# 1.0 ENVIRONMENTAL DESIGN CRITERIA FOR PROJECT ENGINEERING

## 1.1. Executive Summary

The environmental criteria for project design are environmental specifications to minimize potential negative effects on the environment during the whole life span of a project, i.e., construction, operation and decommissioning & post-closure phases. Environmental criteria are classified according to the environmental aspects that a project is expected to display during each phase. Having identified the aspects in each project phase and the environmental components that they potentially impact, the rules for the design criteria should be established. This provides the owners and designers with a justification for the criteria. The rules are based both on the aspect (e.g. by emission controls) and the affected component (e.g. by environmental quality criteria). A hierarchy is proposed with the first (highest) level provided by legislation in the regulatory regime where the project is located. The second level is conformance with international guidelines, and the third level is accepted practice in the local regulatory regime. Once the rules are established, then the design criteria are described for each of the individual project facilities according to each facility's aspects and consequently affected components. This may generate multiple and sometime conflicting criteria for some facilities, which can be resolved by applying the preference hierarchy for the criteria.

## 1.2. Scope and objectives

The environmental criteria for project design are environmental specifications to minimize through engineering design, potential negative effects on the environment during the whole life span of a Project. This incorporates factors related to the emplacement, operation and post-closure residual effects of the facilities, such as those for a possible mine project illustrated in Figure 1. This paper addresses environmental concerns, which includes the environmental effects on public health and safety; however, it is not tailored towards social issues nor work place health and safety issues.

In proposing environmental design criteria, the environmental professional should endeavor to translate the context of the analysis of potential impacts to environmental components, into matters directly applicable to the design of the installations and activities of the project. The link between the former and the latter is through the environmental aspects of the project. Different types of project and different type of environment generate different sets of environmental aspects and potential impacts, so it is essential to focus the analysis on the particular project and environmental setting in question. There is no generic solution or "one size fits all".

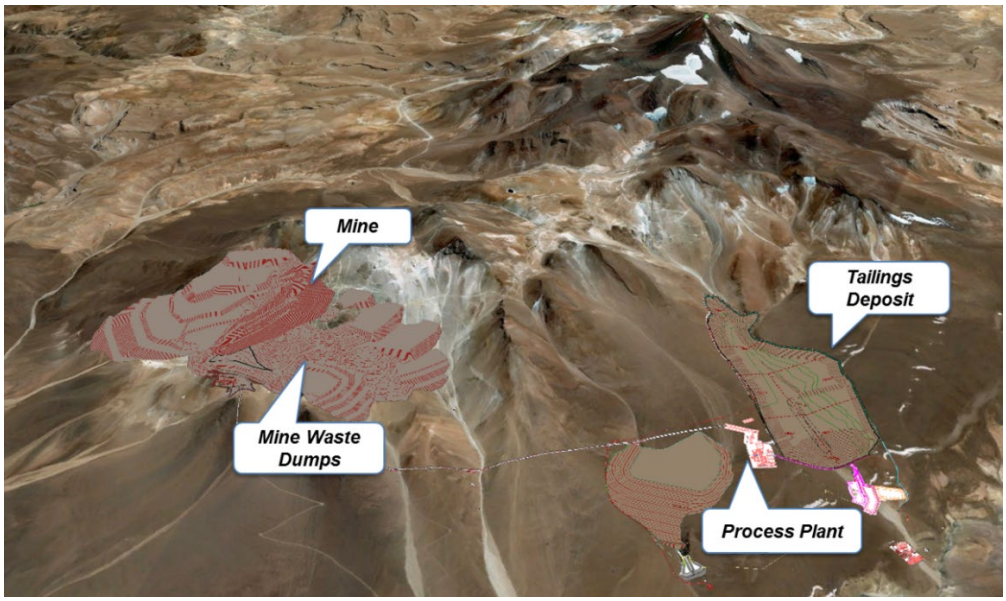


**Figure 1 Layout of a possible mine project**

### 1.3. Methodology

**Environmental design criteria** are proposed in order to protect the environment from potential impacts or risks. They are classified in relation to **environmental aspects** of the project, as they pertain to the emplacement, operation and post-closure conditions. Environmental aspect is used in the ISO-14001 sense, as an element of an organization's activities or products or services that can interact with the environment. Therefore, the generation of environmental design criteria requires an analysis of the relationship:

*Activity or Installation –> Environmental Aspect –> Potential Environmental Impact.*

The starting point for applying environmental design criteria is to identify the environmental aspects of the facilities in question. Following this it is necessary to identify the environmental components that are potentially affected by the environmental aspects. This environmental analysis links the installations and activities to potential impacts.

The second step is to identify environmental criteria associated with the aspects and potential impacts. In some cases, the environmental aspects themselves are regulated or guidelines exist, and these provide indications for the designs and environmental controls that should be incorporated in the installations. *(An example of this is the regulation concerning the quality of liquid discharges to surface waters)*. Then it is necessary to identify the regulatory requirements or the guidelines concerning the protection of the potentially affected components. These regulations and guidelines provide additional indications for the design of the facilities. *(An example of this is the regulation concerning water quality for different uses, applicable to receiving water courses and water bodies)*. This can be displayed on a generic matrix of environmental criteria by environmental aspect.

The third step is to apply these general criteria to each installation or activity in particular, generating a data sheet for each one, as a tool for the design engineer.

## 1.4. Arrangement of the Tables and Datasheets

The environmental analysis is shown in tabular form, as follows. Table 1 is a matrix that shows installations and activities for which environmental design criteria should be determined as a function of their environmental aspects. The table covers the three phases of the mine life cycle that most influence design, namely: emplacement, operation and post closure. (Construction and closure activities have not been considered since their environmental control is addressed mainly through environmental management plans rather than design). In this table, grey cells indicate environmental aspects that can give rise to impacts or risks, associated with each activity.

Table 2 shows the list of environmental aspects relevant to this project, and four possible sources of environmental design criteria: Only a subset of the 28 aspects identified in Table 1 is shown, because of the restrictions of space.

- A generic description of the environmental design criteria for each of the aspects base don best practice
- IFC guidelines pertaining to each aspect
- National regulations pertaining to each aspect
- Environmental quality regulations that pertain to the components potentially impacted

The hierarchy in which these should be applied is:

1. Regulations – which are obligatory
2. Guidelines – which are recommended
3. Practice – which is orientative

The environmental design criteria have been arranged by activity or installation in a series of datasheets in the Appendix. Only part of one datasheet is shown, for brevity. For the full analysis, there would be one datasheet for each installation and activity, with rows for each of the aspects and potential impacts associated with that installation or activity. In each datasheet the environmental setting of each activity or installation should be described briefly, in order to understand which environmental components or sensitivities need to be addressed at each installation. The indications of the aspects and potential impacts, and therefore the design criteria applicable to each one, are then laid out in each datasheet.

## 1.5. Conclusion

The environmental team should provide essential input to the project design for an environmental coherent project. Table 2 and the EDC datasheets of the appendix can be provided to the project design team as a tool to guide the design engineering. It should be borne in mind that the job of the environmental analyst is to provide the criteria and their justification, but not to provide the design itself. It is the job of the design engineer to find the best engineering solution to meet these criteria.

**Table 1 Environmental aspects versus activities considered in the emplacement, operations and post-closure conditions.**

| | | | Environmental Aspects and Aspect Groupings of the Project | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atmospheric emissions | | | | Liquid effluents | | | Water Consumption | | Ground Water Modifications | Surface Water Modifications | Land Surface Modifications | Land Occupation | Equipment movement / Energy Release | | | Materials Handling | | | |
| | | | Sedimentable Dust Emissions | Respirable Dust Emissions | Gas Emissions | Noise Emissions | ARD / ML Generation | Residual Water Generation | Sewage Water Generation | Industrial Water Consumption | Potable Water Consumption | Modification aquifer level | Surface Water Course Modifications | Landform Modification and Erosion | Land Occupation | Hazard and Disturbance to Wildlife | Vibration emissions | Vehicle traffic | Hazardous Materials Vectors | Hazardous Waste Vectors | Sanitary Vectors | Vectors accentuated by Geohazards |
| EMPLACEMENT | Mine | Water Interception System | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| | | Equipment Maintenance | | | | ■ | | ■ | ■ | ■ | ■ | | | | | ■ | | | ■ | ■ | | |
| | | Block Caving Mine | | ■ | ■ | ■ | ■ | | | | | ■ | | ■ | ■ | ■ | ■ | | ■ | | | ■ |
| | | Ore transport | | | | | | | | | | | | | | | | | | | | |
| | Plant | Process Plant | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | | | | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ |
| | | Tailiings Disposal | ■ | ■ | | ■ | | ■ | | | | | ■ | ■ | ■ | ■ | | | | | | ■ |
| | | Water Interception System | | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | ■ |
| | External Infrastructure | Concentrate Transport | | | | | | | | | | | | | | | | | | | | |
| | | Waste Management | | | ■ | | | ■ | | | | | ■ | ■ | ■ | ■ | | | | ■ | ■ | ■ |
| | | Camp Operation | | | ■ | ■ | | | ■ | | ■ | | | | ■ | ■ | | | ■ | | ■ | ■ |
| | | Desalination Plant | | ■ | ■ | | | ■ | ■ | ■ | | | | | ■ | | | | | | ■ | ■ |
| | | Port Facilities | ■ | ■ | | ■ | | ■ | | ■ | | | | | | | ■ | | ■ | | | ■ |
| OPERATIONS | Mine | Water Interception System | | | | | | | | | | | ■ | ■ | | | | | | | | ■ |
| | | Equipment Maintenance | | | | ■ | | ■ | ■ | ■ | | | | | | ■ | | | ■ | ■ | | ■ |
| | | Block Caving Mine | | ■ | ■ | ■ | ■ | ■ | | | | ■ | | ■ | ■ | ■ | ■ | | ■ | | | ■ |
| | | Ore transport | ■ | ■ | | ■ | | | | | | | | | | ■ | | | | | | ■ |
| | Plant | Process Plant | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | | | | | | ■ | ■ | | ■ | ■ | | ■ |
| | | Tailiings Disposal | ■ | ■ | | ■ | | ■ | | | | | ■ | ■ | ■ | ■ | | | | | | |
| | | Water Interception System | | | | | | | | | | ■ | ■ | ■ | | | | | | | | |
| | External Infrastructure | Concentrate Transport | ■ | ■ | | ■ | | | | | | | | | | ■ | ■ | ■ | ■ | | | |
| | | Waste Management | | | ■ | | | ■ | | | | | | ■ | ■ | ■ | | | | ■ | ■ | ■ |
| | | Camp Operation | | | ■ | ■ | | | ■ | | ■ | | | | | ■ | | | ■ | | ■ | ■ |
| | | Desalination Plant | | ■ | ■ | | | ■ | ■ | ■ | | | | | | | | | | | ■ | ■ |
| | | Port Facilities | ■ | ■ | | ■ | | ■ | | ■ | | | | | | | ■ | | ■ | | | ■ |
| POST CLOSURE | Mine | Water Interception System | | | | | | ■ | | | | ■ | ■ | ■ | ■ | | | | | | | |
| | | Equipment Maintenance | | | | | | | | | | | | | | | | | | | | |
| | | Block Caving Mine | | | | | ■ | ■ | | | | ■ | | ■ | ■ | ■ | | | | | | |
| | | Ore transport | | | | | ■ | | | | | | | ■ | ■ | | | | | | | |
| | Plant | Process Plant | | | | | | | | | | | | | | | | | | | | |
| | | Tailiings Disposal | ■ | ■ | | | | ■ | | | | | ■ | ■ | ■ | ■ | | | | | | |
| | | Water Interception System | | | | | | | | | | | ■ | ■ | ■ | | | | | | | |
| | External Infrastructure | Concentrate Transport | | | | | | | | | | | | | | | | | | | | |
| | | Waste Management | | | | | | ■ | | | | | ■ | ■ | ■ | ■ | | | | ■ | ■ | ■ |
| | | Camp Operation | | | | | | | | | | | | | | | | | | | | |
| | | Desalination Plant | | | | | | | | | | | | | | | | | | | | |
| | | Port Facilities | | | | | | | | | | | | | | | | | | | | |

* See Section 1.3 for an explanation of this table.

## Table 1 General Environmental Design Criteria by Aspect (subset only)

| Aspect group | Aspect | Generic environmental design criteria, based on accepted practice | International Guideline | Aspect regulation | Potentially affected components and their regulatory references | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Liquid effluents | ARD / ML Generation | Contact between natural waters and mineralized rock should be minimized and contact water should be separated from non-contact water, in order to protect the environment from geochemically altered water. | **EHS Guidelines for Mining:**<br>Implementation of ARD and ML preventive actions to minimize ARD including:<br>- Limiting exposure of PAG materials by phasing of development and construction, together with covering and/or segregating runoff for treatment<br>- Implementation of water management techniques such as diverting clean runoff away from PAG materials, and segregating "dirty" runoff from PAG materials for subsequent treatment; grading PAG material piles to avoid ponding and infiltration | ARD / ML Generation<br>Ley 20551/2011<br>Dec 41/2012 - MM | Water chemistry | Aquatic biota<br>NCH.1333 | Flora and Vegetation | Agricultural water users<br>NCH.1333<br>NCH 409 | Potable water users<br>NCH.409 | |
| | Residual Water Generation | Residual water from earth movements and industrial processes should be minimized, managed and if necessary treated to discharge levels to protect the enviroment from industrially altered water. | **EHS Guidelines for Mining:**<br>- The quality and quantity of mine effluent streams discharged to the environment, including stormwater, leach pad drainage, process effluents, and overall mine works drainage should be managed and treated to meet the applicable effluent discharge guideline values in Section 2.0<br>- Discharges to surface water should not result in contaminant concentrations in excess of local ambient water quality criteria outside a scientifically established mixing zone. | Residual Water Generation<br>DFL 725/67 - Minsal<br>DS 594/1999 - Minsal<br>DS.90/2000 - MSGP<br>DS.46/2003 - MSGP<br>Dec1/1992 - Directamar<br>DL 2222/1978 | Water chemistry | Aquatic biota<br>NCH.1333 | Flora and Vegetation | Agricultural water users<br>NCH.1333<br>NCH 409 | Potable water users<br>NCH.409 | Marine waters and biota<br>DL 2222/1978 |
| | Sewage Water Generation | Sewage water should be minimized and treated to regulatory levels before discharge, to protect natural waters from organic contamination. | **EHS Guidelines for Mining:**<br>Sanitary wastewater should be managed via reuse or routing into septic or surface treatment as described in the General EHS Guidelines - Environmental Wastewater and Ambient Water Quality:<br>- Segregation of wastewater streams to ensure compatibility with selected treatment option (e.g. septic system which can only accept domestic sewage);<br>- Segregation and pretreatment of oil and grease containing effluents (e.g. use of a grease trap) prior to discharge into sewer systems; | Sewage Water Generation<br>DFL 725/67 - Minsal<br>DS 236/1926 - Minsal | Water chemistry | Aquatic biota<br>NCH.1333 | Flora and Vegetation | Agricultural water users<br>NCH.1333<br>NCH 409 | Potable water users<br>NCH.409 | |
| Water Consumption | Industrial Water Consumption | Industrial Water Consumption: Water consumption should be minimized through process efficiency and recycling, in order to minimize the reduction of water resources. | **EHS Guidelines for Mining:**<br>Consider reuse, recycling, and treatment of process water where feasible (e.g. return of supernatant from tailings pond to process plant), minimizing the amount of make-up water. | Industrial Water Consumption | GW Hydrology<br>Res.425/2007<br>MOP | SW Hydrology<br>DFL.1122/1981 | Water Use<br>DFL.1122/1981<br>Res.425/2007<br>MOP | | | |
| | Potable Water Consumption | Potable Water Consumption: Water consumption should be minimized through process efficiency, in order to minimize the reduction of water resources. | | Potable Water Consumption | GW Hydrology<br>Res.425/2007<br>MOP | SW Hydrology<br>DFL.1122/1981 | Water Use<br>DFL.1122/1981<br>Res.425/2007<br>MOP | | | |
| Ground Water Modifications | Aquifer Depression | Minimizing water extraction from mine workings: Water extraction should be managed in order to minimize impacts on the ground water regime, surface flows, ecological flows and other permitted water users. | **EHS Guidelines for Mining:**<br>Develop a Sustainable Water Supply Management Plan to minimize impact to natural systems by managing water use, avoiding depletion of aquifers, and minimizing impacts to water users. | Aquifer Depression | GW Hydrology<br>Res.425/2007<br>MOP | SW Hydrology<br>DFL.1122/1981 | Flora and Vegetation<br>DS 14/2012<br>MMA<br>DS 71/2014<br>MMA | Wildlife and habitat<br>DS 14/2012<br>MMA<br>DS 71/2014<br>MMA | Aquatic biota<br>DS 14/2012<br>MMA<br>DS 71/2014<br>MMA | Water Use<br>DFL.1122/1981<br>Res.425/2007<br>MOP |
| | GW Discharge & Mixing | Ground water extraction and drainage should be managed in order to minimize impacts in the mixing zone of ground and surface waters | **EHS Guidelines for Mining:**<br>Develop a Sustainable Water Supply Management Plan to minimize impact to natural systems by managing water use, avoiding depletion of aquifers, and minimizing impacts to water users. | GW Discharge & Mixing<br>DFL 725/1967 - Minsal | Water chemistry | Agricultural water users<br>NCH.1333<br>NCH 409 | | | | |

## 2.0 EDC Datasheets by Installation and Activity (example only)

| **Water Interception System - Process Plant** | | | | |
|---|---|---|---|---|
| *Environmental Context, (based on the current understanding of the project)* | | *Vegetated area, some wetlands in stream course. Potential for archaeological sites in valley bottoms. Runoff will be diverted around the process plant and tailings facilities in order to reduce the water balance of these facilities and minimise the risks of their erosion. Runoff will be discharged back into the same basin. Wetlands and aquatic life in the water course may be affected.* | | |
| **Components** | | **Environmental Design Criteria (EDC)** | **Source of EDC** | **Level** |
| **Aspect** | **Residual Water Generation** | Contact between natural waters and mineralized rock should be minimized and contact water should be separated from non-contact water, in order to protect the environment from geochemically altered water. | BGC experience with regulatory acceptance of this practice | Practice |
| | | Implementation of water management techniques such as diverting clean runoff away from PAG materials, and segregating "dirty" runoff from PAG materials for subsequent treatment; grading PAG material piles to avoid ponding and infiltration | IFC EHS Guidelines for Mining | Guideline |
| | | Art.13. Closure plan requirements.<br>The closure plan must at least contain the supporting information and documents indicated as follow:<br>e) The set of measures and activities proposed by the mining company to obtain physical and chemical stability of the site where the mining works are located... | Ley 20551/2011 | Regulatory |
| Affected component | Water chemistry | No regulatory specification | | |
| | Aquatic Biota | Use aquatic life standard | NCH 1333 | Regulatory |
| | Flora and Vegetation | No regulatory specification | | |
| | Wildlife Habitat | No regulatory specification | | |
| **Aspect** | **Surface water course modification** | Maintain to the extent possible, natural drainage paths and restoring them if they are disrupted;<br>- Protecting stream channel stability by limiting in-stream and bank disturbance, and employing appropriate setbacks from riparian zones;<br>- Constructing, maintaining, and reclaiming watercourse crossings that are stable, safe for the intended use, and that minimize erosion, mass wasting and degradation of the channel or lake bed. | IFC EHS Guidelines for Mining | Guideline |
| | | Maintain, to the extent possible, natural drainage paths and restoring them if they are disrupted;<br>- Maintaining water body catchment areas equal or comparable to pre-development conditions; | IFC EHS Guidelines for Mining | Guideline |
| Affected components | GW Hydrology | No regulatory specification | | |
| | SW Hydrology | Art. 49. The obligation to maintain stream beds or works part of a drainage system, is of all those who report benefits from the same, in conformity with what is stated in the following articles. | DFL.1122/1981 | Regulatory |
| | | Ecological flow | DS 14/2012 MMA<br>DS 71/2014 MMA | Regulatory |
| | Aquatic biota | Aquatic life use guideline | NCH 1333 | Guideline |
| | Flora and Vegetation | Site access routes and facilities in locations that avoid impacts to critical terrestrial habitat, and planning exploration and construction activities to avoid sensitive times of the year, | IFC EHS Guidelines for Mining | Guideline |
| | Wildlife Habitat | Site access routes and facilities in locations that avoid impacts to critical terrestrial habitat, and planning exploration and construction activities to avoid sensitive times of the year, | IFC EHS Guidelines for Mining | Guideline |
| | Water users | Water use is subject to the water rights conditions | DFL 1222/1981 | Regulatory |