3 Liner Geomembrane

The May 1995 Crandon Project TMA Feasibility Report (Foth & Van Dyke, 1995) and subsequent addenda (Foth & Van Dyke, 1996a and b, and 1997), hereafter collectively referred to as the Feasibility Report, discuss both design principles and methods, and identifies high density polyethylene (HDPE) as best suited for use in the TMA base liner. Figure 1 presents a decision matrix that can be employed at any future date to evaluate and select an alternative geomembrane for use in the base liner.

The matrix has four columns. The extreme left column contains the design/performance requirements which are based on the design computations presented in the Feasibility Report. The second column describes the methods for evaluating the alternative material. The third column illustrates the decision process. The fourth column indicates the action to be taken based on the material evaluations and subsequent decision process. A detailed discussion describing how the matrix is applied to a material for each design/performance requirement follows.

3.1 Chemical Compatibility

The geomembrane base liner decision matrix (Figure 1) includes two design/performance requirements. The first relates to geomembrane compatibility with tailings and leachate. The second relates to the longevity of the geomembrane. Each is discussed below.

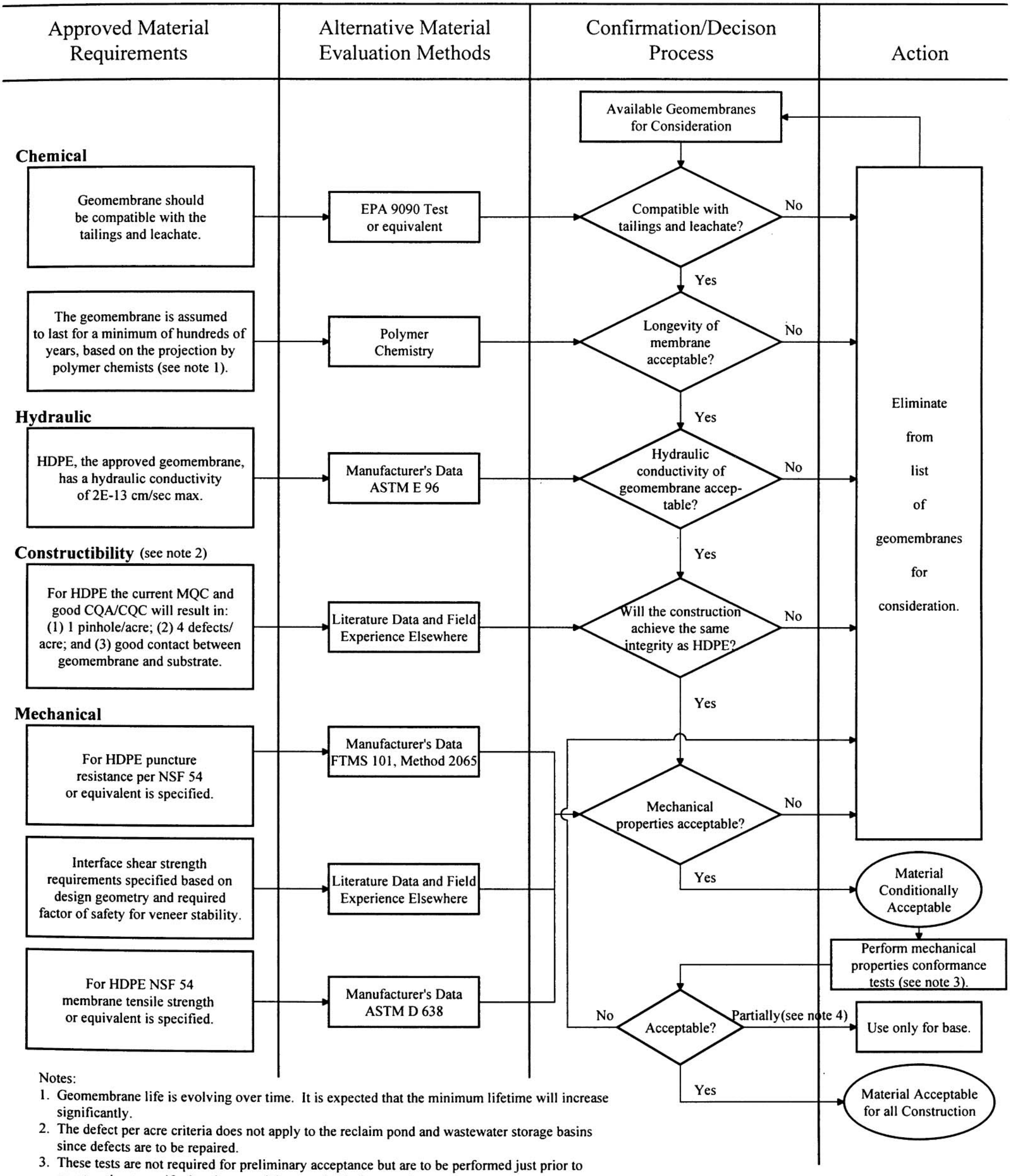
3.1.1 Compatibility

One of the primary requirements for geomembranes in liner applications is chemical compatibility with the materials they come in contact with. In the case of the Crandon Project TMA, the liner will be in contact with the geosynthetic clay liner (GCL) below and the drainage medium (processed till, sand, or a geocomposite) above.

The liner will also come in contact with mine water before the start of tailings deposition, and after with process water and/or leachate as the process water and the tailings react. The leachate could include lower pH conditions. In view of the above, compatibility needs to be established between the geomembrane and the liquids described.

EPA's 9090 test is the current standard compatibility test for geomembranes. To assess compatibility, the evaluation of an alternative geomembrane would be accomplished by the EPA 9090 test, or equivalent, using both process water and a manufactured leachate with characteristics as defined by the TMA source term characterization work. If the EPA 9090 test shows that statistically significant changes in wide width tensile strength and water vapor transmission do not exceed 10 percent, the material will be considered to be compatible with the tailings and leachate, and the analysis will continue to the next step. If the material is determined to be incompatible, it will be eliminated from further consideration.

Figure 1
Crandon Project
Decision Matrix for Geomembrane Application for Base Liners



Notes:
1. Geomembrane life is evolving over time. It is expected that the minimum lifetime will increase significantly.
2. The defect per acre criteria does not apply to the reclaim pond and wastewater storage basins since defects are to be repaired.
3. These tests are not required for preliminary acceptance but are to be performed just prior to construction to verify that the material meets the design requirements.
4. Passes mechanical properties conformance tests except for interface shear test.

3.1.2 Longevity

When disposed of as a waste material in landfills, plastics are considered indestructible and permanent without the possibility of deterioration. When plastics are used as liners for containment purposes, their longevity is at times questioned. Based on the December 1996 report prepared by GeoSyntec Consultants of Boca Raton, Florida, titled *Assessment of Long-Term Performance of the Proposed HDPE Geomembrane Liner and Cap at the Crandon Project TMA Facility* (GeoSyntec, 1996), ". . . the HDPE geomembrane liner and cap at the TMA facility should function as designed for a very long time (e.g., hundreds of years) without deterioration in performance."

If an alternative geomembrane is considered in the future as a substitute for the currently specified material (HDPE) and polymer chemists estimate its lifespan will meet the lifespans for materials available at the time of evaluation, it will be deemed to meet the longevity design/performance requirements.

3.2 Hydraulic Conductivity

In the water balance computations discussed in the TMA Feasibility Report, the geomembrane hydraulic conductivity used corresponds to that of HDPE. Even though minor changes in the hydraulic conductivity of the geomembrane, normally estimated from water vapor transmission tests (ASTM E96), will not change the computed percolation from the site significantly, the decision matrix specifies that the maximum allowable hydraulic conductivity for alternative geomembranes will be $2x10^{-13}$ cm/sec as estimated based on the ASTM E96 water vapor transmission test, or equivalent.

3.3 Constructibility

Constructibility issues are important to geomembrane performance, but are critical only if the construction practices impact the quantitative results used in the design and evaluation of the system containing the geomembranes. Therefore a substitute geomembrane would be acceptable from a constructibility standpoint if it can be installed to the same degree of integrity as HDPE. This qualitative comparison will be largely based on experience in the field elsewhere. Other issues to be considered in this regard are ease of installation and ability to weld, including to previously placed HDPE, in a timely fashion.

3.4 Mechanical Properties

3.4.1 Required Properties for an Alternative Geomembrane

The relevant geomembrane mechanical properties when considering an alternative material are tensile strength, puncture resistance, and interface shear strength characteristics. The tensile strength and puncture resistance properties described in the NSF 54 specifications (NSF, 1993) for an HDPE 60 mil liner have been specified in the TMA design presented in the Feasibility Report and will be the minimum acceptable values for an alternative geomembrane.

Interface shear strength is an important parameter to verify stability of the cover soils (soil veneer) during the operation period of the TMA. The friction angle value specified (a minimum 21.2°) in Appendix C of Addendum No. 3 to the Feasibility Report (Foth & Van Dyke, 1997) is for the loading conditions anticipated in the field without any excess pore water pressure considered (i.e., total stress strength parameter). Interface shear strength values for an alternative geomembrane that are less than that specified will result in a factor of safety smaller than the design factor of safety and will not be considered as acceptable.

3.4.2 Verification of Properties for an Alternative Geomembrane

The acceptability of an alternative geomembrane will be evaluated as follows. For tensile properties and puncture resistance, manufacturers' data will be compared to NSF 54 specifications (NSF, 1993) to determine preliminary acceptability of the alternative material. Standardization of testing methods and the awareness of the strict QA/QC procedures which occur during construction, plus efforts by geosynthetic societies and trade organizations have established the credibility of material properties published by manufacturers. Therefore, manufacturers' data are sufficient and appropriate for preliminary acceptance of an alternative geomembrane. However, during the construction stage, the QA/QC procedures outlined in Appendix A of Addendum No. 3 to the Feasibility Report (Foth & Van Dyke, 1997) require that manufacturers' QC test data be obtained for each roll of material. In addition, the procedures outlined in Appendix A also require conformance testing (ASTM D 638 as modified by NSF 54 Appendix A for tensile properties and FTMS 101C, Method 2065 for puncture resistance) on a specified number of rolls. These procedures will assist in verifying that the material in the field meets the design requirements.

In the case of interface strength, there is a slight difference in the proposed procedure. The required strength properties for the HDPE liner and GCL interface specified in the Feasibility Report were arrived at based on facility geometry, the required factor of safety, and a total stress analysis. The interface strength, then, must be obtained as a total stress strength parameter, i.e., using a test which simulates the most critical loading condition in the field. For the soil veneer stability over the base liner of the TMA along the lower interface between the geomembrane and the GCL, the most critical loading condition is a slow rate of shear with drainage permitted after the GCL is saturated. Therefore, the test performed should be a direct shear box test at a very low rate of displacement and under saturated conditions.

For evaluating failure potential along the upper interface, i.e., between the geomembrane and the cushioning geotextile or the geomembrane and the geocomposite, a similar test can be performed with the GCL being replaced by the geocomposite or geotextile. Since excess pore water pressures are not likely to develop, the total and effective stress shear tests and analyses will be exactly the same. The stability of the soil veneer under extreme conditions of rainfall which could lead to the development of steady flow parallel to the slope and ultimately to erosion, will be managed through repairing the erosion occurrences.

During the placement of cover soils on the sideslope, very little movement will occur along the interfaces, if at all. This is because the construction specifications will require oversight of soil placement, prevention of pushing more than 1 ft of soil ahead of the low ground pressure machinery that will be used, and avoiding large braking forces. Thus, the peak strength (along the interface) will be the appropriate total stress strength. However, to be conservative, especially for the lower interface, the residual strength available in published literature/field experience will be used for preliminary selection.

Before construction starts, it is anticipated that a pre-construction report will be prepared. By that time, the availability and acceptability of the materials would have been finally evaluated and a final selection made, not only of the geomembrane, but also of the materials which form the critical interfaces. Therefore, interface shear tests (ASTM D 5321, or equivalent) will be performed prior to installation at the rate of one test per 400,000 square feet of geomembrane expected to be installed on the sideslopes. The tests will be conducted on the interfaces (both above and below the membrane) under saturated conditions with drainage permitted (low rates of displacement). These tests will be run to large strains to obtain residual strengths. If the interface strength values from these tests (residual strengths) do not meet the design requirements, the alternative geomembrane will be rejected. If they meet the requirements, the material will be accepted for use in TMA construction.

3.5 Summary

In summary, the decision matrix in Figure 1 illustrates how CMC would proceed to evaluate a material other than HDPE as an alternative geomembrane liner. Chemical, hydraulic, and mechanical requirements of the geomembrane design will be evaluated for the proposed alternative material against the criteria established above. Installation requirements the alternative material will need to meet include compatibility with the previously installed geomembrane to which the alternative material may have to be welded, potential installation defects, etc. Unquantifiable features which facilitate an easier installation may be considered based on engineering judgement, but only if the other requirements as shown on the decision matrix are met first.