

MEMORANDUM

Project:	WBM Updates to Support CCM Operations	Date:	21 August 2023
To:	Capricorn Copper Pty Ltd	From:	Tim Wallis
ATT:	Barry Shean	CC:	Travis Warren, Sarah Green Goldberg
Subject:	Gunpowder Creek Release Assessment		

1. INTRODUCTION

Capricorn Copper Mine (CCM) received a large rainfall event in March 2023 which resulted in significant inflows to the mine affected water (MAW) system and the flooding of the Esperanza South (ESS) underground workings. MAW storage in both Mill Creek Dam (MCD) and Esperanza Pit (EPit) currently exceed the maximum operating Level (MOL) with an estimated additional 500ML in the underground workings requiring dewatering to EPit before mining can recommence in ESS. CCM have proposed bulk treatment (neutralisation using lime dosing) to reduce the excess MAW inventory and have engaged Engeny to assess a number of potential release options.

This release assessment has considered both existing (as specified in Environmental Authority EPML00911413) and potential enhanced release conditions to estimate the potential volume of water that could be released compliantly from the site during operation of the proposed bulk neutralisation works.

2. PURPOSE

The purpose of this assessment is to assess the opportunity during wet seasons to undertake release of treated mine affected (MAW) water from CCM to Gunpowder Creek. The treatment and release of (MAW) is a key control for ensuring MAW does not accumulate onsite across multiple wet seasons, increasing the risk of uncontrolled released and resultant environmental harm to the receiving environment.

3. RELEASE ASSESSMENT MODEL

3.1 Model Development

The release assessment model was developed using GoldSim software. The standalone model is separate to the current site water balance model (WBM) for CCM (i.e., does not reflect the water management and process circuit) and represents the following:

- Recorded Gunpowder Creek streamflow (refer to Section 3.1.1.1 below);
- Mill Creek Dam storage and release; and
- Transfer from EPit.

A schematic of the model structure is provided in Figure 3.1 below.



Figure 3.1: Release Assessment Model Schematic

3.1.1 Model Inputs

3.1.1.1 Gunpowder Creek Streamflow Data

Approximately 52 years of historic streamflow data for Gunpowder Creek (gauge site 913006A), from January 1971 to March 2023, were input to the WBM. Streamflow data for Gunpowder Creek shows a distinct seasonal distribution with the high flow season typically restricted to the wet season months of November through May, with peak mean daily stream flow of 4,300 ML/d occurring in January. A low flow season is seen to extend through the dry season months of June through October, where mean daily flow ranges from 53 ML/d in October to 3 ML/d or less from June through September (Figure 3.2). Daily flow duration (Figure 3.3) indicates that on average Gunpowder Creek experiences cease to flow conditions approximately 74% of all days, with the steeply declining curve representative of a relatively rapid streamflow recession following cessation of rainfall.

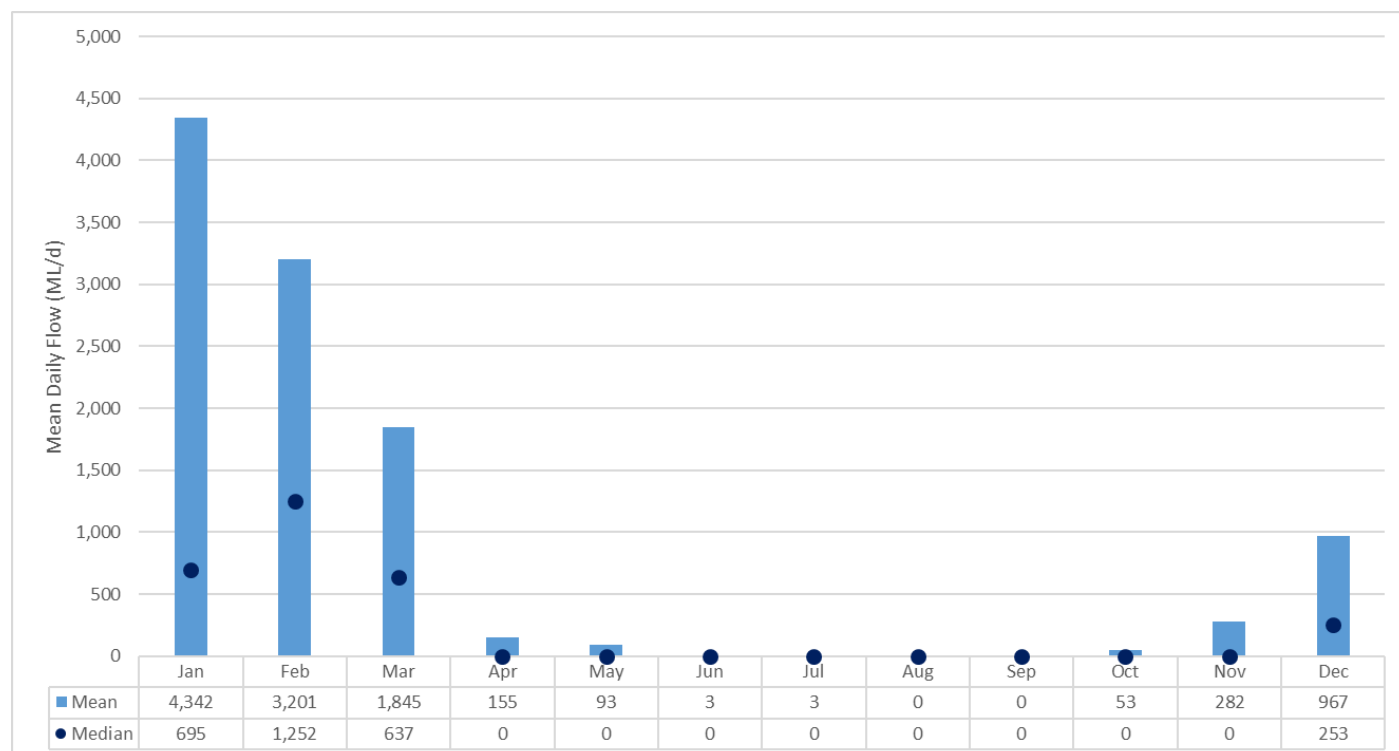


Figure 3.2: Gunpowder Average Daily Streamflow

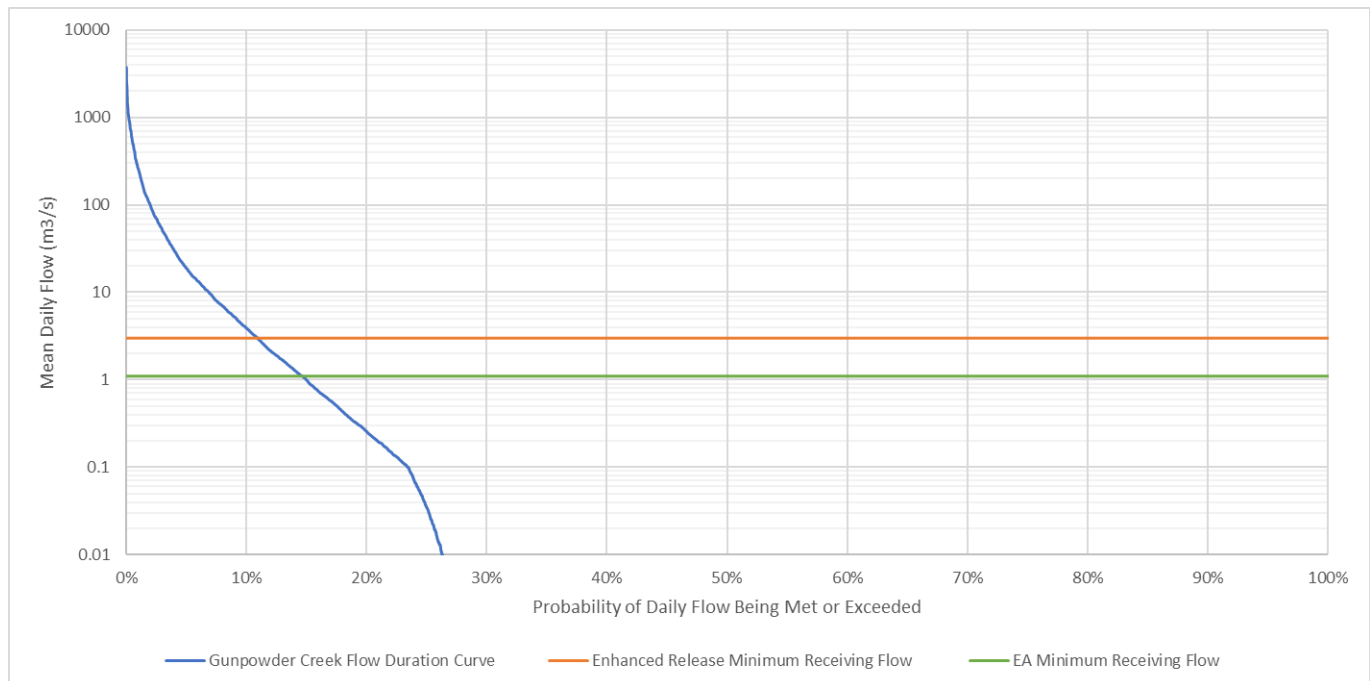


Figure 3.3: Gunpowder Creek Flow Duration Curve

3.1.1.2 Bulk Neutralisation Operation

The release model simulates the top-up of MCD with treated MAW from EPit and two different treatment scenarios (either a simultaneous release and treatment process or a batch treatment then release process) have been assessed as described below.

General Assumptions

The following assumptions apply to both treatment scenarios:

- The initial volume available to release from MCD at the start of the wet season (1st November) is 498ML (equivalent to a total volume in storage of 598 ML at MRL).
- It is assumed that MAW stored in the workshop area adjacent to MCD (totalling a volume of 120ML as advised by CCM) will become immediately available for transfer to MCD once the volume stored in MCD is below the MRL.
- Releases are made from MCD to Gunpowder Creek as per scenario conditions (refer to Table 3.2).
- The minimum drawdown from MCD during releases is 100ML as MCD is required to maintain a minimum volume of 100ML to supply Ponds 3 and 4.
- A continuous supply of 8 ML/d from MCD to Ponds 3 and 4 is required.
- The maximum rate of transfer from EPit to MCD is 25 ML/d.
- Under normal operations (i.e., no releases) MCD is maintained at MRL (598 ML with 498 ML available for immediate release) through simultaneous top of supply from EPit at 8 ML/d and supply to Ponds 3 and 4 also at 8 ML/d.
- Water stored in MCD is always of a quality suitable for release as per conditions specified in the EA.

Simultaneous Treatment and Release

- During and following a release event the rate of topup from EPit may increase to the maximum rate of 25 ML/d while still maintaining supply to Ponds 3 and 4 (i.e., a maximum net topup rate of 17 ML/d).

Batch Treatment and Release

Under the batch treatment and release operation MCD cannot receive inflows and release at the same time:

- Following an initial controlled release of water from MCD to Gunpowder Creek transfers from EPit to MCD must cease although MCD will continue to supply water to Ponds 3 and 4 at 8 ML/d.

- Topup of MCD from EPit may not recommence until MCD is drawdown (though supply to Ponds 3 and 4 and/or additional releases) to 100ML, EPit will begin transfers to MCD at a maximum rate of 25ML/day (i.e., net inflow of 17 ML/d after supply to Ponds 3 and 4 accounted for).
- No further releases are permitted from MCD until a sufficient inventory is established in MCD. This release topup threshold has been set at 200 ML as per CCM advice.
- Top up transfers from EPit to MCD will continue until a) MCD reaches its MRL, or b) the volume stored in MCD reaches the specified volume and streamflow conditions allow MCD to further release to Gunpowder Creek in which case transfers from EPit will cease until MCD drawdown to 100 ML is completed and topup may resume.

3.1.1.3 Simulation Properties

The initial release assessment (*QC1022_001-MEM-001-0-CCM Release Assessment*) utilised a deterministic simulation (single realisation completed for the duration of the available Gunpowder Creek streamflow data). For the current assessment this has been updated to a multi-realisation simulation where each realisation comprises of a single year (1 Nov through 31 Oct). In total, 52 1-year realisations (as per the length of record for recorded streamflow data (Section 3.1.1.1)) were completed with the MCD initial condition (598 ML) set at the start of each realisation. This allows for annual release potential statistics to be derived from 52 annual results that are fully independent of each previous year. This was required to ensure that in the batch treatment and release scenarios annual release opportunity for each year is not influenced by any releases occurring late in the previous year and the maximum volume is available at the start of each wet season.

3.1.1.4 Model Limitations

The following model limitations are noted:

- The model does not consider rainfall, runoff, evaporation or seepage inflows and outflows from either EPit or MCD.
- The model does not consider the actual volume stored in EPit and transfers made from EPit to MCD are only limited by the availability of MCD to receive these transfers, the specified maximum transfer rate and annual release volume limitations (as per EA conditions only, refer to Section 3.1.2).
- Gunpowder Creek streamflow data has been reviewed for continuity and quality (based on reported quality coding's); no assessment of the gauge rating curve has been conducted. Mean daily flow data has been utilised in the assessment.
- The storage curve is static, it is assumed that as treatment of MAW occurs in MCD this would result in residual sludges settling in MCD reducing the water storage capacity of MCD however Engeny understands that CCM's intention is to undertake dredging of the MCD to maintain capacity through sludge removal.

3.1.2 Release Conditions

Two sets of release conditions were assessed:

- (1) Existing approved CCM EA; and
- (2) Assumed temporary release conditions as advised by CCM.

Release conditions are summarised in Table 3.1.

TABLE 3.1: RELEASE ASSESSMENT CONDITIONS

Condition	EA Conditions	Enhanced Release Conditions
Minimum Gunpowder Creek receiving flow (m ³ /s)	1.1	3
Event release limit (ML/72-hours)	70	100 ML/d (pump capacity limitation, no 72-hr limitation)
Dilution rate	>1:10 (assessed for sensitivity)	>1:10 (assessed for sensitivity)
Annual release limit (ML/year)	500	No annual limit

3.1.3 Scenarios Modelled

A total of twelve scenarios were modelled for the purpose of this assessment. The scenarios modelled allow for an assessment of release opportunities for the conditions specified in Table 3.1 under two different bulk neutralisation scenarios and for various release ratios. It should be noted the approved release ratio for release from MCD to Gunpowder Creek (end of pipe (EOP): Gunpowder Creek) as per EA conditions is $\geq 1:10$. Scenarios modelled are detailed in Table 3.2.

TABLE 3.2: RELEASE ASSESSMENT SCENARIOS

Scenario ID	Release Conditions	Bulk Neutralisation Scenario	Release Ratio (EOP: Gunpowder Creek)
Scenario 1.0	EA Conditions	Simultaneous treat/release.	$\geq 1:10$ (as per EA conditions)
Scenario 1.1		Simultaneous treat/release.	$\geq 1:15$
Scenario 1.2		Simultaneous treat/release.	$\geq 1:20$
Scenario 2.0		Batch process.	$\geq 1:10$ (as per EA conditions)
Scenario 2.1		Batch process.	$\geq 1:15$
Scenario 2.2		Batch process.	$\geq 1:20$
Scenario 3.0	Enhanced Release Conditions	Simultaneous treat/release.	$\geq 1:10$ (as per EA conditions)
Scenario 3.1		Simultaneous treat/release.	$\geq 1:15$
Scenario 3.2		Simultaneous treat/release.	$\geq 1:20$
Scenario 4.0		Batch process.	$\geq 1:10$ (as per EA conditions)
Scenario 4.1		Batch process.	$\geq 1:15$
Scenario 4.2		Batch process.	$\geq 1:20$

4. RESULTS

Annual release volume statistics for each of the modelled scenarios are presented in Figure 4.1 and Table 4.2 shows relative and absolute changes to estimated annual release volume. It should be noted that yearly totals are from the start of the wet season on 1st of November to the 31st of October the following year. Modelling results for monthly release volume statistics for each of the scenarios are provided in Appendix A.

Results indicate that:

- EA Conditions:
 - Assumed EA release conditions (annual and 72-hour limits) present the greatest impact on release potential with the annual discharge limit (500 ML) and 70 ML 72-hour limit applied in Scenarios 1 and 2 resulting, in a significant reduction in estimated annual release potential when compared to Scenarios 3 and 4.
 - Under a continuous release and treat scenario (Scenario 1) the annual release limit is reached at the 25th percentile result for all modelled release ratios (Scenario 1.0 to 1.2) and by the 75th percentile result for a batch treatment and release scenario (Scenario 2).

- For Scenario 3 (no annual release limits are applied) annual release volumes are restricted only by the maximum daily release capacity (100 ML/day) and dilution ratio. Therefore, despite a higher flow threshold trigger (3m³/s compared to 1.1m³/s under EA conditions), estimated annual release potential reaches a significantly higher maximum annual release volume ranging from 920 ML to 2,154 ML (50th percentile to maximum respectively) for the various release ratios modelled.
- Scenario 4 results show a similar trend to Scenario 3 but are further limited by the batch process bulk neutralisation scenario. The estimated annual release potential reaches an annual release volume ranging from 680 ML to 1,851 ML (50th percentile to maximum respectively) for the various release ratios modelled.
- While the increased flow trigger adopted for Scenarios 3 and 4 provides a limitation to the number of potential release events (from Figure 3.3 it can be seen that the probability of 1.1 m³/s (Scenario 1 and 2) and 3 m³/s (Scenario 3 and 4) being met or exceeded is 14.6 and 10.9% respectively), an uncapped annual limit and greater release capacity (100 ML/d with no 72-hour restriction) significantly overcomes this limitation.
- Dilution ratio:
 - Regardless of treatment process or EA release conditions, results indicate that an increased dilution ratio reduces release opportunity. This trend of increasing dilution ratio and reduced release opportunity reduces as the result percentiles increase. This is indicative of non-dilution limited conditions prevailing i.e., as release event streamflow increases, release opportunity transitions from dilution-limiting to EA-limiting (Scenarios 1 and 3) or infrastructure-limiting (Scenarios 2 and 4).
 - Therefore, while dilution ratio is therefore generally considered to be of relatively low significance, it is dependent on the prevailing climatic condition and is therefore expected to be more material under prolonged dry conditions where small, low flow release events may be prevalent in Gunpowder Creek. Under wet conditions with more frequent, larger release events dilution ratio is unlikely to have a material impact on release volumes.
- Treatment process:
 - Adoption of a batch treatment and release scenario (Scenarios 2 and 4) results in a reduction in estimated release opportunity when compared to a continuous treat and release scenario (Scenarios 1 and 3).
 - The extent to which this presents a limitation can be seen in Table 4.2:
 - Under the existing EA conditions a batch treatment and release process results in a reduction in estimated annual release potential of between 10.9 and 18,6% depending on dilution (Scenarios 2.1 to 2.3 compared to Scenario 1.0)
 - Under enhanced EA conditions the batch treatment and release process results in a significantly higher proportional reduction in estimated annual release opportunity of 15.2 to 32.8% (Scenarios 4.1 to 4.3 compared to Scenario 3.0)

Appendix A shows estimated monthly release opportunity for each scenario:

- Results for lower percentiles (5th and 10th) are generally more convergent and are typically indicative of smaller and shorter release opportunities, where the release opportunity is dependent on flow trigger exceedance and are dilution-limited.
- Monthly 10th and 5th percentile results for all modelled scenarios indicate no opportunity for release, and are indicative of the inherent variability associated with streamflow in Gunpowder Creek.
- Estimated monthly release volumes all exhibit a similar trend reflective of monthly flows in Gunpowder Creek with the highest mean estimated release potential for most modelled scenarios (with the exception of Scenario 4.0) in January.

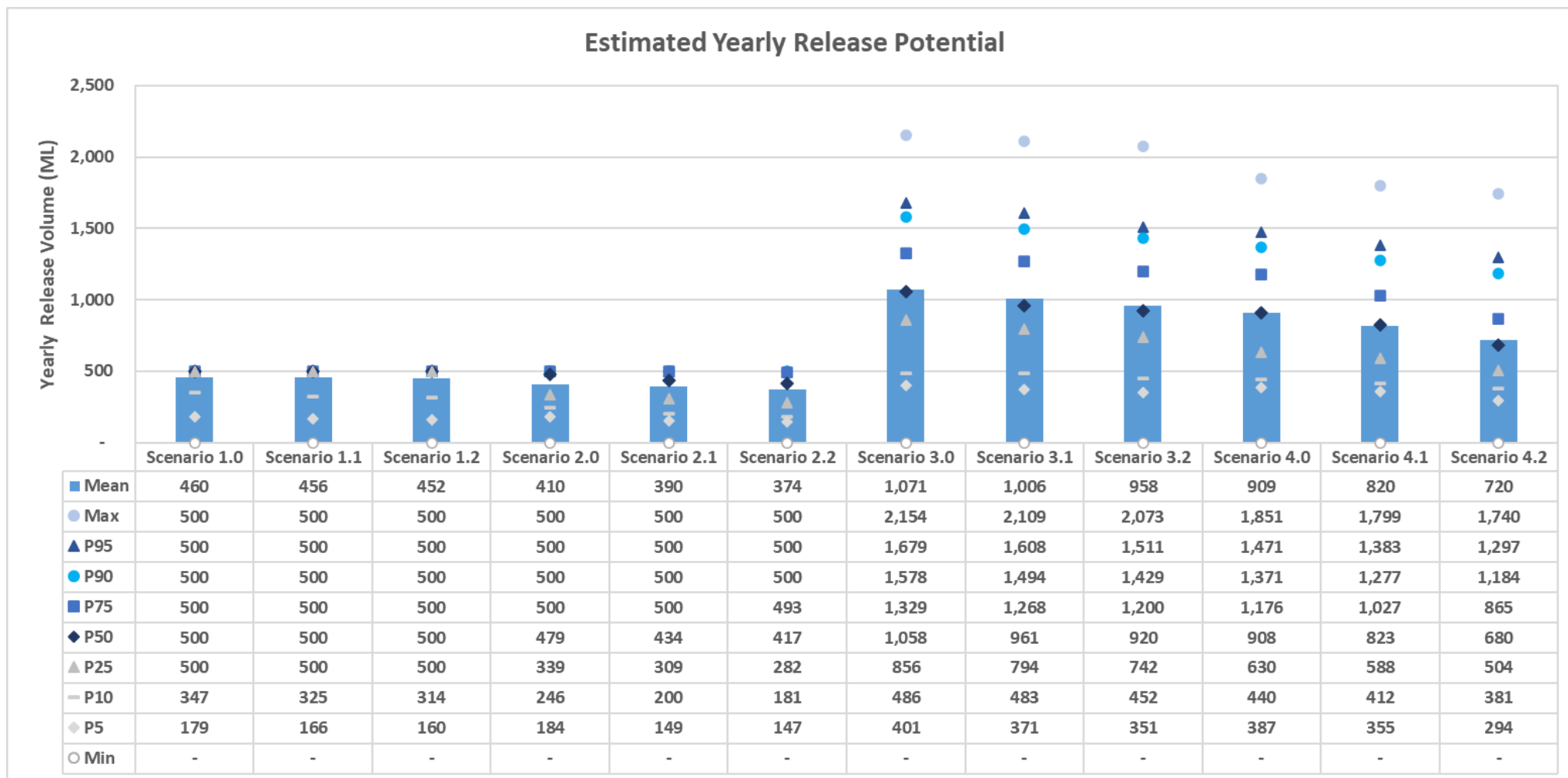


Figure 4.1: Estimated Yearly Release Potential

TABLE 4.2: ESTIMATED ANNUAL RELEASE VOLUME CHANGE (MEAN RESULTS)

Scenario ID	Absolute Change (ML)	Relative Change (%)
Scenario 1.0	460.0 ML	460.0 ML
Scenario 1.1	-4.1	-0.9%
Scenario 1.2	-8.0	-1.7%
Scenario 2.0	-50.0	-10.9%
Scenario 2.1	-70.2	-15.3%
Scenario 2.2	-85.6	-18.6%
Scenario 3.0	1,071.4 ML	1,071.4 ML
Scenario 3.1	-65.3	-6.1%
Scenario 3.2	-113.5	-10.6%
Scenario 4.0	-162.9	-15.2%
Scenario 4.1	-251.9	-23.5%
Scenario 4.2	-351.0	-32.8%

4.1 Delayed Release

As part of this assessment CCM requested that Engeny consider total yearly volumes released if releases begin on 1st November, and where releases are delayed by two weeks and begin on 15th November. Engeny assessed the impact of this two-week delay during their initial assessment (delivered 2 August 2023) with changes in yearly release volumes being immaterial. As such, a delayed release scenario was not remodelled. It should be noted that longer delays between the start of the wet season and the initial release will likely decrease the total annual volumes under enhanced conditions that have no annual release limit (Scenario 3 and Scenario 4).

5. SUMMARY

This release assessment indicates that:

- The annual and 72-hour caps on release volumes in the current EA presents the largest limitation to estimated release potential and that removal of these caps will significantly increase estimated annual release opportunity even when a higher flow trigger is considered.
 - In addition, it also demonstrates that increased rates of treated mine affected water could be achieved whilst also limiting environmental harm through the use of higher dilution ratios.
- As the required dilution ratio increases, estimated release opportunity will decrease, however the reduction is generally small when compared to the other variables assessed (EA conditions and treatment process).
- The use of a batch treatment and release (in contrast to simultaneous release) process reduces the estimated annual release opportunity, however under the existing EA conditions the overall reduction for the mean results is approximately half that seen under the enhanced EA release conditions. It is noted however that under the existing EA conditions, a batch treatment process (Scenarios 2.0 to 2.3) also reduces the likelihood of being able to achieve the 500 ML annual limit.

It should be noted the estimated release volumes presented in this assessment are *not* directly correlated to potential reductions in the CCM MAW inventory as rainfall, runoff and evaporation have not been considered. For example, under optimum release conditions (prolonged high flow in Gunpowder Creek) precipitating rainfall would likely result in increases to the MAW inventory while simultaneously presenting an enhanced release opportunity. Conversely, under dry conditions the MAW inventory could be expected to reduce through evaporative losses, and water destruction (evaporators) despite a low likelihood of release opportunity.

6. RECOMMENDATIONS

As part of this assessment, having demonstrated the limitations of the existing EA water discharge criteria, Engeny proposed the following recommendations:

- CCM should engage with the Department of Environment and Science (DES) regarding the amendment of the CCM EA conditions. The current release conditions provide a clear limitation to releasing the volumes of water required to reduce the current inventory to DSA and potentially increase the risk of additional excessive accumulation over the coming 2023 wet season. The controlled release of treated MAW whilst receiving flows in Gunpowder Creek are large, providing significant dilution, is preferable to the ongoing accumulation of MAW and the risk of an uncontrolled release of MAW.
- To sufficiently assess any amendment to the EA, DES will require impact assessment to determine if the amendment has the potential to increase environmental harm. To facilitate this, the following work could be undertaken:

Update the existing CCM site WBM to include:

- Detailed representation of current (and potential) EA release conditions that reference streamflow in Gunpowder Creek and consider both the quality of receiving flow and estimated concentrations of key contaminants (electrical conductivity and sulphate¹) released via controlled discharge. This will allow for:
 - A more detailed assessment of existing and future release conditions on site inventory recovery and operations that allows for consideration of process water usage, water management and inventory reduction strategies and potential effects of climatic fluxes (rainfall, runoff and evaporation).
 - Development of a more detailed understanding of potential release volumes and contaminant loadings to Gunpowder Creek under current and proposed release conditions which could inform any EA release condition amendment process.
 - Assessment of potential water recycling and reuse strategies on the estimated quality of water stored within the MAW system.

While the length of recorded streamflow data for Gunpowder Creek (913006A Gunpowder Creek at Gunpowder) is over 50 years, it is not commensurate with the length of input climate data for the WBM (SILO Data Drill, 130 years). To extend the length of streamflow data available for use in the WBM a calibration of the Australian water Balance Model (AWBM) to the Gunpowder Creek gauge data is also recommended.

While this assessment has focussed on estimating controlled release potential from the site it is noted that generation of sufficient and sustained streamflow in Gunpowder Creek will likely be commensurate with increased inflows to the MAW inventory through ingress of rainfall and runoff from the same precipitating rainfall event. As such, a net reduction in the MAW inventory for each release opportunity may not always be possible. Previous modelling has indicated that the sustained drawdown of the MAW inventory achieved through use of forced evaporation over drier wet seasons can result in large inventory reductions over time despite reduced MAW release opportunities and volumes.

¹ Water quality modelling would assume fully conserved adjective transport.

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APPENDIX A: ESTIMATED MONTHLY RELEASE VOLUMES



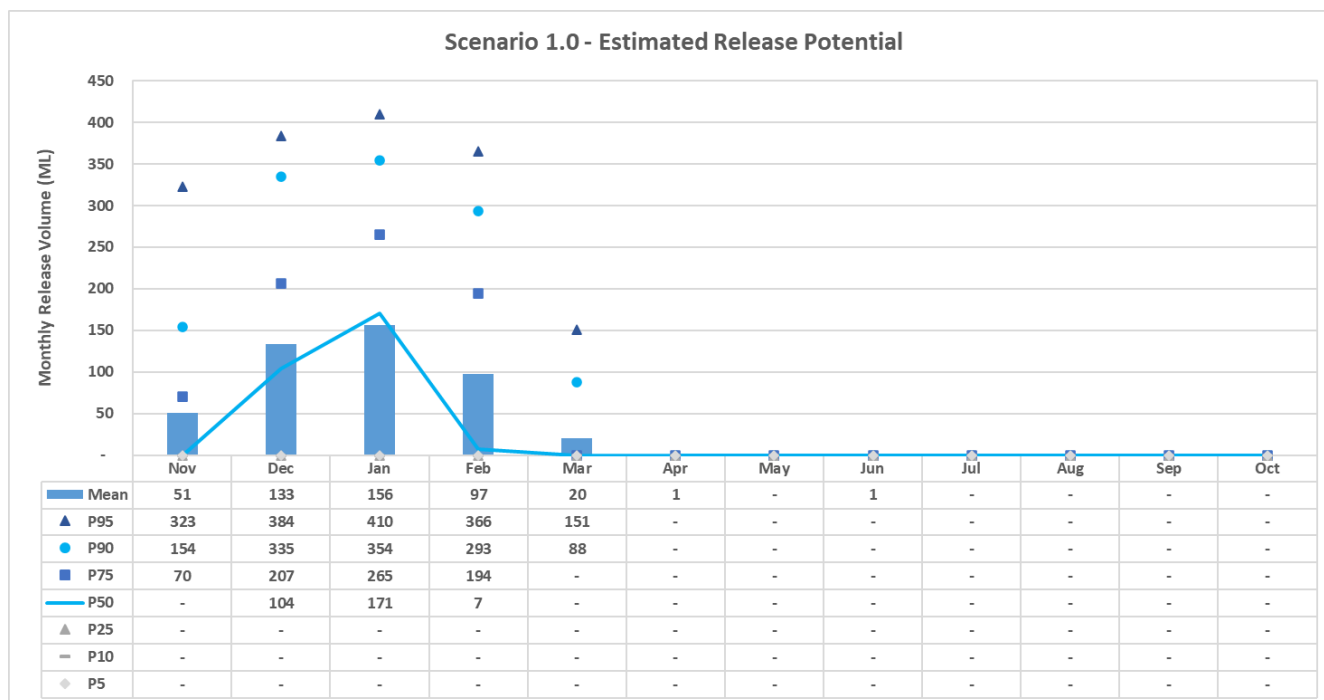


Figure 6.1: Estimated Monthly Release Volumes – Scenario 1.0

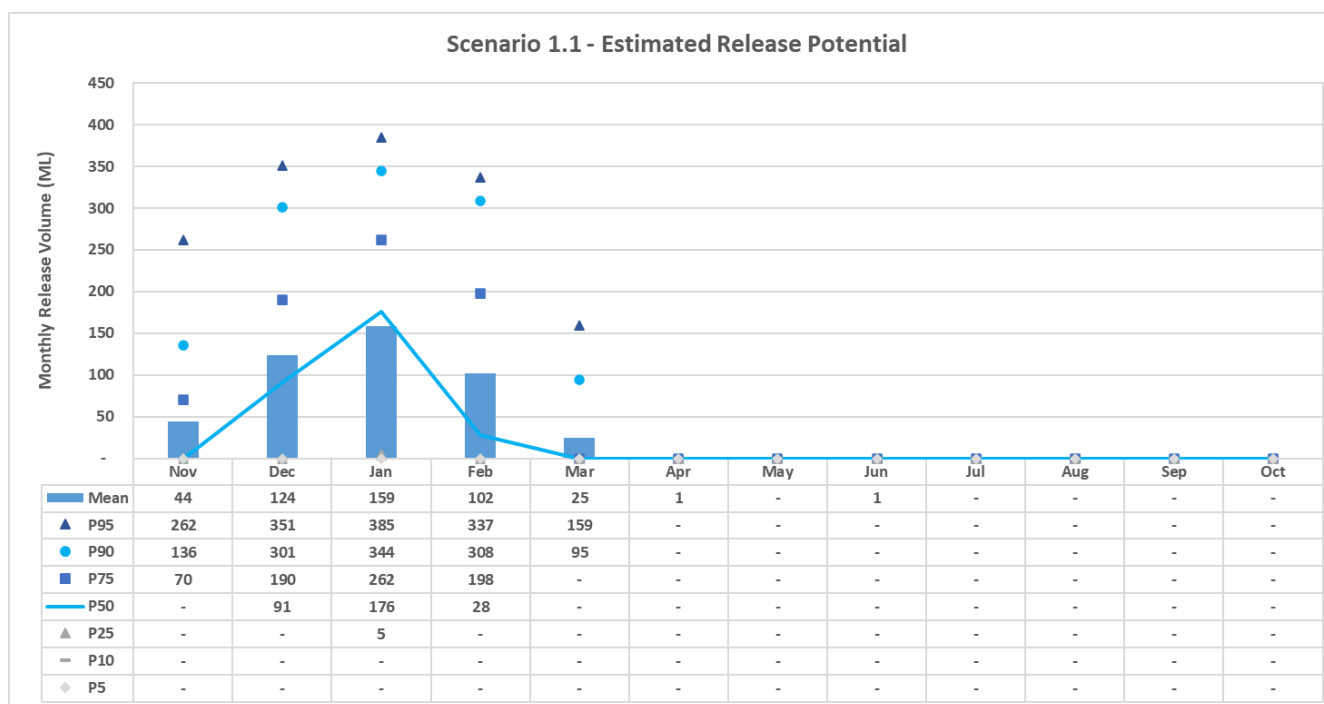


Figure 6.2: Estimated Monthly Release Volumes – Scenario 1.1

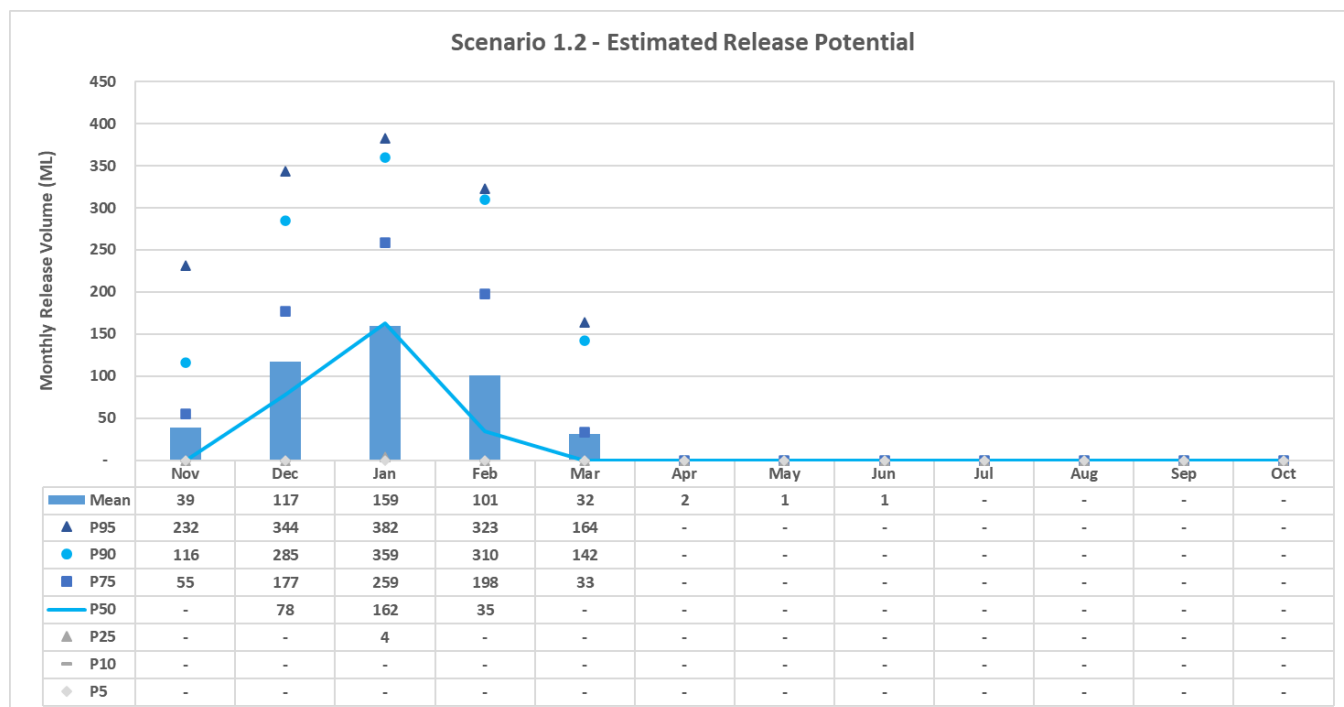


Figure 6.3: Estimated Monthly Release Volumes – Scenario 1.2

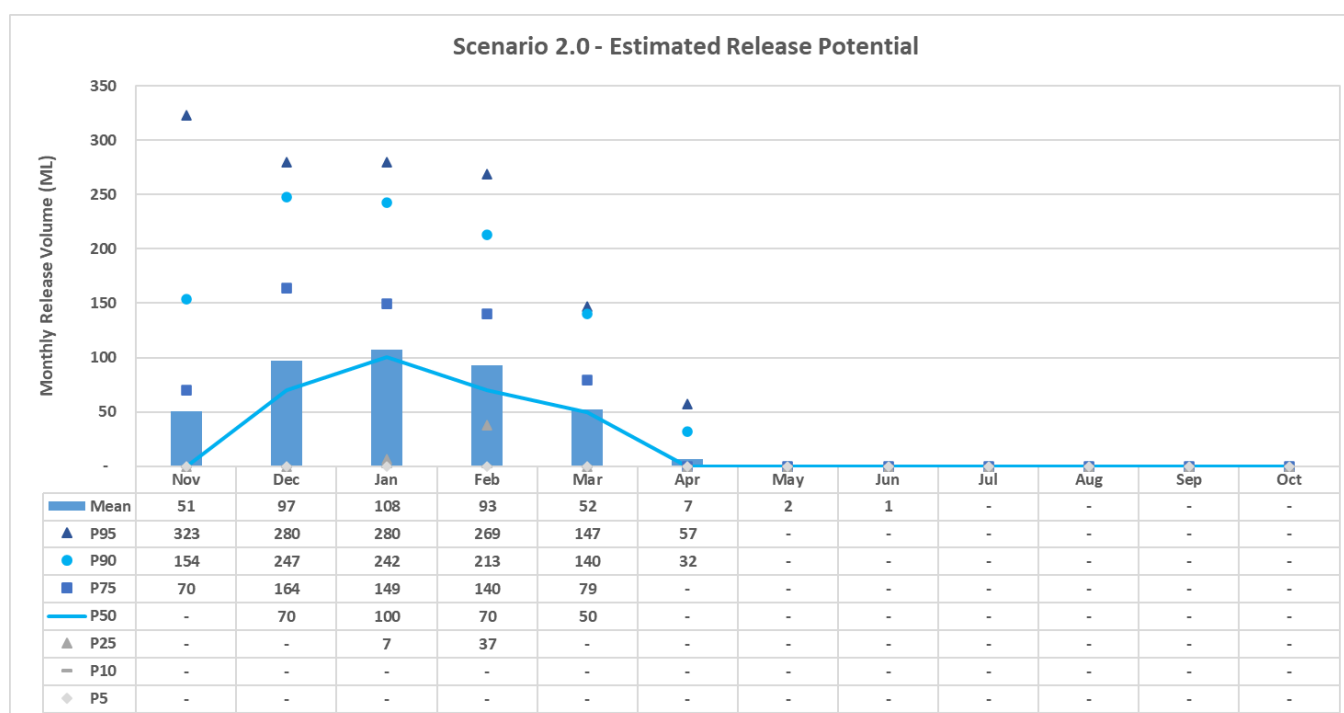


Figure 6.4: Estimated Monthly Release Volumes – Scenario 2.0

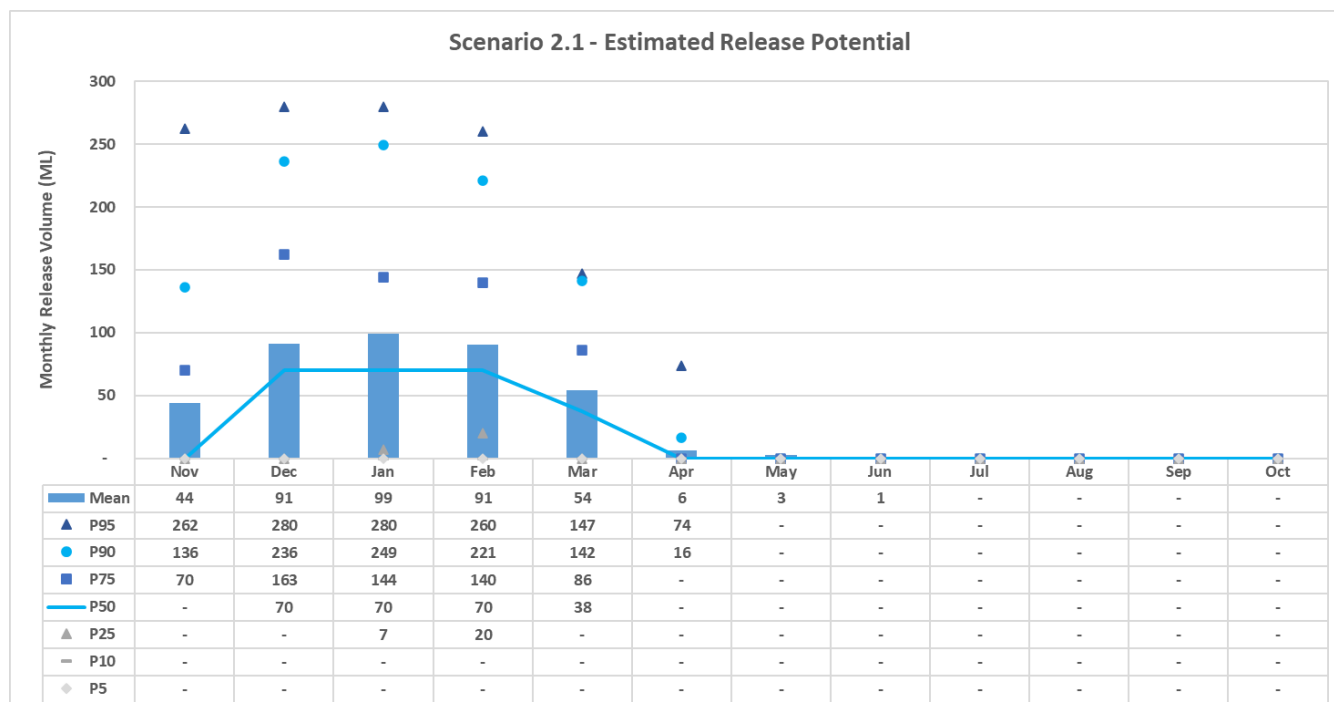


Figure 6.5: Estimated Monthly Release Volumes – Scenario 2.1

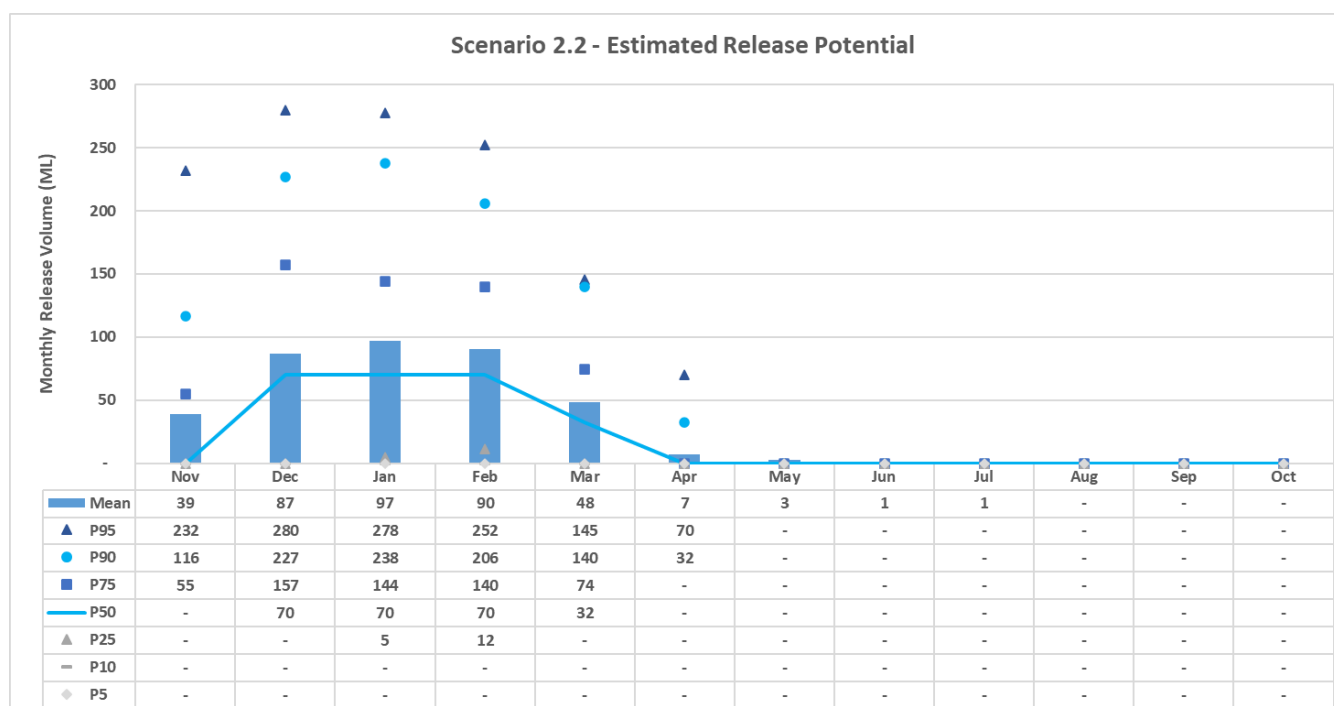


Figure 6.6: Estimated Monthly Release Volumes – Scenario 2.2

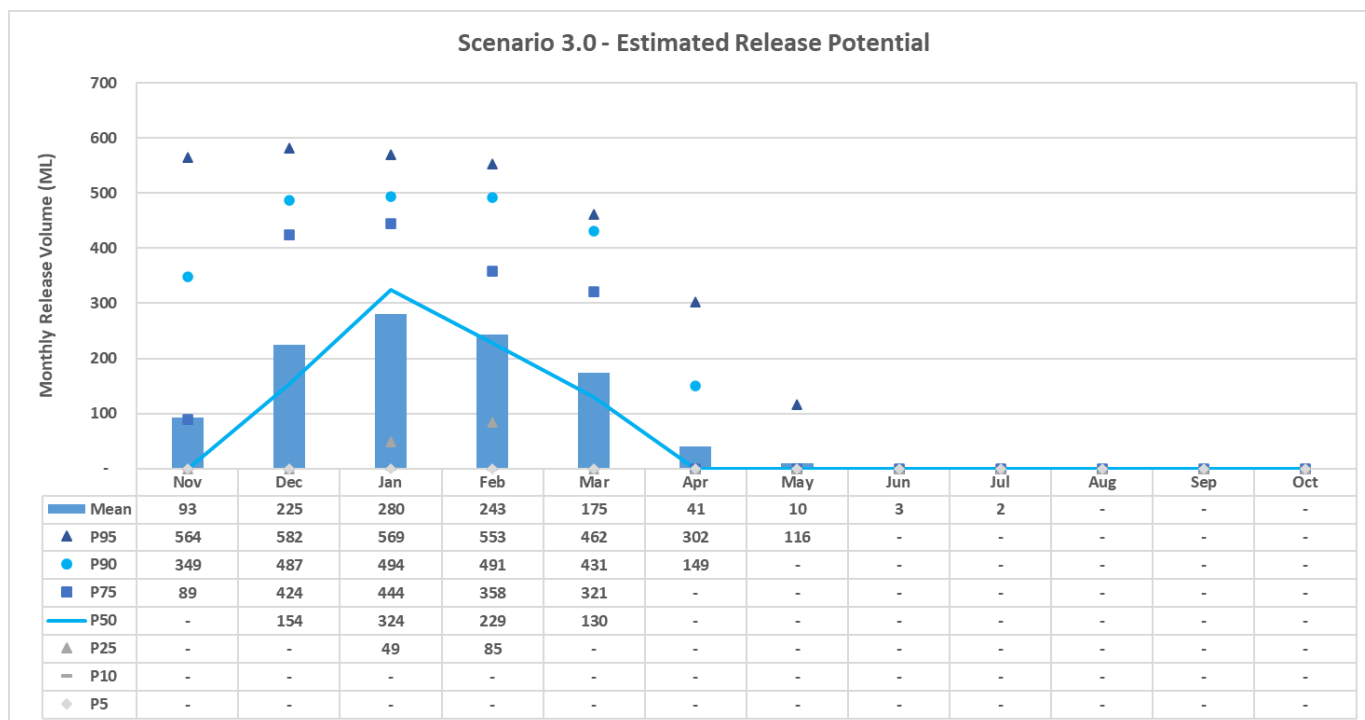


Figure 6.7: Estimated Monthly Release Volumes – Scenario 3.0

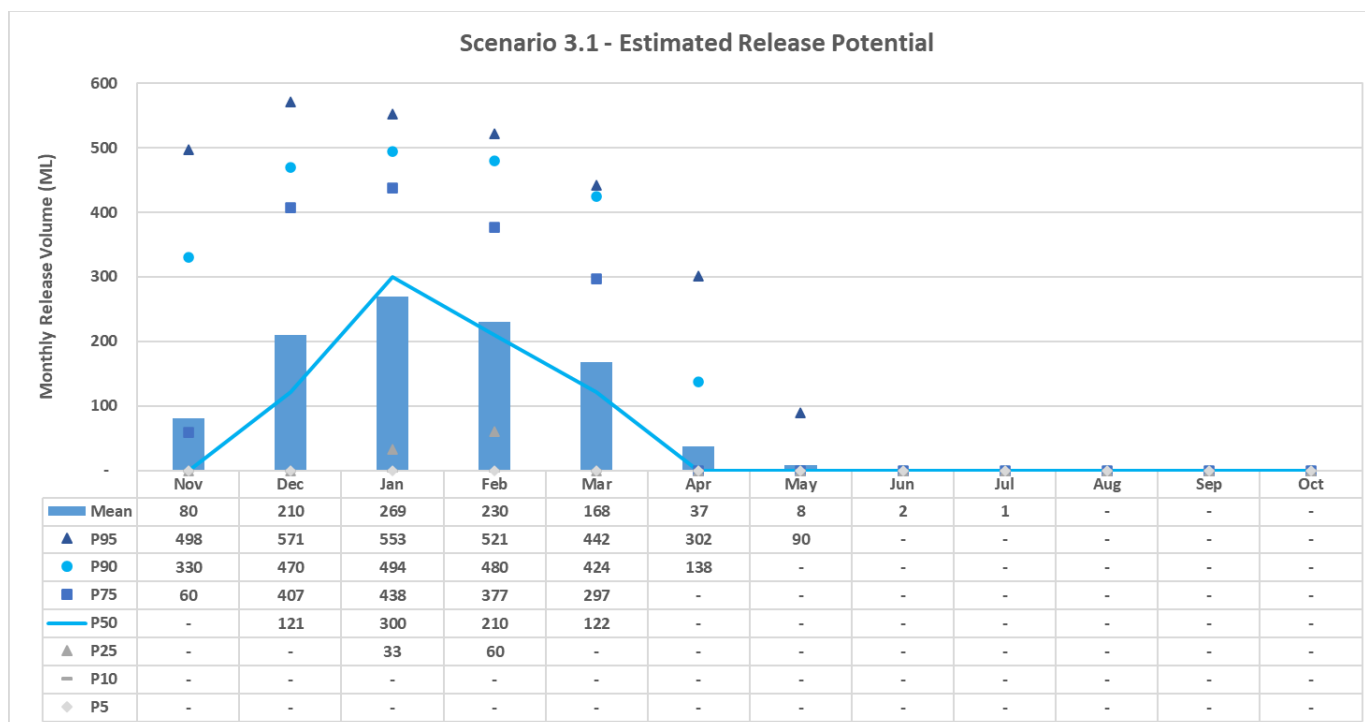


Figure 6.8: Estimated Monthly Release Volumes – Scenario 3.1

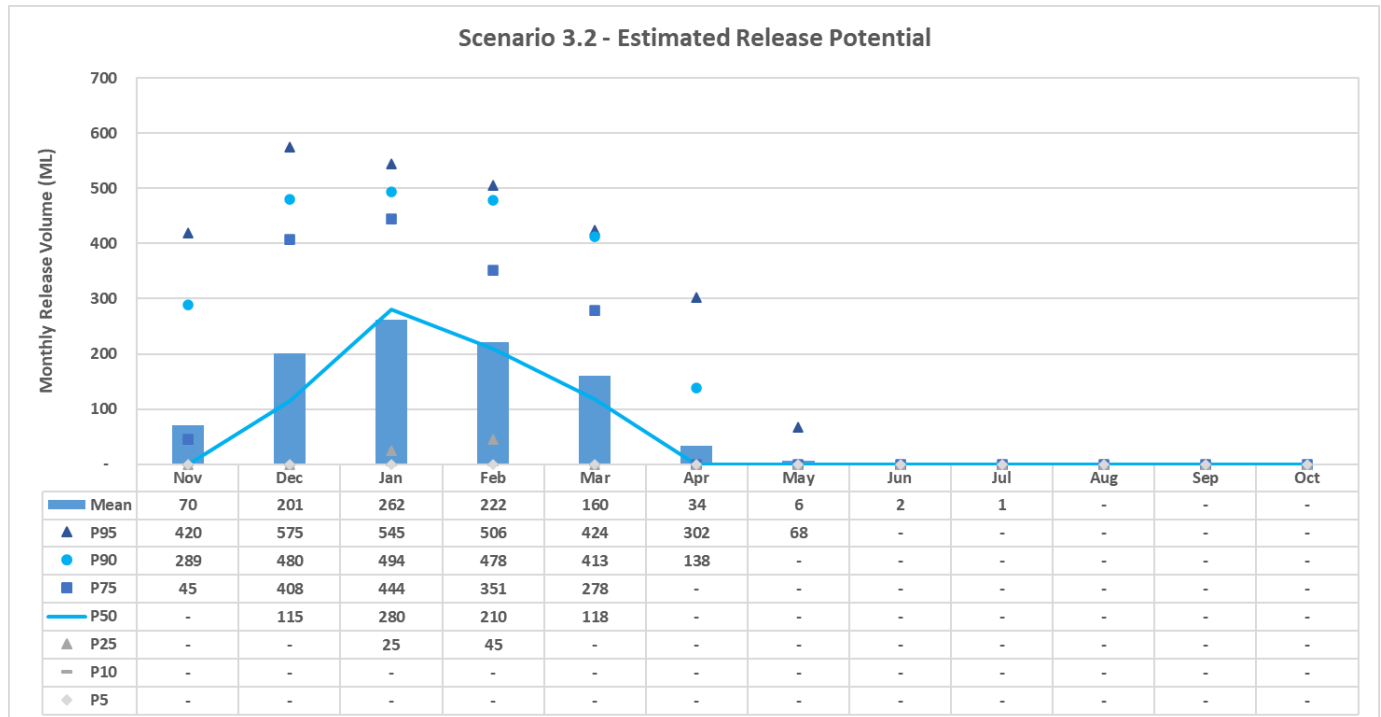


Figure 6.9: Estimated Monthly Release Volumes – Scenario 3.2

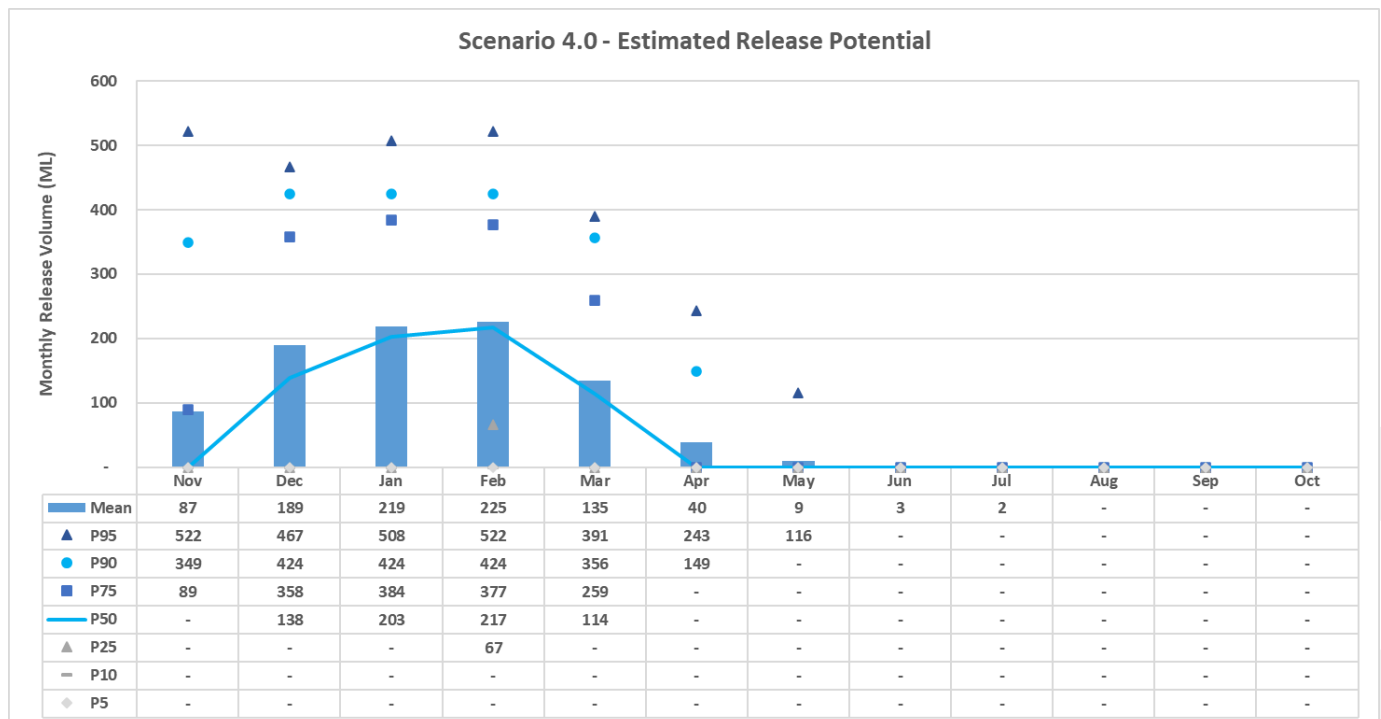


Figure 6.10: Estimated Monthly Release Volumes – Scenario 4.0

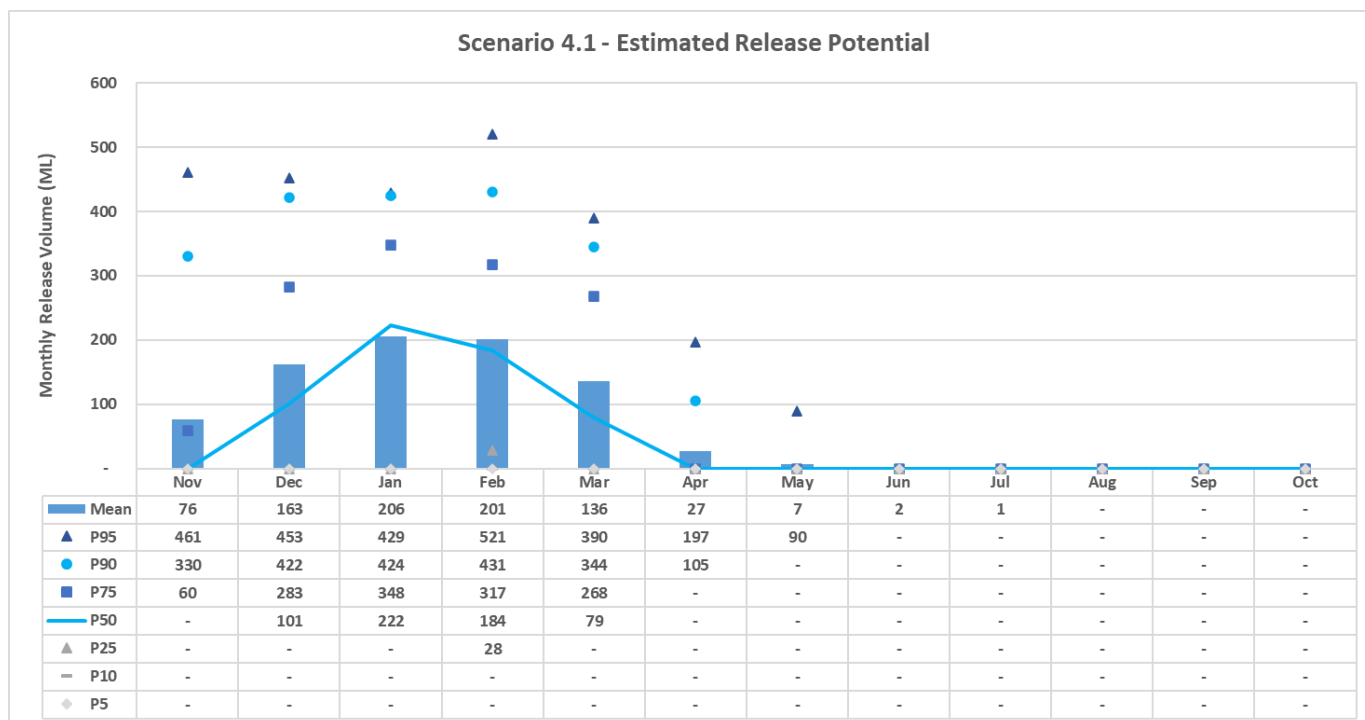


Figure 6.11: Estimated Monthly Release Volumes – Scenario 4.1

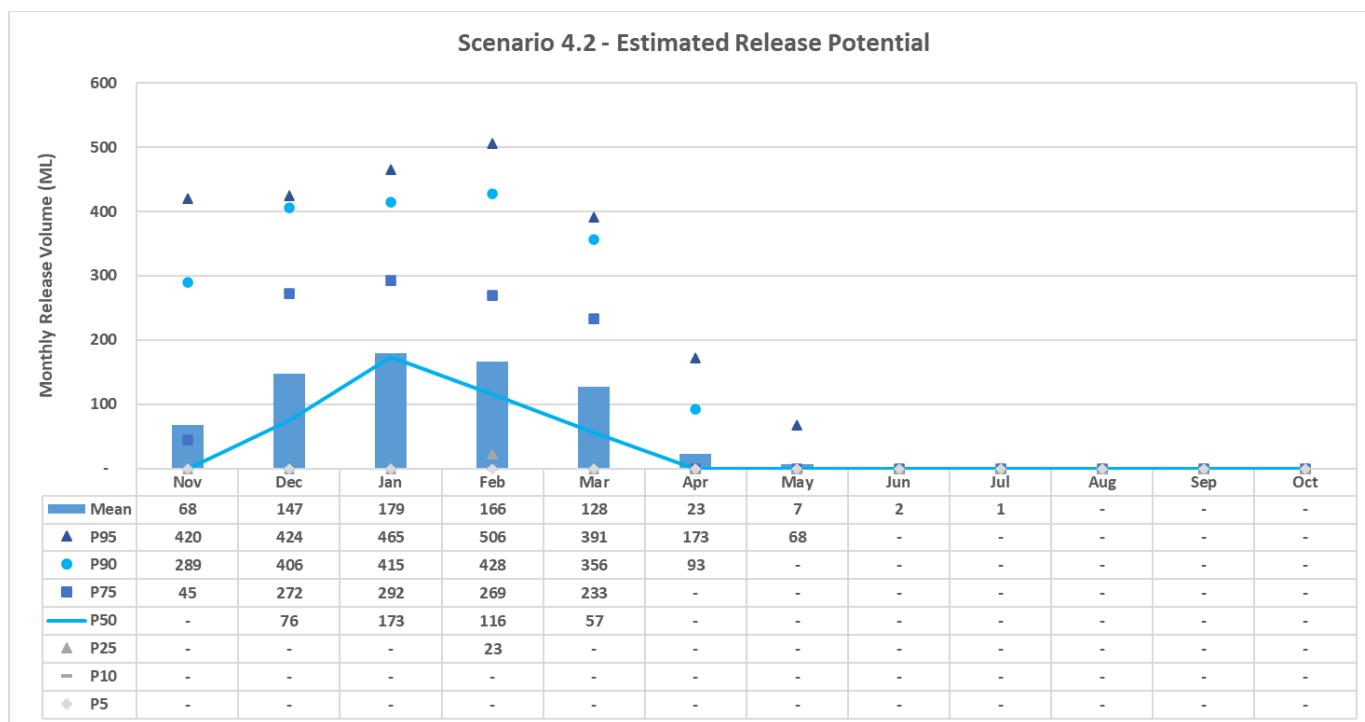


Figure 6.12: Estimated Monthly Release Volumes – Scenario 4.2