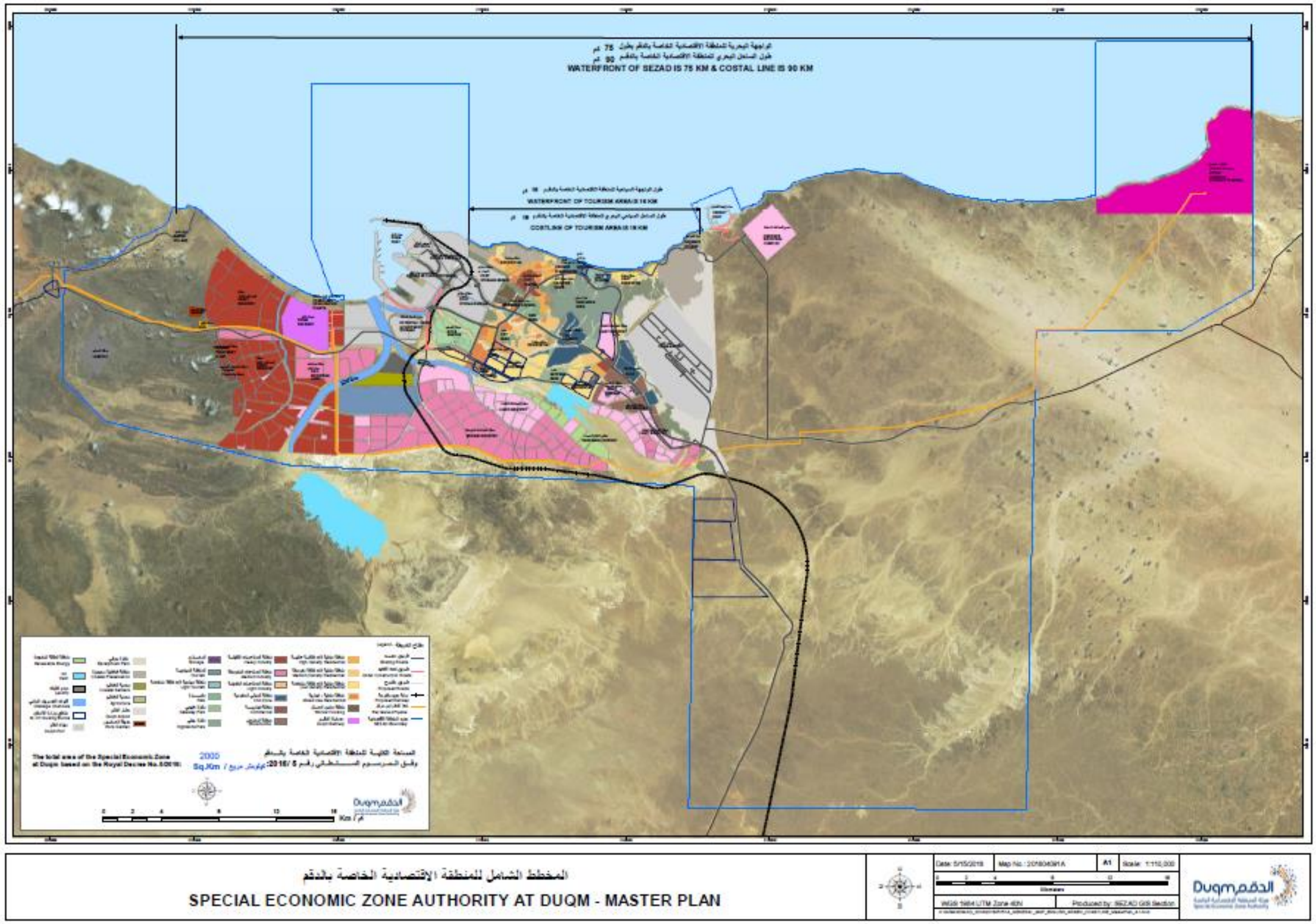

Figure 1-1: SEZD Area

2 Applicable Standards

In accordance with Royal Decree (RD 79/2013), SEZAD-Environmental Regulatory Department has the functions of the Ministry of Environment and Climate Affairs (MECA) in relation to issuing environmental permits for projects and implementing environmental regulations within the SEZ.

This Chapter details the applicable standards and legislation for water quality (surface and groundwater) management within the SEZ. At all times local requirements will override international requirements. The international standards are to be complied with, only in the absence of local standards.

Table 2-1 lists the relevant legislation and guidelines applicable to water quality requirements.

Each legislation has only been briefly summarised within this Chapter to provide an introduction to the legislation. The applicant is required to refer to the complete official copy of the legislation and standards in-order to identify all applicable requirements.

*** It shall be noted that within SEZ, SEZAD will have the authority of concerned Ministries mentioned in the below national regulations.**

Table 2-1: Water Quality Legislations and Guidelines

Water Quality Legislations and Guidelines	
National	
RD 114/2001	Law for the Conservation of the Environment and Prevention of Pollution
RD 29/2000	Law of Protection of Water Resources
Omani Standard 8/2012	Un-bottled Drinking Water - (Issued by the Directorate General for Specifications and Measures, Ministry of Commerce and Industry).
MD 145/1993	Regulations for Wastewater Reuse and Discharge
RD 115/2001	Law on Protection of Potable Water Sources from Pollution
MD 421/1998	Regulations For Septic Tanks, Soak away Pits, and Holding Tanks.
MD 200/2000	Regulations for Crushers, Quarries and Transport of Sand from Coast, Beaches and Wadis
MD 79/2006	Specifications and requirements of sub-surface reservoirs for storage of Hydrocarbons and hazardous materials.
MD 12/2017	Amending some articles of MD 145/1993
International	

Water Quality Legislations and Guidelines	
Dutch Standards (2009)	Soil and Groundwater standards (target and intervention values)

2.1 National Standards

2.1.1 RD 114/2001: Law for the Conservation of the Environment and Prevention of Pollution

The articles of RD 114/2001 provide guidance on allowable discharge into wadis, watercourses, groundwater recharge areas, rainwater and flood drainage systems or aflaj and their channels. It also notes that it is not permitted to use or to discharge untreated wastewater in the above mentioned places. No treated wastewater should be used or discharged unless a permit to that effect is obtained according to applicable procedures and conditions.

2.1.2 RD 29/2000: Law of Protection of Water Resources

RD 29/2000 regulates water conservation in Oman. This law and the by-laws associated with it are of direct importance to the options for sourcing water from aquifers and wadis. As part of the articles within RD 29/2000, it is prohibited to undertake any work which negatively affects the underground supply of the water table, whoever the owner of the land in which the water table exists might be.

It is not permissible to undertake any work, which may change the direction of a falaj or its uses without a license.

2.1.3 Omani Standard 8/2012: Unbottled Drinking Water

The Omani Standard OS 08/2012 regulates the drinking water quality requirements. It supersedes and is an update of OS 8/1994 and OS 8/2006. OS 08/2012 applies to all sources of Unbottled drinking water (treated or untreated) such as via network system, from wells, springs or surface water. OS 8/2012 indicates the maximum allowed values for chemical, inorganic, organoleptic constituents and biological and microbiological characteristics. In addition it sets guidelines for 128 radionuclides. The standard considers 2 criteria for Unbottled drinking water: quality level, which is the value that should be achieved and the maximum level that is allowed. The latter is mandatory and should be implemented.

Table 2.2 to Table 2.6 provides the standards for various parameters as per OS 8/2012.

Table 2-2: Organoleptic and inorganic Parameters as per OS 8/2012

Substances or characteristics	Quality level	Maximum level	Unit
a) Organoleptic parameter			
Colour	Non	<15	Truecolourunit
Turbidity	1	>5	Nephelometric turbidity unit
Taste & Odour	Not offensive ac	Acceptable	
Temperature	Not offensive ac	Acceptable	
b) Inorganic constituents			
Ammonia	-	1.5	
Chloride	≤250	600	

Substances or characteristics	Quality level	Maximum level	Unit
Sodium	≤200	400	
Sulphate	≤250	400	mg/L
Total hardness	≤200	500	mg/L
Total dissolved solids	120-600	1000	mg/L
Nitrate (as NO3)		50	
Nitrate (as NO2)		3 (Short term exposure)	
		0.2 (long-term exposure)	
Hydrogen sulphide		0.1	mg/L
pH	6.5-8 (natural water) 6.5 – 8.5 (desalinated water)	9	
Fluoride	0.6 – 0.8 for desalinated water	Maximum level is mentioned in Table (2.6)	mg/L
Magnesium		30 if sulphites> 250	mg/L
		150 if sulphites < 250	mg/L
* if present			

Table 2-3: The maximum level for health – related inorganic constituents

Constituent	Maximum Limit (mg/L)
Aluminium	0.1 For large water treatment facilities
	0.2 For small water treatment facilities*
Antimony	0.02
Arsenic	0.01
Barium	0.7
Boron	0.5 for natural water
	2.4 desalinated water
Brom (as bromate)	0.01
Cadmium	0.003
Chromium	0.05
Copper	2
Cyanide	0.07
Fluoride	1.5
Iron	1
Lead	0.01
Manganese	0.4
Mercury	0.001
Molybdenum	0.07
Nickel	0.02
Selenium	0.01
Zinc	3
*Fewer than 10000people	

Table 2-4: Maximum limits for chemicals that are of health significance

Chemical	Maximum Limit (mg/L)
Acrylamide	0.0005
Alchalor	0.02

Chemical	Maximum Limit (mg/L)
Aldicarb	0.01
Aldrin and dieldrin	0.00003
Atrazine	0.002
Benzene	0.01
Benzo[a]pyrene	0.0007
Bromodichloromethane	0.06
Bromoform	0.1
Carbofuran	0.007
Carbon tetrachloride	0.004
Chloral hydrate (trichloroacetaldehy)	0.01
Chlorate	0.7
Chlordane	0.0002
Chlorine	5 For effective disinfection, there should be a residual conc. of free chlorine of >0.5 mg/l after at least 30 min. contact time at pH<8.0
Chlorite	0.7
Chloroform	0.2
Chlorotoluron	0.03
Chlorpyrifos	0.03
Cyanazine	0.0006
Cyanogen chloride	0.07 For cyanide as total cyanogenic compounds
2.4-D (2.4-dichlorophenoxyacetic acid)	0.03

Table 2-5: Maximum limits for Chemicals that are of Health Significance in Drinking Water

Chemical	Maximum Limit (mg/L)
2,4-DB	0.9
DDT and metabolites	0.001
Di (2-ethylhexyl) phthalate	0.008
Dibromoacetonitrile	0.07
Dibromochloromethane	0.1
1,2-Dibromo-3-chloropropane	0.001
1,2-Dibromoethane	0.0004
Dicloroacetate	0.05
Dichloroacetonitrile	0.02
Dichlorobenzene, 1,2-	1
Dichlorobenzene, 1,4-	0.3
Dichlorobenzene, 1,2-	0.03
Dichlorobenzene, 1,1-	0.03
Dichlorobenzene, 1,2-	0.05
Dichloromethane	0.02
1,2-Dichloropropane (1,2-DCP)	0.04
1,3-Dichloropropene	0.02
Dichloroprop	0.1
Dimethoate	0.006
Edetic acid (EDTA)	0.6 Applies to the free acid

Chemical	Maximum Limit (mg/L)
Endrin	0.0006
Epichlorohydrin	0.0004
Ethylbenzene	0.3
Fenoprop	0.009
Formaldehyde	0.9
Hexachlorobutadiene	0.0006
Isoproturon	0.009
Lindane	0.002
MCPA	0.002
Mecoprop	0.01
Methoxychlor	0.02
Metolachlor	0.01
Microcystin-LR	0.001
Molinate	0.006
Monochloramine	3
Monoclorocetate	0.02
Nitrilotricetic acid (NTA)	0.2
Pendimethalin	0.02
Pentachlorophenol	0.009
Pyriproxyfen	0.3
Simazine	0.002
Styrene	0.02
2,4,5-T	0.009

Chemical	Maximum Limit (mg/L)
Terbuthylazine	0.007
Tetrachloroethene	0.04
Toluene	0.7
Trichloroacetate	0.2
Trichloroethene	0.07
Trichlorophenlo, 2,4,6-	0.2
Triluralin	0.02
Trihalomethanes	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Uranium	0.015
Vinyl chloride	0.0003
Xylenes	0.5

Table 2-6: Levels of radionuclides in drinking water

Radionuclides	Guidance Level (Bq/liter)	Radionuclides	Guidance Level (Bq/liter)	Radionuclides	Guidance Level (Bq/liter)
3H	10 000	93Mo	100	140La	100
7Be	10 000	99Mo	100	139Ce	1000
14C	100	96Tc	100	141Ce	100
22Na	100	97Tc	1000	143Ce	100
32P	100	97mTc	100	144Ce	10
33P	1 000	99Tc	100	143Pr	100
35S	100	97Ru	1000	147Nd	100
36Cl	100	103Ru	100	147Pm	1000
45Ca	100	106Ru	10	149Pm	100
47Ca	100	105Rh	1000	151Sm	1000
46Sc	100	103Pd	1000	153Sm	100
47Sc	100	105Ag	100	152Eu	100
48Sc	100	110mAg	100	154Eu	100
48V	100	111Ag	100	155Eu	1000
51Cr	10 000	109Cd	100	153Gd	1000
52Mn	100	115Cd	100	160Tb	100
53Mn	10 000	115mCd	100	169Er	1000
54Mn	100	111In	1000	171Tm	1000
55Fe	1000	114mIn	100	175Yb	1000
59Fe	100	113Sn	100	182Ta	100
56Co	100	125Sn	100	181W	1000
57Co	1 000	122Sb	100	185W	1000
58Co	100	124Sb	100	186Re	100
60Co	100	125Sb	100	185Os	100
59Ni	1 000	123mTe	100	191Os	100
63Ni	1 000	127Te	1000	193Os	100
65Zn	100	127mTe	100	190Ir	100
71Ge	10 000	129Te	1000	192Ir	100
73As	1000	129mTe	100	191Pt	1000
74As	100	131Te	1000	193mPt	1000
76As	100	131mTe	100	198Au	100
77As	1 000	132Te	100	199Au	1000
75Se	100	125I	10	197Hg	1000
82Br	100	126I	10	203Hg	100
82Rb	100	129I	1	200Tl	1000
85Sr	100	131I	10	201Tl	1000
89Sr	100	129Cs	1000	202Tl	1000
90Sr	10	131Cs	1000	204Tl	100
90Y	100	132Cs	100	203Pb	1000
91Y	100	134Cs	10	206Bi	100
93Zr	100	135Cs	100	207Bi	100
95Zr	100	136Cs	100	210Bib	100
93mNb	1000	137Cs	10	210Pbb	0.1
94Nb	100	131Ba	1000	210Pob	0.1
95Nb	100	140Ba	100	223Rab	1
224Rab	1	235Ub	1	242Cn	10

226Rab	1	237U	100	244Cm	1
228Rab	0.1	126Ub,c	10	245Cm	1
227Thb	10	237Np	1	246Cm	1
228Thb	1	239Np	100	247Cm	1
229Thb	0.1	236Pu	1	248Cm	0.1
230Thb	1	237Pu	1000	249Bk	100
231Thb	1 000	238Pu	1	246Cf	100
232Thb	1	239Pu	1	248Cf	10
234Thb	100	240Pu	1	249Cf	1
230Pa	100	241Pu	10	250Cf	1
231Pab	0.1	242Pu	1	251Cf	1
233Pa	100	244Pu	1	252Cf	1
230U	1	241Am	1	253Cf	100
231U	1000	242Am	1000	254Cf	1
232U	1	242mAm	1	253Es	10
233U	1	243Am	1	254Es	10
234Ub	1			254mEs	100

2.1.4 MD 145/1993: Regulations for Wastewater Reuse and Discharge

MD 145/1993 sets out standards for wastewater re-use on land (i.e. for agricultural and irrigation use) to be used as the design basis for treatment plants both temporary and permanent, and other applicable uses. Maximum permissible concentrations of various pollutants in the wastewater have also been specified in MD 145/1993 (as shown in Table 2-7 and Table 2.8).

2.1.5 MD 421/1998: Regulations for Septic Tanks, Soak away Pits, and Holding Tanks

MD 421/1998 regulates the provision of septic tanks, soakaway pits and holding tanks and provides (1) a methodology to calculate capacity of septic tanks, (2) design and measurement criteria for septic tanks and holding tanks, (3) a procedure to test for percolation and design soakaway pit.

2.1.6 MD 200/2000: Regulations for Crushers, Quarries and Transport of Sand from Coast, Beaches and Wadis

MD 200/2000 regulates the use of crushers and quarries (permit, location, environmental considerations) and prohibits damage to wadis and their vegetation.

2.1.7 RD 115/2001: Law on Protection of Potable Water Sources from Pollution

The Omani regulations most applicable to this WQP Technical Note is RD 115/2001 issuing laws on protection of potable water from pollution.

Appendix 1 of RD 115/2001 provides conditions for the treatment, re-use and discharge of wastewater. Table 2-7 and Table 2-8 detail the limits for wastewater discharge and areas of application.

In addition to the provision of discharge standards, RD 115/2001 specifies requirements of obtaining licenses and permits to discharge,

fines payable in case of delay of license renewal, requirements of construction of septic tanks, notes on potable water sale, etc.

Appendix 3 of RD 115/2001 provides standards for discharge of non-household liquid waste into the sewage system, as shown in Table 2-9. Non-household liquid waste refers to liquid waste flowing out of any site used partially or wholly for industrial, agricultural, commercial and construction or research purposes.

Table 2-7: Wastewater Standards as per RD 115/2001 and MD 145/1993

Matter	Maximum Allowable Limits (mg/l)	
	A-1 (see Table 2-8)	A-2 (see Table 2-8)
Biochemical oxygen demand (5 days @ 20º c)	15	20
Chemical oxygen demand	150	200
Suspended solid	15	30
Total dissolved solids	1500	2000
Electrical conductivity (µs/cm)	2000	2700
Sodium absorption ratio	10	10
PH (within range)	6-9	6-9
Aluminium (as Al)	5	5
Arsenic (as As)	0.1	0.1
Barium (as Ba)	1	2
Beryllium (as Be)	0.1	0.3
Boron (as B)	0.5	0.5
Cadmium (as Cd)	0.01	0.01
Chloride (as Cl)	650	650
Chromium (total as Cr)	0.05	0.05
Cobalt (as Co)	0.05	0.05
Copper (as Cu)	0.5	1
Cyanide (as Cn)	0.05	0.1
Fluoride (as F)	1	2
Iron (total as Fe)	1	5
Lead (as Pb)	0.1	0.2
Lithium (as Li)	0.07	0.07
Magnesium (as Mg)	150	150
Manganese (as Mn)	0.1	0.5
Mercury (as Hg)	0.001	0.001
Molybdenum (as Mo)	0.01	0.05
Nickel (as Ni)	0.1	0.1
Nitrogen: Ammonical (as N)	5	10
Nitrogen: Nitrate (as NO3)	50	50
Nitrogen: Organic	5	10
Oil and Grease (total extractable)	0.5	0.5
Phenols (total)	0.001	0.002
Phosphorus (total as P)	30	30
Selenium (as Se)	0.02	0.02
Silver as (Ag)	0.1	0.1
Sodium (as Na)	200	300
Sulphide (as S)	0.1	0.1
Vanadium (as V)	0.1	0.1
Zinc (as Zn)	5	5

Matter	Maximum Allowable Limits (mg/l)	
	A-1 (see Table 2-8)	A-2 (see Table 2-8)
Faecal Coliform Bacteria (per 100 ml)	200	1000
Viable Nematode Ova (per litre)	< 1	< 1

Table 2-8: Standards for Wastewater Re-use based on Areas of Application as per RD 115/2001 and MD 145/1993

	A-1	A-2
Grass and ornamental areas	Public Parks Areas and lakes accessed by the public	Areas with no public access
Crops	Vegetables and fruits likely to be eaten raw within two weeks of irrigation	Vegetables to be cooked or processed Fruits if not irrigated within two weeks of cropping Fodder cereal and seed crops
Aquifer re-charge	All aquifer recharge controlled and monitored by the Ministry	
Methods of irrigation	Spray or any other method of aerial irrigation not permitted in areas with public access unless with timing control.	
Any other re-use applications	Subject to prior approval	

Table 2-9: Standards for Discharge of Non-Household Liquid Waste into Sewage System as per RD 115/2001

Components	Maximum Allowable Limits
pH	6-10
Colour	Raises no objection
Biochemical Oxygen Demand (5 days)	Not more than (1000) mg/L
Chemical Oxygen Demand	Not more than (1500) mg/L
Temperature	Not more than 43°C
Suspended solid	Not more than (1000) mg/L
Total dissolved solids	Not more than (3000) mg/L
Grease and oil	Not more than (30) mg/L
Sulphide (expressed in tons)	Not more than (3) mg/L
Sulphate (expressed in tons)	Not more than (500) mg/L
Phenols	Not more than (5) mg/L
Cyanide	Not more than (1) mg/L
Detergents	Not more than (30) mg/L
Alkalinity	Not more than (2000) mg/L
Toxic metals	Not more than (10) mg/L
Aluminium (expressed in tons of Al)	Not more than (10) mg/L
Arsenic (expressed in Arsenic)	Not more than (1) mg/L
Barium (expressed in Barium)	Not more than (10) mg/L
Beryllium (expressed in Beryllium)	Not more than (5) mg/L
Cadmium (expressed in cadmium)	Not more than (2) mg/L
Chromium (total in tons of chromium)	Not more than (2) mg/L
Copper (expressed in tons of copper)	Not more than (1) mg/L
Iron (expressed in tons of iron)	Not more than (5) mg/L
Lead (expressed in tons of lead)	Not more than (2) mg/L
Mercury (expressed in tons of mercury)	Not more than (0.1) mg/L
Nickel (expressed in tons of nickel)	Not more than (2) mg/L
Silver (expressed in tons of silver)	Not more than (0.1) mg/L
Zinc (expressed in tons of zinc)	Not more than (2) mg/L
Calcium Carbide.	Not seen
Radioactive substances	Not seen

Components	Maximum Allowable Limits
Yeast, sugar, raw tar, crude oil.	Not seen
Hydrogen sulphide and polysulphides.	Not seen
Petroleum spirit, flammable solvents or volatile noxious solvents gases or solids.	Not seen
Unpolluted water (including condensation and cooling water and water drained from roofs of buildings).	Not seen
Insecticides, herbicides, pesticides, fungicides	Imperceptible
Any substance (whether by itself or with any other substance allowed to be discharged into sewage system).	Imperceptible
Any material that may render wastewater harmful or makes formal treatment of such waste difficult.	Imperceptible

2.1.8 MD 79/2006 – Regulation specifying requirements of sub-surface reservoirs for storage of Hydrocarbons and hazardous materials

The above MD sets out the specification and requirements of the underground storage of hydrocarbons and hazardous materials. Article 2 of the Decision specifies that construction of tanks for the storage of hydrocarbons or any hazardous materials will be allowed only after obtaining an environmental permit from the Ministry in accordance with the specifications and requirements provided in the Decision.

The tank specification as well requirement of monitoring wells to monitor the impact on groundwater from the tanks are also specified in Article 2.

2.1.9 MD 12/2017 – Regulation amending MD 145/93

The decision has added the following wastewater types to MD 145/93 and the decision requires that a separate permit/discharge license is obtained for the same from the Ministry/ Authority.

- Discharge of treated waste water;
- Discharge of produced water from oil production;
- Discharge of reject water from desalination plant;
- Discharge of waste water to evaporation pond;
- Permit to discharge water (NOL)

2.2 SEZAD Licenses

As mentioned earlier, per Article 79/2013 SEZAD has the functions of MECA in relation to issuing environmental permits for projects within the SEZ. Following are some of the licenses issued by SEZAD for the projects within SEZ.

- License to discharge of non-reusable treated waste water and/or No Objection Letter (NOL) to discharge water;
- License to discharge of reject water from desalination plant;
- License to discharge of waste water to evaporation pond;

2.3 International Standards

For parameters that are not included in OS 08/2-012, international standards may be followed and complied with. Some international standards are included in the following section.

2.3.1 Dutch Standards

The "Dutch Soil Remediation Circular 2009" (Ministry of Housing, Spatial Planning and Environment Directorate General for Environmental Protection, 2009), hereby referred to as Dutch Standards, are recommended for reference to determine the severity of pollution and whether urgent remediation is necessary.

Groundwater Target and Intervention values are provided in Annex 1 of this Circular. Groundwater target values provide an indication of the benchmark for environmental quality in the long term, assuming that there are negligible risks for the ecosystem. Intervention Values are the maximum tolerable concentrations above which remediation are required.

A case of serious contamination is deemed to exist if the average concentration measured of at least one substance in a pore-saturated soil volume of at least 100 m^3, is higher than the intervention value. The applicant is required to refer to the complete official copy of this Circular in-order to identify all applicable requirements. Moreover, in the absence of national guidance on methodologies for water quality monitoring and assessment, reference has been made to various international sources, one of which is British Standard BS 5930:2015 *Code of practice for ground investigations.* This standard BS 5930:2015 deals with the investigation of sites in order to assess their suitability for construction and to identify the characteristics of a site that affect the design and construction of the project. It introduces new information on geophysical surveying and ground testing and updated guidance on desk studies, field reconnaissance, and ground investigations on contaminated ground.

3 Environmental Permitting Requirements

3.1 Environmental Regulatory Procedure

The environmental permitting requirements within SEZ are governed by SEZAD Environmental Regulatory Department. A summary of the permitting procedure is outlined below:

1. In accordance with SEZAD Decision 326/2015, the SEZAD Environmental Regulatory Department have developed a list of projects within the SEZ that require an Environmental Impact Assessment (EIA).
2. MECA regulation promulgated under MD 48/2017, issued in May 2017, has categorised the projects into three types and has listed the projects, which require EIA study. MD 48/2017 shall also be taken into consideration during the permitting requirement.
3. For projects requiring an EIA study, the development shall undergo the following:
   - Scoping study, identifying the topics and methodology, that need to be included in the EIA. Reviewing of scoping report takes up to 15 days.
   - On approval of scoping study, an EIA study is conducted and submitted to SEZAD. The reviewing of an EIA report shall take 40 days as per SD 326/2015.
4. On approval of the EIA report, a permit application is submitted to SEZAD with required documents.
5. For projects, which do not require an EIA study, the development can directly go for permitting, with the required documents.
6. For projects not listed in SD 326/2015 and/or which falls in Category C of MD 48/2017, a screening exercise is conducted by SEZAD Environmental Regulatory Department, depending on the project application, and a screening opinion,[1] is provided.

3.2 Environmental Impact Assessment (EIA)

The EIA study shall be developed by a MECA registered environmental consultant[2]. SEZAD have the authorization to reject environmental reports which are conducted by companies who are not registered with MECA to undertake these studies.

[1] SEZAD reserves the right to request EIA study for projects that are not listed in the regulations. This shall be decided during the screening stage of the project and depending on type of project and likely impacts

[2] A list of the MECA registered environmental consultants can be obtained from MECA.

The EIA is a procedure undertaken for those projects with major/significant impacts to the environment. For an industrial project, the EIA generally would assist in determining site suitability as well as the necessary environmental control and mitigation measures.

The objectives of the EIA are summarised as follows:

- To examine and select the best from the project options available;
- To identify, predict and assess significant residual environmental impacts;
- To recommend and incorporate into the project plan, appropriate abatement and mitigating measures; and
- To identify the environmental costs and benefits of the project to the community.

For details on Environmental Impact Assessment, Refer SEZAD Environmental Impact Assessment Guideline.

3.2.1 Construction Environmental Management Plan (CEMP) / Operational Environmental Management Plan (OEMP) / Decommissioning Environmental Management Plan

A CEMP/OEMP/DEMP is a practical plan of management measures which are designed to minimise environmental impacts from the construction and operation phase of a project. The document will need to outline the below requirements (at a minimum):

- Site specific activities of the development.
- Address the associated environmental and heritage issues.
- Provide planned management strategies to avoid and minimise impacts.
- A CEMP/OEMP/DEMP will also provide a management plan for how wastes generated by the activities will be contained and cleaned-up appropriately.

Refer SEZAD Environmental Impact Assessment Guideline for details on CEMP/OEMP.

4 Monitoring and Assessment Methodologies

To ensure water conservation and compliance with national water quality standards, this Chapter addresses water quality monitoring and assessment methodologies for all Project phases including: prior to construction (baseline), construction, operation and decommissioning.

4.1 Monitoring Methodologies

Monitoring methodologies are discussed for the pre-construction phase to develop the baseline water conditions, and for construction, operation, and decommissioning phases to ensure safe water quality.

The suggested monitoring methodologies are considered common for all proposed industries in the SEZ, except for the parameters to be analysed during operation phase, which are industry-specific.

4.1.1 Baseline monitoring prior to Construction

Prior to construction, it is typical to undertake baseline studies to establish the existing water profile on-site and determine the parameters for monitoring during the construction works.

As there are no permanent surface water features within the SEZ area, this section shall focus on groundwater monitoring.

Where possible, the Project applicant shall undertake baseline studies during the EIA phase of the Project and shall include desktop studies and geo-environmental investigations. The geo-environmental investigations shall comprise of the following:

- Drilling of rotary driven boreholes – including rock coring;
- Installation of standpipe piezometers to monitor groundwater levels;
- Collection of water samples from boreholes;
- Laboratory testing of water samples to determine physical and chemical parameters.

4.1.1.1 Sampling Locations

Groundwater sampling locations shall be selected within the site boundaries closest to the sensitive receptors. A non-targeted sampling approach, which uses the grid sampling methodology, can be employed to have a representative set of samples of the site area.

The number of wells is dependent on the lateral and vertical placement of monitoring wells, which is determined by the geology and hydrogeology of the site.

4.1.1.2 Collection of Groundwater Samples

Following the installation of the boreholes, each borehole is stabilised for 24 hours then purged three times the well volume. To calculate the volume of water in the well, the following equation can be used:

$$\text{Well Volume } (V) = \pi.r^2.h$$

Where:

- π= pi (3.14)
- r = radius of monitoring well (m)
- h = height of the water column (m)
- Total Volume to be purged (Litre) = Well volume (V) x 3

Using a bailer, water is filled into the desired containers and labelled clearly (Time, Location No.). Samples are capped and stored in cool boxes at a temperature of approximately 4˚C until delivered to the laboratory.

A submission sheet and Chain of Custody (COC) form must accompany all samples submitted to the laboratory to ensure sample traceability.

After collecting the groundwater samples, a standpipe piezometer is installed within each borehole to record the groundwater levels and direction of groundwater flow in accordance with the procedure specified in BS 5930:2015 *Code of practice for ground investigations* (Bristish Standards Institution, 2015).

4.1.1.3 Analysis of Parameters

Groundwater quality shall be compared against the parameters listed in OS 08/2012 – Omani standard for un-bottled drinking water. The parameters listed in OS 08/2012 include, but are not limited to, the following:

- Organoleptic parameters e.g. Colour, turbidity, taste & odour, pH and temperature
- Metals and Heavy Metals
- Inorganic substances
- Aromatic compounds
- Chlorinated hydrocarbons
- Pesticides
- Microbiological characteristics e.g. E.coli
- Radioactive characteristics

Additional parameters that are not listed in OS 08/2012 shall be compared against the Dutch Standards to determine the presence of contamination in the groundwater.

The applicant is required to refer to the complete official copy of the Dutch Standards to identify all parameters that shall be analysed that are not included in OS 08/2012.

Analysis shall be conducted by laboratories permitted or certified for this purpose and Quality Assurance/Quality Control (QA/QC) plans shall be prepared and implemented. QA/QC documentation shall be included in monitoring reports. Blind ground sample should be collected to confirm the quality and the results of the samples. One blind sample shall be collected from each 10 collected groundwater samples.

4.1.2 Monitoring during Construction

The purpose for undertaking water quality monitoring during construction activities is to record water consumption from the construction works and detect any exceedance in water contaminants from the effluent discharges.

4.1.2.1 Sampling Locations

When effluent water quality is monitored from discharge points, sampling locations shall be chosen as close as possible to the discharge points.

4.1.2.2 Collection of Samples

Groundwater samples are collected in accordance with the methodology described in Section 4.1.1.2.

Effluent water samples are collected using a bailer, water is filled into the desired containers and labelled clearly (Time, Location No.). Samples are capped and stored in cool boxes at a temperature of approximately 4˚C until delivered to the laboratory.

A submission sheet and COC form must accompany all water samples submitted to the laboratory to ensure sample traceability.

During construction the volume of water consumption, effluents discharge and water reused shall be recorded to ensure water resources are preserved.

4.1.2.3 Analysis of Parameters

If effluent water is discharged onto the ground, effluent water samples shall be analysed for parameters listed in Appendix 1 of RD 115/2001.

Otherwise, when effluent water is discharged into the storm water drainage system, the parameters to be analysed are those listed in Appendix 3 of RD 115/2001.

4.1.2.4 Frequency of Monitoring

The frequency of monitoring during construction is influenced by the sensitivity value of the sensitive receivers and whether or not the concentration of measured parameters approach the relevant criteria.

It is recommended that continuous (daily) monitoring is conducted at the outfall channel. The reporting frequency will be determined by SEZAD-Environmental Regulatory Department on a case by case basis. This information will be provided to the industry in the permits or other such official communication by SEZAD Environmental Regulatory Department.

4.1.3 Monitoring during Operation

During operation, effluent water quality and water consumption shall be monitored based on the type of industry. The purpose is to maintain adequate water standards, conserve the water resources, and identify any leaks in the industrial drainage system. A detailed

plan shall be included in the OEMP prepared by the operator appointed environmental consultant.

Groundwater monitoring shall be conducted if water is being discharged directly into the groundwater or if there are any hazardous materials storage facilities, such as oil tank farms.

4.1.3.1 Sampling Locations

Effluent sampling stations shall be located at the project boundary and at the connection to the common outfall channel, once the same is operational in SEZD. Any other requirement shall be included by SEZAD in the approval on a case by case basis and as per the project.

Groundwater samples will be collected from the same boreholes used during the construction phase to monitor changes in water quality over time.

4.1.3.2 Collection of Samples

The methodology for collecting effluent discharges and groundwater samples is the same as that described in Section 4.1.2.2.

4.1.3.3 Analysis of Parameters

Pollutants of concern differ between industries as certain discharge characteristics from the industrial processes should be considered. In reference to the World Meteorological Organization (World Meteorological Organisation, 2013), Table 4-1 lists the water quality variables for industrial sources of pollution common to the SEZ area.

Analysis shall be conducted by laboratories permitted or certified for this purpose and QA/QC Control plans shall be prepared and implemented. QA/QC documentation should be included in monitoring reports. The related water monitoring program during the operation should be detailed as part of the Operation Management Plan to be developed by the related contractors.

4.1.3.4 Frequency of monitoring

Monitoring of industrial effluents during operation should consider time-dependent variations in discharges.

It is recommended that continuous (daily) monitoring is conducted at the outfall channel. The reporting frequency will be determined by SEZAD-Environmental Regulatory Department on a case by case basis. This information will be provided to the industry in the permits or other such official communication by SEZAD Environmental Regulatory Department.

The frequency of groundwater monitoring during operation shall depend on the type of project activity and the potential impact on groundwater quality.

4.1.4 Monitoring during Decommissioning

Normally, the methodology for monitoring water quality during construction is representative of the methodology adopted during decommissioning, as the equipment and procedures employed are similar. It is however acknowledged that some industries can be

polluting during their operation phase and can potentially contaminate the groundwater from the subsurface structures. In such case, it is advised that the proponent refers to SEZAD-Environmental Affairs Department for a monitoring methodology during decommissioning.

Once the decommissioning phase has been completed it is recommended that a water monitoring program shall be conducted to identify the need for remedial activities. If the monitoring results show the need for remediation, then a Water Management Program shall be established.

Table 4-1: Water Quality Parameters for Industrial Sources of Pollution Common to the SEZ Area (WMO, 2013)

	Vehicles (Machine Production)	Silica sand and Glass (Metallurgy)	Limestone and Cement	Petrochemicals (oil extraction/ refining)	Power generation
Temperature	x	x	x	x	
Colour	x	x		x	
Odour	x	x		x	
Residues	x	x		x	
Dissolved solids			x		x
Suspended solids	x	x	x	x	x
Conductivity	x	x	x	x	
pH	x	x	x	x	x
Redox potential	x	x		x	
Dissolved Oxygen	x	x		x	x
Hardness	x	x	x	x	x
Ammonia	x	x		x	x
Nitrate/nitrite		x			
Organic nitrogen					
Phosphorous compounds	x				
Total Organic Carbon (TOC)	x	x		x	
Chemical Oxygen Demand (COD)	x	x		x	x
Biological Oxygen Demand (BOD)	x	x		x	
Sodium				x	
Potassium			x	x	
Calcium	x	x		x	x
Magnesium		x		x	x
Carbonate components				x	x

	Vehicles (Machine Production)	Silica sand and Glass (Metallurgy)	Limestone and Cement	Petrochemicals (oil extraction/ refining)	Power generation
Chloride	x	x		x	x
Sulphate	x	x	x	x	x
Sulphide		x		x	
Silica	x			x	x
Fluoride		x			
Boron	x	x		x	
Cyanide	x	x			
Heavy metals	x	x		x	
Arsenic		x			
Trace elements (aluminium, copper, iron, manganese, zinc)					x
Selenium	x	x		x	
Fats	x				
Oils and hydrocarbons	x	x		x	x
Organic solvents	x				
Phenols		x		x	
Pesticides					
Other organics		x			
Surfactants	x	x		x	x

4.2 Assessment Methodology

This section discusses the preferred assessment methodology to be followed by the Project applicant when assessing the impact on water quality during all the Project phases. The methodology is considered common for all proposed industries.

4.2.1 Identification of Exceedance

Prior to assessing the impact on water quality, the results of the sample analysis conducted during monitoring shall be compared against the relevant standards to depict any exceedances in water indicators.

If effluent water is discharged into the groundwater aquifers, the groundwater samples shall be assessed against the parameters stated in the Dutch Standards.

If water is discharged to land or storm water system, the parameters shall be assessed against the national wastewater standards listed in RD 115/2001.

4.2.2 Impact Assessment

If exceedances are identified, the significance of the impact from each project activity shall be determined by comparing the value and sensitivity of the water resources against the magnitude of impact of the resultant effect. The assessment follows a three-step process:

- Evaluating the value of the water resource and sensitivity of the receptors;
- Assessing the magnitude of the impact of the proposed industry on the water resource, be it adverse or beneficial; and
- Determining the significance of effect resulting from impact (of a certain magnitude) on the resource (of particular value)

Refer SEZAD EIA guideline for generic classifications for environmental value, magnitude of impact and significance of effect.

5 General Pollution Prevention Guidance Notes

This Chapter gives an overview of the Pollution Prevention Guidance Notes (PPGN) commonly used during each Project phase and international Best Management Practices for the proposed industries in the SEZ area.

Any exceptions to complying with the required discharge standards will be included in the environmental permit issued by the SEZAD Environmental Regulatory Department.

5.1 Construction and Decommissioning Pollution Prevention Guidelines

Construction activities can lead to adverse impacts on the water resources (surface water and groundwater) from discharges of polluted water and dewatering.

The construction activities that have potential for impacting water quality are, but not limited to, the following:

- Dewatering and discharge of dewatering effluent.
- Excavation (cut and fill).
- Chemical management (storage, handling and disposal of chemicals, leakages, spills).
- Hazardous waste management (waste oil, solvent, waste chemicals, chemical containers, batteries, filters, fluorescent bulbs, etc.).
- Water and wastewater management (discharge from concrete batch plants, vehicle wash down water etc.).

To prevent pollution of water resources during the Project construction phase specific details shall be included in the below mentioned plans, as part of the CEMP, which shall be developed and implemented by the construction contractor:

- Dewatering Management Plan.
- Water (including groundwater and surface water) Management Plan.
- Spill Control and Response Plan.

It should be noted that PPGN for the decommissioning phase shall require a DEMP which shall include the same management plans as the construction phase. Therefore, this section can be considered applicable to the decommissioning phase.

5.1.1 Groundwater Quality Pollution Prevention Guidelines

If dewatering is required during the construction works, the PPGN shall be implemented as per the Dewatering Management Plan developed by the contractor as part of the CEMP for the main works.

The system to be installed shall maintain the dewatering effluent within applicable discharge limits in RD 115/2001.

Discharged water shall be contained within holding tanks until tested. Once tested and if found to be within the permissible limit of the applicable Omani standards, it can be re-used (as dust suppression).

If the test results are found to exceed the allowable limits, water shall be treated or disposed as hazardous waste by a certified company. Treatment of the water could be done either onsite or it can be tankered for off-site treatment.

The onsite water treatment systems shall consist of:

- Oil water separators (with appropriate secondary containment) and granular activated carbon units (with provisions for monitoring points).
- Sedimentation control (whether sediment tanks, bag filters, or other systems) to remove suspended solids from effluent.

5.1.2 Surface Water Quality Pollution Prevention Guidelines

The CEMP shall include a Water Management Plan that will provide PPGN to maintain adequate surface water quality during construction. The PPGN shall include, but is not limited to, the following guidelines:

- All materials to be used during construction shall be identified and their hazard potential evaluated.
- All liquid outputs and waste effluents, including the type(s), quantities, and source(s) shall be identified.
- Discharge of pollutants from spills and leaks shall be minimised and a Chemical Spill and Leak Prevention Procedure shall be implemented.
- All incidents of spills shall be immediately reported to SEZAD Environmental Regulatory Department.
- Regular maintenance of on-site drainage schemes shall be undertaken to remove accumulated sediments and prevent flooding and overflow.
- Containers of hazardous chemicals (if any) and/or waste fuels and spent lubricants shall be equipped with appropriate valves and temporary stored in impermeable surfaces with secondary containment to avoid spilling or dripping of hazardous materials to wastewater drains.
- All washing activities shall take place in sediment basins or alternative control that provides equivalent or better treatment prior to discharge.
- Any concrete batching plant constructed as a part of the Project shall be fully operated with the appropriate water recycle systems and sedimentation bases for barrel washing.
- Any contaminated industrial effluent shall be treated to comply with relevant Omani discharge standards.
- Oil interceptors shall be provided in the downstream drainage to prevent any oils or grease from entering the storm water drainage system.
- The main construction site shall be preferably connected to local sewer systems. However, in areas where sewer systems are not available, it shall be necessary to provide facilities for

the management of sewage effluent such as onsite storage of the effluent in septic tanks, or alternatively constructing dedicated wastewater treatment plants at the construction site.

5.2 Pollution Prevention Guidelines during Operation

During operation and as new industries are established, water consumption and effluent discharge will increase. This can potentially impact water resources if not properly managed and treated. Potential sources of water quality impacts during operation include, but are not limited to, the following:

- Increased water consumption
- Effluent discharge from industrial processes (chemicals management, hazardous/non-hazardous waste management, maintenance activities)
- Sewage effluents generated from the workforce

Wastewater generated from industrial operations includes wastewater from utility operations (cooling, demineralisation system, etc.), sanitary wastewater and storm water runoff.

Sections 5.2.1 to 5.2.3 provide general PPGN for protecting groundwater and surface water resources from overexploitation and pollution during operation.

Since every industry uses different raw materials and processes the wastewater generated will be different in content and quantity and therefore the management approach will be different. Industry-specific best management practices (BMP) are discussed in Section 5.3

5.2.1 Groundwater Quality Pollution Prevention Guidelines

No specific operational measures are required for groundwater, as long as the effluent is adequately managed by the implementation of the surface water quality PPGN.

5.2.2 Surface Water Quality Pollution Prevention Guidelines

5.2.2.1 Process Wastewater Management

Process wastewater, including wash waters, is considered contaminated water and shall not be disposed in storm water drainage system unless treated.

5.2.2.2 Storm water Management

- Storm water shall be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.
- Surface runoff from process areas or potential sources of contamination shall be prevented and separated from potentially less contaminated runoff.
- Runoff from areas with potential sources of contamination shall be minimized (i.e.by minimizing the area of impermeable surfaces) and the peak discharge rate should be reduced (i.e.by using vegetated swales and retention ponds);

- Oil water separators and grease traps shall be installed and maintained as appropriate at refuelling facilities, workshops, parking areas, fuel storage and containment areas.
- Sludge from storm water catchments or collection and treatment systems may contain elevated levels of pollutants and shall be disposed in compliance with local regulatory requirements.
- Fuel storage tanks of diesel shall be fitted with overfill protection device and shall have a secondary contamination system to avoid and leaks or spills. The secondary containment system shall have a total volume exceeding 110% of the volume of the tank.
- All washing operations shall take place at a location where wastewater effluent will be disposed in a careful and acceptable manner.
- All plumbing fixtures, drains, appurtenances and appliances used to receive or discharge liquid wastes or sewage shall be directly connected to the storm water system of the building or premises.

5.2.2.3 Sanitary Wastewater Management

- Sewage sludge shall be disposed and applied to land (if needed) in compliance with the requirements of RD 115/2001.
- If sewage from the industrial facility is to be discharged to either a septic system, or where land is used as part of the treatment system, treatment to meet applicable national or local standards for sanitary wastewater discharges shall be required.

5.2.3 Water Conservation Guidelines

- Zero discharge design shall be included in the Project design process. Such initiatives include:
  - Grey water shall be reused for irrigation of landscaping features around fixed facilities.
  - Treated wastewater shall be used for cooling towers.
  - Closed circuit cooling systems with cooling towers shall be used rather than once-through cooling systems.
  - Closed heating systems shall be used, flash steam shall be recovered, condensate shall be returned to the boiler house and heat exchangers shall be used rather that direct steam injection.
- The facility shall be designed to have adequate collection, spill control and leakage control system.
- Plumbing shall be regularly maintained and leaks shall be repaired.
- Water conservation techniques shall be considered in conjunction with the development of the metering system. Such techniques include:
  - Self-closing taps
  - Automatic shut-off valves

- Low water use spray nozzles
- Pressure reducing valves
- Water conserving fixtures
- Flow control optimisation (i.e. Flow meters, high pressure/low volume, etc.)

- Water shall be shut off in unused areas.

5.3 Industry-Specific Best Management Practices

5.3.1 Petrochemical Industry

Water is used in large quantities in the petrochemical industry, from extraction activities through to refineries and petrochemicals. The water effluent often becomes contaminated with chemicals and by-products and its discharge could critically impact the water resources if not managed properly. This water results from injection, tank farms, product discharge, processing areas, pipe tracks, cooling water blowdown, flushing/cleaning water and accidental release of raw materials or finished products.

To avoid water pollution caused by the discharge of liquid effluents, the following BMP are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Before any discharge, the liquid effluent shall be analysed to include, at a minimum a review of the critical pollutants described in Table 4.1.
- Effluent parameters shall comply with the relevant Omani standards.
- The liquid effluent shall be treated using primary treatment techniques (neutralization, filtration, sedimentation, ion exchange, skimming/gas floatation, static hydrocylones, mechanical centrifugation, or gas stripping etc.) before discharge.
- pH level of effluent discharge shall be maintained between 6.0 and 9.0.
- Storage areas and drainage shall be maintained to prevent accidental spillage of hazardous material.
- Provide secondary containment, such as dikes or portable containers, with a height sufficient to contain a spill (the greater of 10 percent of the total enclosed tank volume or 110 percent of the volume contained in the largest tank).
- All incidents of spills shall be immediately reported to the Environmental Regulatory Department.
- Solid materials, fuels and waste piles shall be covered or confined to prevent pollution of surface water when encountered with runoff of rainwater.
- Treat benzene, phenols and hydrocarbons in wastewater at the point of generation, using techniques such as:
  - Nitrogen or air stripping for benzene recovery from wastewater,

- Liquid-liquid extraction from wastewaters for phenol extraction from wastewater,
- Reduction of hydrocarbons and aromatic compounds,
- High-pressure wet air oxidation,
- Low-pressure oxidation, and
- Supercritical water oxidation process.

Due to the large quantities of water used in this industry, some water minimisation approaches are recommended below:

- Cooling water, storm water, bund water and effluents of different origins shall be separated in order to permit appropriate recycling options.
- Water shall be recycled either from one process to another (i.e. using water drain of high pressure boilers as boiler fuel at low pressure or treated effluent as make-up water wherever possible) or a system shall be designed that will recycle water repeatedly for the same purpose (i.e. employing cooling towers or steam condensate as boiler feed water).
- Good housekeeping and maintenance practices shall be applied by studying the range of products, using suction equipped vehicles or dry cleaning methods for spills, applying inspection procedures and maintenance to reduce leakage.

5.3.2 Limestone/Cement Industry

Wastewater from limestone/cement industries is generated mainly from utility operations and the process staging areas. In “dry” process plants, the only effluent is cooling water which can be eliminated through the use of cooling towers or ponds. In the “wet” process, plants may leach collected kiln dust to remove soluble alkali, leading to clarifier overflow which requires neutralization before discharge. Wastewater from this industry has generally high pH, dissolved solids (potassium and sulphate) and suspended solids. Runoff and leaching from material storage and waste disposal areas can be a source of pollution to surface water and groundwater.

To avoid water pollution and to minimize water consumption caused by the discharge of liquid effluents, the following BMP are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Storm water flowing through pet–coke, coal, and waste material stockpiles shall be prevented by diking, covering or enclosing stockpiles.
- Infiltration of storm water that has been in contact with raw material stockpiles shall be controlled by paving or lining the base of the stockpiles, installing run-off controls around them and collecting the storm water in a lined basin to allow particulate matter to settle before separation, control, and recycling or discharge.
- Pollution prevention techniques for dust emissions from stockpiles of raw materials, clinker, coal, and waste shall help minimize contamination of storm water.

- "Wet" process wastewater shall be recycled to kiln and "dry" wastewater effluent shall be recycled to cooling towers and ponds.
- Before any discharge, the liquid effluent shall be analysed to include, at a minimum a review of the critical pollutants described in Table 4.1.
- Effluent parameters shall comply with the relevant Omani standards.
- The liquid effluent shall be monitored and treated (neutralization, filtration, sedimentation, ion exchange, etc.) before discharge if it exceeds limits.
- pH level of effluent discharge shall be maintained between 6.0 and 9.0.
- Slurry tank wash or spills shall not be discharged.

5.3.3 Fisheries Industry

Fishery industry requires large amounts of water, primarily for washing and cleaning purposes, but also as media for storage and refrigeration of fish products before and during processing as well as for process water. The wastewater has a high organic content, and subsequently a high biochemical oxygen demand (BOD), because of the presence of blood, tissue, and dissolved protein. It also typically has a high content of nitrogen (especially if blood is present) and phosphorus.

Detergents and disinfectants may also be present in the wastewater stream after application during facility cleaning activities, if any. Range of chemicals are typically used for cleaning as well as disinfectants. The disinfectants commonly used include chlorine compounds, hydrogen peroxide, and formaldehyde.

The following recommended methods may be used to enhance the removal of solid waste prior to entry into the wastewater stream:

- Collect internal organs and other organic materials separately, for processing into by-products;
- Design the production line so that cooling water, storm water, and process effluents can be kept separate to permit appropriate treatment options;
- Conduct a dry pre-cleaning of equipment and production areas before wet cleaning (e.g. rubber scraping of work tables and plant floor before hosing);
- Establish procedures for the dry removal of offal, using dry vacuum systems where feasible;
- Fit and use floor drains and collection channels with grids and screens, and / or traps, to reduce the amount of solids entering the wastewater;
- Equip the outlets of wastewater channels with screens and fat traps to recover and reduce the concentration of coarse material and fat in the combined wastewater stream;

- Ensure that tanks are effectively bunded and provide overfilling protection on bulk storage tanks;
- Choose cleaning agents that do not have adverse impacts on the environment in general, or on wastewater treatment processes and sludge quality for agricultural application;
- Avoid cleaners that contain active chlorine or prohibited, banned, or restricted chemicals.

Process Wastewater

Techniques for treating industrial process wastewater in this sector include grease traps, skimmers or oil water separators for separation of floatable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers or settling ponds; biological treatment, typically anaerobic (if high in organic content) followed by aerobic treatment, for reduction of soluble organic matter (BOD); biological nutrient removal for reduction in nitrogen and phosphorus; chlorination of effluent when disinfection is required; dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible. Additional engineering controls may be required to contain and neutralize nuisance odors.

It shall be noted that all fish processing and/or fishmeal and fish oil industries shall have a dedicated wastewater treatment plant for treating the wastewater generated from the process.

In case the wastewater is disposed in a common sewage treatment plant it shall be ensured that the wastewater is pre-treated to the standards specified in Appendix 3 of RD 115/2001 –for non-household discharge into sewer network.

5.3.4 Silica Sand/Glass, Metal Casting and Production Industry

For glass manufacturing, wastewater will mainly consist of cleaning water, cooling water and surface water runoff. Amounts of liquid effluents discharged from the glass industry are marginal in comparison with other industrial sectors and are limited to particular processes. Discharges may be affected by glass solids, soluble glass-making materials (i.e. sodium sulphate), organic compounds (caused by lubricant oil used in the cutting process), and treatment chemicals (i.e. dissolved salts and water treatment chemicals) for the cooling-water system.

To avoid water pollution and to minimize water consumption caused by the discharge of liquid effluents, the following BMP are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Before any discharge, the liquid effluent shall be analysed to include, at a minimum a review of the critical pollutants described in Table 4.1.
- Effluent parameters shall comply with the relevant Omani standards.

- Monitor the effluent for rate, pH, temperature, COD/BOD, turbidity, oil, heavy metals, chlorine, chloride, fluoride, phenol, formaldehyde, ammoniacal nitrogen, sulphate.
- The liquid effluent shall be treated with oil-water separators, load and flow equalization with pH adjustment, screening and sedimentation for suspended solids, multi-media filtration for non-settle able suspended solids.
- Discharge to municipal water treatment plants where further reduction of pollutants is necessary.
- pH level of effluent discharge shall be maintained between 6.0 and 9.0.
- Closed water process system shall be used to minimize water losses.

In terms of the metal casting and production industry, considerable quantities of wastewater are generated in the course of making iron and steel. This wastewater contains ammonia and other components (phenols, cyanide, thiocyanate, ammonia, sulphide and chloride) released in the coking process.

To avoid water pollution and to minimize water consumption caused by the discharge of liquid effluents, the following BMP are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Before any discharge, the liquid effluent shall be analysed to include, at a minimum a review of the critical pollutants described in Table 4.1.
- Effluent parameters shall comply with the relevant Omani standards.
- The liquid effluent shall be monitored and treated (neutralization, filtration, sedimentation, ion exchange, etc.) before discharge if it exceeds limits.
- pH level of effluent discharge shall be maintained between 6.0 and 9.0.
- Solvents and acids shall be handled, stored in double walled tanks and disposed as hazardous substances.
- Leaks detection systems for tanks and pipes shall be installed, and regular inspections shall be undertaken.
- Open storage areas shall be lined and solid material, fuel and waste files shall be covered to prevent percolation of runoff.
- Coagulation and settling facilities shall be required for used water due to the high solids content.
- Production shall be planned to minimise number of processing steps and eliminate unnecessary procedures.
- Where possible, raw material or toxic product products shall be replaced with other materials that produce less waste.
- Good flow management shall be practiced through:

- Managing storm water from process areas through collection and treatment
- Using cascade blowdowns from compatible non-contact cooling water and water recycle systems

5.3.5 Automotive Industry

The automotive industry is a major consumer of water for various production processes. Major water uses in the automotive manufacturing industry includes surface treatment and coating, paint spray booths, washing, rinsing, hosing, cooling, air-conditioning systems and boilers.

To avoid water pollution and to minimize water consumption caused by the discharge of liquid effluents, the following BMP are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Before any discharge, the liquid effluent shall be analysed to include, at a minimum a review of the critical pollutants described in Table 4.1.
- Effluent parameters shall comply with the relevant Omani standards.
- The liquid effluent shall be monitored and treated (neutralization, filtration, sedimentation, ion exchange, etc.) before discharge if it exceeds limits.
- Flow restrictions on tap water supply line shall be installed.
- Before hosing, all areas shall be swept clean when dry.
- Leaks shall be eliminated and regular inspection and maintenance shall be undertaken.
- Water shall be reused, treated and recycled, wherever possible.
- Chemicals (such as fuels, solvents, oils and coolants) shall be kept in a bunded and covered storage area.

5.3.6 Desalination Industry

The reject brine from the seawater desalination plants is generally discharged to sea. But in some special cases, particularly small capacity plants, it is discharged to over the land surface, onto unlined pits. Therefore, there is a possibility for groundwater contaminations with chemical constituents from various sources (i.e. reject brine, pre-treatment waste and cleaning waste of desalination plants). The major constituents of reject brine are inorganic salts. The brine also contains small quantities of anti-scale additives, corrosion products, and other reaction products. High salt contents in reject effluent with elevated levels of sodium, chloride, and boron can degrade the groundwater resources by increasing water hardness and build-up of heavy metals and inorganics, which could lead to health problems.

To avoid water pollution, the following BMPs are recommended, as a minimum:

- Industry shall apply "zero-discharge of brine" concept, by recycling, reusing water, and developing alternative technology.
- In particular, in the case of coastal and/or brackish water, design the reverse osmosis process to allow reduction of the salinity of the rejected effluent.
- Lined disposal pits or ponds shall be used for disposal of reject brine.
- Reject brine chemical composition and concentrate disposal shall follow national or international regulations and policies.
- Pollution reduction programs including recycling and reusing water and developing alternative technology, shall be applied by industries.
- Solar ponds shall be used in large desalination plants for the production of heat and electricity.
- Evaporation mechanism shall be enhanced by increasing the size of the evaporation pond, spraying of brine, creating turbulence in the pond and creating airflow over the pond.
- Reject brine from desalination plants can be used as a growth medium for spirulina, fish, and shrimp culture i.e. arthospira platensis and tilapia, which are of high commercial value.
- Minerals can be extracted from the reject brine and salt concentrate can be chemically converted to chemicals such as sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$) and ammonium chloride (NH_4Cl) using a series of batch gas bubbler.
- Salinity of groundwater shall be monitored prior to operation of the desalination plant, to distinguish if the salinity is attributed to seawater intrusion or to brine disposal.

5.3.7 Power Generation Industry

Power generation facilities can either be large utility plants or industrial combustion plants, providing power (e.g. in the form of electricity or mechanical power), steam, or heat to industrial production processes. The main factors that affect water quality are the effluents from a thermal power plants (e.g. cooling tower blowdown; ash handling wastewater; material storage runoff; backflush from ion exchange boiler water purification unit, etc.), the solid waste generated due to the high percentage of ash in the fuel (e.g. fly ash, bottom ash, boiler slag, etc.), and the hazardous materials stored and used in the combustion facilities (e.g. liquid fuel, chemicals, etc.).

To avoid water pollution and reduce water consumption, the following BMPs are recommended, as a minimum:

- All materials to be used during operation shall be identified and their hazard potential evaluated.
- Pollution prevention techniques for dust emissions shall be implemented to help minimize contamination of soil.

- All hazardous materials shall be stored, contained treated and disposed in appropriate facilities.
- Emergency Spill Response procedures shall be implemented.
- Storage areas and drainage shall be maintained to prevent accidental spillage of hazardous material.
- Solid materials, fuels and waste piles shall be covered or confined to prevent pollution of surface water and ultimately soil.
- Industrial process wastewater shall be treated before disposal using primary treatment methods.
- Dry bottom ash and fly ash from power plants shall be collected and recycled if containing high levels of economically valuable metals.
- A closed-cycle, recirculating cooling water system or shall be used. Cooling ponds or cooling towers are the primary technologies for a recirculating cooling water system.
- Soot blowers or other dry methods shall be considered to remove fireside wastes from heat transfer surfaces so as to minimize the frequency and amount of water used in fireside washes.
- In coal-fired power plants without FGD systems, process wastewater shall be treated for pH adjustment and removal of total suspended solids (TSS), and oil / grease (these treatment systems can also be used to remove most heavy metals to part-per-billion (ppb) levels by chemical precipitation as either metal hydroxide or metal organosulfide compounds).

5.3.8 Infrastructure (Port, Harbour and Terminals, Airport, Gas Distribution Network)

Infrastructure project may include airport, ports, harbour and terminals, gas distribution network, etc. The water pollution source from infrastructure project varies depending on the type of project as well as operational activities.

5.3.8.1 Port Harbour and Terminals

Construction activities (such as dredging, reclamation), and operational activities (such as maintenance dredging, ship maintenance, and ship effluent disposal) can result in increased turbidity via suspension of sediment in the water column. In addition, the introduction of pollutants can have adverse impacts on aquatic flora and fauna (including benthic communities), and excessive nutrient loading leading to eutrophication, oxygen depletion, and toxic algal blooms.

The water effluents generated by ships typically include sewage, tank cleaning water, bilge water, ballast water etc. Water effluents are typically collected and transported using trucks or pipes within the port area. Ports may collect and treat the wastewater using on-site wastewater treatment systems before discharging to surface water, or municipal sewage treatment plants. The treated wastewater shall meet Omani regulation for treated wastewater discharge.

5.3.8.2 Airports

Effluents from airport operations mainly consist of stormwater runoff from paved surfaces and sanitary wastewater from public and employee services and from airplanes. Stormwater runoff may include pollutants associated with leaks and spills of oil, diesel, and jet fuels during operation and maintenance of ground service vehicles, and fuel storage and handling activities.

- Diverting and treating stormwater drainage from areas of potentially frequent leaks and spills of chemicals and fuels through use of an oil / water separator prior to discharge to land and/or surface water bodies;
- Collection systems for aircraft and airport facility sanitary sewage should be provided. Collected sanitary wastewater effluents should be either treated in onsite STP or discharged to common STP;
- Monitoring of effluents, to check conformance with relevant regulations, prior to discharge to land and/or sea;
- Segregation of wastewater streams to ensure compatibility with selected treatment option (e.g. septic system which can only accept domestic sewage);
- Segregation and pre-treatment of oil and grease containing effluents to meet relevant standards prior to discharge into sewer systems;

5.3.8.3 Mining

Management of water use and quality, in and around mine sites, can be a significant issue. Potential contamination of water sources may occur early in the mine cycle during the exploration stage and many factors including indirect impacts can result in negative impacts to water quality. Mining activities should include adequate monitoring and management of water use, in addition to treatment of effluent streams including storm water run-off from the mine property.

The quality and quantity of mine effluent streams discharged to the environment, including storm water, leach pad drainage, process effluents, and overall mine works drainage should be managed and treated to meet the applicable national and/or international regulations.

- Discharges to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria outside a scientifically established mixing zone.
- Efficient oil and grease traps or sumps should be installed and maintained at refuelling facilities, workshops, fuel storage depots, and containment areas, and spill kits should be available with emergency response plans;
- Water quality in open storage systems (e.g. leachate areas, solution ponds, and tailings ponds or impoundments) should be based on the results of a site specific risk assessment with appropriate control measures put in place to mitigate the risk or meet the relevant regulations;

- Sanitary wastewater should be managed via reuse or routing into septic or treating to standards specified in the relevant regulations.

References

Bristish Standards Institution. (2015). BS 5930:2015 *Code of Practice for Ground Investigations.*

Directorate General for Specifications and Measurements (DGSM). (*2012). OS 8/2012 Unbottled Drinking Water.*

Environment Agency- Abu Dhabi. (2014). *Best Management Practices (BMP) Technical Guidance Document for Discharges from Construction Activities.*

EPA Victoria. (2009, June). *Sampling and Analysis of Waters, Wastewaters, Soils and Wastes. Industrial Waste Resource Guidelines.*

Five Oceans (2011). Duqm Industrial and Free Zone Masterplan Final EIA Report. Rev 02.

International Finance Corporation-World Bank Group. (2007). *Wastewater and Ambient Water quality.*

HMR Consultants. (2014). Geology, Hydrogeology & Hydrology Report (Module 3) - *Environmental Baseline Study for Duqm Development and Surroundings Report*.

Ministry of Environment and Climate Affairs (MECA). (2013). *Omani Environmental Regulations International References Documents*

SEU Guidance Notes- 2nd Edition. ARWA, Sohar Environmental Unit.

Ministry of Housing, *Spatial Planning and Environment Directorate General for Environmental Protection. (2009). Soil Remediation Circular.*

Road Traffic Authority (RTA). (2010). *Guidelines for Construction Water Quality Monitoring.*

Southern Research Institute for the Environmental Protection Agency. (1974). *Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Cement Manufacturing Point Source Category*.

UK Environmental Agency. (2012). *Pollution Prevention Guidelines- Working at Construction and Demolition Sites*: PPG6. Bristol: Environment Agency.

United States Environmental Protection Agency. (1974). evelopment *Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Pressed and Blown Glass Segment of the Glass Manufacturing Point Source Category.*

United States Environmental Protection Agency. (2002). *Development Document for Final Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category.* Washington, DC.

United States Environmental Protection Agency. (2014). *Technical Support Document for the 2004 Effluent Guidelines Program Plan*. Washington, DC.

United States Environmental Protection Agency. (n.d). *Iron and Steel Manufacturing Effluent Guidelines.* Retrieved from EPA:

United States Environmental Protection Agency. (n.d). *Petroleum Refining Effluent Guidelines.* Retrieved from EPA: http://www.epa.gov/eg/petroleum-refining-effluent-guidelines

Unites States Environmnetal Protection Agency. (n.d). *Seafood Processing Effluent Guidelines.* Retrieved from EPA*:* http://www.epa.gov/eg/seafood-processing-effluent-guidelines

World Meteorological Organisation. (2013). *Planning of Water Quality Monitoring Systems.* Geneva.