Optimizing quality of information in RAw MAterial data collection across Europe

Technical Guidance Note: Practical Exercises in Reporting Resource and Reserve Data according to the United Nations Framework Classification (UNFC)

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Author(s):	Gus Gunn, Tom Bide, Carolin Kresse
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[1] PU=public, PP= Restricted to other programme participants (including the Commission Services), RE= Restricted to a group specified by the consortium (including the Commission Services), CO= Confidential, only for members of the consortium (including the Commission Services)

Simple Guide to Bridging between CRIRSCO-aligned codes and UNFC

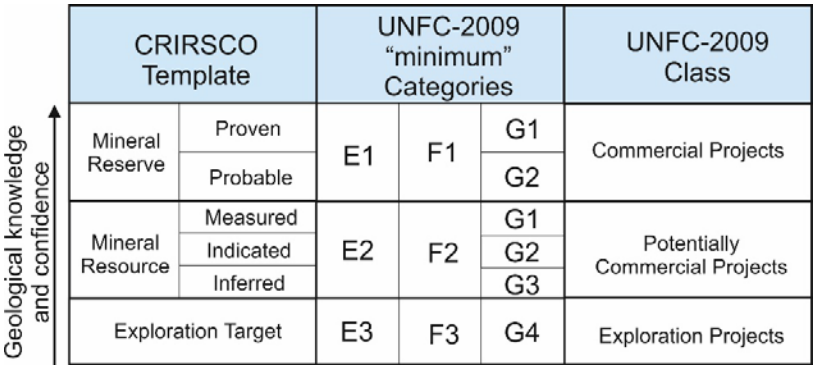


Figure 1: Mapping of CRIRSCO to UNFC-2009 "minimum" Categories and Classes. (Source: UNFC).

Application of the G-axis (geological uncertainty)

This is defined by geological studies, including estimates of tonnes, grade, quality etc. These enable classification on the geological axis based on the detail of the study and the degree of confidence in the geological model.

- Mineral reserves are classified as G2 (probable) or G1 (proven).
- Mineral resources are classified as G3 (inferred), G2 (indicated) or G1 (measured) reflecting an increasing level of geological knowledge and confidence.

Application of the E (economic and social viability) and F (technical feasibility) axes

- Mineral reserves are the economically minable quantities and always correspond to categories E1 F1 (G1 or G2). At time of reporting, extraction is reasonably justified defined by pre-feasibility or feasibility studies.
    - Proved mineral reserves are classified as 111.
    - Probable mineral reserves are classified as 112.
- Mineral resources are generally classified as E2 F2 (G1, G2 or G3).
    - Measured resources are classified as 221.
    - Indicated resources are classified as 222.
    - Inferred resources are classified as 223.
- E and F categories set minimum standards for UNFC Classes which means mineral resource estimates can also be classified as E1 F2 (where there is no doubt of economic viability) or E2 F1 (where there is no doubt of technical viability). These combinations do not change the UNFC Class as Potentially Commercial Projects.
- E and F axis can be sub-categorised but this is not considered here.

Exploration Target

This is a project located in a defined geological setting and with a statement or estimate (range of tonnes and a range of grade or quality) of its exploration potential.

- Exploration is insufficient to estimate mineral resources, e.g. in case of early stage exploration projects.
- Exploration Targets are classified as E3 F3 G4.
- CRIRSCO excludes 'undiscovered' and 'uneconomic' quantities.

Further Information

For further information on UNFC please consult the website: https://www.unece.org/energywelcome/areas-of-work/unfc-and-resource-management/about-unfc-and-sustainable-resource-management.html. Additional information is also available in the accompanying report "Deliverable 1.5 Good practice guidelines for harmonisation of resource and reserve data" and its associated guidance notes.

Practical Exercises

These exercises provide examples of the type of resource data that are most commonly encountered today when assessing resources within individual projects. These include: (i) resource estimates published by companies using a CRIRSCO-aligned code; and (ii) historic resource estimates that are not associated with any known reporting code. The UNFC classes that have been attributed to these examples are given on pages 6-8.

Exercise 1: Gairloch, Scotland, UK

Background and available data

Gairloch is a volcanogenic massive sulfide (VMS) deposit that was explored for copper, zinc and gold in the 1980s by Consolidated Goldfields Ltd. The orebody is complex and discontinuous in form. It occurs in deformed metamorphic supracrustal Lewisian (Palaeoproterozoic) rocks in the north-west Highlands of Scotland. The base metal mineralisation is stratiform, 4 metres thick and can be traced along strike over at least 1 kilometre. The orebody is strongly deformed. It comprises a number of steeply dipping sheets that crop out at surface but have not been systematically assessed at depth.
BGS holds an archive of records from work carried out at Gairloch, which included drilling 87 boreholes that produced about 9200 metres of core. No resource figures have been published although the deposit is described in a paper by Jones et al (1987)[2]. A single resource figure of 500,000 tonnes @ 1.2% Cu, 0.6% Zn, 1.7 g/t Au and 3.6 g/t Ag is reported in a document in the BGS archive dated 1980. However, there is no information about how this estimate was made, how many boreholes were taken into account or who made the estimate.

Record any issues, problems and uncertainties under 'Comments'.

Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Resource estimate	Unknown	1980	0.5				

[2] Jones, E.M., Rice, C.M. & Tweedie, J.R. 1987. Lower Proterozoic sulphide deposits in Loch Maree Group, Gairloch, northwest Scotland. *Applied Earth Science*, vol. 96, pp. B128–B140.

Exercise 2: Drakelands tungsten-tin mine, Devon, UK

Background and available data

Drakelands Mine, formerly known as Hemerdon, is a large, low grade tungsten-tin (W-Sn) stockwork deposit. It was discovered in 1867 and mined for short periods during World War I and World War II with limited production. Between 1960 and 2006 the project ownership changed a number of times and several resource assessments were made. A mining feasibility study in 1982 reported a resource of 73 million tonnes of ore grading 0.143% WO_3 and 0.026% Sn. Permission to mine was granted in 1986 but due to the low tungsten price mining was not economic at that time. In 2007 Wolf Minerals acquired the rights to mine the deposit. Further JORC-compliant resource estimates were published in 2008 and in 2010. The most recent resource and reserve estimates were published in 2011 and mining operations commenced in 2014. However, as a result of technical problems, the mine closed in late 2018 when Wolf went into voluntary administration. Use this information and the data in the table below to assign appropriate UNFC codes to the reported resource estimates in 1982 and 2011. Given the recent closure of the mine, how would your UNFC categories differ if they were assigned today?

Record any issues, problems and uncertainties under 'Comments'.

Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Resource estimate	Unknown	1982	73				
Proved Mineral Reserves	JORC	2011	27.9				
Probable Mineral Reserves	JORC	2011	7.8				
Measured Mineral Resources	JORC	2011	39.9				
Indicated Mineral Resources	JORC	2011	18.7				
Inferred Mineral Resources	JORC	2011	86.6				

Exercise 3: Polyhalite resources, NE England, UK

Background and available data

Polyhalite is a potassium-rich mineral used in fertiliser applications where it can be applied directly to the land surface with limited processing. Potassium minerals (potash), principally in the form of carnalite, have been mined in NE England for over 30 years. However, polyhalite has only recently been considered a mineral resource. In the UK, it is only known to exist in economic quantities in NE England and is hosted in Permian evaporite deposits.

There is one operating mine, Boulby Mine, operated by Cleveland Potash. Construction has also begun on a second polyhalite mine, the Woodsmith mine, in North Yorkshire, operated by Sirius Minerals, which is due to be operational by 2021.

Sirius Minerals has published a CRIRSCO compliant probable reserve figure of 248 million tonnes in 2016. In addition Sirius Minerals reported indicated (710 million tonnes) and inferred resources (1570 million tonnes) in 2016. Cleveland Potash reported in 2013 measured (39 million tonnes), indicated (83 million tonnes) and inferred resources (880 million tonnes). Note all figures are exclusive of each other (i.e. reserves are not included in resource figures). Considerable resources also exist outside the areas defined by the two projects. In 2017 The British Geological Survey have undertaken a preliminary assessment of the volume of material contained outside the licensed areas based on borehole data and geological interpretation. The thickness of the polyhalite seam has been be combined with the mapped area of the subcrop using simple spatial analysis to calculate the geological potential of the resource: this gives an approximate value of 286 200 million tonnes.

Record any issues, problems and uncertainties under ‘Comments’.

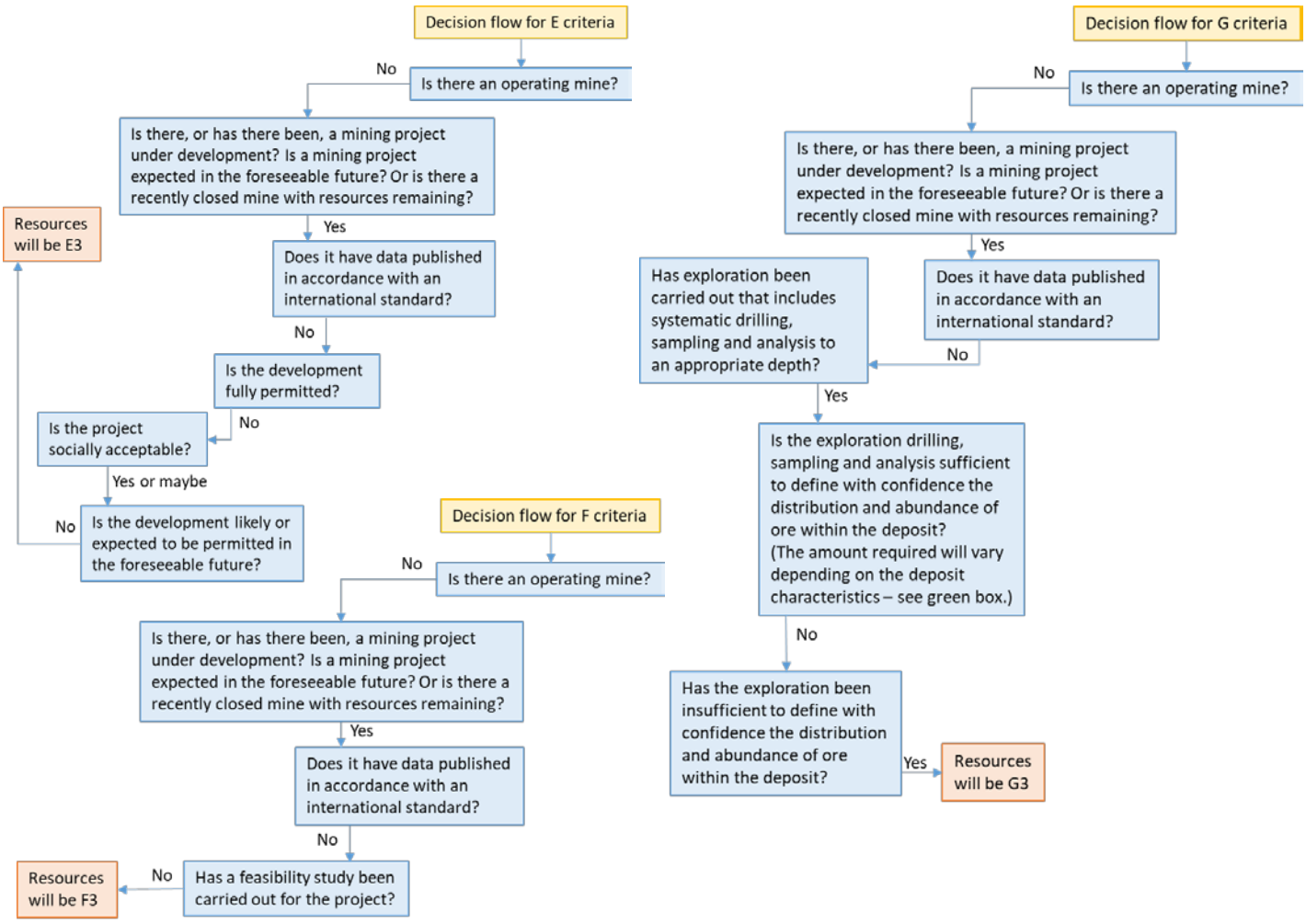
Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Probable Mineral Reserves	JORC	2016	248				
Measured Mineral Resource	JORC	2013	39				
Indicated Mineral Resource	JORC	2013 and 2016	793				
Inferred Mineral Resource	JORC	2013 and 2016	2450				
Estimate based on subcrop	None	2017	286 200				

UNFC classes for the previous exercises

Gairloch, Scotland, UK

Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Resource estimate	Unknown	1980	0.5	3	3	3	Non-compliant historic resource figure. Extraction and sale is not expected to become economically and socially viable in the foreseeable future. Technical feasibility cannot be evaluated due to limited technical data. Geological certainty can be estimated with a low level of confidence. See below for the decision flow path for this using the UNFC decision flow tool produced by the ORAMA project

Decision flow for resource categorisation at Gairloch:



Drakelands tungsten-tin mine, Devon, UK

Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Resource estimate	Unknown	1982	73	3	3	3	Non-compliant historic resource figure. Extraction and sale is not expected to become economically and socially viable in the foreseeable future. Technical feasibility cannot be evaluated due to limited technical data. Geological certainty can be estimated with a low level of confidence. The decision flow path for this, using the UNFC decision flow tool produced by the ORAMA project, is the same as for the Gairloch example.
Proved Mineral Reserves	JORC	2011	27.9	1 (2)	1 (2)	1	Based on UNFC–CRIRSCO bridging document
Probable Mineral Reserves	JORC	2011	7.8	1 (2)	1 (2)	2	Based on UNFC–CRIRSCO bridging document
Measured Mineral Resources	JORC	2011	39.9	2 (3)	2	1	Based on UNFC–CRIRSCO bridging document
Indicated Mineral Resources	JORC	2011	18.7	2 (3)	2	2	Based on UNFC–CRIRSCO bridging document
Inferred Mineral Resources	JORC	2011	86.6	2 (3)	2	3	Based on UNFC–CRIRSCO bridging document

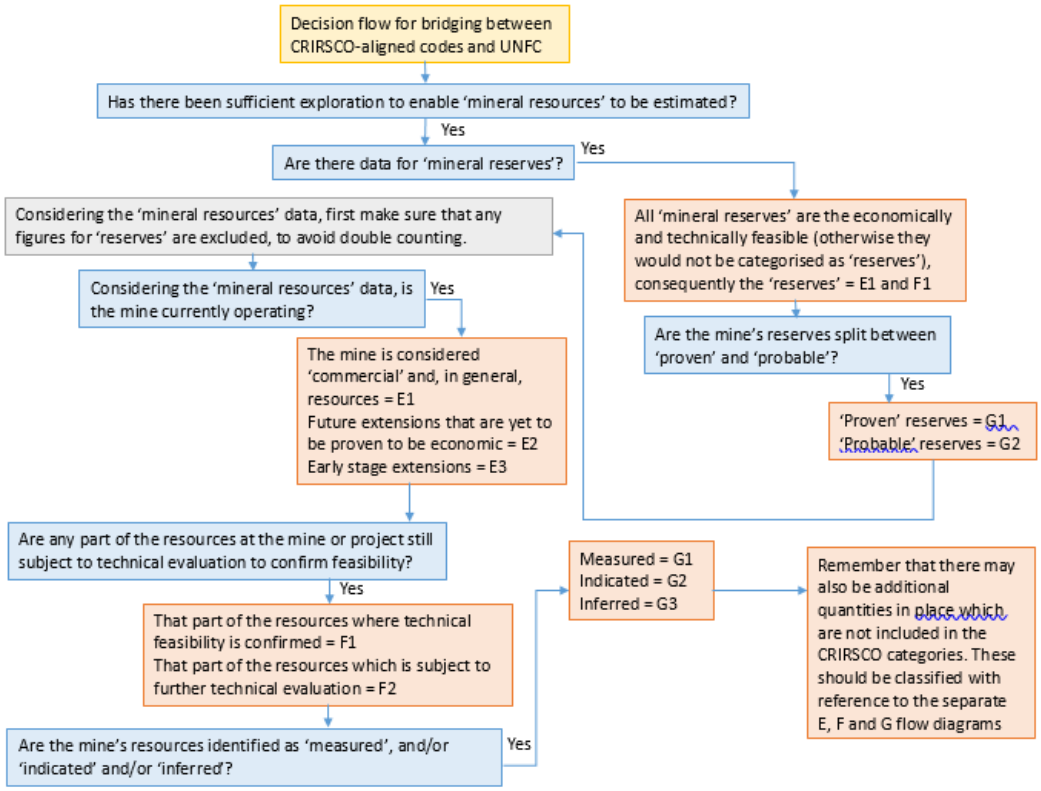
(Figures in brackets indicate UNFC class based on closure of the mine)

See the above example for Gairloch for the decision flow for resource categorisation for the 1982 resource estimate.

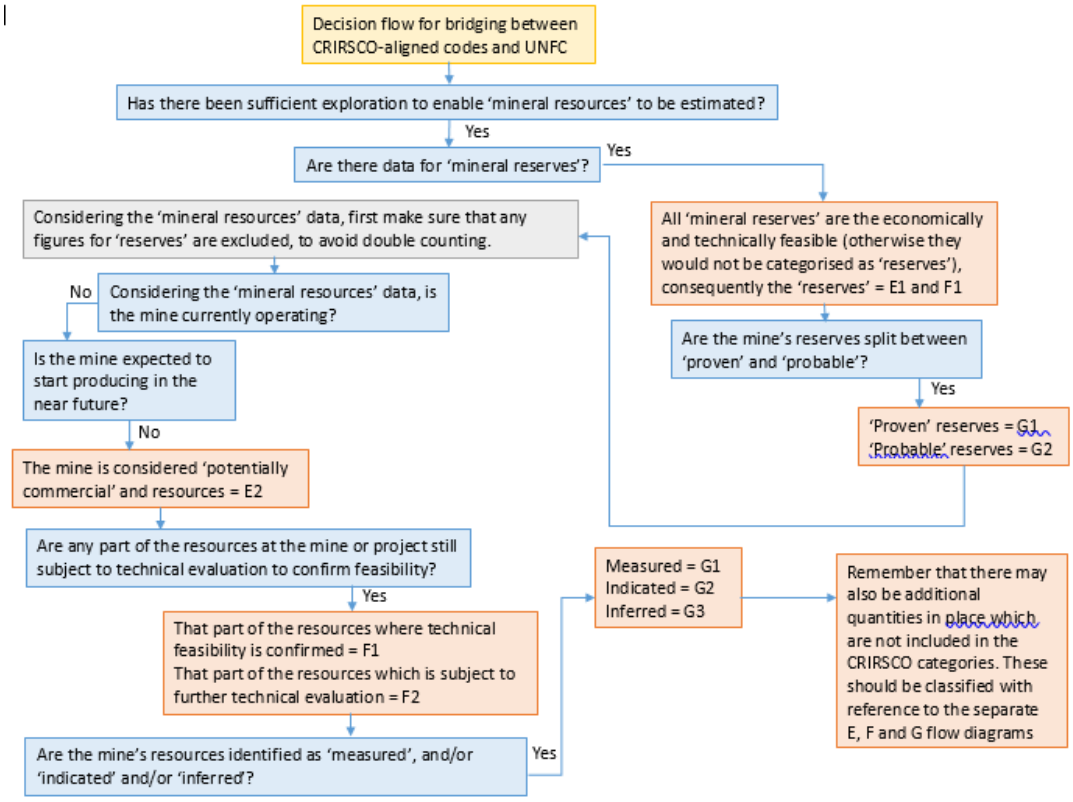
See next page for the decision flow path for the UNFC-CRIRSCO bridging document, both prior to and following the mine's closure.

As the mine closure was because the operator entered voluntary administration the mine's position on the E (economic viability) axis is adjusted downwards. Because this financial difficulty was due in part to technical problems the mine's reserves on the F (technical feasibility) axis are also adjusted downwards.

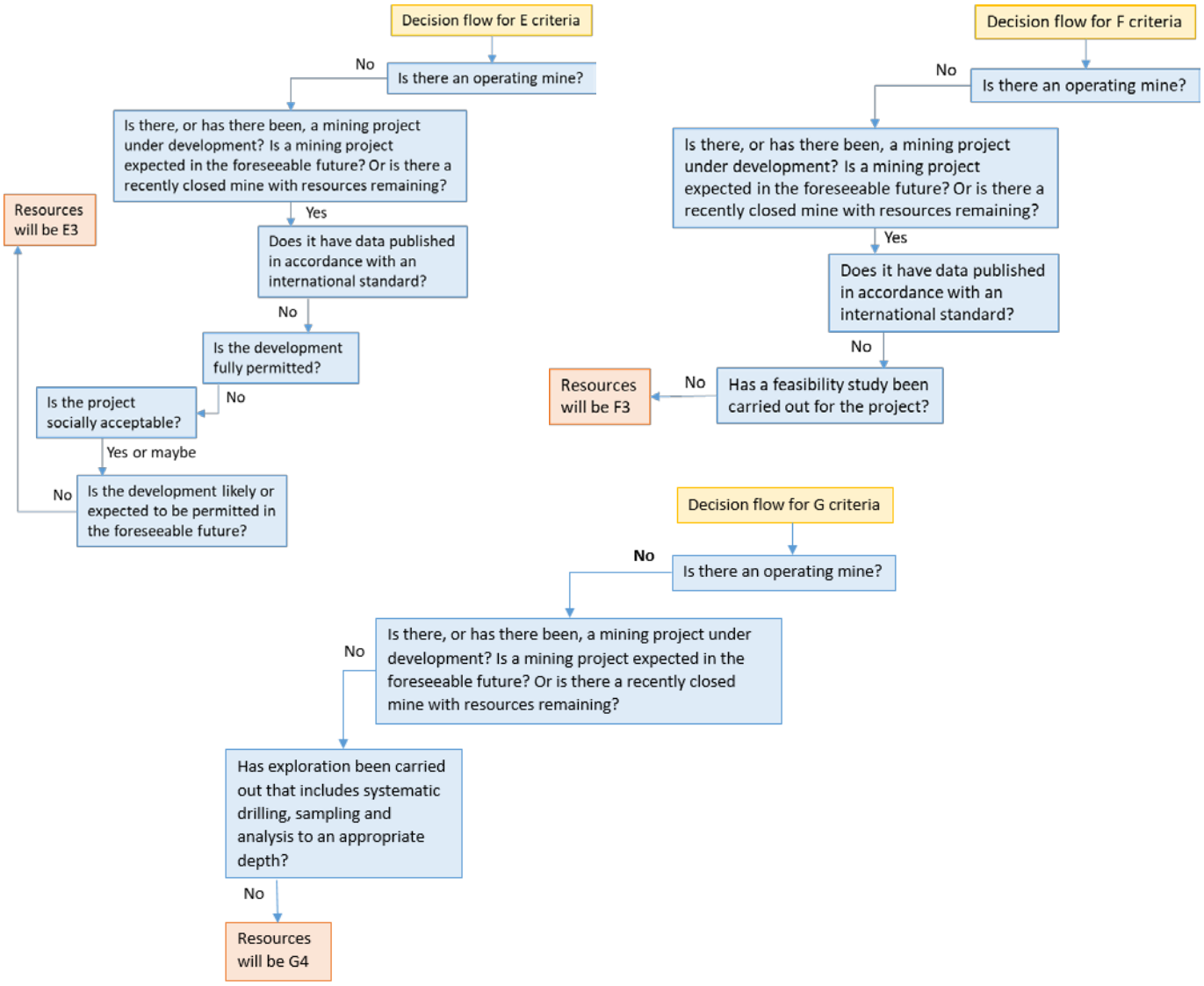
Decision flow for bridging from CRIRSCO to UNFC for Drakelands mine (prior to closure)



Decision flow for bridging from CRIRSCO to UNFC for Drakelands mine (after closure)



Polyhalite resources, NE England, UK

Category	Reporting Code	Year of reporting	Tonnage of ore (million tonnes)	UNFC category			Comments
				E	F	G	
Probable Mineral Reserves	JORC	2016	248	1	1	2	Based on UNFC–CRIRSCO bridging document
Measured Mineral Resource	JORC	2013	39	2	2	1	Based on UNFC–CRIRSCO bridging document
Indicated Mineral Resource	JORC	2013 and 2016	793	2	2	2	Based on UNFC–CRIRSCO bridging document
Inferred Mineral Resource	JORC	2013 and 2016	2450	2	2	3	Based on UNFC–CRIRSCO bridging document
Estimate based on subcrop	None	2017	286 200	3	3	4	Non-compliant estimated resource figure. Extraction and sale is not expected to become economically and socially viable in the foreseeable future. Technical feasibility cannot be evaluated due to limited technical data. Geological data based on estimated quantities associated with a potential deposit based primarily on indirect evidence. See next page for the decision flow path for this using the UNFC decision flow tool produced by the ORAMA project

Decision flow for polyhalite estimate based on subcrop resource categorisation: