Annexure No. 2

Geotechnical Investigation and TMF Design Report

TMF Design Report

There is no 'standard' approach to TMF Design Report as each TMF is unique. However the TMF Design Report should consider and/or cover the following topics included in the typical report table of contents as follows:

EXECUTIVE SUMMARY
1.0 INTRODUCTION
- 1.1 Project Description and Background

2.0 SITE CONDITIONS
- 2.1 Topography and Physiography
- 2.2 Climate
  - 2.2.1 Precipitation
  - 2.2.2 Evaporation
  - 2.2.3 Wind
- 2.3 Geological, Geotechnical, and Hydrogeological Summary
  - 2.3.1 Geology
  - 2.3.2 Geotechnical Foundation Information
  - 2.3.3 Geotechnical Tailings Information
  - 2.3.4 Hydrogeology
- 2.4 Seismicity
- 2.5 Hydrology

3.0 DESIGN CRITERIA AND APPROACH
- 3.1 General
- 3.2 Design Guidelines
- 3.3 Facility Classification
  - 3.3.1 Design Flood
  - 3.3.2 Seismic Design Event
  - 3.3.3 Freeboard
  - 3.3.4 Stability
- 3.4 Siting and Location
- 3.5 Geometry
- 3.6 Containment

4.0 TSF STARTER FACILITY DESIGN OVERVIEW AND CONSTRUCTION
- 4.1 Site Preparation
  - 4.1.1 Condemnation Borehole Decommissioning
- 4.2 Haul Road and Process Line Crossings
- 4.3 Starter Facility Rockfill Embankments
- 4.4 Foundation Grading
- 4.5 TSF Liner System
- 4.6 Underdrain Collection System
- 4.7 Underdrain Pond
- 4.8 Return Water Pond
- 4.9 Tailings Beach Geometry
- 4.10 Decant Pond
- 4.11 Decant Ramp and Northeast Access Ramp
- 4.12 Pipeline Containment Channel
- 4.13 Pipeline Containment Channel Event Pond
- 4.14 Ultimate Facility Geometry and Sustaining Capital Construction

5.0 ENGINEERING ANALYSES
- 5.1 Tailings Consolidation and Seepage
- 5.2 Seepage and Stability
- 5.3 Filter Compatibility
- 5.4 Water Balance and Water Management

6.0 CONSTRUCTION MONITORING AND SPECIFICATIONS
7.0 FACILITY OPERATIONS
- 7.1 General Operational Intent

7.2 Tailings Deposition
7.3 Return Water
7.4 Operational Monitoring
8.0 STUDY LIMITATION
9.0 CLOSING
10.0 REFERENCES

Typical field investigation and Geotechnical report

There is no 'standard' approach to field investigations and geotechnical analysis, and should be carried out as per recommendation of the competent designer / engineering company. Based on the field investigation and geotechnical analysis, the geotechnical investigation report may cover following topics:

- Literature review for existing/ available geologic and geotechnical maps, reports of or surrounding the site.
- Site Reconnaissance
- Geological and Topographic mapping.
- Soil survey
- Sub surface exploration
    - Test boring done with in the footprint of the dam and appurtenant structure.
    - Test pits
    - Rock coring
- Sampling
    - Disturbed sampling
    - Undisturbed sampling
- Borrowed material study
- In-situ / Field testing
- Laboratory testing
    - Classification tests
    - Compaction tests
    - Strength tests
    - Consolidation tests
    - Permeability tests
- Geo technical analysis
    - Stability analysis
    - Seepage analysis
    - Settlement analysis

The extent and number of locations to be investigated will vary considerably depending on the site-specific conditions and existing information, as well as budgetary and jurisdiction-related constraints. Field investigations can include any number of the following:

- Shallow test pits excavated (to ~3 m) with backhoe (back actor), excavator or, in specific cases, through manual means (e.g. hand augers). These used to examine near-surface soils, carry out field classification and extract samples for laboratory testing. In some instances, it may be justified to widen the shallow test pits into investigation trenches.
- Boreholes drilled to hard rock/bedrock and/or groundwater whichever is the deeper. If bedrock is not likely to be encountered, the depth should be at least 50% greater than the highest point of the embankment. Specialist advice should be sought by the tailings practitioner on the type of drilling equipment, diameter of hole, in situ testing to be carried out (including hydrogeological testing) and methods of sample recovery in order to obtain the information required for analysis and design purposes. In some cases, the boreholes may be converted to long-term monitoring bores or extraction wells.
- Cone penetration testing to characterize soft materials and pore pressures. CPT is an ideal method of investigation, particularly if there is a pre-existing TSF nearby. The results collected can be used to identify the stratigraphy, provide parameters for modelling and an indication of the propensity of the materials to liquefy.

- Geophysics is now a well-established technique to provide information on the sub-surface materials. It is a specialist area and advice should be sought from appropriately experienced personnel.

An indication of the types of investigations that may be considered for various design stages is provided in the following Table.

Types of Investigations for Design Stages

Study Level	Test Pits	Boreholes	CPT	Geophysics
Scoping	Possible	Unlikely	Very Unlikely	Very Unlikely
PFS (prefeasibility Study)	Typically 10 to 50 depending on site size	Typically 3, but in some circumstances none and in other cases up to 10 may be warranted	Unlikely	Unlikely
FS (feasibility Study)	Supplementary to typically provide coverage of 1 test pit per 5 to 10 ha, or every 50 m along a perimeter embankment	Infill bores to provide information required for design and possibly monitoring. A total of least 6 per site (2 sections) but many more may be warranted.	Advisable depending on geology and location of the site. 5 to 10 locations depending on cost effectiveness.	May be justified depending on the complexity of the stratigraphy and the sensitivity of the downstream environment, or if tenement conditions preclude invasive investigations
DED (Detailed Engineering)	Could have been completed at FS level but infill pits may be required at targeted locations	Could have been completed at FS level but infill boreholes may be required at targeted locations or for future monitoring or seepage control	Could have been completed at FS level but may be required at targeted locations to improve confidence in parameter selection and optimize design	If not completed at FS level, would likely only be undertaken if there are uncertainties that need to be addressed

Typical Laboratory Testing

Samples are extracted from test pits, hand augers holes, boreholes or through CPT for the purpose of laboratory testing. It is important that appropriate testing is undertaken in order to support classification and obtain parameters for use in analysis and design. The laboratory test program should be carefully considered to ensure that the correct tests are stipulated, the correct number of tests are carried out and unnecessary tests are not undertaken. There is no 'one size fits all' and specialist advice should be sought by the tailings practitioner. Typically, testing will need to be carried out obtain the following information:

- Classification of the materials to support development of the (hydro)geological model (e.g. particle size distribution, Atterberg limits, specific gravity)
- Strength of foundation and embankment materials for use in stability analysis
- Consolidation of foundation materials to inform the design
- Whether the materials are likely to be dispersive
- To identify candidate materials for use as construction materials and to obtain parameters (strength, permeability, filter compatibility) for use in analyses and design.

The laboratory testwork program should be developed ahead of the field investigation plan so that suitable samples can be collected. Input from experienced geotechnical engineers is essential.