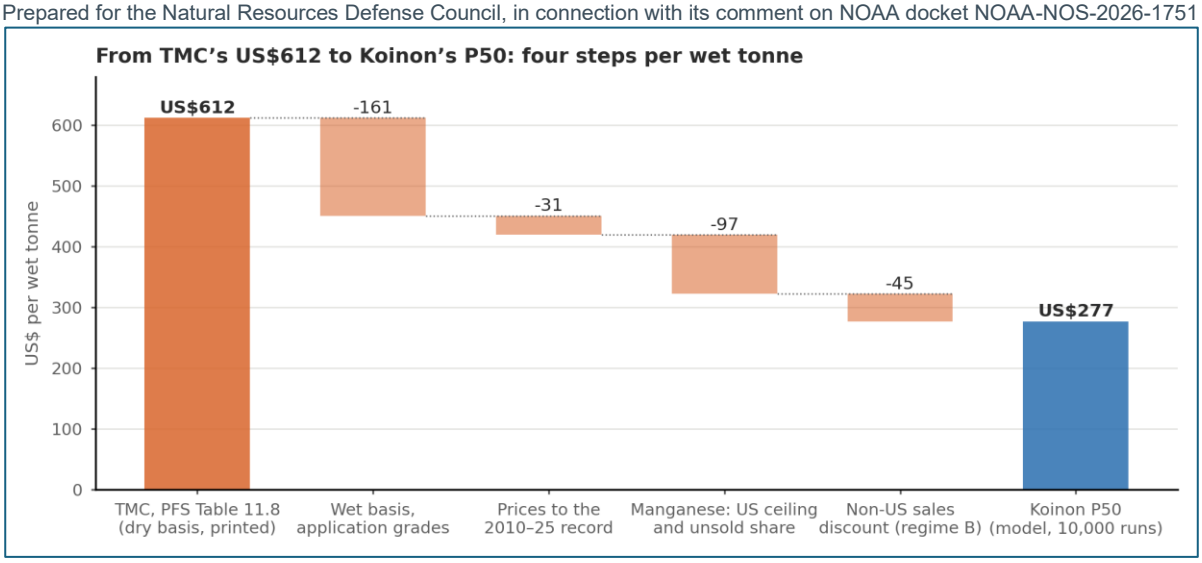
KOINON

Value, Cost and Capital: NORI-D by the Wet Tonne

Five findings on the unit economics of TMC USA's consolidated application to NOAA

16 OCTOBER 2026

Prepared for the Natural Resources Defense Council, in connection with its comment on NOAA docket NOAA-NOS-2026-1751



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1. Purpose and status

This note asks what a wet tonne of NORI-D nodules is worth, what it costs to collect and process, and whether the margin between them can carry the capital the project needs. It is written to support the feasibility sections of NRDC's comment under 15 CFR 971.214(d) and completes a series of four Koinon notes, with those on the resource and reserve, on mineral security and on the information criteria.

The application itself declares no economics. It states a resource, a reserve and a cut-off, and for their basis it cites the NORI-D pre-feasibility study (PFS). The PFS and its companion Initial Assessment (IA), both filed by TMC with the SEC, do contain figures for revenue and cost per tonne, and in places those figures contradict each other. This note therefore works in two layers: first it tests TMC's published figures against one another, then it adds Koinon's own adjustments.

Where the documents differ, the application is taken first, the PFS second and the IA third. Koinon's assessment is built in a model published with this note. Results are given per wet tonne and per collector-hour, not as project totals: this note tests the applicant's figures rather than supplying the project analysis it has not.

Earlier critiques of the PFS have addressed its metal prices, the conversion of resources to reserves and the market for manganese silicate (Emerman 2026, for the Deep Sea Mining Campaign, Greenpeace International and MiningWatch Canada). Koinon has not found a published treatment of the points made in Findings 2 and 3: the basis of the revenue figures in TMC's cut-off tables and the collector assumptions behind them.

2. Summary of findings

The application asks NOAA to find commercial recovery feasible, but it states no revenue, cost or margin. Those have to be assembled from TMC's SEC filings, and the filings, set against one another, do not support the 4 kg/m² cut-off on which the resource rests. The revenue in TMC's cut-off tables can be reproduced only if the nodules' 28% moisture is left out. The test also pairs the cost of the first-generation collector with the sweep rate of a second-generation machine that exists only as a specification. Rebuilt on the application's own collector, with historical real prices, **a realistic market for manganese silicate and a discount on non-US sales, a wet tonne is worth a median US$277 against an operating cost of US$227. Breakeven is about 15 kg/m², close to the field mean of 17.4.**

Capital changes the result in kind. Once production systems 2–4, a smelter and first-of-kind overruns are counted, the whole project needs about US$25bn, and the operating surplus can carry a median of US$5bn. Some 70% of onshore funding is to come from debt and incentives that no party is obliged to provide. Lenders could expect to lose nearly half of it, so public support on these terms would act as a grant. Figure 1 shows value, operating cost and capital per wet tonne at the medians.

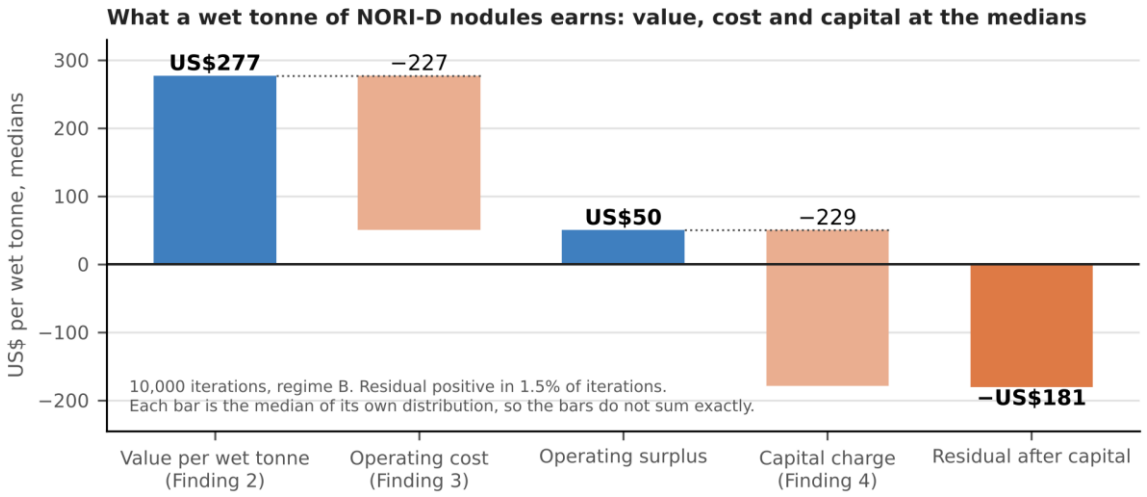

Figure 1. Value, operating cost and capital per wet tonne of NORI-D nodules at the medians of 10,000 iterations, regime B. Value from Finding 2, operating cost with overrun from Finding 3, capital charge from Finding 4 (capital after overrun, annuitised at 8% over 19 years, over the tonnes the collectors deliver). Each bar is the median of its own distribution; differences between bars are not the medians of the differences, which are given in the text. Sources: Application; PFS; IA; Koinon_NORI-D_UnitEconomics_Model.xlsm.

Finding	What the record shows	Consequence
1. The application itself declares no economics	Resource, reserve and a 4 kg/m² cut-off are asserted; revenue, operating cost, capital and margin are absent or redacted. The cut-off rests on the PFS, whose figures are incomplete and in places inconsistent with the IA.	Viability must be assembled from TMC's SEC filings, on the order application, PFS, IA.
2. A wet tonne is worth a lot less than TMC figures suggest	TMC justifies the cut-off with $421–612 per wet tonne; its own life-of-mine estimates give $424–446. The cut-off figures reproduce only on a dry basis.	On TMC's own figures the cut-off rests on revenue stated on a dry basis, about 36% above its wet value. Constant prices, limited manganese sales and discounts outside the United States lower it further: Koinon's median is $277 per wet tonne, with a 10–90% range of $221–352 (Figures 4 and 5).
3. At the declared cut-off the collector loses money	The cut-off test mixes the PFS collector's cost with the IA collector's sweep. On the application's own collector, seabed at 4 kg/m² loses about $23,000–34,000 per collector-hour.	Rebuilt in the model, the operating breakeven is about 15 kg/m² (10–90% range 11–20) against TMC's 2.5–3.6, rounded to 4. On TMC's own abundance–tonnage curve the median leaves 92% of the resource above breakeven, but one iteration in four puts the breakeven above the field's mean of 17.4.
4. The surplus cannot carry the capital	The project needs about US$25bn of capital once systems 2–4, a smelter and the overruns seen on first-of-kind projects are counted, against US$6.6bn in the PFS's capital table. Annuitised at TMC's own 8% and 19 years, the operating surplus can carry a median US$5.4bn.	Capital at risk: median US$19bn, 10–90% range US$9–28bn. The residual per tonne after capital is positive in 1.5% of iterations; the capital-inclusive breakeven, a median 29 kg/m², lies above every panel in NORI-D in 81% of iterations.
5. The gap is a call on public money	About 70% of onshore funding is to come from debt and government incentives; no party is obligated to provide any of it.	Debt and incentives of about US$9bn require US$0.96bn a year; the operating surplus delivers a median US$0.56bn and falls short in 73% of iterations. Expected loss to lenders US$4.5bn, 49% of the debt. The mineral security note draws its fiscal cost from the same run.

Table 1. The five findings in summary. Sections 3 to 7 set out the claim and evidence for each.

3. Finding 1 — The application itself declares no economics

Claim. The application states a resource, a reserve and an abundance cut-off of 4 wet kg/m² and cites the PFS as their basis. It publishes no revenue, operating cost, capital cost or margin. The economics behind its claims have to be read from TMC's SEC filings, where they are incomplete and in places inconsistent.

3.1 What the regulation asks for

Two of the requirements in 15 CFR 971.214(d) bear on economics. Paragraph (d)(2) asks for information sufficient to show that the applicant can commit or raise the resources to cover the estimated costs of the commercial recovery programme; paragraph (d)(5) asks for a description of the projected commercial recovery activities with sufficient information for NOAA to make its determinations. Neither can be tested without a statement of what the programme costs and what it earns.

Against (d)(2) the application offers TMC's record of raising equity, its market capitalisation and its liquidity; the budgets themselves are redacted, and for the onshore plant it gives a funding structure without an amount. Against (d)(5) it offers a production schedule (Table 44) and a resource statement, but no revenue, operating cost or margin for the activities scheduled. Koinon's note on the information criteria treats both in full (sections 5 and 7); this note takes up what they leave open, the economics on which both depend.

3.2 What the application asserts

- Tables 5–6 and 36–38: resource at a cut-off of 4 wet kg/m²; note 5 attributes the cut-off to "AMC (2025a)", the PFS.
- Table 37, notes 7–9: reserve prices and metallurgical recoveries; collector recovery of 77% for type 1 and 62% for types 2–3.
- Section 3.2, Tables 10–11: budgets redacted. Section 7.4.3: funding structure, no capital figure.
- For TMC USA A-A (West), cost estimates and economic analysis are listed as work still to be done.

3.3 How this note uses the three documents

Three documents carry TMC's figures. The application is the document before NOAA and is taken first wherever it states a figure. The PFS, filed with the SEC in August 2025, is the cited basis for the NORI-D resource, reserve and cut-off, and the only document with revenue and cost for NORI-D; it is taken second. The IA, filed the same day by the same consultant, covers NORI A–C and TOML, not NORI-D, and is used third: as corroboration, and as the source of figures the PFS itself borrows, notably the $188 per tonne in its cut-off test.

Where they conflict, three rules apply. A figure the application states displaces the PFS figure for the same quantity. A PFS figure for NORI-D displaces an IA figure for other areas. Where a document borrows a figure from another, it is traced to its source and tested there.

4. Finding 2 — A wet tonne is worth a lot less than TMC figures suggest

Claim. TMC justifies its 4 kg/m² cut-off with revenue of $421–612 per wet tonne. Its own life-of-mine estimates average $424–446, and its grades, recoveries and prices reproduce the cut-off figures only on a dry basis. Koinon's adjustments — constant real prices at historical levels, limited sales of manganese silicate and discounts outside the United States — lower the value further.

4.1 TMC's figures as published

Source	Route or basis	US$ per wet t, as labelled	What TMC uses it for
PFS Table 11.8	Alloy / matte / sulphate	421 / 479 / 612	To justify the 4 kg/m² cut-off for the NORI-D resource (PFS s.11.8)

Source	Route or basis	US$ per wet t, as labelled	What TMC uses it for
IA Table 11.16	Nine areas, NORI A–C and TOML	430–517	To justify the 4 kg/m² cut-off for those areas
PFS Table 16.8	Life of mine, PFS route mix	~424	TMC's life-of-mine revenue for NORI-D (PFS s.16 and s.19); per-tonne figure is Koinon's division by the implied wet tonnage
IA s.19	Life of mine, IA route mix	~446	TMC's life-of-mine economic analysis for the IA areas; Koinon's division of US$298.9bn by 670 Mwmt

Table 2. Revenue per wet tonne in TMC's filings and the purpose each figure serves in them.

What a wet tonne is worth also depends on where in the processing chain TMC sells. Figure 2 shows the four points of sale for nickel and cobalt on TMC's own parameters: alloy from the smelter, $151 per wet tonne; matte from the converter, $179; sulphate from the refinery, $246; and Class 1 metal, about $234, an option the application names but does not cost. With copper the first three are $201, $234 and $324. Payable rates fall the earlier the product is sold, because each buyer keeps a margin for the processing still to be done.

The PFS sells alloy in its first years, matte to year 5, and sulphate only from year 6; the application plans matte in 2028–29 and about 87.5% sulphate and metals at steady state (Table 44). Koinon's model values all output on the sulphate and cathode route, the highest of the four, rather than either schedule, so that every adjustment in this note starts from the figure most favourable to TMC. The US demand ceilings of Table 4 therefore describe steady-state output in sulphate and cathode; the matte of the first years (2028–29 in Table 44) has no US buyer until refining begins at Brownsville.

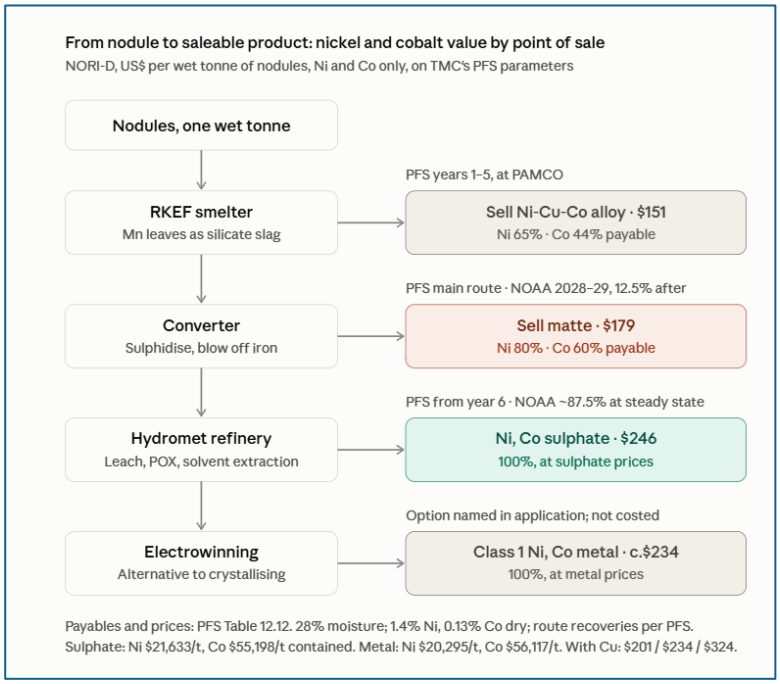

Figure 2. Nickel and cobalt value per wet tonne of NORI-D nodules by point of sale. Payables and prices: PFS Table 12.12; 28% moisture; PFS reserve grades of 1.4% nickel and 0.13% cobalt, dry; route recoveries per PFS Table 16.2. Koinon computation.

4.2 The reconstruction

Grades are reported dry; tonnes and abundance are reported wet. Revenue per wet tonne must therefore be reduced by the moisture content, 28% for NORI-D and TOML and 24% for NORI A–C. TMC's cut-off figures behave as if that step were omitted.

On a wet basis TMC's own inputs value NORI-D nodules on the sulphate route at $445 per wet tonne, not $612. The nine IA areas, on the matte route the IA assumes, are worth $298–385 per wet tonne, not $430–517: all nine rebuild to TMC's printed figures within 1–5% only when moisture is left out. The life-of-mine figures, which are on a wet basis, sit where the wet rebuild predicts.

Workings in Appendix D, Tables D3 and D4.

4.3 Koinon's assessment

Koinon's distribution of value per wet tonne is built in four steps, each a separate variable in the model (Koinon_NORI-D_UnitEconomics_Model.xlsm, published with this note):

- **Prices.** Constant real prices for nickel, copper and cobalt, drawn from the 2010–25 real price record as lognormal distributions fitted to its mean and standard deviation. No upward adjustment for future demand is made, as in Koinon's CCZ model: the record is taken as it stands. Regime B is described in the fourth step. Table 3 sets TMC's prices against that record.
- **Manganese.** The share of manganese silicate that can be sold, at TMC's price. In the United States, 6–12% of output (Table 4; s.4.4), drawn through a Bernoulli trial on whether NORI-D wins that market at all. Outside the United States, a share drawn between 5% and 25%, most likely 15%, since no buyer has been named and only China and India have furnaces of size; it carries the regime B discount. The remainder is unsold and bears a disposal cost (s.4.4).
- **Allocation.** Output divided between US and non-US buyers by product, the US share capped by US consumption of that product form. Table 4 gives a first pass.
- **Discount outside the United States.** The non-US share priced at benchmark less a discount for product of disputed legal status and lack of social license constricting market access (regime B); the US share at benchmark.

Metal, US$/t real 2025	TMC: PFS and application	TMC: IA	Koinon: 2010–25 real mean / median / P10–P90	Difference and reason
Nickel	20,295 (metal); 21,633 (in sulphate)	20,360; 21,835	20,816 / 19,148 / 14,417–30,330	TMC at about the mean; reached in 8 of 16 years. Since 2022 the market has been in surplus, led by Indonesian supply (USGS MCS 2026).
Copper	11,440	11,456	9,326 / 9,359 / 7,527–11,145	TMC 23% above the mean and above P90; reached in 1 of 16 years. TMC's price would hold copper at the top of its historical range for the life of the mine.
Cobalt	56,117 (metal); 55,198 (in sulphate)	62,530	53,989 / 45,085 / 38,610–76,380	TMC 4% above the mean, 24% above the median; reached in 6 of 16 years. The mean is raised by the 2017–18 and 2021–22 spikes.
Manganese in silicate	$5.45/dmtu ($545/t Mn)	$4.7/dmtu	Ore, 44% CIF China: 2015–25 real mean 6.17 / median 5.82 / range 4.18–9.18 per dmtu	TMC below the ore record in 8 of 11 years. Not charted: the silicate is not ore and has no market of its own; the issue is its discount to ore and its volume (s.4.4). Treated through the saleable share.

Table 3. TMC's price assumptions against the historical record. TMC: PFS Tables 1.8 and 16.1, metals from Benchmark Mineral Intelligence (2025), manganese silicate from CRU (2024), repeated in Application Table 37 note 7; IA Table 19.2, BMI as of 30 June 2025. The cut-off test in PFS Table 11.8 uses separate CRU forecasts for 2034–46, not published. Koinon: annual averages deflated to 2025 dollars by US CPI-U.

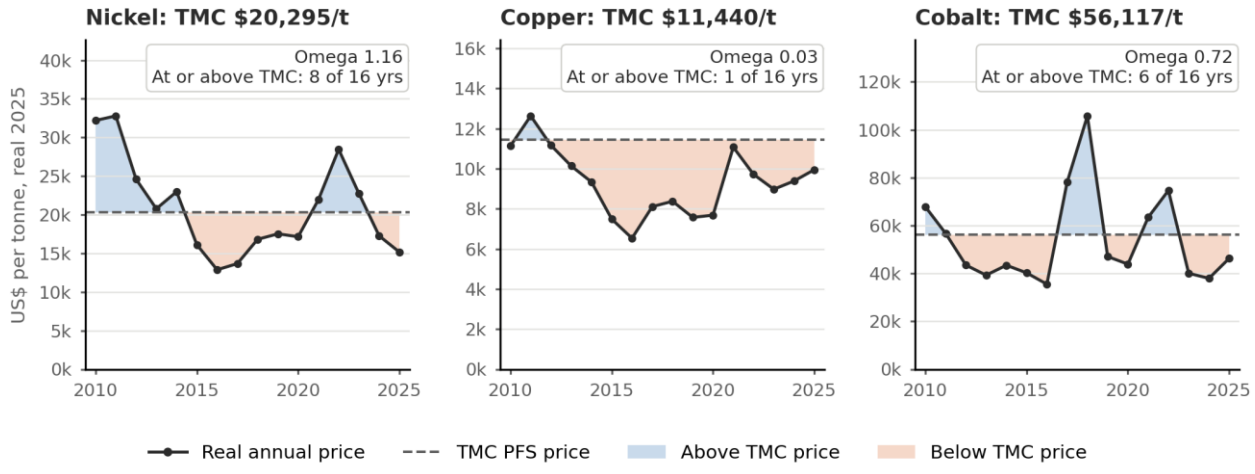

Figure 3. Nickel, copper and cobalt: real annual prices 2010–25 against TMC's PFS price, with the areas above and below it. Omega is the area above divided by the area below. Sources: IMF global prices of nickel and copper (LME basis), FRED series PNICKUSDM and PCOPPUSDM; USGS US spot cathode cobalt price (Minerals Yearbook, Mineral Commodity Summaries); annual averages deflated to 2025 dollars by US CPI-U; TMC price from PFS Table 12.12. Koinon analysis.

Product	Output at 12 Mtpa	US consumption of that form (USGS MCS 2026)	Ceiling: share of output US demand could absorb	Product's share of value per wet tonne
Copper cathode	85 kt Cu	2,200 kt refined, 57% imported; output is about 4%	All	18%
Nickel sulphate	114 kt Ni	US apparent consumption of primary nickel 90 kt (220 kt with scrap); no US refined output since 1985; over 85% used in steels and alloys that do not take sulphate, about 13.5 kt outside them	About 12%	46%
Cobalt sulphate	9.3 kt Co	US apparent consumption 9.6 kt; chemical uses 25%, outside superalloys about 50%	26–51%	10%
Manganese silicate	6.3 Mt (2.7 Mt Mn)	No stated US buyer. US ore-fed demand about 7% of NORI-D's manganese; about 24% if all alloy imports were smelted domestically from silicate (USGS MCS 2026; s.4.4). Model uses 6–12%	6–12%	27%
All products				At most 28–32% of value sold in the US; 47–55% abroad; 17–24% is manganese silicate with no buyer

Table 4. First pass at allocating NORI-D output between US and non-US buyers, by product form. Output at 12 Mtpa wet, 28% moisture, application grades and sulphate-route recoveries. Value shares at TMC prices with all manganese sold. Matte produced before refining begins at Brownsville has no US buyer. Directional; Koinon computation, Appendix C. The ceiling assumes NORI-D displaces all other supply to US buyers of each product form: 12% of NORI-D's nickel sulphate would equal the whole of US nickel demand outside steels and alloys, and 26–51% of its cobalt sulphate the whole of US demand for cobalt chemicals.

The model runs two price regimes, A and B, each as a full Monte Carlo run over all metals together, with manganese treated the same way in both. The results are set out in s.4.5.

4.4 The market for manganese silicate

Manganese silicate is the largest product by weight, about 6.3 Mt a year at 12 Mtpa, and carries about 27% of the value per wet tonne at TMC's prices. It has one use. It is a furnace feed that stands in for manganese ore, or for manganese-rich slag, in the submerged-arc furnaces that make silicomanganese and ferromanganese; those alloys are added to molten steel to remove oxygen and sulphur and to harden it. The application expects upwards of 90% of the silicate to go to silicomanganese producers (s.4.8.5.2). The silicate has no traded price. TMC prices the manganese in it at US$5.45 per dry metric tonne unit, that is per 10 kg of contained manganese, or US$545 per tonne of manganese and about US$229 per tonne of silicate at 42% manganese; the 2025 China ore price was US$4.50 per unit, down 22% on 2024 (USGS).

The market is the smelters' feed. World mine production was about 20 Mt of contained manganese in 2025, led by South Africa (7.6 Mt), Gabon (5.0), Ghana (2.0) and Australia (1.6); world silicomanganese consumption is of the order of 18–22 Mt of alloy a year, of which China supplies 50–60% and India is the second producer, with smaller furnace bases in Norway, Malaysia, Korea, Japan, South Africa, Georgia and Indonesia. NORI-D's 2.7 Mt of manganese a year would be about 13% of world mine supply. The PFS itself records that 2.8 Mt a year "could be challenging to place without impacting pricing" (s.16.4) and names Asia as the target market; the application names no furnace operator who has agreed to take the product.

In the United States there is no market of that size. Apparent consumption was 640 kt of contained manganese in 2025, all imported: about 350 kt of ore, 350 kt of ferromanganese and 310 kt of silicomanganese, with two unnamed companies making the alloys (USGS MCS 2026). The ore-fed demand that silicate could replace is about 7% of NORI-D's manganese; if every tonne of alloy now imported were instead smelted in the United States from silicate, about 24%. The model takes 6–12% as the US ceiling: ore-fed demand at the low end, and at the high end that demand plus a part of the alloy imports. Reaching 24% would require three to five new US furnaces that nobody has proposed, while existing supply is diverse and largely from allies; it is noted here and not modelled.

TMC's evidence that the silicate is usable is a single commission. In 2022 SINTEF Industri of Trondheim, Norway's principal metallurgical research institute and a long-standing adviser to the Norwegian ferroalloy industry, made silicomanganese at kilogram scale using the silicate as the sole manganese source, and ran a value-in-use desk study on TMC's cost inputs. TMC reports a 7–17% higher value in use "depending on carbon tax regimes" and, in the application, a 7–17% cost saving and 24% lower CO_2 for smelter customers (s.4.8.5; Figure 81). The PFS test-work register lists the smelting trial as a "preliminary investigation of suitability" (24 January 2022). Neither report has been published; what exists is TMC's press release of 3 May 2022 and a planned conference paper. The work shows the silicate can make the alloy in a laboratory furnace. It does not show that any furnace will buy 6 Mt a year of it, at what price, or that it qualifies as feed in an industrial furnace, and the economics rest on TMC's own unit costs and a carbon-price assumption.

Manganese is the one product where TMC's price is not above the record. The only traded benchmark is 44% metallurgical ore delivered to China, which USGS reports from CRU. In 2025 dollars it averaged US$6.17 per dry metric tonne unit over 2015–25, with a median of US$5.82 and a range of US$4.18 (2015) to US$9.18 (2018). TMC's US$5.45 sits below that mean, and below the annual price in eight of the eleven years; the IA's US$4.70 is lower still. Koinon does not chart this series against TMC's price as it does for nickel, copper and cobalt, because the comparison would mislead. Those three charts set a forecast against the history of the same product. Here the history is that of ore, a product with buyers in every steelmaking country, and the forecast is for a slag that has none.

The question is therefore not whether US$5.45 is a fair price for manganese units, but what discount to ore a furnace operator would demand for a new feed, of a different mineralogy, from a single untested source, offered in quantities that would move the ore price itself. TMC assumes none: its US$5.45 is a CRU ore forecast applied to the silicate at parity. SINTEF's value-in-use study goes further and argues a premium of 7–17%. That argument is made per tonne of manganese contained. It estimates what a smelter might save per unit if it chose to buy the silicate; it says nothing about how many units any smelter would choose to buy, and a premium per unit on a product without demand is a premium on nothing. The same holds for the claim of 24% lower CO_2. A less carbon-intensive route to a product that no furnace has agreed to take saves no carbon, and the comparison is drawn at the furnace gate: it credits the silicate with avoiding ore pre-reduction without counting the electric-furnace smelting of nodules that produced the silicate in the first place.

What is not sold is waste. The silicate is not the manganese in the nodule but everything the furnace leaves behind: of the 720 kg of dry solids in a wet tonne, some 5–7% is reduced to alloy and the rest, about 0.53 t, reports to the slag as manganese oxide, silica, alumina, lime, magnesia and the residual iron. The application's claim that processing produces no solid waste holds only by naming that slag a product. On the model's saleable shares roughly four fifths of it, about 5 Mt a year, would have no buyer, and 4 Mt a year of slag at a port site is a permitted monofill or stockpile under Texas rules, with dust and leachate control, haulage and closure bonding. Analogous slag and tailings disposal costs run of the order of US$5–20 per tonne, so US$20–80 million a year, and land that fills within a few years. The model charges the unsold tonnes a disposal cost of US$5–20 per tonne of silicate, base US$10, on the Opex sheet, about US$3.6 per wet tonne in the base case, until a Texas benchmark replaces the placeholder.

4.5 Consequence

On TMC's own figures, the cut-off rests on revenue stated as if the nodules were dry, about 36% above its value per wet tonne. Koinon's steps take the value lower still, and Figure 4 traces them in sequence. Converting TMC's printed sulphate figure to a wet basis at the application's grades gives $451. Replacing TMC's prices with the 2010–25 record removes a further $31, most of it copper, for which TMC's price sits above almost the whole of the record (Figure 3). Limiting manganese to what the market can take, with the unsold remainder charged to disposal on the cost side, removes $97. The discount on sales outside the United States, which under regime B falls on 88% of the nickel, half to three quarters of the cobalt and the non-US manganese, removes a further $45.

The median of the model's 10,000 iterations under regime B is $277 per wet tonne; the 10–90% range is $221–352 and the mean $283 (Figure 5). Under regime A, without the discount, the median is about $322, the third stage of Figure 4. Operating cost before capital is $201 per wet tonne (Table 8), so at the median the operating margin is about $76 per wet tonne before any capital is charged; when operating cost is itself drawn with its overrun (Finding 3, Figure 7) the median margin, taken draw by draw, is $50 and it is negative in 18% of iterations.

Figure 6 shows where the value sits. Nickel carries the median at $154 and almost all of the spread, its price being the most volatile of the four; copper gives $65, cobalt $34 and manganese $19. Manganese, 27% of value at TMC's prices with everything sold, is 7% of Koinon's median; its 5–95% range is $9–31 against TMC's $121.

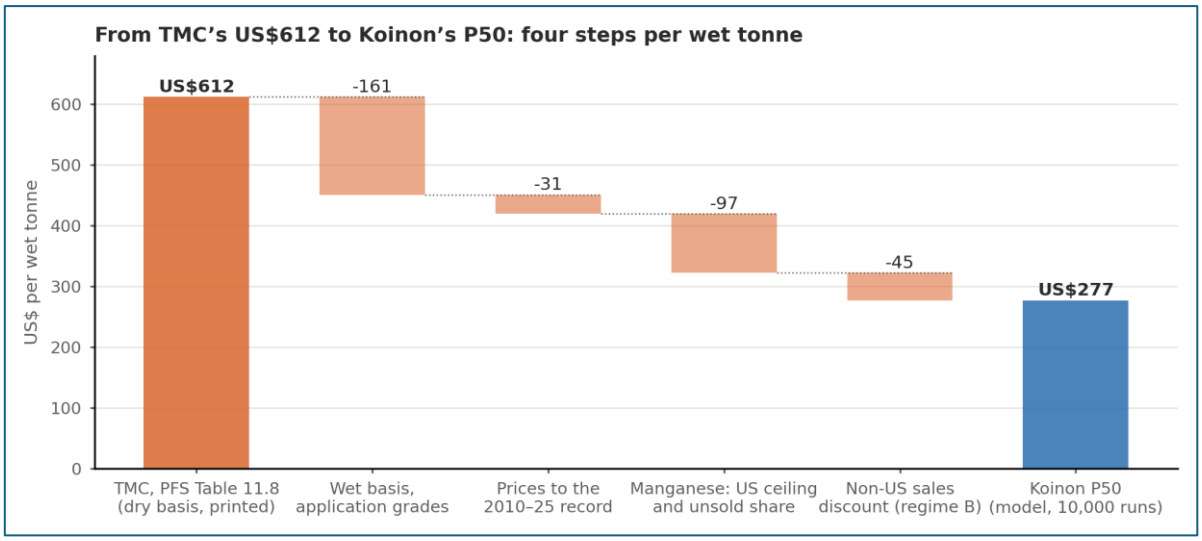

Figure 4. From TMC's printed value to Koinon's median, US$ per wet tonne. Stages: PFS Table 11.8, sulphate route; wet basis at 28% moisture with application Table 5 grades, TMC prices, all output sold; prices at the 2010–25 real record; manganese limited to the US ceiling and the non-US share, the remainder unsold; regime B discount on non-US sales. Stage values are medians taken in sequence in the model's Python cross-check (400,000 draws), which reproduces the ModelRisk median to within $0.3; the final bar is the ModelRisk run (Koinon_NORI-D_UnitEconomics_Model.xlsm, 10,000 iterations). The order matters: the discount taken before the manganese step would carry more of the fall.

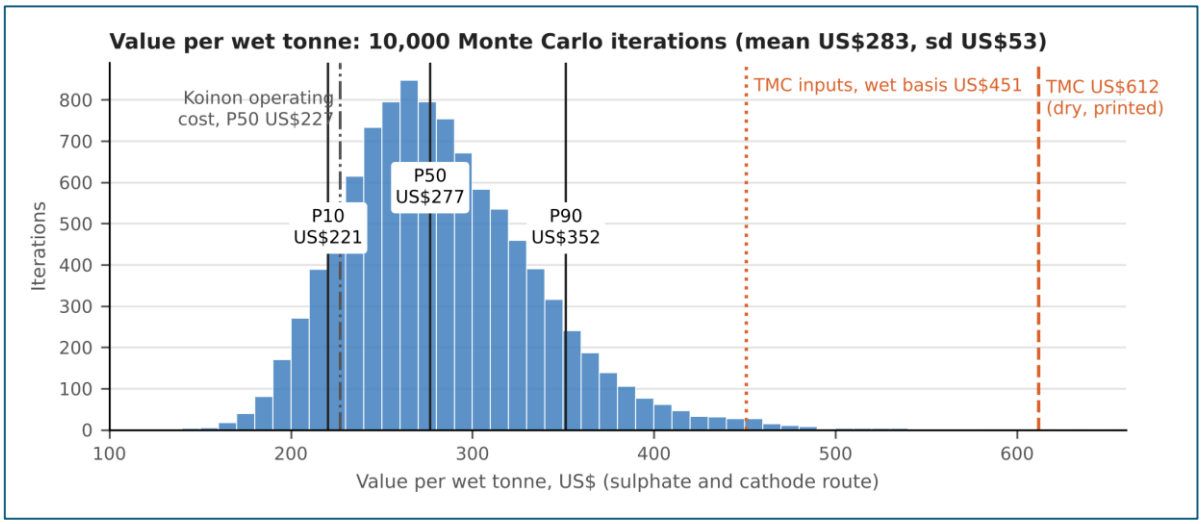

Figure 5. Value per wet tonne, 10,000 iterations, regime B, sulphate and cathode route. Reference lines: TMC's printed $612; TMC's inputs on a wet basis, $451; Koinon operating cost, P50 $227 (Finding 3). Source: Koinon_NORI-D_UnitEconomics_Model.xlsm, sheet SimValues.

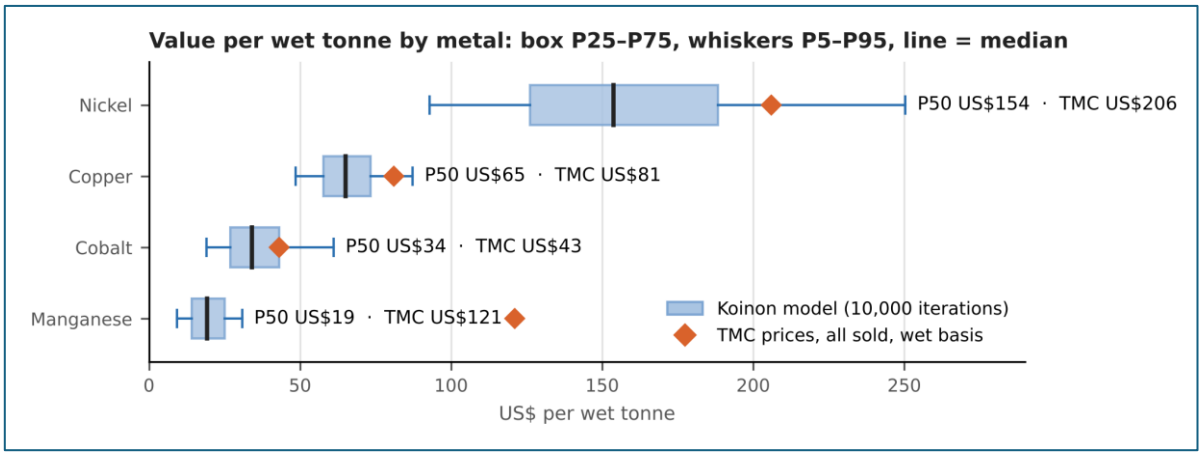

Figure 6. Value per wet tonne by metal, same run: box P25–P75, whiskers P5–P95, line at the median; diamonds mark TMC's prices with all output sold, wet basis. Source: as Figure 5.

5. Finding 3 — At the declared cut-off the collector loses money

Claim. TMC's cut-off test sets the hourly cost of the PFS's first-generation collector against the sweep rate of the IA's second-generation collector. Rebuilt on the application's own collector, seabed at 4 kg/m² loses about $23,000–34,000 per collector-hour, even with TMC's grades and prices.

5.1 TMC's breakeven method

The test finds the abundance at which an hour of collection earns as much as it costs: breakeven abundance equals cost per hour divided by revenue per tonne times the area swept per hour. Capital is excluded (PFS s.11.8).

The cost per tonne in the test, $188 per wet tonne, is not the PFS's own figure for NORI-D. It is the IA's life-of-mine operating cost for NORI A–C and TOML with second-generation systems (IA Table 18.7, $188.3), which the PFS adopts for its cut-off on the ground that most of the NORI-D resource would be mined in that later period. The PFS's own NORI-D figure is $243.6 (Table 18.14).

On TMC's figures the second-generation system both sweeps more seabed and costs less. It sweeps 33,660 m² an hour against 21,600. Excluding the capital that both documents carry inside operating cost, the recovery of production-system capital (PFS Table 18.15, $29.1 per wet tonne; IA Table 18.8, $20.6) and the capital element of the toll fee (PFS Table 15.4), it costs $150.7 per wet tonne against $196.8 for NORI-D,

about 23% less. Koinon takes the PFS figure for NORI-D as its base, in line with the order of authority, strips all capital from it to carry it over into Finding 4, and treats remaining operating cost as uncertain in the model.

Neither system has been built. A 6 m prototype, 40% of the production width, was field-tested in 2022, collecting 4,500 t and lifting 3,000 t in about 35 hours (Application s.2.1.5). The PFS records that the production collector's design has not been finalised and that its productivity, recovery, speed and availability have not been determined. The second generation exists only as a specification in the IA, whose operating costs are prepared to AACE Class 5.

5.2 Two collectors in one calculation

Figure in the cut-off test	Decomposition	Collector
PFS $50,584 per hour	188 × (21,600 × 0.77 × 17 × 0.95) = 188 × 269 t/hr	First generation: 15 m, 0.4 m/s, 1.5 Mtpa (Application s.4.4.6.1)
IA $61,339 per hour	188 × 326 t/hr; 1.8 Mtpa over 5,584 hours	Second generation (IA)
33,660 m² per hour	20 m × 0.55 m/s × 3,600 × 85%	Second generation (IA Table 13.12)

Table 5. The inputs to TMC's cut-off tests and the collectors they belong to. The hourly costs are printed in PFS Table 11.8 and IA Table 11.16; the decompositions are Koinon's.

The two TMC tests are not two estimates of the same thing. The IA's higher cost per hour buys 21% more tonnes per hour at the same $188 per tonne, so its hourly cost rises with its assumed throughput while its value per tonne differs by area. Table 6 sets each test out per hour and per tonne, with Koinon's rebuild on the application's collector beside them. The two Koinon rebuild rows are still TMC's own inputs, converted to the wet basis with capital taken out of operating cost; they are not Koinon's conclusion. The last row gives the medians of the Monte Carlo of Findings 2 and 3, in which the value per tonne falls from $451 to $277 (the 2010–25 price record, the manganese treatment and the non-US discount) and the cost rises from $197 to $227 (the operating-cost overrun and the lower availability). The hour's surplus shrinks from $254 to $50 per tonne.

Source and case	Cost per hour, US$	Tonnes per hour	Value per hour, US$	Cost per tonne, US$	Value per tonne, US$	Surplus per tonne, US$
PFS Table 11.8: first-generation cost, sulphate route	50,584	269	164,700	188	612	424
IA Table 11.16: second-generation cost, TOML-F	61,339	326	159,200	188	488	300
Koinon: application collector, wet basis, sulphate route, at 17 kg/m²	52,900	269	121,200	196.8	451	254
Koinon: the same at the 4 kg/m² cut-off	52,900	63	28,500	836	451	−385
Koinon: Monte Carlo medians, regime B (Findings 2 and 3)	63,000	266	73,600	227	277	50

Table 6. TMC's cut-off tests per hour and per tonne, and Koinon's rebuild. TMC tonnes per hour are cost per hour divided by cost per tonne; value per hour is value per tonne times tonnes per hour. IA values range from $430 to $517 by area; TOML-F is shown. TMC values are as printed, on the dry basis discussed in Finding 2; Koinon's are wet. Koinon's cost per hour is held fixed, so cost per tonne rises as abundance falls. The last row shows the median of each column separately, so the columns do not multiply exactly across; its cost per hour exceeds the rebuild's because the same annual cost is spread over fewer collecting hours.

The 5,584 hours are productive collecting hours: 8,760 × 75% availability × 85% field efficiency (IA Table 13.3), about 15 hours a day. The application gives its own figure in Table 30: 6,545 production hours a year at steady state, after downtime of 25% for weather, maintenance and repairs, or about 5,560 collecting hours

at 85% field efficiency. Years 1 to 3 are lower, at 4,000 to 6,000 hours, and drydocking every tenth year halves that year. Collection at 4,000 m is unaffected by daylight, and round-the-clock operation is normal for dynamically positioned offshore vessels. The binding uncertainty is availability: 75% is assumed, and the 2022 test, about 35 hours of lifting, does not demonstrate it. The model treats availability as uncertain.

5.3 The test on the application's own collector

Operating cost basis	Manganese	Surplus per hour at 17.4 kg/m², US$	Surplus per hour at 4 kg/m², US$	Breakeven, wet kg/m²
$188/wmt (IA Table 18.7, used in PFS Table 11.8)	All sold	+69,900	−22,800	7.3
$196.8/wmt (PFS Table 18.14, all capital removed; Table 8)	All sold	+67,500	−25,200	7.6
$201.0/wmt (as above, plus disposal of unsold silicate)	6% US, 15% non-US, rest to disposal	+34,600	−33,600	10.6
Koinon Monte Carlo, medians of 10,000 iterations (Findings 2 and 3; s.5.4)	Regime B: 6–12% US by Bernoulli trial, 5–25% non-US, rest to disposal	+10,600	−46,000	14.9

Table 7. Operating surplus per collector-hour on the application's grades, prices, recoveries and collector, with collector recovery weighted by nodule type (74.8%) and all output valued on the sulphate and cathode route, the most generous to TMC (Figure 2). Manganese at TMC's price in the first three rows; the third row applies Koinon's saleable shares and charges the unsold silicate to disposal. The fourth row replaces TMC's inputs with the distributions of Findings 2 and 3: value falls to a median of $277 per wet tonne and cost rises to $227, and the breakeven moves from 10.6 to 14.9 wet kg/m². All rows are before capital, freight and sales costs. Koinon computation; Appendix D.

PFS Table 18.14 gives NORI-D's life-of-mine operating cost by component; Table 8 reproduces it with Table 18.13's totals, Koinon's adjusted figure and its treatment of each line. Two lines carry capital inside operating cost. Collection includes $29.1 per wet tonne to recover the capital of production systems 2–4 (Table 18.15). Processing is entirely toll charges to PAMCO and Indonesian smelters (Table 18.19), and the PFS states that the toll fee includes the processor's capital recovery (s.12).

PFS operating cost component	LOM US$m (Table 18.13)	PFS US$/wmt (Table 18.14)	Koinon US$/wmt	Koinon treatment
Collection	12,343.6	75.2	46.1	Capital recovery for production systems 2–4, $29.1 (Table 18.15), removed and charged as capital at cost in Finding 4, following the CCZ model. Vessels, support and supply kept.
Transfer and shipping	3,070.7	18.7	18.7	Kept pending re-base from the PFS route (CCZ to Indonesia and Japan) to the application's CCZ–Brownsville route (Koinon freight extract).
Contractor (offshore)	1,855.1	11.3	11.3	Kept; operating-cost overrun applies.
Consumables (offshore fuel)	3,848.3	23.4	23.4	Kept; operating-cost overrun applies.
Processing	13,621.8	83.0	65.4	Toll fee of $79.95 per wet tonne (PFS Table 15.4) includes depreciation $6.56, capital modification recovery $3.85 and toll profit $6.57. These are removed in proportion, 21%, leaving an owner's operating cost at Indonesian input costs; US power and labour are likely dearer. Smelter capital charged in Finding 4.
Refining	3,253.7	19.8	19.8	Kept for the TMC-owned refineries; operating-cost overrun applies.
Corporate	1,984.6	12.1	12.1	Kept.

PFS operating cost component	LOM US$m (Table 18.13)	PFS US$/wmt (Table 18.14)	Koinon US$/wmt	Koinon treatment
Disposal of unsold silicate	—	—	4.2	Not in the PFS, which treats all silicate as product. Unsold share × silicate mass (about 0.53 t per wet tonne) × US$5–20 per tonne of silicate; base US$10. Koinon placeholder pending a Texas monofill benchmark.
Total	39,977.8	243.6	201.0	Operating cost only, including disposal. All capital is charged in Finding 4.

Table 8. NORI-D operating cost in the PFS and Koinon's treatment of each line. Sources: PFS Tables 18.13, 18.14, 18.15 and 18.19; s.12.

The result does not depend on whether TMC's revenue figures are dry or wet: the hourly cost was built at 17 kg/m², so the sweep rate cancels and breakeven abundance equals 17 times cost per tonne divided by revenue per tonne.

5.4 Koinon's assessment

Collector recovery is weighted by nodule type: 77% for Type 1 and 62% for Types 2 and 3 (Application Table 37, note 8). Neither the application nor the PFS states the split over the 202.5 Mt mine plan. The PFS's 287 NORI-D box cores give a proxy: 239 typical of Type 1, 28 dominated by Types 2 and 3 and 20 mixed, which weights recovery to about 75%.

Before the hourly test, the two distributions can be set side by side per tonne. Figure 7 places the value per wet tonne from Finding 2 against operating cost per wet tonne, the PFS base of Table 8 with the overrun multiplier applied to the operating lines. The median cost is $227 and its 10–90% range $195–266; TMC's $188 sits below the sixth percentile. The median operating surplus, taken draw by draw, is $50 per wet tonne, before capital, freight and sales costs; taken iteration by iteration the surplus has a 10–90% range of −$19 to $130 and is negative in 18% of draws. The two boxes overlap between $220 and $265: in that band a tonne is worth no more than it costs to recover and process, with nothing yet charged for the capital of Finding 4.

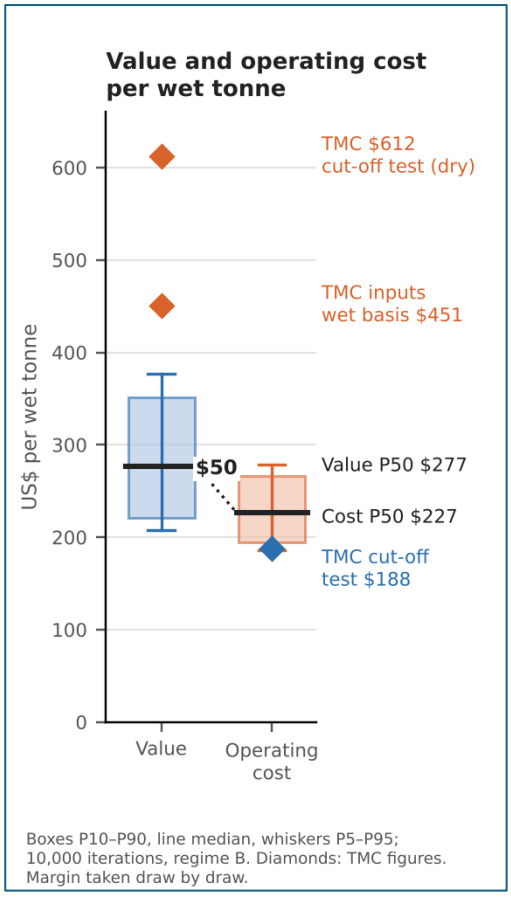

Figure 7. Value and operating cost per wet tonne, 10,000 iterations, regime B. Boxes P10–P90, line at the median, whiskers P5–P95; diamonds mark TMC's figures: $612 (PFS Table 11.8, dry basis), $451 (TMC's inputs on a wet basis, all output sold) and $188 (operating cost in TMC's cut-off tests). Operating cost includes the overrun multiplier (lognormal, mean 1.15, as in Koinon's CCZ model) on all lines except corporate. The gap between the boxes is not the median margin, which is taken draw by draw in the text. Source: Koinon_NORI-D_UnitEconomics_Model.xlsm, sheet SimValues.

The per-hour test gives the same answer as a distribution. Breakeven abundance, the point at which an hour's value covers an hour's operating cost, has a median of 14.9 wet kg/m² over 10,000 iterations, a 10–90% range of 11.1–19.9 and a 5–95% range of 10.2–21.5; the deterministic base case of Table 7 is 10.6. No iteration brings it below 4 kg/m², so the probability of a positive operating surplus on seabed at the declared cut-off is nil in all 10,000 iterations. The move from TMC's 2.5 to Koinon's 15 has three parts of comparable weight: the collector, since the application's machine sweeps about 15,300 m² of effective area an hour against the 33,660 in TMC's test (a factor of 2.2); value per wet tonne, TMC's printed figure against Koinon's median of $277 (also 2.2); and cost per hour, up by about a fifth with the overrun and availability draws.

5.5 Consequence for the resource

A cut-off is a reporting device until it is set against the field. TMC supplies the field itself: PFS Figure 11.29 gives the share of the NORI-D resource that lies in 3.5 km panels at or above each cut-off, and records that no panel is below 12 wet kg/m². The declared 4 kg/m² therefore never binds; it was derived to satisfy the resource definition and the mine plan then uses a zero cut-off (PFS s.12.5). The field is tight: 100% of the 363 Mt sits in panels above 13 kg/m², 91% above 15, 61% above 17, 23% above 19 and nothing above 24; half the resource lies in panels below about 17.6.

Two further readings follow from the curve. The first asks how much of the resource fails the hour's test. Each iteration has its own breakeven, and reading the curve at that breakeven gives the share of the resource lying in panels below it. Averaged over the 10,000 iterations, that share is 26%: a tonne taken at random from NORI-D has about a one-in-four chance of lying in a panel that does not pay for its hour. The second asks how often the average panel fails. In 25% of iterations the breakeven is above 17.4 kg/m², the field's mean abundance; in those iterations the typical panel, not only the thin ones, does not cover its hour's cost. Two cautions apply. The curve is drawn at panel scale, which averages out the variation inside each panel; the 1,200 m and 4,800 m mining blocks of the mine plan are more varied, so the share below breakeven at block scale is higher than the curve shows. And the breakeven carries the operating-cost overrun that is still a placeholder.

TMC's own documents place a second threshold in the same band. The collector was sized to deliver 1.5 Mt a year at 17 kg/m² and 0.4 m/s; its speed can rise to 0.5 m/s at most, so the PFS states that 0.4/0.5 × 17 = 13.6 kg/m² is "the minimum average abundance on which production targets can be maintained" (PFS s.13). Below that, the tonnes per year fall short, and every cost fixed by the year rather than by the hour, the Brownsville plant, corporate cost, the capital of four offshore systems and the plant, and the return the financing requires, rises per tonne. The 4 kg/m² test contains none of these; the 13.6 is where TMC's own plan begins to fail to earn them.

Koinon's median operating breakeven sits a little above it. But the capital-inclusive breakeven of Finding 4, at a median of 29.2 kg/m² (Figure 8, purple), sits above every panel in the field, as it does in 81% of iterations.

The consequence for the reserve is therefore not that a large, defined fraction falls away at a new cut-off, but that the whole of NORI-D lies within a few kilograms per square metre of the point at which an hour stops paying for itself, with nothing yet charged for capital. The reserve note's treatment of the resource-to-reserve conversion is read in that light.

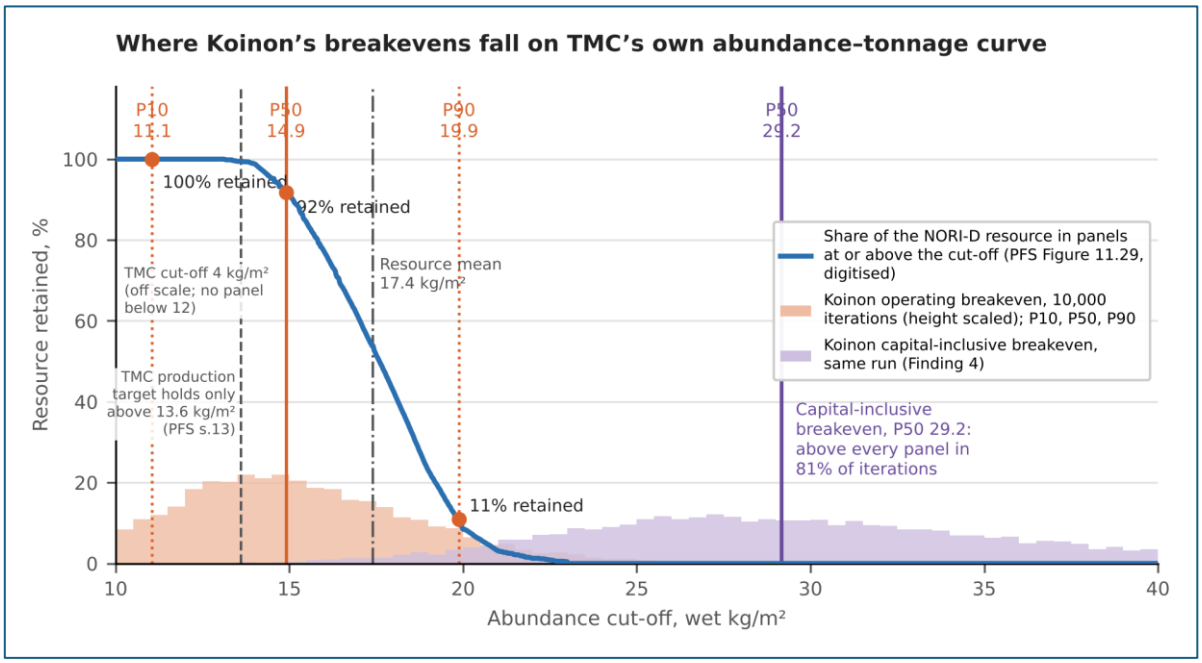

Figure 8. Koinon's breakevens set against TMC's abundance–tonnage curve. Blue: share of the NORI-D resource in 3.5 km panels at or above each cut-off, digitised from PFS Figure 11.29 (no panel below 12 kg/m²). Orange: distribution of breakeven abundance over 10,000 iterations (height scaled), with P10, P50 and P90 marked and the share of the resource retained at each. Dashed grey: TMC's 13.6 kg/m² throughput floor (PFS s.13) and the resource mean of 17.4. TMC's declared cut-off of 4 is off the scale. Purple: the capital-inclusive breakeven of Finding 4, same run, with its median. Both breakevens are outputs of the model run (Koinon_NORI-D_UnitEconomics_Model.xlsm, sheet SimValues).

6. Finding 4 — The surplus cannot carry the capital

Claim. Charged per wet tonne at full scale, the capital for the offshore systems, smelter and refineries, with overruns, exceeds the operating surplus per wet tonne in 98% of iterations. The project needs about US$25bn; the surplus can carry about US$5bn; the difference, capital at risk, has a median of US$19bn.

6.1 Capital in the record

- **Offshore:** production system #1, PFS $544.8m net of the Allseas credit. Systems 2–4, US$1,454.2m each, US$4,362.6m in all, which the PFS recovers through operating cost with a 10% uplift (US$1,599.6m each, Table 18.15). Following the CCZ model, Koinon treats them as capital at their cost.
- **Refining:** two US refineries in the PFS, US$2,213m each, US$4,426m in all (Table 18.2).
- **Smelting:** the RKEF smelter and converters the application moves to Brownsville. The PFS assumed toll treatment in Indonesia and Japan and costed no smelter; the application costs none. Koinon's directional estimate is US$2.45–3.65bn for the smelter, US$6.9–8.1bn for the integrated plant (security note, Appendix C).
- **Sustaining and closure:** US$1,550m and US$115m (PFS).
- **Overruns:** lognormal capital multipliers from the CCZ model, mean 1.88 for offshore systems and 1.45 for onshore plant, consistent with megaproject norms.

6.2 The capital charge per wet tonne

Capital is converted to a charge per wet tonne without a cash-flow model. A capital recovery factor turns a lump sum into the level annual payment that repays it with interest over n years; at TMC's own 8% discount rate and 19-year life (PFS s.19) the factor is 0.104. The annual payment is divided by the wet tonnes the collectors deliver, 12 Mt a year at design, scaled in each draw by the availability and collector recovery drawn in Finding 3. The same factor run the other way gives the capital the surplus can carry: the operating surplus per tonne times tonnes, divided by the factor, is the present value of everything the surplus could ever repay. Three quantities follow, each computed draw by draw and reported at the same percentiles:

capital required, the capital cost after overrun and interest during construction; capital carried, the present value of the operating surplus at the same rate and life; and capital at risk, the excess of capital required over capital carried in that draw, nil where the surplus covers it. Because each is a distribution of its own, the median of capital at risk need not equal the difference between the other two medians. Interest during construction is added over a three-year build for the offshore systems and a five-year build for the Brownsville plant. Ramp-up years, tax and financing cost above the single rate are left out; all three favour TMC. The arithmetic is on the Capital sheet of the model.

6.3 Koinon's assessment

Each model draw is one set of per-tonne conditions: prices, manganese sales, US and non-US allocation and discount, collector recovery, availability, operating cost, the smelter estimate and the two capital overrun multipliers. For each draw the model computes the capital required, the charge per tonne, the residual after operating cost and capital, the capital the surplus can carry and the capital at risk. The result stays per tonne and per annuity; no project cash flow is built.

Capital required has a median of US$24.6bn (10–90% range US$19.2–31.9bn), against US$14.0bn with the same items at TMC's figures and US$6.6bn in the PFS's capital table. About US$7.4bn of the difference is reclassification, systems 2–4 and the smelter brought into capital from operating cost and toll charges; the rest is the overrun multipliers and interest during construction. The charge per wet tonne has a median of US$229 (US$176–300), more than four times the median operating surplus of US$50. The residual after operating cost and capital is therefore negative at the median, −US$181 per wet tonne, and positive in 1.5% of iterations.

Figure 9 puts the two sides of the capital test against each other. The capital the surplus can carry has a median of US$5.4bn; in 18% of iterations the surplus is negative and it carries nothing; its P90 is US$14.1bn, still below the P10 of capital required. Capital at risk, the gap, has a median of US$19.2bn and a 10–90% range of US$9.1–28.1bn; the share of capital recoverable from operations is 21% at the median and above 50% in one iteration in six. Read as a cut-off, the capital-inclusive breakeven abundance, the point at which an hour pays for its capital as well as its operating cost, has a median of 29.2 kg/m² (P10 21.9), beyond the highest panel in NORI-D (Figure 8); in 81% of iterations the field cannot carry the plant that is to process it at any abundance it contains.

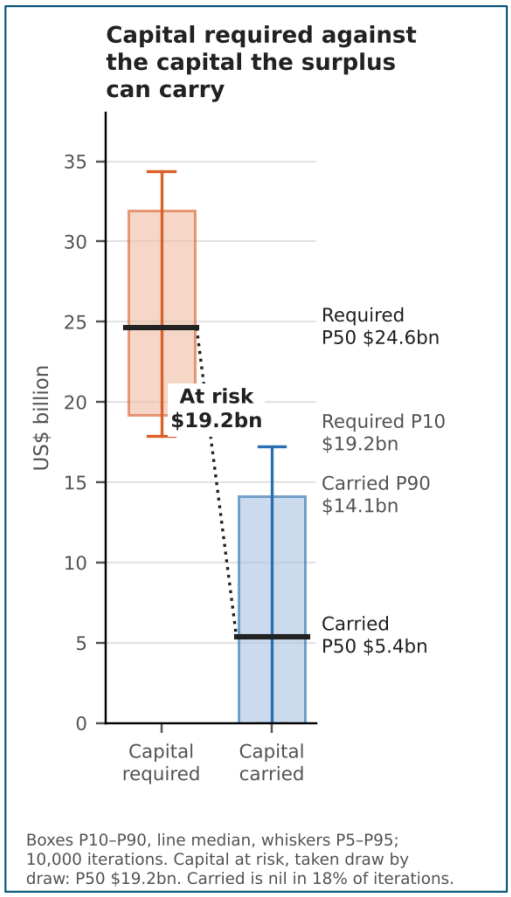

Figure 9. Capital required against the capital the operating surplus can carry, US$bn, 10,000 iterations. Boxes P10–P90, line at the median, whiskers P5–P95. Capital required: offshore systems, refineries and smelter after overrun and interest during construction, with sustaining and closure. Capital carried: the operating surplus annuitised at 8% over 19 years. Capital at risk is taken draw by draw, so its median need not equal the gap between the two medians. Source: Koinon_NORI-D_UnitEconomics_Model.xlsm, sheet SimValues.

The overrun multipliers follow Koinon's CCZ model. The smelter estimate is Koinon's own, since the application leaves the smelter uncosted. Neither changes the sign of the result: with the overrun multipliers set to one, capital at risk is still US$6.6bn in the deterministic base case.

7. Finding 5 — The gap is a call on public money

Claim. The onshore plant is to be financed about 30% by equity and 70% by debt and government incentives, about US$9bn on Koinon's capital figures. The operating surplus falls short of servicing that debt in 73% of iterations; the expected loss to lenders is US$4.5bn, nearly half the debt. Public support on these terms is not a bridge to a profitable operation but a grant covering the difference between what the nodules earn and what the plant cost.

7.1 What the application says

Section 7.4.3 of the application states that the onshore facility is to be financed through "a blended finance package of private equity, commercial debt, and public support", with "~30 % equity and ~70 % as debt and government incentives". Equity is to include "up to approximately $750 million" from TMC USA's parent, the rest from partners including Glencore. "No party is currently obligated to provide financing to the project." No capital figure is given, so the 70% has no amount.

7.2 Debt service against the surplus

The application gives the structure but no amount. Applied to Koinon's onshore capital after overrun and interest during construction, 70% is a median US$8.8bn (10–90% US$6.0–13.0bn). At 7% over 15 years that debt requires US$0.96bn a year. The operating surplus, value less operating cost times the tonnes delivered, has a median of US$0.56bn a year, a P10 of −US$0.21bn and a P90 of US$1.47bn (Figure 10). Compared draw by draw, the surplus is below debt service in 73% of iterations. Because every year is the same year in this method, a shortfall is not a timing problem that a grace period cures but a permanent one: the plant cannot earn its own debt service from the nodules at the prices, recoveries and costs drawn.

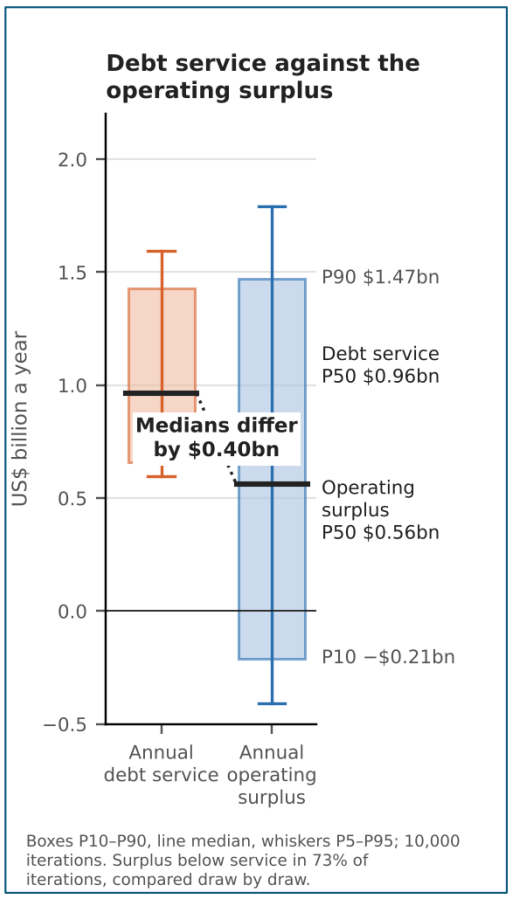

Figure 10. Annual debt service on the debt-and-incentives tranche against the annual operating surplus, US$bn a year, 10,000 iterations. Boxes P10–P90, line at the median, whiskers P5–P95. Debt = 70% of onshore capital after overrun and IDC; service at 7% over 15 years; surplus = (value − operating cost) × tonnes delivered. Source: Koinon_NORI-D_UnitEconomics_Model.xlsm, sheet SimValues.

7.3 The chance that public money is not repaid

Debt is repaid before equity, so lenders lose only what the surplus cannot cover over the tenor. The loss to lenders is nil in 27% of iterations, US$4.0bn at the median, US$10.2bn at P90 and US$4.5bn on average, 49% of the debt. The application does not say how much of the 70% tranche is government incentive rather than commercial debt; taking public money as 50–70% of onshore capital, the public share of the expected loss is US$3.2–4.5bn, against gross public exposure at face of US$6.3–8.8bn at the median. Public money is counted on the onshore plant only, as the application describes it; if public lenders or guarantors also back the offshore systems, the liability is larger. Expressed as a subsidy rate, the expected loss on the tranche is 49%: for every dollar of public money lent or guaranteed on the application's own structure, about 49 cents would not come back from the operation. The equity, including the parent's up to US$750m, stands behind the debt and is lost first.

8. Questions NOAA could put to the applicant

- The workings behind PFS Table 11.8 and IA Table 11.16, including whether moisture was applied to revenue per wet tonne (Finding 2).
- The SINTEF smelting trial and value-in-use study on manganese silicate, in full, with the cost and carbon-price inputs supplied by TMC; and any furnace operator that has agreed to take the silicate, in what quantity and on what terms (Finding 2).
- The disposal plan, permit route and cost for manganese silicate that is not sold, given that the material is about half the wet tonnage processed (Finding 2).
- The collector, hourly cost and sweep rate on which the 4 kg/m² cut-off for NORI-D rests, and the cut-off that results on the collector proposed in the application; and the abundance–tonnage curve of PFS Figure 11.29 at mining-block scale, with the tonnage in each block of the mine plan (Finding 3).
- Revenue, operating cost and margin per wet tonne for the route mix in Table 44, with the share of output expected to be sold outside the United States and at what price (Findings 2 and 3).
- How the capital of production systems 2–4 is to be financed and recovered (Finding 4).
- The split of the mine plan between Type 1 and Types 2 and 3 nodules, by year (Finding 3).
- Capital cost for the Brownsville facility by stage, and the amount and source of each tranche of funding (Findings 4 and 5).

Appendix A. Input register and contradiction log

Every input in the model is listed below as it stands in the Inputs sheet of Koinon_NORI-D_UnitEconomics_Model.xlsm, with its source in the order of authority used throughout: application first, PFS second, IA third, Koinon where none of the three supplies the figure. “Approved 16 Oct 2026” marks Koinon judgments confirmed for the published run; “PLACEHOLDER” marks the inputs that remain Koinon’s judgment pending a better source; each is also flagged in the sheet. Values are the base case; the distributions drawn around them are in Appendix C. The inputs for the security benefit and fiscal cost (Inputs rows 133–149) are set out in the mineral security note.

ID	Parameter	Value	Unit	Source · reference	Status
	Switches				
MC_On	Monte Carlo on (1) / base case (0)	1	switch	Koinon	
Regime	Price regime: 1 = A (historical record, constant real prices); 2 = B (A plus discount on non-US sales)	2	switch	Koinon · Note s.4.3	
PriceSrc	Price source: 1 = TMC PFS prices; 2 = Koinon historical distribution	2	switch	Koinon	
	Nodule				
Moist	Moisture content, wet basis	28%	fraction	Application · s.6.2.1; Table 5 note 2	
g_Ni	Nickel grade, dry	1.4%	fraction	Application · Table 5, All	
g_Cu	Copper grade, dry	1.1%	fraction	Application · Table 5, All	
g_Co	Cobalt grade, dry	0.1%	fraction	Application · Table 5, All	
g_Mn	Manganese grade, dry	31.1%	fraction	Application · Table 5, All	

ID	Parameter	Value	Unit	Source · reference	Status
gr_Ni	Nickel grade, PFS reserve (for TMC check)	1.4%	fraction	PFS · Reserve statement; Table 37	
gr_Cu	Copper grade, PFS reserve	1.1%	fraction	PFS · Table 37	
gr_Co	Cobalt grade, PFS reserve	0.1%	fraction	PFS · Table 37	
gr_Mn	Manganese grade, PFS reserve	31%	fraction	PFS · Table 37	
Abund	Resource mean abundance, NORI-D	17.4	wet kg/m²	Application · Table 5, All	
Cutoff	Declared abundance cut-off	4	wet kg/m²	Application · Tables 5–6, 36–38	
AbundUser	Abundance for the user case	10	wet kg/m²	Koinon	
Design	Design abundance behind TMC's hourly cost	17	wet kg/m²	Application · s.4.4.6.1	
	Recoveries and payables — sulphate and cathode route (most generous to TMC; Note Figure 2)				
rec_Ni	Nickel recovery to sulphate	94.6%	fraction	Application · Table 37 note 9; PFS Table 16.2	
rec_Cu	Copper recovery to cathode	86.2%	fraction	Application · Table 37 note 9	
rec_Co	Cobalt recovery to sulphate	77.2%	fraction	Application · Table 37 note 9	
rec_Mn	Manganese recovery to silicate	98.9%	fraction	Application · Table 37 note 9	
pay_S	Payable, sulphate and cathode	100%	fraction	PFS · Table 12.12	
pay_Mn	Payable, manganese in silicate	100%	fraction	PFS · Table 12.12	
	Prices — TMC				
pT_Ni	Nickel in sulphate, PFS LOM average	21,633	US$/t Ni	Application · Table 37 note 7; PFS Table 1.8	
pT_Cu	Copper cathode, PFS LOM average	11,440	US$/t	Application · Table 37 note 7	
pT_Co	Cobalt in sulphate, PFS LOM average	55,198	US$/t Co	Application · Table 37 note 7	
pT_Mn	Manganese in silicate (US$5.45/dmtu)	545	US$/t Mn	Application · Table 37 note 7; PFS Table 16.1	
	Prices — Koinon historical record, real 2025, annual averages 2010–25				
pH_Ni_m	Nickel, mean	20,816	US$/t	Koinon · IMF/FRED PNICKUSDM; CPI-U	
pH_Ni_s	Nickel, standard deviation	6,200	US$/t	Koinon · as above	
pH_Cu_m	Copper, mean	9,326	US$/t	Koinon · IMF/FRED PCOPPUSDM; CPI-U	
pH_Cu_s	Copper, standard deviation	1,659	US$/t	Koinon · as above	

ID	Parameter	Value	Unit	Source · reference	Status
pH_Co_m	Cobalt, mean	53,989	US$/t	Koinon · USGS spot cathode; CPI-U	
pH_Co_s	Cobalt, standard deviation	19,342	US$/t	Koinon · as above	
	Price regime B — Koinon				
dMin	Regime B: discount on non-US sales, minimum	10%	fraction of price	Koinon · Note s.4.3; security note s.5.6	Approved 16 Oct 2026
dMode	Regime B: discount, most likely	20%	fraction of price	Koinon	Approved 16 Oct 2026
dMax	Regime B: discount, maximum	40%	fraction of price	Koinon	Approved 16 Oct 2026
	US market ceilings — share of NORI-D output US demand could absorb (Note Table 4)				
us_Ni	Nickel sulphate: US demand outside steels and alloys ÷ output	12%	fraction	USGS MCS 2026 · Nickel chapter	
us_Cu	Copper cathode	100%	fraction	USGS MCS 2026 · Copper chapter	
us_Co_lo	Cobalt sulphate: chemical uses only	26%	fraction	USGS MCS 2026 · Cobalt chapter	
us_Co_hi	Cobalt sulphate: all uses outside superalloys	51%	fraction	USGS MCS 2026 · Cobalt chapter	
us_Mn_lo	Manganese silicate: US ceiling, low = ore-fed demand	6%	fraction	USGS MCS 2026 · Manganese chapter; Note s.4.4	
us_Mn_hi	Manganese silicate: US ceiling, high = ore plus all alloy imports smelted domestically	12%	fraction	USGS MCS 2026 · Manganese chapter; Note s.4.4	
mnP	Probability NORI-D wins the US silico-manganese market	50%	probability	Koinon · Note s.4.3	Approved 16 Oct 2026
nuMn_min	Manganese silicate sold outside the US: minimum share of output	5%	fraction	Koinon · Note s.4.3	Approved 16 Oct 2026
nuMn_mode	Manganese silicate sold outside the US: most likely share	15%	fraction	Koinon · Note s.4.3	Approved 16 Oct 2026
nuMn_max	Manganese silicate sold outside the US: maximum share	25%	fraction	Koinon · Note s.4.3	Approved 16 Oct 2026
sil_Mn	Manganese content of the silicate	42%	fraction	PFS · Mn silicate product specification	
disp_min	Disposal cost of unsold silicate, minimum	5	US$/t silicate	Koinon · Note s.4.4	Approved 16 Oct 2026
disp_mode	Disposal cost of unsold silicate, most likely	10	US$/t silicate	Koinon	Approved 16 Oct 2026
disp_max	Disposal cost of unsold silicate, maximum	20	US$/t silicate	Koinon	Approved 16 Oct 2026
	Collector — application				
Width	Collector width	15	m	Application · s.4.4.6.1	
Speed	Nominal collecting speed	0.40	m/s	Application · s.4.4.6.2	

ID	Parameter	Value	Unit	Source · reference	Status
FE	Field efficiency	85%	fraction	Application · s.4.4.6.1; Table 30	
Avail	Availability (share of calendar hours in production)	75%	fraction	Application · s.4.4.6.1; Table 30 (25% downtime at steady state)	
Buffer	Planning buffer	5%	fraction	Application · s.4.4.6.1	
r1	Collector recovery, Type 1 nodules	77%	fraction	Application · Table 37 note 8	
r23	Collector recovery, Types 2 and 3	62%	fraction	Application · Table 37 note 8	
t1Min	Share of Type 1 in the mine plan, minimum	70%	fraction	Koinon · Note s.5.4	
t1Mode	Share of Type 1, most likely	85%	fraction	Koinon	
t1Max	Share of Type 1, maximum	90%	fraction	Koinon	
avMin	Availability, minimum	55%	fraction	Koinon · Note s.5.1	Approved 16 Oct 2026
avMax	Availability, maximum	80%	fraction	Koinon	Approved 16 Oct 2026
Hours	Calendar hours per year	8,760	h	—	
	Operating cost — PFS Table 18.14 and Koinon treatment (Note Table 8)				
ox_coll	Collection, PFS	75.2	US$/wmt	PFS · Table 18.14	
ox_coll_cap	of which capital recovery, systems 2–4	29.1	US$/wmt	PFS · Table 18.15	
ox_ship	Transfer and shipping, PFS	18.7	US$/wmt	PFS · Table 18.14	
ox_ship_k	Transfer and shipping, Koinon (CCZ–Brownsville)	18.7	US$/wmt	Koinon · Freight extract v1.7	PLACEHOLDER
ox_contr	Contractor (offshore)	11.3	US$/wmt	PFS · Table 18.14	
ox_fuel	Consumables (offshore fuel)	23.4	US$/wmt	PFS · Table 18.14	
ox_proc	Processing (toll charges), PFS	83	US$/wmt	PFS · Table 18.14; 18.19	
toll	Indonesian toll fee	80.0	US$/wmt	PFS · Table 15.4	
toll_cap	of which depreciation, capital modification recovery and toll profit	17.0	US$/wmt	PFS · Table 15.4	
ox_ref	Refining	19.8	US$/wmt	PFS · Table 18.14	
ox_corp	Corporate	12.1	US$/wmt	PFS · Table 18.14	
ox_cut	Operating cost used in TMC's cut-off tests	188	US$/wmt	PFS / IA · PFS Table 11.8; IA Table 18.7 (188.3)	

ID	Parameter	Value	Unit	Source · reference	Status
oxM_m	Operating-cost overrun multiplier, mean	1.15	factor	Koinon · DSM_Koinon v0.6, MC Register	Settled with CCZ model
oxM_s	Operating-cost overrun multiplier, standard deviation	0.15	factor	Koinon · as above	Settled with CCZ model
	TMC cut-off tests (for TMC_Check)				
T_sweep	Sweep rate in both tests	33,660	m²/h	PFS / IA · PFS Table 11.8; IA Table 11.16	
T_cost_P	Cost per hour, PFS	50,584	US$/h	PFS · Table 11.8	
T_cost_I	Cost per hour, IA	61,339	US$/h	IA · Table 11.16	
T_rev_A	Revenue per wet tonne, alloy	421	US$/wmt	PFS · Table 11.8	
T_rev_M	Revenue per wet tonne, matte	479	US$/wmt	PFS · Table 11.8	
T_rev_S	Revenue per wet tonne, sulphate	612	US$/wmt	PFS · Table 11.8	
T_rev_F	Revenue per wet tonne, TOML-F	488	US$/wmt	IA · Table 11.16	
T_be_A	Breakeven printed, alloy	3.60	kg/m²	PFS · Table 11.8	
T_be_M	Breakeven printed, matte	3.10	kg/m²	PFS · Table 11.8	
T_be_S	Breakeven printed, sulphate	2.50	kg/m²	PFS · Table 11.8	
T_be_F	Breakeven printed, TOML-F	3.70	kg/m²	IA · Table 11.16	
T_tpa_I	IA annual tonnes per collector	1,800,000	wmt/a	IA · s.11.4	
T_hrs_I	IA productive hours per year	5,584	h	IA · Table 13.3	
T_pS_Ni	PFS price, Ni sulphate (TMC check)	21,633	US$/t	PFS · Table 16.1	
T_pS_Cu	PFS price, Cu cathode	11,440	US$/t	PFS · Table 16.1	
T_pS_Co	PFS price, Co sulphate	55,198	US$/t	PFS · Table 16.1	
T_pS_Mn	PFS price, Mn in silicate	545	US$/t	PFS · Table 16.1	
	Capital and financing — Findings 4 and 5 (Note s.6–7)				
capOff1	Offshore production system 1	544.8	US$m	PFS · Table 18.2	
capOff234	Offshore production systems 2–4, at cost	4,362.6	US$m	DSM_Koinon v0.6 · Inputs row 220	
capRef	Refineries, two (PFS)	4,426	US$m	PFS · Table 18.2	
smMin	Brownsville smelter (RKEF and converters), minimum	2,450	US$m	Koinon · Security note, Appendix C	Approved 16 Oct 2026
smMode	Brownsville smelter, most likely	3,040	US$m	Koinon · Security note, Appendix C	Approved 16 Oct 2026

ID	Parameter	Value	Unit	Source · reference	Status
smMax	Brownsville smelter, maximum	3,650	US$m	Koinon · Security note, Appendix C	Approved 16 Oct 2026
capSust	Sustaining capital, life of mine	1,550	US$m	PFS · Table 18.2	
capClos	Closure	115	US$m	PFS · Table 18.2	
ovOff_m	Offshore capital overrun multiplier, mean	1.88	factor	DSM_Koinon v0.6 · MC Register	
ovOff_s	Offshore capital overrun multiplier, standard deviation	0.56	factor	Koinon	Settled with CCZ model
ovOn_m	Onshore capital overrun multiplier, mean	1.45	factor	DSM_Koinon v0.6 · MC Register	
ovOn_s	Onshore capital overrun multiplier, standard deviation	0.44	factor	Koinon	Settled with CCZ model
r	Discount rate, real	8%	fraction	PFS · s.19	
life	Plant life for capital recovery	19	years	PFS · s.19, Table 19.1	
constr	Construction period, offshore systems, for interest during construction	3	years	Koinon	Approved 16 Oct 2026
constrOn	Construction period, Brownsville onshore plant, for interest during construction	5	years	Koinon · Decision, 16 Oct 2026	Approved 16 Oct 2026
nColl	Collectors at full scale	8	count	Application · Table 44	
debtSh	Debt and government incentives, share of onshore funding	70%	fraction	Application · s.7.4.3	
rd	Debt interest rate	7%	fraction	Koinon	Adopted 16 Oct 2026
tenor	Debt tenor	15	years	Koinon	Adopted 16 Oct 2026
pubCapLo	Public money, share of onshore capital, low end	50%	fraction	Koinon · Decision, 16 Oct 2026	Approved 16 Oct 2026
pubCapHi	Public money, share of onshore capital, high end (the whole debt-and-incentives tranche)	70%	fraction	Koinon · Decision, 16 Oct 2026	Approved 16 Oct 2026

Table A1. Input register, Koinon_NORI-D_UnitEconomics_Model.xlsm, Inputs sheet. Base-case values; the distributions are in Table C1.

Contradiction log

Where the three documents differ, the note takes the application first, then the PFS, then the IA, and says what it did with the difference. The log below records each conflict met in the course of the work.

Item	Application	PFS	IA	Resolution in this note
Moisture content	28% (s.2; Table 5)	28% NORI-D	28% TOML; 24% NORI A–C	Application: 28% used throughout.
Revenue per wet tonne in the cut-off tests	None stated	$421–612 "/wmt" (Table 11.8)	$430–517 (Table 11.16)	Rebuilt on a dry basis within 1–5%; on a wet basis they are $298–445. Treated as dry figures mislabelled (Appendix D).

Item	Application	PFS	IA	Resolution in this note
Operating cost used in the cut-off test	None stated	$188/wmt, borrowed from the IA	$188.3/wmt (Table 18.7), second generation	PFS Table 18.14, $243.6 for NORI-D, taken as base; all capital removed to $196.8 (Table 8); the $188 kept only to reproduce TMC's test.
Collector sweep in the cut-off test	15 m × 0.4 m/s (Table 37): 21,600 m²/h	33,660 m²/h (second generation)	33,660 m²/h, 20 m × 0.55 m/s × 85%	Application collector used; PFS cost per hour shown to belong to it (Appendix D).
Collector recovery	77% Type 1, 62% Types 2–3 (Table 37 note 8)	Same	Same	Weighted by nodule type; Type 1 share PERT 70/85/90%.
Productive hours	6,545 production hours at steady state (Table 30)	5,584 collecting hours (8,760 × 75% × 85%)	Same as PFS	Consistent (6,545 × 85% ≈ 5,560). 5,584 used; availability drawn PERT 55/75/80%.
Capital of production systems 2–4	Owned by TMC USA	Vendor-financed; recovered through opex at $29.1/wmt with 10% uplift (Table 18.15)	PV5–12 recovered through opex at $20.6/wmt (Table 18.8)	Removed from opex; charged as capital at cost, US$4,362.6m, as in the CCZ model.
Processing	Owned RKEF smelter and refinery at Brownsville	Toll smelting in Indonesia and Japan; two owned refineries	Toll processing	Toll fee stripped of its capital and profit elements (PFS Table 15.4); smelter capital added as a Koinon estimate, PERT US$2.45/3.04/3.65bn.
Manganese price	Not stated	US$5.45/dmtu (CRU 2024)	US$4.70/dmtu	PFS price kept; uncertainty placed in volume (US ceiling, non-US share, disposal).
Discount rate and life	Not stated	8%, 19 years (s.19)	9% (2021 IA)	PFS values used for the capital annuity.
Cut-off	4 kg/m² (resource)	4 kg/m² for the resource; zero in the mine plan (s.12.5)	4 kg/m²	TMC's test reproduced (2.5–3.6); Koinon's breakeven rebuilt; field read from PFS Figure 11.29.
Nodule type split over the mine plan	Not stated	Not stated; 287 box cores: 239 Type 1, 28 Types 2–3, 20 mixed	Not stated	Type 1 share drawn 70–90%; NOAA asked for the split by year.

Table A2. Contradictions between the application, the PFS and the IA, and how each was resolved.

Appendix B. TMC tables reproduced

The TMC tables relied on in the body of the note are reproduced here as printed, so that the reader can check each reconstruction against its source without the filings to hand. PFS Table 18.14, the NORI-D operating cost by component, is already reproduced in full as Table 8 of the note and is not repeated.

B1. PFS Table 11.8, NORI-TOML breakeven cut-off abundance estimate

Route	Variable opex, $/wmt	Production, m²/h	Nodule revenue, $/wmt	Opex per hour, $/h	Breakeven abundance, kg/m²	Revenue per hour, $/h
Alloy	188	33,660	421	50,584	3.6	50,584
Matte	188	33,660	479	50,584	3.1	50,584
Sulphate	188	33,660	612	50,584	2.5	50,584

Source: AMC Consultants, Technical Report Summary of Prefeasibility Study of NORI Area D, s.11.8. The text that follows the table states that "a cut-off of 4 kg/m² abundance … remains appropriate".

B2. IA Table 11.16, NORI-TOML breakeven cut-off abundance estimate

Area	Opex, $/wmt	Production, m²/h	Nodule revenue, $/wmt	Opex per hour, $/h	Breakeven abundance, kg/m²	Revenue per hour, $/h
NORI-A	188	33,660	484	61,339	3.8	61,339
NORI-B	188	33,660	517	61,339	3.5	61,339
NORI-C	188	33,660	465	61,339	3.9	61,339
TOML-A	188	33,660	430	61,339	4.2	61,339
TOML-B	188	33,660	458	61,339	4.0	61,339
TOML-C	188	33,660	491	61,339	3.7	61,339
TOML-D	188	33,660	492	61,339	3.7	61,339
TOML-E	188	33,660	478	61,339	3.8	61,339
TOML-F	188	33,660	488	61,339	3.7	61,339

Source: AMC Consultants, Initial Assessment of TOML and NORI Properties, s.11.4. The IA concludes that 4 kg/m² "is appropriate" for NORI-A, B and C and TOML-A to F.

B3. PFS Table 16.8, revenue forecast, US$ 2025 real (life of mine)

Metal	LOM revenue, US$m real 2025	Share	Of which years 0–4, US$m
Nickel	31,449.5	45%	2,722.9
Cobalt	6,465.7	9%	304.3
Copper	12,090.9	17%	1,069.8
Manganese	19,856.1	28%	2,251.9
Total	69,862.2	100%	6,348.9

Source: PFS s.16.5. Years 0–4 are 2027–31. Life-of-mine revenue per wet tonne, Table 2 of the note, is this total divided by the PFS's life-of-mine wet tonnage.

B4. PFS Table 18.15, collection cost opex

Component	Total LOM, US$m	Average LOM, US$/wmt
Production vessel	5,299.9	32.3
Production support	543.3	3.3
Supply vessel	1,701.5	10.4
System 2 capital recovery	1,599.6	9.7
System 3 capital recovery	1,599.6	9.7

Component	Total LOM, US$m	Average LOM, US$/wmt
System 4 capital recovery	1,599.6	9.7
Collection costs total	12,343.6	75.2

Source: PFS s.18.4.1. The three capital-recovery lines, US$29.1 per wet tonne in all, are the vendor-financed capital of production systems 2–4 (US$1,454.2m each at cost, US$1,599.6m with the 10% uplift).

B5. IA Tables 18.7 and 18.8, operating cost summary and collection costs

Component	Total LOM, US$m	Average LOM, US$/wmt
Collection	31,139	46.5
of which supply vessel	3,753	5.6
of which production vessel	12,391	18.5
of which corporate, production support	1,199	1.8
of which PV5–12 capex recovery	13,796	20.6
Shipping		9.1
Contractor (offshore)		5.3
Consumables (offshore fuel)		17.7
Processing		80.0
Refining		23.8
Corporate		5.9
Total opex		188.3

Source: IA s.18.4. The PV5–12 capex recovery line, US$20.6 per wet tonne, is the IA's equivalent of the PFS's systems 2–4 recovery; like for like, excluding both, the IA's second-generation opex is US$150.7 against the PFS's US$196.8.

B6. Application Table 44, expected onshore processing quantities, Mt wet nodule equivalent

Year	Period	Stage 1 matte	Stage 2 matte	Stage 3 metals	Phase 2 metal	Processed	Cumulative
2028	1	0.5			–	0.5	0.5
2029	2	1.5	0.5		–	2.0	2.5
2030	3	1.5	1.5	1.5	–	4.5	7.0
2031	4	1.5		3	5.0	9.5	16.5
2032	5	1.5		3	7.5	12.0	28.5
2033	6	1.5		3	7.5	12.0	40.5
2034	7	1.5		3	7.5	12.0	52.5
2035	8	1.5		3	7.5	12.0	64.5
2036	9	1.5		3	7.5	12.0	76.5
2037	10	0.75		1.5	7.5	9.8	86.3
2038	11	1.5		3	6.8	11.3	97.5
2039	12	1.5		3	6.0	10.5	108.0

Year	Period	Stage 1 matte	Stage 2 matte	Stage 3 metals	Phase 2 metal	Processed	Cumulative
2040	13	1.5		3	6.0	10.5	118.5
2041	14	1.5		3	7.5	12.0	130.5
2042	15	1.5		3	7.5	12.0	142.5
2043	16	1.5		3	7.5	12.0	154.5
2044	17	1.5		3	7.5	12.0	166.5
2045	18	1.5		3	7.5	12.0	178.5
2046	19	1.5		3	7.5	12.0	190.5
2047	20	1.5		3	7.5	12.0	202.5

Source: Application s.4.8, Table 44. Full scale is 12 Mt a year from 2032; cumulative 202.5 Mt by 2047. Stage 1 and 2 matte is produced before refining begins; from 2031 Phase 2 metal (sulphate and cathode) carries most of the throughput.

Appendix C. Model method and distributions

The model is an Excel workbook, Koinon_NORI-D_UnitEconomics_Model.xlsm, built to the FAST conventions: inputs in yellow, imports between sheets in blue, calculations in black, one calculation per line, spaced formulae. ModelRisk is the simulation engine. Each uncertain input on the Uncertainty sheet is written =IFERROR(Vose…(parameters), base), so that with the add-in installed the cell samples and without it the cell shows the base value, and the workbook opens cleanly for any reader. The results of the published run, 10,000 iterations, are stored as values in the SimValues sheet, from which every figure and table in this note is drawn; a reader without ModelRisk can recompute any statistic from that sheet with ordinary Excel functions.

Sheets

Inputs (every parameter, with source and status); Uncertainty (the fourteen draws of Table C1, and the USGS score factor used by the mineral security note); Value (value per wet tonne by metal, in blocks: common factors, contained and recovered metal, price, market, value); Opex (PFS Table 18.14 lines with capital removed and the overrun applied); Hour (the collector-hour test and the operating breakeven); TMC_Check (reproduction of PFS Table 11.8 and IA Table 11.16, and the dry/wet rebuild, Appendix D); Capital (Findings 4 and 5); Output (recovered metal and the delivered schedule); Security_Benefit and Security_Cost (the mineral security note's benefit and fiscal cost, from the same run); Outputs (a display of the results, each registered as a simulation output on its own sheet); Checks (twenty tests, all of which read OK in the published run); SimValues (the stored iterations).

Price regimes and the manganese treatment

Nickel, copper and cobalt prices are drawn from lognormal distributions fitted to the mean and standard deviation of real 2010–25 annual averages (Table 3). No upward adjustment for future demand is made. Regime A sells everything at those prices; regime B, the published case, applies a discount to the share of each product sold outside the United States, drawn from a PERT distribution. Manganese is held at TMC's own price, US$545 per tonne of contained manganese; its uncertainty is in volume: a US ceiling drawn uniformly between 6% and 12% of output and conditioned on a Bernoulli trial of whether NORI-D wins that market at all, a non-US share drawn PERT 5/15/25%, and a disposal cost per tonne of silicate on the remainder, which is charged to operating cost.

Allocation, collector and cost

The US share of each product is capped at the ceiling in Table 4; the rest is sold abroad at the regime B discount. Collector recovery is weighted by nodule type with the Type 1 share drawn PERT 70/85/90%;

availability is drawn PERT 55/75/80% around the application's 75%. Operating cost is the PFS NORI-D figure with all capital removed (Table 8), multiplied by a lognormal overrun with mean 1.15 and standard deviation 0.15 on all lines but corporate; the parameters are those settled with the CCZ model. Cost per hour treats the year's operating cost as fixed and divides it by the productive hours drawn.

Capital

Capital items are those of s.6.1. The offshore and onshore totals carry lognormal overrun multipliers with means of 1.88 and 1.45 from the CCZ model and standard deviations of 30% of the mean, as settled with that model; the smelter is a PERT draw. Interest during construction is (1 + r)^(years ÷ 2), over three years for the offshore systems and five for the Brownsville plant. Capital is annuitised with the capital recovery factor at the PFS's 8% and 19 years and divided by the tonnes the collectors deliver in the draw; the same factor annuitises the operating surplus to give the capital it can carry. Debt is 70% of onshore capital after overrun and interest during construction, serviced at 7% over 15 years; public money is taken as 50–70% of onshore capital, with losses shared pro rata with private lenders. No correlations are imposed between draws; price, cost, availability and overrun are independent, which understates the spread of the results.

Running the model

Open the workbook with ModelRisk loaded; set MC_On (Inputs!D6) to 1; press F9 (the file is on manual calculation); run 10,000 iterations; in the Results Viewer open the Data tab, copy the grid and paste it over SimValues; save. The published run used a fixed seed, 20261016. Set MC_On to 0 for the deterministic base case, in which every draw returns its base value and the Checks sheet should read OK throughout. The German-locale note: ModelRisk writes the Data grid with the system decimal separator, so Excel's separators must match it.

ID	Uncertain input	Distribution	Parameters	Base	Note
	Prices (Koinon historical record)				
p_Ni	Nickel price, US$/t	Lognormal(mean, sd)	20,816, 6,200	20,816	Real 2010–25 annual averages.
p_Cu	Copper price, US$/t	Lognormal(mean, sd)	9,326, 1,659	9,326	
p_Co	Cobalt price, US$/t	Lognormal(mean, sd)	53,989, 19,342	53,989	Right-skewed; lognormal fits the 2017–18 and 2021–22 spikes.
	Price regimes				
disc	Regime B: discount on non-US sales	PERT(min, mode, max)	10%, 20%, 40%	20%	Approved 16 Oct 2026.
	US market and manganese				
us_Co	Cobalt sulphate: US ceiling	Uniform(lo, hi)	26%, 51%	26%	Base = chemical uses only.
us_Mn	Manganese silicate: US ceiling	Uniform(lo, hi)	6%, 12%	6%	Base = low ceiling.
mn_B	Manganese: NORI-D wins the US market (1/0)	Bernoulli(p)	50%	100%	Base case assumes it does; probability approved 16 Oct 2026.
nuMn	Manganese silicate: share sold outside the US	PERT(min, mode, max)	5%, 15%, 25%	15%	Regime B discount applies to it.

ID	Uncertain input	Distribution	Parameters	Base	Note
disp	Disposal cost of unsold silicate	PERT(min, mode, max)	5, 10, 20	10	US$ per tonne of silicate.
	Collector				
t1	Share of Type 1 nodules	PERT(min, mode, max)	70%, 85%, 90%	85%	
av	Availability	PERT(min, mode, max)	55%, 75%, 80%	75%	Mode = application 75%.
	Operating cost				
oxM	Operating-cost overrun multiplier	Lognormal(mean, sd)	1.15, 0.15	1	Base = 1 (PFS as stated). Parameters as settled with the CCZ model.
	Capital (Finding 4)				
ovOff	Offshore capital overrun multiplier	Lognormal(mean, sd)	1.88, 0.56	1	Base = 1 (PFS as stated). CCZ model multiplier and standard deviation.
ovOn	Onshore capital overrun multiplier	Lognormal(mean, sd)	1.45, 0.44	1	Base = 1 (PFS as stated). CCZ model multiplier and standard deviation.
smelt	Brownsville smelter capital, US$m	PERT(min, mode, max)	2,450, 3,040, 3,650	3,040	Koinon estimate at 28% moisture; not in the PFS.

Table C1. The uncertain inputs, Koinon_NORI-D_UnitEconomics_Model.xlsm, Uncertainty sheet. Lognormal parameters are mean and standard deviation; PERT parameters are minimum, most likely, maximum; Uniform parameters are low and high. Base = value used when MC_On is 0.

Output name in SimValues	Definition and cell
K_WT_Value, K_Ni_Value, K_Cu_Value, K_Co_Value, K_Mn_Value	Value per wet tonne, total and by metal (Value!D45:H45)
K_Cost_t	Operating cost per wet tonne with overrun (Opex!H13)
K_Cost_hr	Cost per collector-hour (Hour!D15)
K_OpSurplus_hr, K_OpSurplus_t	Operating surplus per hour and per tonne at the resource mean (Hour!D25, D27)
K_Breakeven_Ab	Operating breakeven abundance (Hour!D31)
K_Capital_Required, K_Capital_Carried, K_Capital_AtRisk, K_ShareRecoverable	Capital!D25, D47, D48, D49
K_CapitalCharge_t, K_Residual_t, K_ResidualFlag	Capital charge, residual after capital and its sign (Capital!D43, D45, D46)
K_Breakeven_CapInclusive	Capital-inclusive breakeven abundance (Capital!D51)
K_Debt, K_Debt_flag, K_LenderLoss, K_Lenderloss_public, K_Lenderloss_public_hi	Debt and incentives, default flag, loss to lenders and its public share with public money at 50% and 70% of onshore capital (Capital!D60, D64, D66, D71, D72)
K_Value_US, K_Value_NiCuCo	Value per wet tonne sold in the US, and value without manganese (Value!H46, H47)

Output name in SimValues	Definition and cell
K_CollectorRecovery, K_OpSurplus_hr_cutoff, K_SurplusFlag_cutoff	Weighted collector recovery; operating surplus per hour at the declared cut-off and its sign (Hour!D6, E25, E28)
K_PublicExposure_lo, K_PublicExposure_hi	Public money at face, at 50% and 70% of onshore capital (Capital!D69, D70)
K_SB_ (11 outputs)	Security benefit, present values at 2, 3 and 7% and annual, for the mineral security note (Security_Benefit!D82:D92)
K_SC_ (18 outputs)	Expected fiscal cost, grant case, net benefit and their signs, for the mineral security note (Security_Cost!D25:D42)

Table C2. The 59 outputs stored in SimValues, 10,000 iterations.

Appendix D. The reconstructions

Each reconstruction below can be repeated with a pocket calculator from the printed figures in Appendix B.

D1. PFS Table 11.8 reproduced

Line	Unit	Alloy	Matte	Sulphate
Revenue per wet tonne, as printed	US$/wmt	421	479	612
Cost per hour, as printed	US$/h	50,584	50,584	50,584
Sweep, as printed	m²/h	33,660	33,660	33,660
Breakeven rebuilt = cost ÷ (revenue × sweep) × 1,000	kg/m²	3.57	3.14	2.46
Breakeven as printed	kg/m²	3.6	3.1	2.5
Difference	kg/m²	−0.03	+0.04	−0.04

Table D1. Breakeven abundance = cost per hour ÷ (revenue per tonne × area swept per hour) × 1,000, on TMC's printed inputs. The method reproduces the printed breakevens within rounding.

D2. Whose collector the hourly cost belongs to

Line	Unit	Value
PFS cost per hour ÷ $188 per wet tonne	wmt/h	269.1
Application collector: 21,600 m²/h × 77% × 95% × 17 kg/m²	wmt/h	268.6
Difference	%	0.2
1.5 Mtpa per collector ÷ 5,584 collecting hours	wmt/h	268.6
IA cost per hour ÷ $188	wmt/h	326.3
IA design: 1.8 Mtpa ÷ 5,584 h	wmt/h	322.4
Difference	%	1.2

Table D2. Decomposition of US$50,584 and US$61,339 per hour. The PFS cost per hour divided by its own US$188 per tonne gives 269 tonnes an hour, the application's first-generation collector at 17 kg/m², not the 326 tonnes of the second-generation collector whose 33,660 m² sweep the test uses.

D3. Dry and wet rebuild of the sulphate revenue figure

Line	Unit	Nickel	Copper	Cobalt	Manganese
Grade, dry (PFS reserve)	%	1.40	1.10	0.13	31.0
Recovery to sulphate / silicate	%	94.6	86.2	77.2	98.9

Line	Unit	Nickel	Copper	Cobalt	Manganese
PFS price	US$/t	21,633	11,440	55,198	545
Revenue per dry tonne	US$/t	286.5	108.5	55.4	167.1
Revenue per wet tonne = dry × 72%	US$/wmt	206.3	78.1	39.9	120.3
Total per dry tonne	US$/t	617.5			
Total per wet tonne	US$/wmt	444.6			
Printed 612 ÷ dry total	ratio	0.99			
Printed 612 ÷ wet total	ratio	1.38 (≈ 1 ÷ 0.72)			

Table D3. PFS reserve grades (reserve statement, s.12), sulphate-route recoveries (Table 16.2) and PFS prices (Table 16.1), 28% moisture, payables 100%. The printed US$612 is within 1% of the dry total and 38% above the wet total.

D4. The nine IA areas on the matte route

Area	Mt	Ni / Cu / Co / Mn, % dry	Rebuilt, dry $/t	Rebuilt, wet $/wmt	Printed $/wmt	Printed ÷ dry	Printed ÷ wet
NORI-A	72	1.35 / 1.06 / 0.22 / 28.0	476	362	484	+1.7%	+34%
NORI-B	36	1.43 / 1.13 / 0.25 / 28.9	506	385	517	+2.2%	+34%
NORI-C	402	1.26 / 1.03 / 0.21 / 28.3	459	348	465	+1.4%	+33%
TOML-A	114	1.11 / 0.96 / 0.23 / 25.0	421	303	430	+2.1%	+42%
TOML-B	80	1.22 / 1.02 / 0.28 / 26.4	463	333	458	-1.1%	+37%
TOML-C	130	1.30 / 1.11 / 0.20 / 28.5	468	337	491	+4.9%	+46%
TOML-D	131	1.30 / 1.20 / 0.20 / 29.1	477	344	492	+3.1%	+43%
TOML-E	58	1.30 / 1.10 / 0.20 / 28.7	468	337	478	+2.0%	+42%
TOML-F	256	1.40 / 1.20 / 0.10 / 32.2	479	345	488	+1.9%	+42%

Table D4. IA Table 1.2 grades (tonnage-weighted where an area has more than one class); matte recoveries 94.8 / 86.4 / 77.5% and payables 80 / 70 / 60% (IA Tables 16.2, 16.3); manganese 98.9% recovery, payable 100%; IA prices Ni US$20,360, Cu 11,456, Co 62,530, Mn US$4.70/dmtu; moisture 24% NORI-A to C, 28% TOML. All nine printed figures sit within −1% to +5% of the dry rebuild and 33–46% above the wet one.

D5. The collector-hour arithmetic, deterministic base case

Line	Unit	At 17.4 kg/m²	At 4 kg/m²
Effective area = 21,600 × 74.8% × 95%	m²/h	15,339	15,339
Tonnes collected per hour = area × abundance ÷ 1,000	wmt/h	266.9	61.4
Value per wet tonne, Koinon manganese case, no discount	US$/wmt	331.9	331.9
Value per hour	US$/h	88,600	20,400
Cost per hour = $201.0 × 1.5 Mt ÷ 5,584 h	US$/h	53,980	53,980
Operating surplus per hour	US$/h	+34,600	−33,600
Breakeven abundance = cost ÷ (value × area) × 1,000	kg/m²	10.6	10.6

Table D5. Hour sheet of the model with MC_On = 0: application collector, weighted recovery 74.8%, Koinon operating cost US$201.0 (Table 8, with disposal), value US$331.9 per wet tonne at the price-record means with manganese at 6% US and 15% non-US. Compare Table 7, row 3.

Appendix E. Sources

TMC USA LLC, Consolidated Application for an Exploration License and Commercial Recovery Permit, TMC USA-A, as published by NOAA 19 August 2026, NOAA-NOS-2026-1751-0002.

AMC Consultants Pty Ltd, Technical Report Summary of Prefeasibility Study of NORI Area D, Clarion Clipperton Zone, AMC project 0225054, effective 4 August 2025 (TMC Form 8-K of 5 August 2025, Exhibit 96.1); Technical Report Summary, Initial Assessment of TOML and NORI Properties, same date (Exhibit 96.2).

15 CFR Parts 970 and 971, as amended by NOAA, Deep Seabed Mining: Revisions to Regulations for Exploration License and Commercial Recovery Permit Applications, 91 FR 2642, 21 January 2026.

17 CFR 229.1300–1305 (SEC Regulation S-K, subpart 1300: Disclosure by Registrants Engaged in Mining Operations).

Emerman, S.H., Implications of The Metals Company Pre-Feasibility Study for Next Steps by the Company, Malach Consulting for the Deep Sea Mining Campaign, Greenpeace International and MiningWatch Canada, January 2026, revised February 2026.

USGS, Mineral Commodity Summaries 2026, 6 February 2026, manganese, nickel, cobalt and copper chapters; manganese ore price series (44% Mn, CIF China) from CRU as reported therein, 2015–25.

IMF Primary Commodity Prices, annual averages 2010–25 for nickel, copper and cobalt, deflated to 2025 dollars by the US CPI; PFS Table 16.1 and Application Table 12 for TMC's prices.

TMC the metals company Inc., press release of 3 May 2022, on the SINTEF Industri silicomanganese smelting trial and value-in-use study; Application s.4.8.5 and Figure 81.

IndexBox, silicomanganese market note, 2025, for world consumption and China's share (secondary; to be replaced by an industry source).

Koinon Consulting, The NORI-D Reserve: Four Findings on the Resource and Reserve Estimates, 16 October 2026; What Backing NORI-D Buys the United States: Four findings on the mineral-security case, 16 October 2026; TMC's Fulfilment of Information Criteria in the NOAA Application, 16 October 2026; NORI-D PFS Freight Extract v1.7, 29 September 2026; Case Not Proven: The Economics of Deep-Sea Mining, July 2026, and the DSM_Koinon v0.6 model (MC Register) on which the overrun multipliers draw.

Koinon Consulting, Koinon_NORI-D_UnitEconomics_Model.xlsm, version 2.3, 16 October 2026 (ModelRisk workbook with stored results, sheet SimValues), published with this note.

About this note. Koinon Consulting has advised more than fifteen governments on mining contracts and fiscal terms. It has no relationship with any seabed minerals contractor and holds no interest in any seabed minerals project. This note was prepared for the Natural Resources Defense Council. Koinon's prior work on deep-sea mining economics, on which it draws, was carried out with the Oceano Azul Foundation, Oceans North, the Deep Sea Conservation Coalition and IUCN, each of which publicly supports a moratorium. We state this plainly because readers are entitled to weigh it. The test we invite is whether the documents say what we report them as saying.