

Stockton Operational AMD

Sludge Management

December 2025

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Summary

Bathurst Resources Limited (**BRL**) is seeking to obtain authorisation through the Fast-track Approvals Act 2024 (**FTAA**) to progress development and mining of the coal resources across the wider Buller Plateaux Continuation Project (**BPCP** or **Project**).

Treatment of acid mine drainage (**AMD**) will be required to continue and expand as part of the BPCP. This includes major active AMD treatment activities at the Mangatini, McCabes, and MW16 Sump Treatment Systems. This report describes low-density sludge (**LDS**)¹ and **AMD Sludge**² management at Stockton mine for the BPCP.

Treatment of AMD affected minewater at Stockton mine primarily consists of collection of AMD affected minewater and dosing with alkaline reagent (currently calcium oxide (**CaO**) but transitioning to magnesium oxide (**MgO**) by 2032) to neutralise acidity. This produces LDS which is a product mainly comprised of stable aluminium (**Al**) and iron (**Fe**) hydroxide precipitates and clastic sediment. All flows currently reporting to the Mangatini and McCabes treatment systems are CaO dosed to neutralise acidity, which generates LDS. The Mangatini Sump Management Plan (GHD 2018) describes flow dependent LDS management as a combination of:

- LDS capture by sedimentation in Mangatini Sump during low to moderate flow rate (<70th percentile) conditions. Captured LDS is then either:
 - Pumped out of Mangatini Sump to filter beds to be dewatered (forming AMD Sludge), excavated, and disposed in slops³ cells in the engineered land form (**ELF**); or
 - Discharged via a controlled process from Mangatini Sump decants to Mangatini Stream during high flow (>70th percentile) conditions.
- LDS bypass of Mangatini Sump⁴ during high flow rate (>70th percentile) conditions.

Significant amounts of dewatered AMD Sludge are expected to be produced by the filter beds over the duration of the BPCP. During the Operational Phase dewatered AMD Sludge will be disposed in slops cells constructed within the ELFs (until 2031 when remaining cells will be buried by waste rock as ELF construction nears completion). Final landform slops cells have been conceptually designed with capacity for up to 750,000 m³ storage of dewatered AMD Sludge and slops between 2032 and 2062.

¹ LDS is produced by neutralisation of AMD using CaO and comprises stable Al and Fe hydroxide precipitates and clastic sediment. LDS typically has a 0 – 4 % solids content, with 2% used for calculation purposes.

² AMD sludge has a solids content of >10% and includes the sludge produced by dewatering of CaO dosed LDS.

³ The term 'Slops' applies collectively to materials that are too saturated to be self-supporting / stable if disposed from a tip head, including sediment pond slop waste (recovered from sediment ponds and sumps), road slop waste (wet material cut off road surfaces during maintenance), and overburden with excessive water content.

⁴ Bypass flows are currently CaO dosed to neutralise acidity.

This is a significantly greater storage capacity than the forecast ~321,000 m³ AMD Sludge volume to be produced by the Mangatini Treatment System over this period.

During high flow conditions (>70th percentile flows) the dosed AMD is fully bypassed around Mangatini Sump (without sedimentation). Infrequent discharges of LDS from Mangatini Sump (via the sump decants or sludge pumps) to Mangatini Stream may also occur during high flow conditions (>70th percentile flows, though operationally decant discharges typically only occur during periods of very high flow), as currently permitted under existing consent RC06206. These bypass and decant discharge events occur when there is considerable dilution in the receiving waterbody and total suspended solids (**TSS**) / turbidity is naturally / historically elevated. This management approach is used to maintain freeboard in the Mangatini Sump to support ongoing AMD treatment and LDS capture during low to moderate flow conditions.

The bypass threshold of >70th percentile flow enables operational efficiency. The effect of bypass on downstream water quality has been assessed by plotting measured dissolved Al, turbidity, and TSS values against flow percentiles. This showed that relative to historic (pre-AMD treatment conditions):

- Dissolved Al concentrations at NR are significantly lower under all flow conditions, since Ultrafine Limestone (**UFL** – limestone crushed to < 100 µm particle size) dosing to Mangatini Stream commenced in March 2007; and
- Current Al concentrations at S14C are also significantly lower since alkaline dosing upstream of Mangatini Sump commenced in June 2010.

Similarly, the downstream turbidity values in Mangatini Stream (at S14B) have improved significantly since Mangatini Sump commissioning (since June 2010), such that Ngakawau River (at NR) turbidity has also improved, particularly during low to moderate flow conditions (i.e., <70th percentile flows). Overall, NR turbidity values are relatively low under the current Mangatini Treatment System configuration (which including CaO dosing upstream of Mangatini Sump and high flow bypass from 2015 onwards), compared to historic values.

The relative contribution of LDS bypass and decant discharge to overall downstream annual sediment loads has been quantified to provide context to the potential effects of the current LDS management. Mass balance calculations showed that for the year 2020 (considered representative of the Operational and End of Mine Life (**EOML**) Phases of the BPCP), the sediment mass load contributed by LDS bypass and decant discharge were similar, at 2,125 t/year and 1,445 t/year, respectively. The combined LDS mass load (3,570 t/year) was equivalent to 18.6 % and 6.9% of the cumulative sediment load at S14B and NR, respectively. Thus, LDS contributions to overall lower Ngakawau River sediment loads are relatively minor.

The McCabes Treatment System is operating without active LDS / AMD Sludge management (other than bypass of high flow alkaline dosed AMD around McCabes Sump) as LDS volumes in McCabes Sump have

not yet accumulated sufficiently to require active management. It is forecast that the McCabes Sump will need LDS removal / desludging starting in 2030 for a period of 3 years. The proposed transition to MgO dosing in 2032 and a corresponding significant reduction in AMD Sludge volumes results in minimal ongoing AMD Sludge management requirements for McCabes Treatment System long-term.

The Millerton Block MW16 Sump annual AMD Sludge generation rates have been calculated from 2047 onwards, after alkaline dosing in-sump commences. The forecast accumulation of ~313,000 m³ of AMD Sludge in MW16 Sump between 2047 and 2106 is significantly less than the MW16 Sump volume (~718,900 m³). As such, AMD Sludge management at MW16 Sump is not forecast to be required.

BRL is transitioning to MgO as the main acidity neutralising agent used in all treatment systems by 2032. This is because MgO has been demonstrated (based on laboratory trial work) to produce a denser LDS / AMD sludge (and therefore lesser volume) in the sumps whilst still delivering the necessary AMD treatment. Laboratory trials have shown MgO will produce AMD Sludge of ~20% solids (compared with the ~2% solids LDS currently produced by CaO dosing). That MgO dosed sludge will consolidate further to ~30% solids content after dewatering.

BRL seeks a continuation of the current consent conditions for continued operation of the Mangatini and McCabes Treatment System and future operation of the MW16 Sump Treatment System (with alkaline dosing directly to MW16 Sump proposed from 2047 onwards). This includes adoption of additional conditions around monitoring effects proposed in Instream (2026) and a continuation of conditions around management of the Mangatini Sump LDS.

1.0 Introduction

1.1 Background

BRL is seeking to obtain authorisation through the FTAA to progress development and mining of the coal resources across the wider BPCP. The purpose of the BPCP is to secure the existing infrastructure and mining operations associated with the Stockton Mine and provide access to additional mining areas as the coal resources in the current operations are depleted. The BPCP proposes to mine approximately 20 million tonnes of coking coal utilising existing infrastructure facilities over a 25-year timeframe to support and extend the mine life of the current Stockton Mine operations.

Water and AMD management at Stockton mine is a complex process, which involves managing the effects of historic / legacy underground mining activities and contemporary opencast mining activities (discussed in the Stockton mine history of AMD Management and Proposed Future Management (BRL 2026a)). Treatment of AMD affected minewater at Stockton primarily consists of AMD collection and dosing with alkaline reagent (currently calcium oxide (CaO) but transitioning to magnesium oxide (MgO) by 2032) to neutralise acidity. This process produces LDS which is a product mainly comprised of insoluble and stable Al and Fe hydroxide precipitates and clastic sediment. When separated from treated supernatant water and dewatered, LDS is managed as an AMD Sludge product.

This management report details the current and future proposed management of treated AMD Sludge (both LDS (0-4 % solids) and AMD Sludge (10 – 30% solids)) for the BPCP at Stockton mine. This includes management of AMD Sludge produced by the three major AMD treatment systems at Stockton:

- Mangatini Treatment System – which treats AMD generated in the Mangatini Catchment and will also treat Millerton Block opencast disturbance footprint AMD until 2046;
- McCabes Treatment System – which treats AMD generated in the Fly Creek, McCabes, and Cypress areas currently and will be expanded to also treat Plover catchment AMD in ~2034; and
- MW16 Sump Treatment System – which will treat remnant AMD generated in the Millerton Block opencast disturbance footprint from 2047 onwards.

The collective ‘Mangatini Treatment System’ includes all associated AMD collection, alkaline dosing, and LDS / AMD Sludge capture / sumps, and treated water discharge infrastructure in the Mangatini Catchment. The collective ‘McCabes Treatment System’ and ‘MW16 Sump Treatment System’ similarly refer to AMD treatment related infrastructure in those respective catchments.

This report also describes the process for disposal / permanent storage of AMD Sludge at Stockton mine. A discussion on AMD Sludge management monitoring and consent conditions is also provided (defined further in Instream (2026)), which covers the effects of controlled LDS discharge from Mangatini Treatment System to Mangatini Stream and Ngakawau River during high flow conditions.

1.2 Objectives

The objectives of this report are to:

- Describe AMD Sludge management in each of the three AMD treatment systems (Mangatini, McCabes, and MW16), including quantification of AMD sludge volumes produced over the BPCP period (2027 to 2062);
- Define AMD Sludge disposal processes and quantify on-site storage capacity; and
- Describe the effects of LDS that is not captured in sedimentation sumps on downstream waterbodies, focusing on LDS bypass and decant discharge in the Mangatini Treatment System.

1.3 Current management approach

AMD captured in the Mangatini and St Patrick / McCabes catchments at Stockton is currently treated by dosing with CaO alkaline slurry from Lime Dosing Plants, **LDP1** and **LDP2**, respectively (Figure 1). This slurry adds alkalinity to the AMD and the resultant LDS settles out in the downstream Mangatini and McCabes Sumps (Figure 1) during low to moderate flow conditions. AMD Sludge management seeks to actively manage the level of accumulated sludge within the settlement sumps to manage freeboard levels and ensure effective ongoing LDS removal (and therefore the sump discharge water quality) is optimized, whilst also minimizing sump out-of-service periods (for sludge removal and disposal). During

high flow conditions CaO dosed AMD bypasses the settlement sumps and this is discussed further in following sections. Relevant water quality monitoring sites and catchments are shown in Figure 2.

Early Mangatini Stream AMD treatment (between 2007 and 2009) involved UFL dosing directly to Mangatini stream (downstream of the S14C monitoring site) before Mangatini Sump was commissioned. Large sumps were subsequently constructed and commissioned for operational LDS capture, with the Mangatini Sump used since 2010 and McCabes Sump since 2024. AMD ‘dose and settle’ treatment strategies employed at Stockton mine since 2007 have removed the former chemical barrier to migratory fish in the Ngakawau River (Instream 2025).

There is a comprehensive sludge management section detailing how LDS is managed in the Mangatini Sump Management Plan (See Appendices 1, GHD 2018). This is discussed further in Section 2.0 and operational performance monitoring data are presented in Section 7.0.

The McCabes Sump has only been operational since 2024 and hence does not require sludge management currently, as LDS only builds up over time. Current forecasting indicates LDS removal from McCabes Sump may only be required for a short period between 2030 and 2033. If required, McCabes Sump LDS / AMD Sludge will be managed using a similar management approach as applies to the Mangatini Sump in terms of pumping LDS to dewatering filter beds, though decant discharge from McCabes Sump is not proposed.

To treat additional AMD that will be generated as part of the BPCP (primarily as a result of further planned mining in the Millerton Block) it is proposed that the MW16 mine void will be turned into a new MW16 Sump through the operational period (commissioning date subject to scheduling ~2032/33). Once MW16 Sump becomes operational it will be used to capture sediment / TSS and AMD runoff and seepage (i.e., mine impacted water) generated from Millerton ELF and other exposed surfaces within the MW16 / Mine Pit disturbance area. Captured AMD from active mine areas will be pumped back to the existing Mangatini Treatment System (as well as AMD from other Millerton mining catchments (i.e., Granity Stream, Miller Stream, Mine Creek, and Twins Stream)) throughout the Operational Phase. This mine impacted water will continue to be pumped from Millerton pit sumps / MW16 Sump to the Mangatini Treatment System until 2046 (when final landform rehabilitation is completed). From 2047 onwards, the reduced acid loads (after Millerton final landform rehabilitation is completed) reporting to MW16 Sump will be treated by alkaline dosing directly to the sump. The MW16 Sump is not anticipated to require AMD sludge management as the Sump is forecasted to have sufficient capacity to store sludge for over 80 years.

The capacity of current and proposed Sumps is shown in Table 1.

Table 1: Capacity of the current and proposed Sumps for AMD treatment and LDS / AMD Sludge retention

Catchment	AMD Treatment Sump	Operational Treatment commencement Date	Sump Capacity (m3)	Operating Live Storage (m3)
Mangatini	Mangatini	2009	886,000	135,000
St Patricks	McCabes	2024	356,000	60,000
Millerton	MW16	2046	718,900	128,000

The management of the AMD Sludge is discussed for each of the three AMD treatment systems in the following three sections.

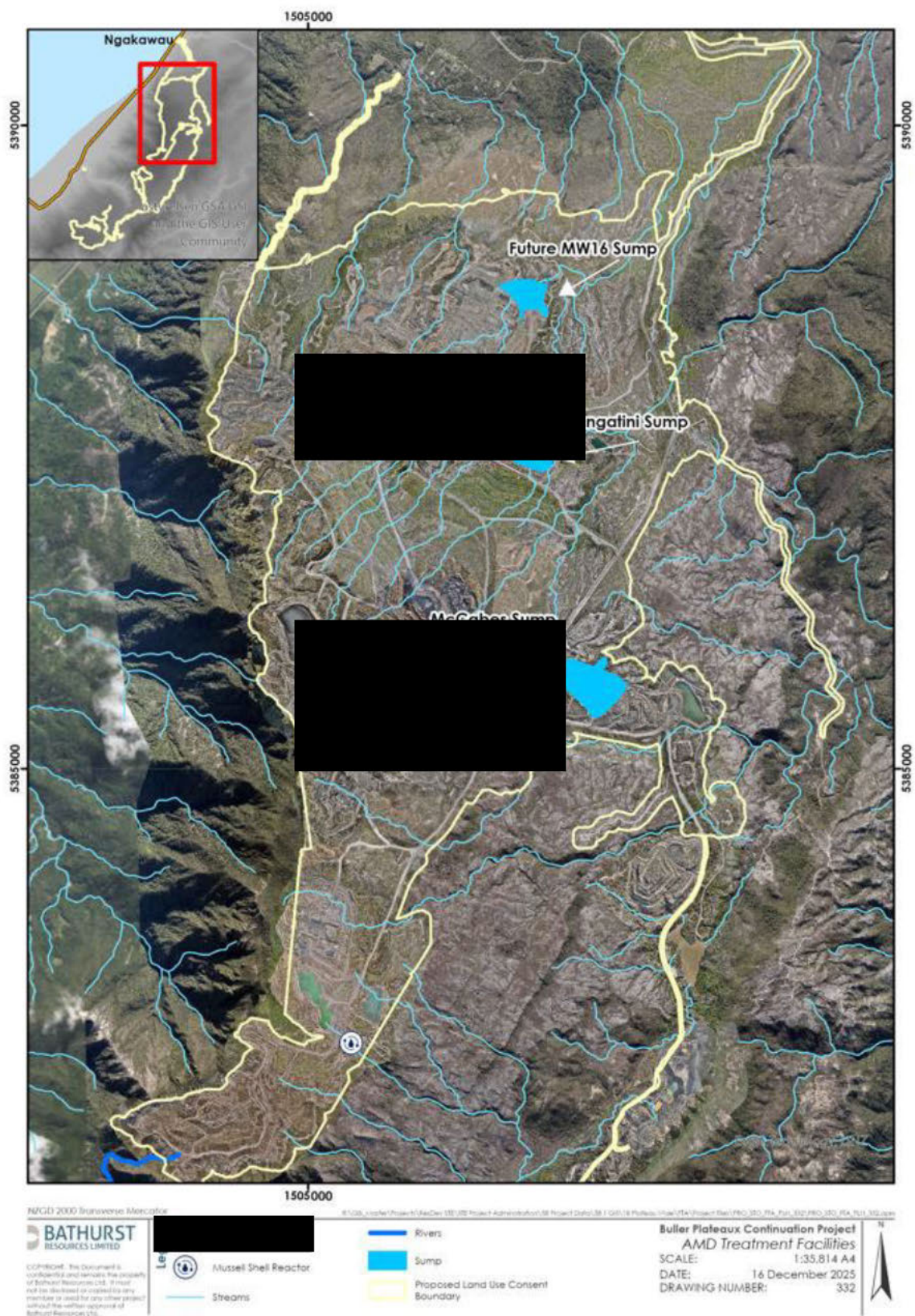


Figure 1: AMD Treatment Facilities, Sumps, [REDACTED] and Mussel Shell Reactor

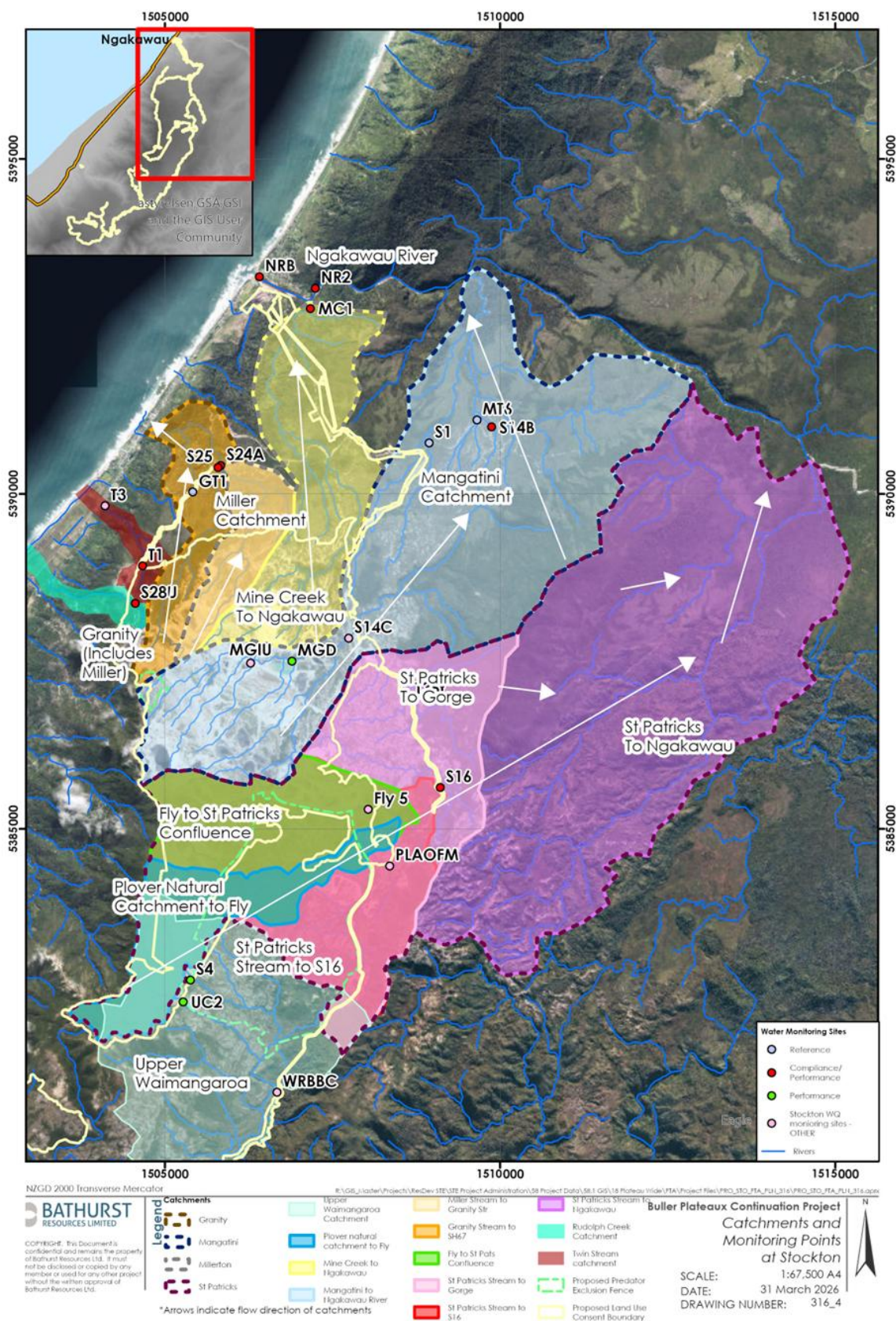


Figure 2. Catchments and water quality monitoring points at Stockton mine

2.0 Mangatini Sump – AMD Sludge Management

2.1 Background

New resource consents associated with the operation of the Mangatini Sump are being sought as part of the BPCP. The Mangatini Sump is a fundamental component of Stockton AMD management infrastructure, including the processes for managing LDS. The existing Mangatini Sump LDS management procedures are proposed to continue going forward, as these have been proven effective operationally and have demonstrated environmental compliance. BRL currently maintains the LDS within the sump such that the LDS level remains relatively consistent, while optimisation of the current systems is targeting progressive gain in the freeboard levels to provide greater operational flexibility.

Optimisations to the operation of the Mangatini Sump since 2018 (leading to establishment of the current management approach) include:

- 2018 – Consistent LDS pumping to filter beds for dewatering.
- 2020 – Installation of pump and winch system to enable LDS removal from the decant end of the sump.
- 2021 – Intermittent CaO dosing upstream of MG Quarry Sump to allow precipitate settling prior to MG Sump.
- 2023 – LDS pumping upstream of MG Quarry Sump for sludge recycling to utilise the remnant acidity neutralising capacity (**ANC**) within the LDS and promote a denser precipitate.
- 2025 – Installation of the inlet weir gate to better control flows entering / bypassing Mangatini Sump and reduce bypass flow time.

2.2 Current management approach

2.2.1 Overview

The Mangatini Sump and Lime Dosing Plant (**LDP1**) are the key infrastructure within the Mangatini Treatment System (Figure 3). All runoff from disturbed and rehabilitated areas within the Mangatini Catchment reports to the Mangatini Stream above Mangatini Sump for management.



Figure 3: Mangatini AMD Treatment Sump and [REDACTED]

The Mangatini Sump has a management plan (Appendix 1: GHD 2018), which requires optimised updates and performance records to be reported to West Coast Regional Council every 2 years as part of RC06206 (expiry 2028). The Mangatini Sump management plan has the main components below:

- Upstream sediment ponds and engineered infrastructure ensure minimal coarse sediment enters Mangatini Sump, optimising freeboard for AMD treatment and LDS capture.
- All AMD reporting to Upper Mangatini Stream (above Mangatini Sump) is alkaline dosed, either directly or by mixing with dosed flow paths. Acid loads of >10,000 t/year have been treated.
- Up to ~70th percentile Mangatini stream flows (downstream of lime dosing) are diverted into Mangatini Sump for sedimentation / capture of LDS.
- This process results in LDS (mainly stable Al and Fe hydroxide precipitates and clastic sediment) accumulating in the 886,000 m³ capacity Sump. One tonne of acidity load treated produces an estimated ~34 m³ of LDS (at ~2% solids content).
- The captured LDS is periodically pumped from the Sump to prepared filter beds at rates up to 340,000 m³/year for dewatering.
- In the filter beds the LDS consolidates to an AMD Sludge product with ~10% solids content (due to the loss of moisture from filtration and evaporation), which can be free dug and transported by trucks to defined slops cells within ELF for co-disposal with overburden.
- Slops cells are located within the ELF to ensure any contaminants re-released from the consolidated AMD Sludge will be captured and treated in AMD treatment sumps along with other AMD seepage from the ELF.
- The Mangatini Sump is routinely surveyed via sonar to ensure enough freeboard is available for effective operation (operational target 135,000 m³ freeboard), including ongoing sedimentation of TSS and LDS.

Freeboard volumes have been calculated based on settlement analysis undertaken using the Modified Fair and Geyer (1954) method (WSUD 2012) and allowances for fluctuating AMD Sludge levels. Calculations for two conservative scenarios were undertaken to evaluate likely performance. This included:

- (1) For storm inflows of 1.5 m³/s when TSS would be dominated by coarse particles, an inflow TSS of 2,500 mg/L and moderate settling velocity (consistent with coarser particle settlement rates) resulted in a modelled outflow TSS of 1 mg/L.
- (2) For lower inflows of 0.2 m³/s when TSS would be dominated by colloidal / AMD precipitates, an inflow TSS of 200 mg/L and low settling velocity (consistent with colloidal / AMD Sludge settlement rates) resulted in a modelled outflow TSS of 2 mg/L.

The settling velocity of the incoming TSS was altered between the two flow scenarios to simulate high flow / high sediment loads versus low / moderate flow predominately AMD precipitate scenarios. The discharge TSS under both of these scenarios is considered acceptable for sedimentation treated supernatant discharge, and similar outflow TSS levels are assumed to occur for intermediate flow ranges.

2.2.2 High flow LDS management

BRL manages Mangatini LDS during high flow conditions (nominally >70th percentile flows) through a combination of:

- **Bypass around Mangatini Sump** – During high flow conditions exceeding the ~70th percentile, all flow is bypassed around Mangatini Sump and discharged directly to Mangatini Stream (above S14C monitoring site). These bypass flows are treated with CaO, so they receive AMD treatment but do not receive sedimentation treatment.
- **Active discharge from Mangatini Sump** – Infrequent discharges of LDS from Mangatini Sump (via the sump decants or LDS / sludge pumps) to Mangatini stream (above S14C) during high flow events are permitted under existing consent RC06206. During high flow conditions (flow >70th percentile when there is considerable dilution in the receiving waterbody) controlled amounts of LDS are actively discharged to the Mangatini Stream to assist with optimising freeboard in the Mangatini Sump to support ongoing AMD treatment and LDS capture during low to moderate flow conditions.

The 70th percentile flow value cut-off for Mangatini Sump bypass was developed in 2018, when BRL operated Mangatini Sump water level at about RL 592.5 m. During rain events, if the sump water level increased to 593.5 mRL the stream could not enter Mangatini Sump due to the relative head in the sump versus the bypass spillway elevation (also 593.5 mRL). Flow rate monitoring data indicated that bypass typically occurred when the stream was at about the 70th percentile flow equivalent.

Water quality performance monitoring data does not indicate any detrimental impacts on receiving water due to this bypass, as bypass flows were CaO dosed to neutralise acidity (this is supported by

additional performance operating data presented in Section 7.0). BRL intends to continue operating Mangatini Sump water level at about RL 592.5 m through the duration of the BPCP.

2.2.3 Operational effects of LDS management

A review of operational dissolved Al concentration and turbidity monitoring data from 2006 onwards at key sites affected by LDS bypass along Mangatini Stream (S14C and S14B) and in Ngakawau River (NR) is provided in Section 7.2. This analysis has been undertaken to demonstrate that the nominal high flow bypass threshold of ~70th percentile flows is providing effective LDS management in the context of the historic NR dissolved Al and turbidity versus flow percentile distribution.

As a brief summary of the Section 7.2 content, Figure 4 shows the median NR turbidity value for a given flow percentile value across four key periods of performance monitoring data. Figure 4 supports continuation of a high flow bypass threshold of 70th percentile flows by showing:

- The current regime (CaO dosing with a nominal >70th percentile flow bypass threshold, Jan 2021 onwards dataset) is delivering NR turbidity values that are comparable to values seen in January 2015 to December 2018, when the high flow bypass threshold was nominally >90th percentile⁵.
- The current regime is delivering relatively low NR turbidity values compared to historic trends prior to AMD treatment and during the period where UFL was dosed directly to Mangatini Stream (without sedimentation).

These observations show that the LDS contribution to NR turbidity is relatively minor, including during > 70th percentile high flow bypass periods. Overall, NR turbidity values are relatively low under the current Mangatini Treatment System configuration (including CaO dosing upstream of Mangatini Sump and high flow bypass from 2015 onwards), compared to historic values.

⁵ The transition from 90th to 70th percentile flow bypass was made to manage the significant increase in LDS volumes (compared to UFL dosing) accumulating in Mangatini Sump and optimise freeboard.

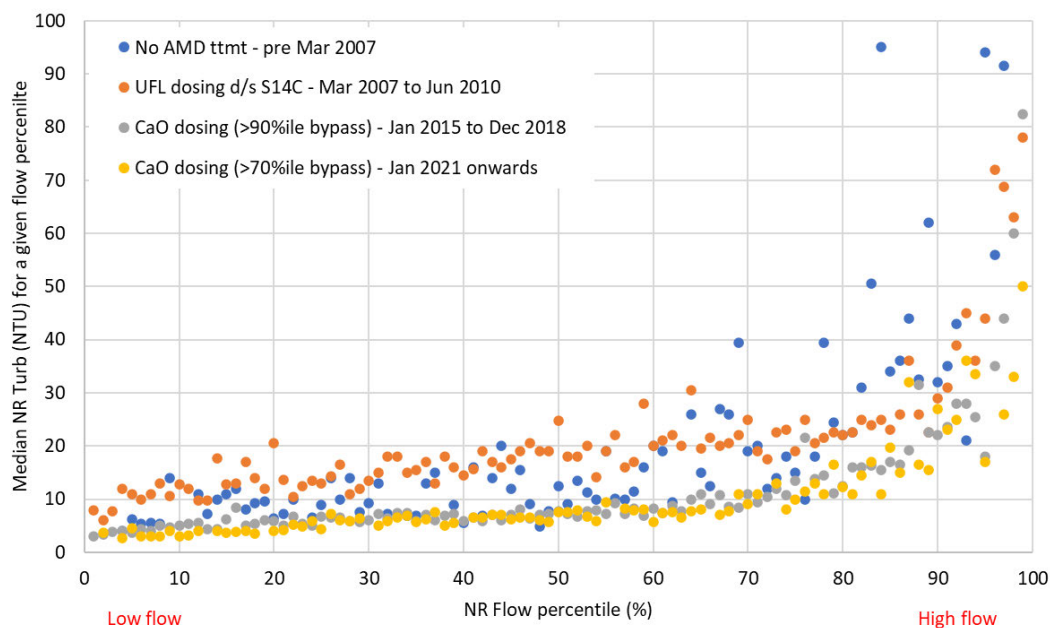


Figure 4. Median NR turbidity versus flow percentile distribution

2.3 Filtration and co-disposal

Filter beds (location shown in Figure 5 and photo in Figure 6) continue to provide the predominant method of management for LDS removed from the Mangatini Sump in recent years, with fewer high flow, long duration events reducing the opportunity for actively managed decant discharges. A submersible pump has been added in the filter beds to remove the supernatant water from the top of the settled LDS. This reduces the volume of water required to filter through the drainage medium. A total of 607,005 m³ of LDS slurry has been pumped to the filter beds between 1 August 2022 to 31 July 2024.

LDS removed (by excavator as shown in Figure 6) from the filter beds is co-disposed in a slops cell within ELF where it is then capped with overburden material. An analysis was undertaken to determine if metals were being leached from the LDS into the downstream pit water. The disposal locations were mapped with downstream water quality being compared with a similar location that does not have LDS within the catchment. There was no discernible increase in metals downstream of the LDS disposal cell locations when compared with what was expected from overburden alone (MWM, 2021).

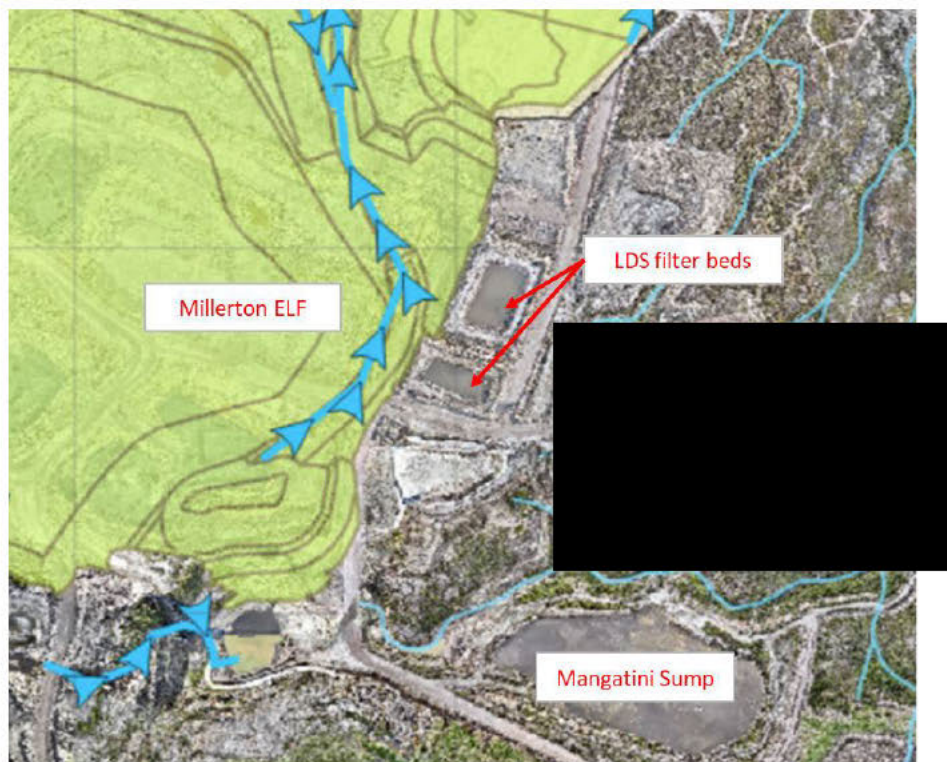


Figure 5. Layout of Mangatini Sump and LDS filter beds



Figure 6. Mangatini Filter Bed #2 cleaning in progress July 2024

2.4 Magnesium oxide (MgO)

It is proposed to transition from CaO to MgO as the dominant alkaline agent for AMD treatment at Stockton. This is because MgO has been demonstrated (based on laboratory trial work) to produce a denser AMD Sludge (and therefore lesser volume, Figure 7) in the sumps whilst still delivering the necessary AMD treatment. Verum (2023) have noted that MgO will produce AMD sludge of ~20% solids

(compared with ~2% solids produced currently from CaO) due to a minimal low density / high volume component dominated by CaSO_4 precipitates, as occurs currently using CaO as the neutralizing agent. Producing a denser sludge using MgO will further optimise freeboard (and therefore settlement performance) within sumps. MgO treated AMD Sludge generation volumes are calculated using a rate of 3.4 m³ AMD Sludge / tonne of acidity neutralised. This a 10-fold reduction from current CaO neutralized sludge generation which produces 34 m³ AMD Sludge / t acidity neutralised. Field trials are ongoing to facilitate this process to be up scaled and optimised for operational implementation and commissioning in both LDP1 and LDP2 by December 2032.

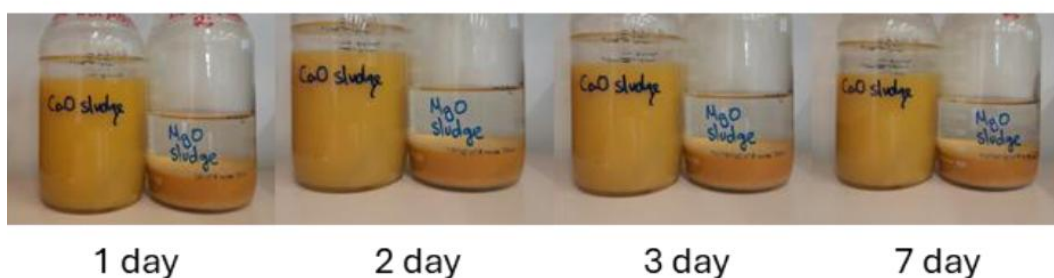


Figure 7: Photographs of Mangatini AMD treated precipitates using CaO and MgO (Verum, 2023)

The optimisation work will also assess the benefits of dosing of AMD upstream of treatment sumps with low dosages of CaO prior to dosing MgO as the primary treatment in the main sump treatment.

Using a mix of Calcium Oxide (CaO) and Magnesium Oxide (MgO) in treating AMD offers significant advantages over using either reagent alone, primarily due to combined rapid pH adjustment and long-term, stable metal removal. Key benefits include improved neutralization efficiency, significantly lower AMD Sludge volumes and enhanced heavy metal stabilization.

- **Enhanced Heavy Metal Immobilization:** The mix effectively removes a broader range of metals (e.g., Cu, Zn, Pb, Mn, Fe) by combining the chemical precipitation of lime with the strong surface adsorption of magnesium hydroxides.
- **Lower Re-mobilization Risk:** MgO-treated systems are more resistant to re-acidification, reducing the risk of precipitated heavy metals leaching back into the water.

Mechanism of Action

- **CaO (Lime):** Rapidly neutralizes high levels of acidity and initiates fast settling.
- **MgO (Magnesium Oxide):** Provides steady, self-buffered alkalinity (via $\text{Mg}(\text{OH})_2$ formation) and acts as an efficient adsorbent for heavy metals.

Optimisation trials on downstream water quality

Optimisation trials will ensure that the Mg:Ca ratios in downstream water will be maintained at levels <9:1 to ensure that there is minimal adverse impact from elevated Mg cations impacting on Ca ions

uptake by aquatic ecology. Toxicity is highly dependent on Mg:Ca ratios, with higher Ca levels significantly mitigating toxicity.

2.5 Projected Mangatini Treatment System AMD sludge volumes

The projected combined AMD Sludge and slops volumes reporting to the Mangatini Sump (including Millerton Block contributions) are shown in Table 2. In addition, there are AMD Sludge and slops volumes that will be settled out in Mangatini quarry pre-Sump and the future Mumms pre-Sump, within the Mangatini Treatment System (i.e., in addition to LDS / AMD Sludge captured in Mangatini Sump). Table 3 presents the total AMD Sludge volumes for disposal in slops cells from 2027 – 2062, including sediment and AMD Sludge captured in all Mangatini Treatment System sumps.

Table 2: AMD Sludge and slops volumes generated from AMD treatment reporting to Mangatini Sump 2027-2062. (CaO neutralant is used from 2027-2032 and then MgO will be used 2033-2062).

Year	Total Acid Load (t/year)	Acid load to be treated (75%) (t/year) **	LDS retained in Sump*** (m ³ /year)	After filter bed, AMD Sludge to be disposed in cells in ELF (m ³ /year)
2027*	10,912	8,184	278,256	55,651
2028	11,324	8,493	288,750	57,750
2029	11,735	8,801	299,250	59,850
2030	11,147	8,360	284,250	56,850
2031	10,559	7,919	269,250	53,850
2032	9,471	7,103	241,500	48,300
2033	8,576	6,432	21,870	14,580
2034	8,375	6,281	21,357	14,238
2035	7,663	5,747	19,540	13,027
2036	7,337	5,502	18,708	12,472
2037	7,084	5,313	18,065	12,044
2038	6,799	5,099	17,338	11,559
2039	6,595	4,946	16,817	11,211
2040	6,392	4,794	16,299	10,866
2041	6,189	4,642	15,783	10,522
2042	5,987	4,490	15,267	10,178
2043	5,786	4,340	14,754	9,836
2044	5,664	4,248	14,443	9,629
2045	5,543	4,157	14,135	9,423
2046	5,422	4,067	13,827	9,218
2047****	2,468	1,851	6,294	4,196
2048	2,460	1,845	6,274	4,183
2049	2,452	1,839	6,254	4,169
2050	2,444	1,833	6,233	4,156
2051	2,437	1,827	6,213	4,142
2052	2,429	1,821	6,193	4,129
2053	2,421	1,815	6,173	4,115
2054	2,413	1,810	6,152	4,102
2055	2,405	1,804	6,132	4,088
2056	2,397	1,798	6,112	4,075
2057	2,389	1,792	6,092	4,061
2058	2,381	1,786	6,071	4,048
2059	2,373	1,780	6,051	4,034
2060	2,365	1,774	6,031	4,021
2061	2,357	1,768	6,011	4,007
2062	2,349	1,762	5,990	3,994
Total	197,100	147,825	1,997,736	556,571

*Including acidity load pumped from Millerton Block to Mangatini for treatment, ** Remaining 25% of LDS discharged via bypass, *** LDS / AMD Sludge volumes of 2% solids CaO treated 2027-32; 20% solids MgO treated 2033-2062, **** Mangatini loads decrease when Millerton AMD treatment in MW16 Sump commences in 2047.

Table 3. Combined Mangatini Sump, Mangatini Quarry, and Mumm's Sump AMD Sludge and slops volumes. Dewatered state to be disposed of in slop cells.

Year	Neutralising agent	Mangatini Sump/Mangatini Quarry/Mumm's Sump combined AMD Sludge / slops volume for disposal (m ³ /year)
2027	CaO	58,364
2028	CaO	60,819
2029	CaO	63,275
2030	CaO	59,767
2031	CaO	56,260
2032	CaO	49,771
2033*	MgO	18,146
2034	MgO	17,719
2035	MgO	16,206
2036	MgO	15,514
2037	MgO	14,978
2038	MgO	14,372
2039	MgO	13,939
2040	MgO	13,508
2041	MgO	13,078
2042	MgO	12,649
2043	MgO	12,221
2044	MgO	11,963
2045	MgO	7,879
2046	MgO	7,766
2047	MgO	5,245
2048	MgO	5,228
2049	MgO	5,211
2050	MgO	5,194
2051	MgO	5,178
2052	MgO	5,161
2053	MgO	5,144
2054	MgO	5,127
2055	MgO	5,110
2056	MgO	5,093
2057	MgO	5,076
2058	MgO	5,060
2059	MgO	5,043
2060	MgO	5,026
2061	MgO	5,009
2062	MgO	4,992
TOTAL		620,089

* Transition to MgO treatment in 2033.

2.6 Mangatini Treatment System capacity

The current Mangatini AMD treatment regime commenced in 2015 (i.e., use of CaO dosing for acidity neutralisation and Mangatini Sump for LDS management), when pre-treatment Mangatini acidity loads were in the order of ~10,000 t/year (Figure 8). Table 2 summarises forecasted acidity loads reporting to the Mangatini Treatment System (including both loads generated within Mangatini Catchment and pumped from Millerton pit sumps) for the BPCP. These forecast future loads are comparable to acidity loads previously treated through the Mangatini Treatment System.

Mangatini catchment acidity concentrations and loads have decreased over time from maximum recorded values in ~2012 to current levels (Figure 8). This decrease coincides with a long-term reduction in active mining activities and an increase in the extent of rehabilitation / revegetation in Mangatini Catchment.

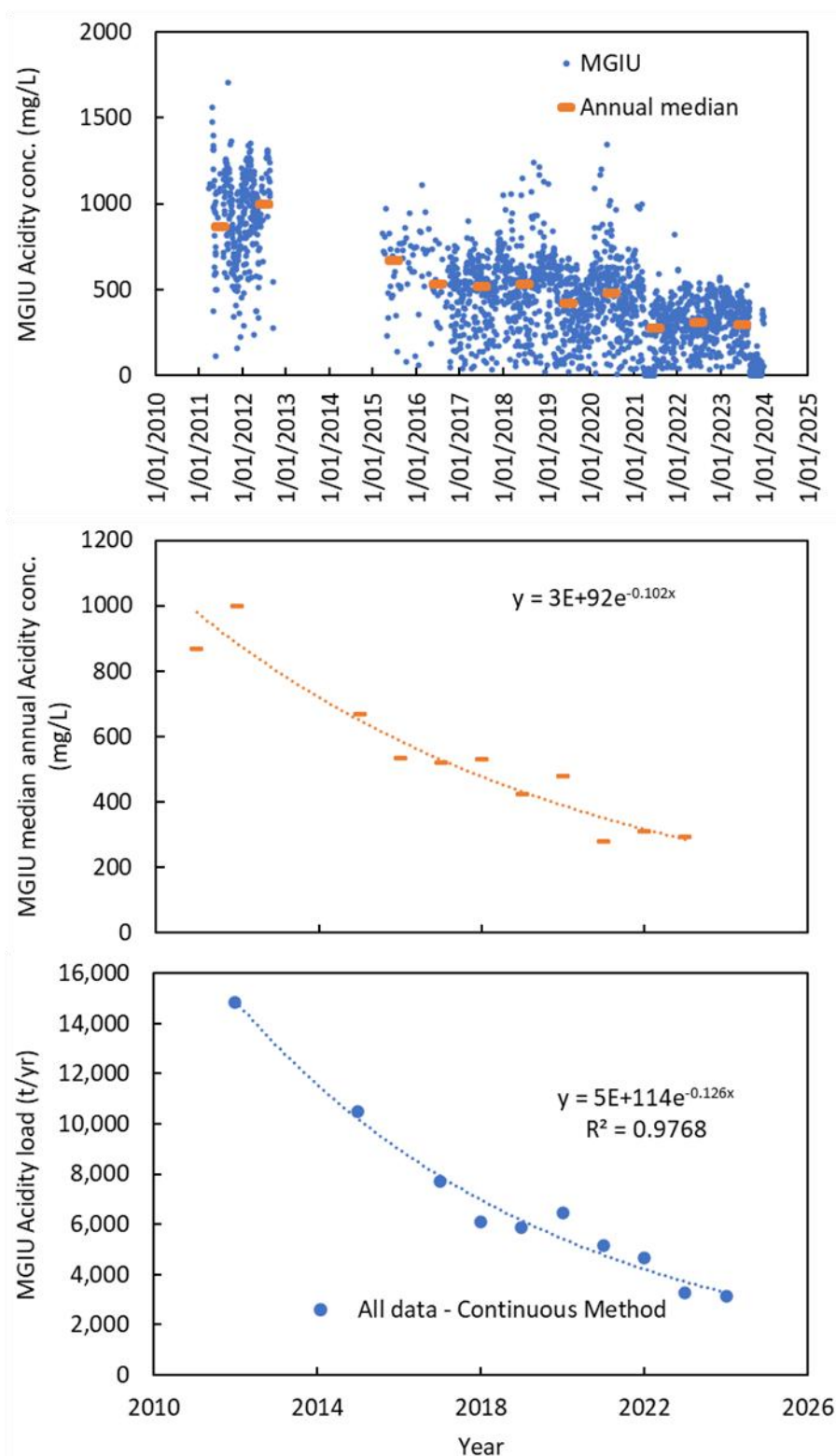


Figure 8. Long term trends in Mangatini Catchment acidity concentrations and loads. Mangatini Sump Inlet Upstream (MGIU) data from mid-2023 onwards are affected by [REDACTED].

There have also been operational improvements / refinements to the Mangatini Treatment System infrastructure since acidity loads were last in the order of ~10,000 t/year (i.e., since 2015), including:

- Ongoing refinement of CaO dosing processes, including moving dosing points higher up in the catchment to provide longer neutralisation periods and better mixing.
- Use of Mangatini Quarry Sump (from mid-2023 onwards) and Mumm's Sump (planned to start in late-2026) for sediment / LDS capture (upstream of Mangatini Sump) to reduce sediment / LDS volumes reporting to Mangatini Sump.
- Installation of a remotely controlled gate at the inlet to Mangatini Sump to enable rapid opening / closing of the Mangatini Sump inlet and more efficiently switch between:
 - Normal operations (<70th percentile flow conditions) where dosed AMD flows into Mangatini Sump for sedimentation; and
 - Bypass around Mangatini Sump (>70th percentile flow conditions) where dosed AMD flows bypass Mangatini Sump sedimentation.

In addition, the incorporation of pit sumps to capture and temporarily store AMD from Millerton will provide operational flexibility around the rates of AMD transfer from Millerton to Mangatini Treatment System.

Finally, commissioning of Lime dosing plant 2 (LDP2) and McCabes Sump provides greater control of AMD contributions from St Patrick Stream to the Ngakawau River, which is also affected by Mangatini Stream discharges.

2.7 Volume of Slops requiring disposal - Mangatini

The total volume of dewatered AMD Sludge / slops requiring co-disposal cells within ELF's will depend on the neutralisation reagent used. AMD Sludge volumes to be generated between 2027 and 2062 are estimated at 620,089 m³ (Table 3):

- Assuming CaO is used as the neutralant and LDS processed in filter beds 2027-2032; and
- Assuming MgO is used as the neutralant and LDS processed in filter beds 2033-2062.

In the Millerton ELF, the designed slop cell areas within the ELF's being constructed will have a total capacity >1,000,000 m³ to accommodate slops / LDS during mining operations until end 2031, when these cells will be buried by further waste rock.

Additional final landform slop cells (Figure 15) available from 2032 onwards have been designed to have capacity >750,000 m³ for disposal of AMD Sludge and slops between 2032 and 2062, and post 2062. The volume of AMD Sludge and slops captured by Mangatini Treatment System between 2032 and 2062 is estimated at 321,604 m³ (calculated from values in Table 3).

2.8 BPCP management approach

Existing operational Mangatini Sump management practices are considered appropriate for the BPCP. This includes methods for LDS dewatering and AMD Sludge disposal.

The 70th percentile is considered appropriate as the nominal high flow bypass threshold for the Mangatini Treatment System during the BPCP. This management approach will continue to optimise LDS accumulation / freeboard within the Mangatini Sump while maintaining low turbidity values and TSS / Al concentrations downstream, relative to historic levels.

The Mangatini Treatment System will treat AMD from both Mangatini Catchment and Millerton Block throughout the BPCP Operational and EOML Phases. Throughout this period optimisation should focus on:

- Effective treatment of the Millerton Block acidity load (targeting increased treatment of Millerton AMD with a relatively high acidity concentration and relatively consistent pumped flow rate); as a priority over
- Increasing the Mangatini Sump bypass threshold to greater than the current operational target of ~70th percentile flows (which would be targeting increased treatment of larger flow volumes with lower acidity concentrations that occur less frequently and with relatively short event durations).

The effects of the >70th percentile high flow LDS bypass and decant discharge from Mangatini Sump on downstream water quality and total sediment loads at S14B and NR are discussed further in Section 7.0.

BRL have also started lime dosing upstream of larger sediment sumps, e.g. Mangatini Quarry Sump (from mid-2023 onwards), and Mumm's Sump (planned to start in late-2026) for sediment / LDS capture and removal to further optimise the performance of AMD treatment in the Mangatini Sump. These structures provide primary settling for sediment and AMD precipitates with the sediment removed using diggers and trucks as required.

3.0 McCabes Sump – AMD Sludge management

McCabes Sump (Location shown in Figure 1, aerial photo in Figure 9) is a treatment Sump for capturing sediment and LDS / AMD Sludge, receiving water from the historically AMD impacted Fly Creek and McCabes catchments including the McCabes Coal Fines Storage facility and pumped water from Cypress work areas. LDP2 provides the CaO slurry for AMD neutralisation/treatment.



Figure 9: McCabes AMD Treatment Sump- operational since 2024

The estimated LDS / AMD Sludge volumes that will be produced and settle in the McCabes Sump are noted in Table 4. McCabes Sump has only been operating since 2024, with minimal accumulation to date, hence currently LDS is not pumped to filter beds as there is sufficient freeboard to ensure optimal settlement. It is forecast that the McCabes Sump will need desludging starting in 2030 and continuing for 3 years.

Similar to Mangatini AMD Sludge management, the 2% LDS (2027-2032 using CaO neutralant) and 20% solids AMD Sludge (2033 onwards using MgO neutralant) will be transferred to a filter bed (to be constructed within the McCabes Sump catchment, location Figure 10) where it will be dewatered prior to disposal in slops cells.

Table 4: AMD Sludge and slops volumes generated from AMD treatment, McCabes Sump 2027- 2062

Year	Total Acid Load (t/year)	Acid load to be treated (75%) (t/year)	LDS retained in Sump* (m ³ /year)	After filter bed, AMD Sludge to be disposed in slop cells (m ³ /year)
2027	2,626	1,970	66,963	13,393
2028	2,626	1,970	66,963	13,393
2029	2,626	1,970	66,963	13,393
2030	2,626	1,970	66,963	13,393
2031	2,626	1,970	66,963	13,393
2032	1,049	787	2,675	1,783
2033	1,049	787	2,675	1,783
2034	1,049	787	2,675	1,783
2035	1,049	787	2,675	1,783
2036	1,049	787	2,675	1,783
2037	1,049	787	2,675	1,783
2038	1,049	787	2,675	1,783
2039	1,049	787	2,675	1,783
2040	1,049	787	2,675	1,783
2041	1,049	787	2,675	1,783
2042	1,049	787	2,675	1,783
2043	1,049	787	2,675	1,783
2044	1,049	787	2,675	1,783
2045	1,049	787	2,675	1,783
2046	1,049	787	2,675	1,783
2047	897	673	2,287	1,525
2048	897	673	2,287	1,525
2049	897	673	2,287	1,525
2050	897	673	2,287	1,525
2051	897	673	2,287	1,525
2052	897	673	2,287	1,525
2053	897	673	2,287	1,525
2054	897	673	2,287	1,525
2055	897	673	2,287	1,525
2056	897	673	2,287	1,525
2057	897	673	2,287	1,525
2058	897	673	2,287	1,525
2059	897	673	2,287	1,525
2060	897	673	2,287	1,525
2061	897	673	2,287	1,525
2062	897	673	2,287	1,525
Total	43,217	32,413	411,537	118,111

*(2% solids CaO treated 2027-32; 20% solids MgO treated 2032-2062).

3.1 Volume of Slops requiring disposal - McCabes

Based on the McCabes Sump volume and storage capacity (total capacity 356,000 m³, operational freeboard ~60,000 m³), some LDS may have to be removed from the Sump by 2030 to maintain operational freeboard. Once MgO dosing commences in 2033 it is expected that the Sump capacity will be sufficient for permanent storage of future MgO dosed AMD Sludge, so that further sludge removal will not be required. Regular annual sonar surveys will confirm the sludge levels and trigger the required sludge pumping to filter beds for dewatering to maintain operational freeboard.



Figure 10. LDS filter bed proposed location adjacent to McCabes sump for LDS dewatering

4.0 MW16 Sump – AMD Sludge management (Millerton Block)

Mine water from the Millerton ELF will be captured in the MW16 Sump (Figure 1, Figure 11), and pumped to the Mangatini Treatment System for treatment from 2033 to 2046. Millerton Block acidity loads transferred to Mangatini Treatment System and associated LDS / AMD sludge generation for this period are included in Section 2.5 estimates.

From 2047 onwards Millerton AMD will be treated in MW16 Sump. MgO slurry will be piped from LDP1 to a mixing tank located within the ELF. Dosing will be automated based on raw water pH with the dosing pipeline discharging into the mixing channels. From 2047 onwards all MW16 Sump inflows will be MgO

dosed. As such, the treated water discharged from MW16 Sump during high flow / spill events (>90th percentile flow conditions) will contain AMD precipitates.

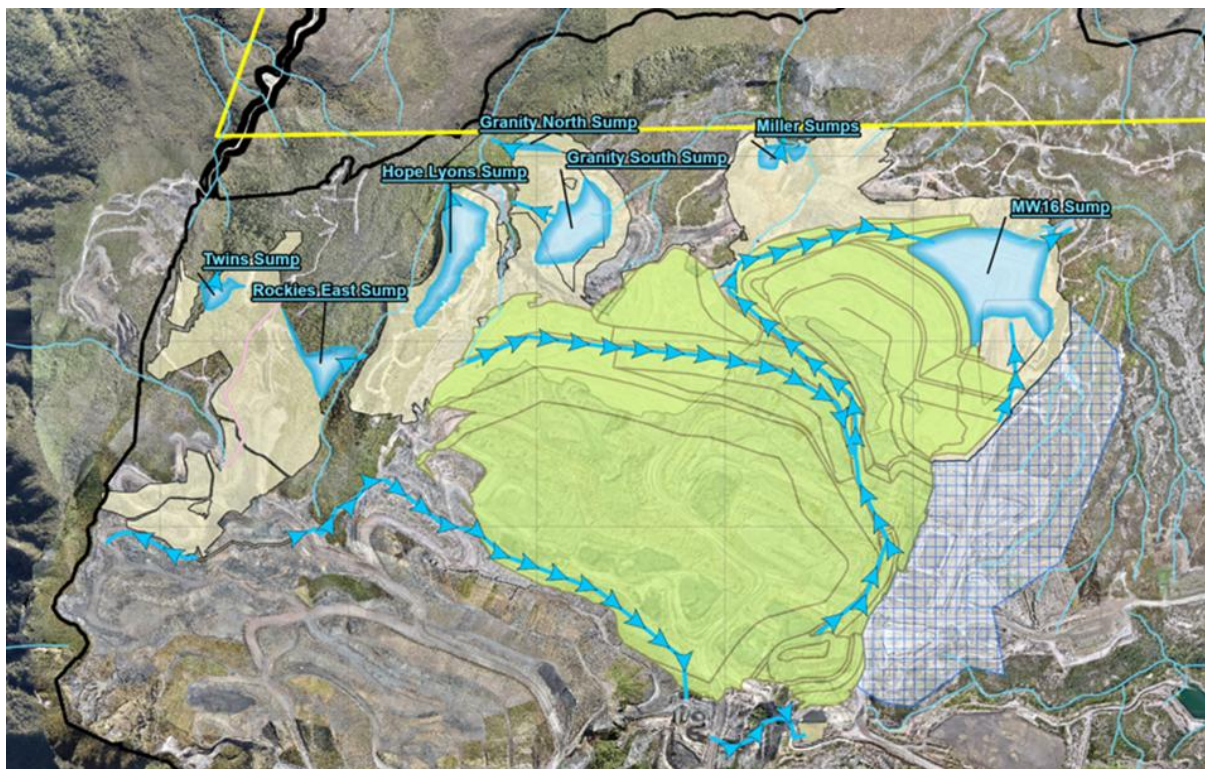


Figure 11. Millerton ELF (green) and MW16 Sump

The expected 2047 onwards MW16 Sump treated acidity load and AMD Sludge generation is summarised in Table 5. This assumes in-Sump MgO slurry dosing commences in 2047 (when pumped transfer to the Mangatini Treatment System ceases). An AMD Sludge generation rate of 3.4 m³ per tonne of acid neutralised was used in calculations and is based on the acidity load assessments in BRL (2026b).

Table 5. Acidity load treated by alkaline dosing to MW16 Sump and AMD Sludge generation

Year	MW16 Sump – Total Acidity load (t/year)	MW16 Sump – Treated Acidity load (75% ttmt) (t/year)	AMD Sludge generation (m ³ /year)*
2047	3,540	2,602	8,848
2048	3,399	2,497	8,489
2049	3,258	2,391	8,129
2050	3,116	2,285	7,770
2051	2,975	2,180	7,411
2052	2,834	2,074	7,052
2053	2,693	1,969	6,693
2054	2,552	1,863	6,334
2055	2,411	1,758	5,976
2056	2,269	1,652	5,617
2057**	2,255	1,642	5,582

* AMD Sludge generation rate equivalent to 3.4 m³ AMD Sludge per t acidity neutralised, ** Modelled acidity loads and AMD Sludge volumes decay at a constant 0.62%/year from 2057 onwards.

The MW16 Sump annual AMD Sludge generation rates (derived in Table 5 and extended out to year 2106) are expected to equate to an accumulation of ~313,000 m³ of AMD Sludge in MW16 Sump by year 2106 (Figure 12). This AMD Sludge volume is significantly less than the MW16 Sump volume (~718,900 m³) and does not affect the MW16 Sump operating live storage capacity of 128,000 m³ (defined in Table 1). As such, AMD Sludge management at MW16 Sump is not forecast to be required.

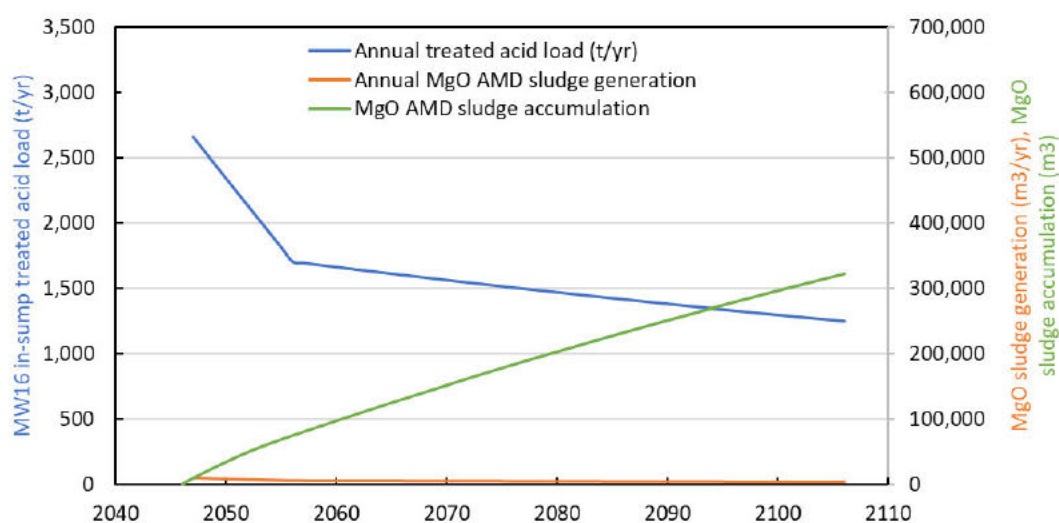


Figure 12. Expected MgO neutralisation AMD Sludge generation rate and accumulation in MW16 Sump

4.1 Twins sub-catchment AMD treatment

A short period of partial AMD treatment in Twins Sump (Figure 11) is proposed to transition between Twins Sump AMD being:

- Pumped to Mangatini Treatment System or Gravity Pit Sumps, until the end of 2040; and
- Controlled discharge from Twins Sump to Twins Stream without AMD treatment from 2046 onwards.

AMD modelling indicates that in-sump treatment would target neutralisation of an approximately 3 t/year acidity load in 2041 to meet betterment reference values (described in the Millerton water and AMD management report (BRL 2026b)). This target neutralisation load would decrease progressively with no treatment required from 2046 onwards as highwall and coal floor AMD generation rates decay. The cumulative 2041 to 2045 acidity load for in-sump treatment is estimated at ~5.8 t acidity to meet betterment reference values. Treatment of this acidity load would generate ~200 m³ of LDS (using the CaO neutralisation LDS generation rate of 34 m³ LDS / t acidity neutralised (and assuming NaOH LDS generation rates are comparable to CaO LDS generation rates). It is likely that a higher degree of acidity neutralisation would occur operationally (to provide additional buffer between remnant concentrations at T1 and betterment reference values). However, given the volume of Twins Sump is ~16,300 m³, LDS accumulation due to temporary in-sump treatment is not expected to affect Twins Sump performance. No LDS management / sludge removal is proposed for Twins Sump.

5.0 Mussel Shell Reactor Sludge – Volumes and disposal

The Whirlwind mussel shell reactor (**MSR**) has been operating since 2012 passively treating approximately 10 tonnes/year of acid in the Whirlwind Stream.

Currently there is ~150 m³ of AMD Sludge removed (Figure 13) every 5 years from the Whirlwind MSR. The proposed current management plan for the small volume of AMD Sludge from this MSR is disposal to slop cells, along with the AMD Sludge resulting from ongoing AMD treatment at Mangatini, McCabes and MW16 Sumps.



Figure 13. Clean out of Whirlwind MSR AMD passive treatment system sludge, 2025

6.0 Disposal of dewatered AMD Sludge

6.1 Slops cell design

All AMD Sludge / slops disposal cells will be situated upstream of treatment Sumps, so any leachate from sludge will be captured and treated.

Slops cells are typically positioned a minimum 10m from ELF extents to minimise risk of internal erosion, seepage, and geotechnical issues for final landform. Greater than 10m width from the outside crest is usually used to enable access around the perimeter of the cell so it can be filled from as many sides as possible

6.1.1 Operational Phase slops cells

Operational slop cells are generally limited to a depth of approximately 5m. The 5m depth enables capping of cells to align with traditional ELF plans/lifts heights.

During the operational phases at Stockton, AMD Sludge generated from the filter beds will be disposed in slop cells constructed within ELFs (Figure 14). There will be disposal cells available in ELFs until the

end of 2031, when remaining cells will be buried by further waste rock as the Operational Phase nears completion.

In the Millerton ELF, the designed slop cell areas within the ELFs being constructed will have a total capacity $>1,000,000 \text{ m}^3$ to accommodate slops / LDS during mining operations until end of 2031.

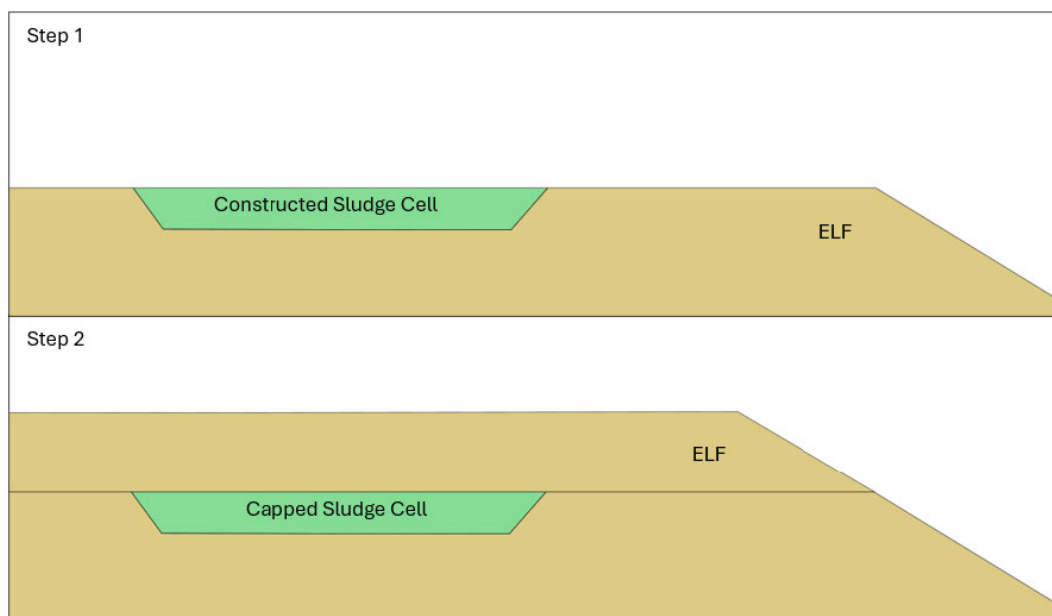


Figure 14. Capping of intra-dump AMD Sludge cells (MWM, 2026)

6.1.2 Final landform slops cells

From 2032 onwards active mining will be near completion and co-disposal of AMD Sludge within the ELF can no longer occur. Instead, AMD Sludge will be retained in final landform slop cells (Figure 15). Final landform slop cells will be constructed to a depth of 7 m below surface and are limited to a slops / AMD Sludge depth of approximately 5m, leaving 2m freeboard for backfill over top.

Operational mine planning has designated slop cells for disposal of dewatered AMD Sludge from filter beds on the ELF surface. Figure 15 indicates 3 potential slop cell sites that will be constructed on top of the final Millerton ELF, if they are all required. Each cell will be of area $50,000 \text{ m}^2$ and contain 5 m storage depth, hence have a combined capacity of $750,000 \text{ m}^3$. There will be adequate capacity for storage of AMD Sludge generated between 2032 and 2062 (volume estimated at $321,604 \text{ m}^3$) with construction of only SC1 and SC2. SC3 would be constructed if additional storage capacity were required. The slop cells will be rehabilitated when full, hence only one cell will remain open by 2062.

- SC1 will be full with final landform rehabilitation completed in approximately 2047.
- SC2 will have approximately $170,000 \text{ m}^3$ storage capacity remaining in 2062.
- SC3 may not be constructed at closure but is an option for continuing slops containment if required.

Note in Figure 15 any leachate from slop cells will be collected and treated in the MW16 sump if required.



Figure 15. Slop Cells to accommodate AMD Sludge from 2032 to 2062 and post 2062, if required.

6.2 Potential additional sources of AMD Sludge

6.2.1 Escarpment (ESE) and Mount Frederick South (MFS) Mine

The BPCP sub areas ESE and MFS have identified Stockton Mine as a potential AMD Sludge disposal option for AMD Sludge generated at those sites. These sludge volumes include:

Construction Phase: It is estimated that approximately 50 k bank cubic meters (**bcm**) of potentially acid forming (**PAF**) waste rock will be deposited at Stockton during the construction of the Upper Waimangaroa Haul Road (**UWHR**). This material will be placed in compacted dumps draining to either the McCabes or Mangatini existing AMD treatment sumps. Resultant maximum sludge from this material will be ~9 m³/year based on 2.6 tonnes of acid/year.

Active WTP phase: After rehabilitation is complete in the ESE and MFS mine areas, AMD Sludge from active treatment plants may be disposed of in Stockton slop cells (Figure 15) and would involve maximum sludge volumes of 5,290 m³ from MFS between 2043 and 2046 and 74,683 m³ from ESE between 2044 and 2057 (MWM, Table E2- 2026), with these end dates coinciding with an end to the active treatment phase.

Passive Treatment Phase: In addition, from 2046, AMD Sludge from the 20 active mussel shell reactors from ESE and MFS will potentially be taken to Stockton for disposal in slop cells (Figure 15) at rates on average of 1000 m³/year (MWM, Table E3-2026).

Alternative disposal options for ESE and MFS AMD sludge are under assessment and include permanent storage cells at ESE / MFS, in pit lakes / voids, or off-site landfills.

6.2.2 Cypress material transferred to Stockton

There is a current consent to move Cypress PAF rock to Stockton Webb area for permanent disposal. This material will be stored permanently in the WE07 ELF, which has a 3.95 Mbcm storage capacity based on current (2026) topographical surfaces and a conceptual final landform design.

An assessment of potential acidity load and AMD Sludge volumes generated by this Cypress material was used to support long term AMD management in the Mangatini Catchment (where WE07 ELF is located). This assessment assumed:

- The maximum 3.95 M bcm storage capacity is utilised;
- All that material transported from Cypress to WE07 was PAF; and
- The Cypress PAF generated acidity at the AMD model rate for St Patrick catchment material of 0.0516 t/year/kbcm (derived from Gandy and Younger (2007) and O’Kane Consultants (2015)).

The extra acidity load generated by the Cypress PAF would equate to an estimated ~163 t/year. WE07 AMD will be captured and treated in the Mangatini sump, and the additional ~163 t/year would equate to a 2% increase in AMD Sludge volumes required to be disposed from the Mangatini Treatment System. For the period of 2032 to 2062, this would equate to an additional ~ 6,400m³ of AMD Sludge for permanent storage, which there is capacity for within SC2 (described in Section 6.1.2).

7.0 LDS / AMD Sludge bypass and decant discharge

As discussed in Section 2.0, BRL manages LDS in the Mangatini Treatment System during high flow (>70th percentile) conditions (as permitted under existing consent RC06206) through a combination of:

- **Bypass around Mangatini Sump** – During high flow conditions exceeding the ~70th percentile, all flow is bypassed around Mangatini Sump and discharged directly to Mangatini Stream. These bypass flows are treated with CaO, so they receive AMD treatment but do not receive sedimentation treatment.
- **Active discharge from Mangatini Sump** – Infrequent discharges of LDS from Mangatini Sump (via the sump decants or LDS / sludge pumps) to Mangatini stream during high flow events are permitted under existing consent RC06206. During high flow conditions (flow >70th percentile when there is considerable dilution in the receiving waterbody) controlled amounts of LDS are

actively discharged to the Mangatini Stream to assist with optimising freeboard in the Mangatini Sump to support ongoing AMD treatment and sludge capture during low to moderate flow conditions.

BRL seeks a continuation of the current consent conditions for operation of the Mangatini and McCabes Treatment Systems, including LDS / AMD Sludge management aspects. This section provides a summary of Mangatini Treatment System, including:

- Original LDS decant discharge assessment of environmental effects (**AEE**) used to support the RC06206 consent application;
- Operational performance monitoring data since 2006 showing effects of high flow LDS / AMD Sludge management on water quality at Mangatini and Ngakawau River monitoring sites;
- Operational assessment of the total sediment loads discharged from Stockton mine during the year 2020 to give context to the LDS contribution operationally; and
- A description of additional performance monitoring proposed as part of the BPCP for LDS management.

7.1 Original LDS decant discharge AEE

There is a summary explanation of the original modelling process used to develop the active LDS decant discharge from Mangatini sump in the Mangatini Sump management plan AEE (GHD 2018, Appendix 1: Okane (2018)). This modelling and AEE was used to support the resource consent application that was granted as RC06206.

Okane (2018) used a TSS load model to calculate the additional TSS load could be discharged from Mangatini Sump during high flow conditions without causing TSS concentrations downstream at NR to increase above the natural maximum background concentrations for a given flow rate. Figure 16 shows the 'TSS discharge envelope' as a green hatched area, which quantifies the additional TSS load that could be discharged for a given NR flow exceedance percentile, without NR TSS concentration exceeding the value specified by the red line (example calculation given after Figure 16). The red maximum TSS load line corresponds to the maximum TSS concentration (for a given flow exceedance percentile) deemed to be naturally occurring in the NR dataset at the time (i.e., up to year 2018) for a given flow condition. To be conservative, the black background TSS mass load line was assumed to be at the 90th percentile of the measured dataset (as opposed to assuming an average or median background TSS load). The Okane (2018) TSS load model had no constraint on LDS discharge during > 95thile flow conditions. However, LDS discharge rates are operationally constrained by the size of the decants in Mangatini Sump.

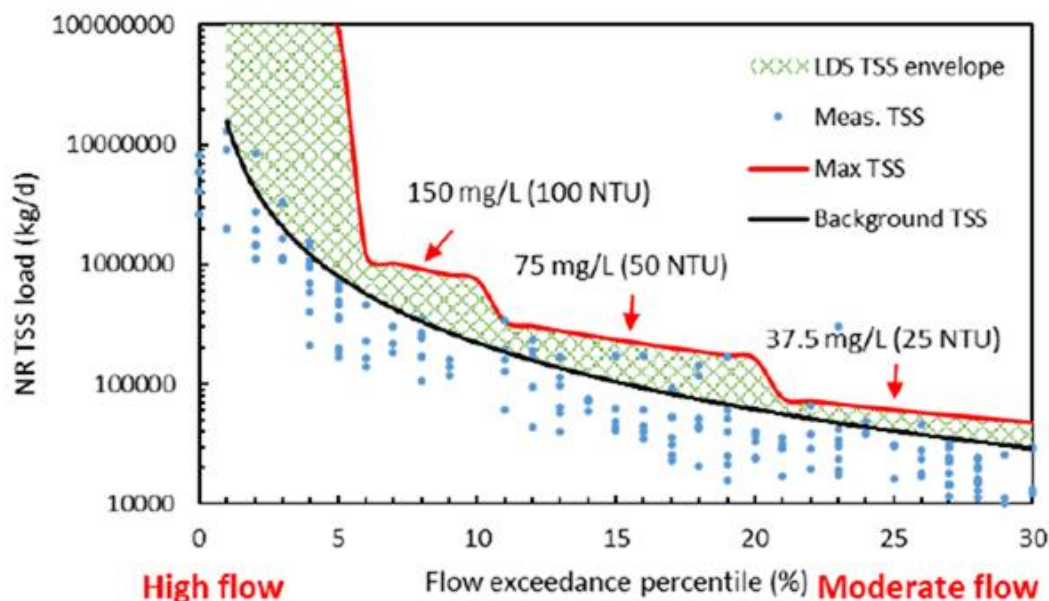


Figure 16. Development of NR LDS TSS envelope (GHD 2018, Appendix 1).

As an example calculation for Figure 16 values, at the 15th flow exceedance percentile the background NR TSS load was ~100 t/d and an additional ~100 t/d could be discharged (within the LDS TSS envelope) without causing NR TSS concentration to exceed 75 mg/L (50 NTU). That potential 100 t/d additional NR TSS load was then converted back to an equivalent LDS discharge rate at Mangatini Decant. The LDS discharge matrix defines maximum LDS discharge flow rates for a given flow condition and decant turbidity (current version shown in Table 9).

Since this original GHD (2018) AEE was done there have been further improvements made to the LDS discharge processes and the original LDS discharge matrix has been revised (as part of the consented two-yearly management plan reviews). Revisions were made to:

- Use S14B as the site to determine the flow rate condition for determining the event specific NR TSS compliance values. There is a lag between when LDS is discharged from Mangatini Sump and when it flows past NR. Operationally controlling decant flow rates relative to flow condition at S14B (which is located closer to the Mangatini Sump than NR, and is therefore less affected by lag periods) proved to be more effective for managing this lag period; and
- Al concentration was removed as a constraint to the LDS discharge matrix as there was no correlation between LDS discharge rates and elevated downstream Al concentration identified in performance monitoring datasets, i.e., TSS is the more important constraint on LDS discharge.

The following sections present operational performance monitoring datasets that show the overall effect of high flow LDS management at Mangatini Treatment System on downstream water quality.

7.2 Operational effects of LDS management

Water quality and flow rate monitoring datasets for sites downstream of the Mangatini Treatment System have been reviewed to show the effect of high flow LDS bypass around Mangatini Sump. This includes a review of datasets for three monitoring sites (location shown in Figure 2):

- Mangatini Stream at S14C – located ~1km downstream of the Mangatini Sump decant and also downstream of the bypass channel, Duncans Sump and Ford Creek confluences / mixing points;
- Mangatini Stream at S14B – located ~5km downstream of Mangatini Sump decant and includes the moderating effects of natural catchment; and
- Ngakawau River at NR – located in Lower Ngakawau River and includes the effects of Mangatini, St Patricks, and other historic mine affected catchments (e.g., Charming Creek), and large areas of natural catchment.

Water quality and flow rate monitoring datasets were reviewed over four date ranges to incorporate different LDP1 and Mangatini Sump operating conditions. These included:

- Pre-March 2007 – no AMD treatment, no Mangatini Sump operating in Mangatini Treatment System;
- March 2007 to June 2010 – AMD treatment by UFL dosing direct to Mangatini Stream (downstream of S14C water quality monitoring site), Mangatini Sump under construction / not operating for LDS capture;
- Jan 2015 to Dec 2018 – CaO dosing upstream of Mangatini Sump (used for LDS capture) and relatively infrequent bypass (nominally >90th percentile flows only); and
- Jan 2021 onwards – CaO dosing upstream of Mangatini Sump (used for LDS capture) and relatively frequent bypass (nominally >70th percentile flows only).

Data for two date ranges have been excluded from this analysis for simplification purposes. These date ranges include:

- June 2010 to January 2015 – during this period UFL was dosed upstream of Mangatini Sump. BRL changed from UFL to CaO as the neutralising agent from 2015 onwards to address clarity issues associated with UFL; and
- January 2018 to Jan 2021 – This period has been excluded to show the comparison between relatively infrequent bypass (nominally >90th percentile flows only) versus relatively frequent bypass (nominally >70th percentile flows only) periods with greater clarity.

The available data and date ranges used for this assessment is defined in Table 6.

Table 6. Available water quality and flow dataset for demonstrating LDS bypass effects

Date range	Phase no.	S14C	S14B	NR
Pre-Mar 2007	1	No data	TSS, Turb Flow rate	Al, TSS, Turb Flow rate
Mar 2007 to June 2010	2	Al, TSS, Turb Flow rate	TSS, Turb Flow rate	Al, TSS, Turb Flow rate
Jan 2015 to Dec 2018	3	Al, TSS, Turb Flow rate	TSS, Turb Flow rate	Al, TSS, Turb Flow rate
Jan 2021 onwards	4	Al, TSS, Turb Flow rate	TSS, Turb Flow rate	Al, TSS, Turb Flow rate*

* NR flow rate record ends in February 2022 after site destroyed by flood and water quality sample collection transitioned to site NR2.

7.2.1 Dissolved Al concentration effects

Timeseries trends in Al concentration in the available S14C and NR water quality monitoring datasets are shown in Figure 17.

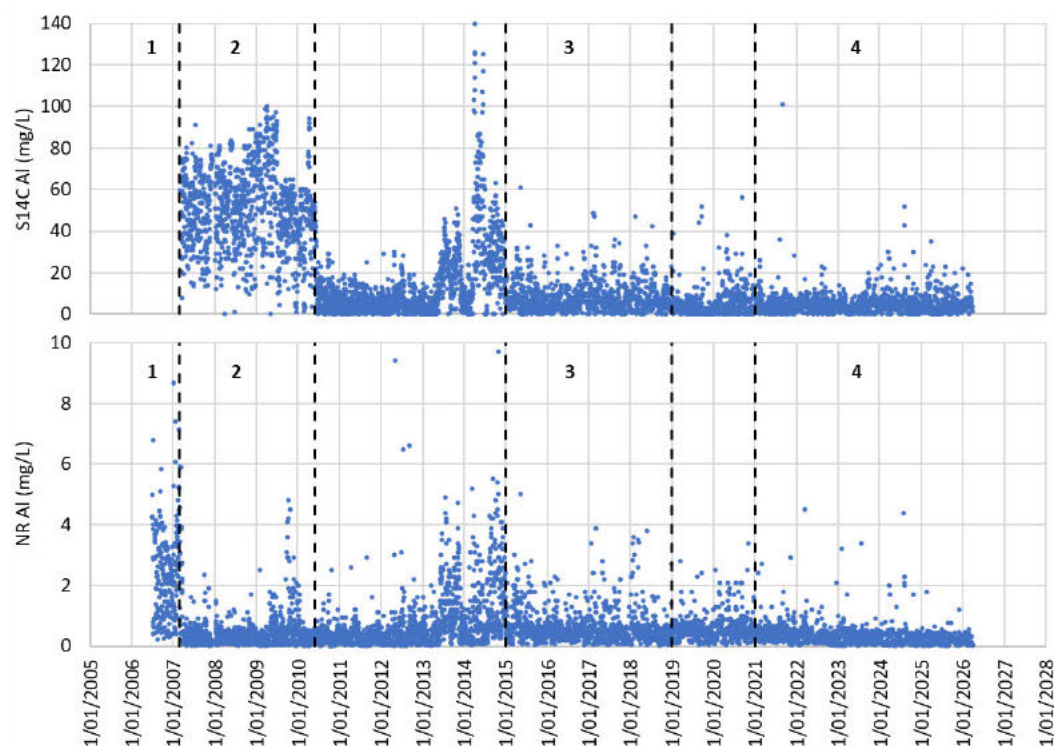


Figure 17. Al concentration data timeseries, with each phase (1-4) used for modelling identified.

Critical milestones in the Al concentration datasets are:

- AMD treatment by UFL dosing directly to Mangatini Stream (downstream of S14C) commencing in March 2007; and

- AMD treatment by UFL dosing upstream of Mangatini Sump (and also upstream of S14C) commencing in June 2010.

Available Al concentration and flow rate monitoring datasets have been coupled for these sites and date ranges (as specified in Table 6) to show the effects of the Mangatini Treatment System and high flow bypass on downstream water quality. To improve clarity these datasets have been processed by:

- Coupling individual water quality sample results with corresponding flow rate (in L/s) at time of sample collection;
- Deriving flow percentile at time of sample collection (rounded to the nearest whole number), using site specific flow distributions; and
- Calculating the median value of all samples with a given flow percentile value for the period of interest.

This process derives the typical (median) Al concentration for a specific flow percentile value (Figure 18).

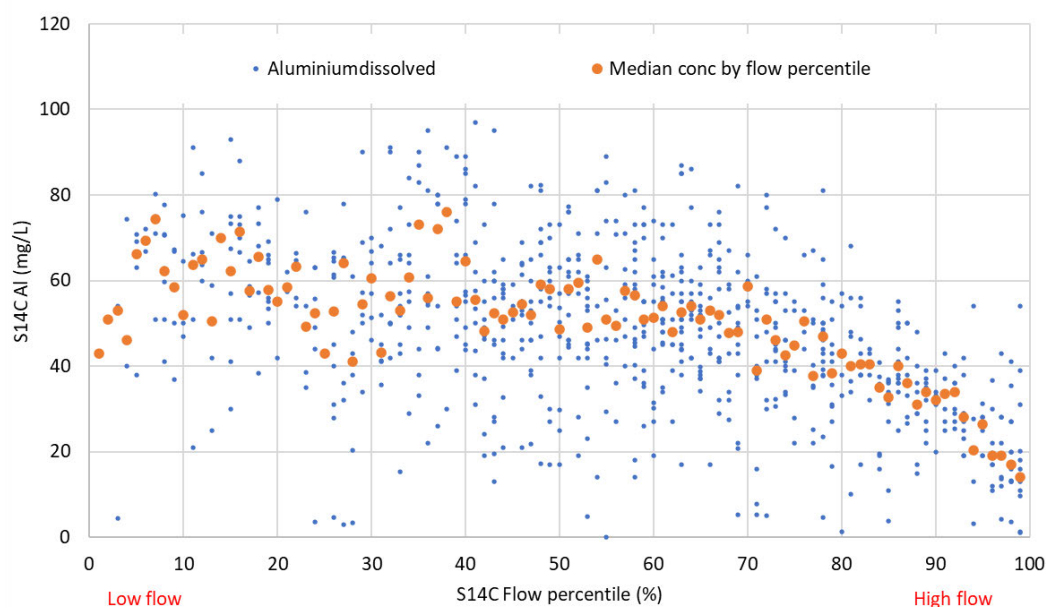


Figure 18. Median S14C Al concentration versus flow percentile dataset (Mar 2007 to June 2010), including calculated median concentration by individual flow percentile value

Calculating the median Al concentration values across the full flow percentile range (0 – 100th percentile flows) shows the relationship between flow rate and Al concentration. This processed dataset for S14C and NR dissolved Al concentration for the four date ranges of interest is presented in Figure 19 (NB: S14B Al data not presented due to limited dissolved Al concentration dataset).

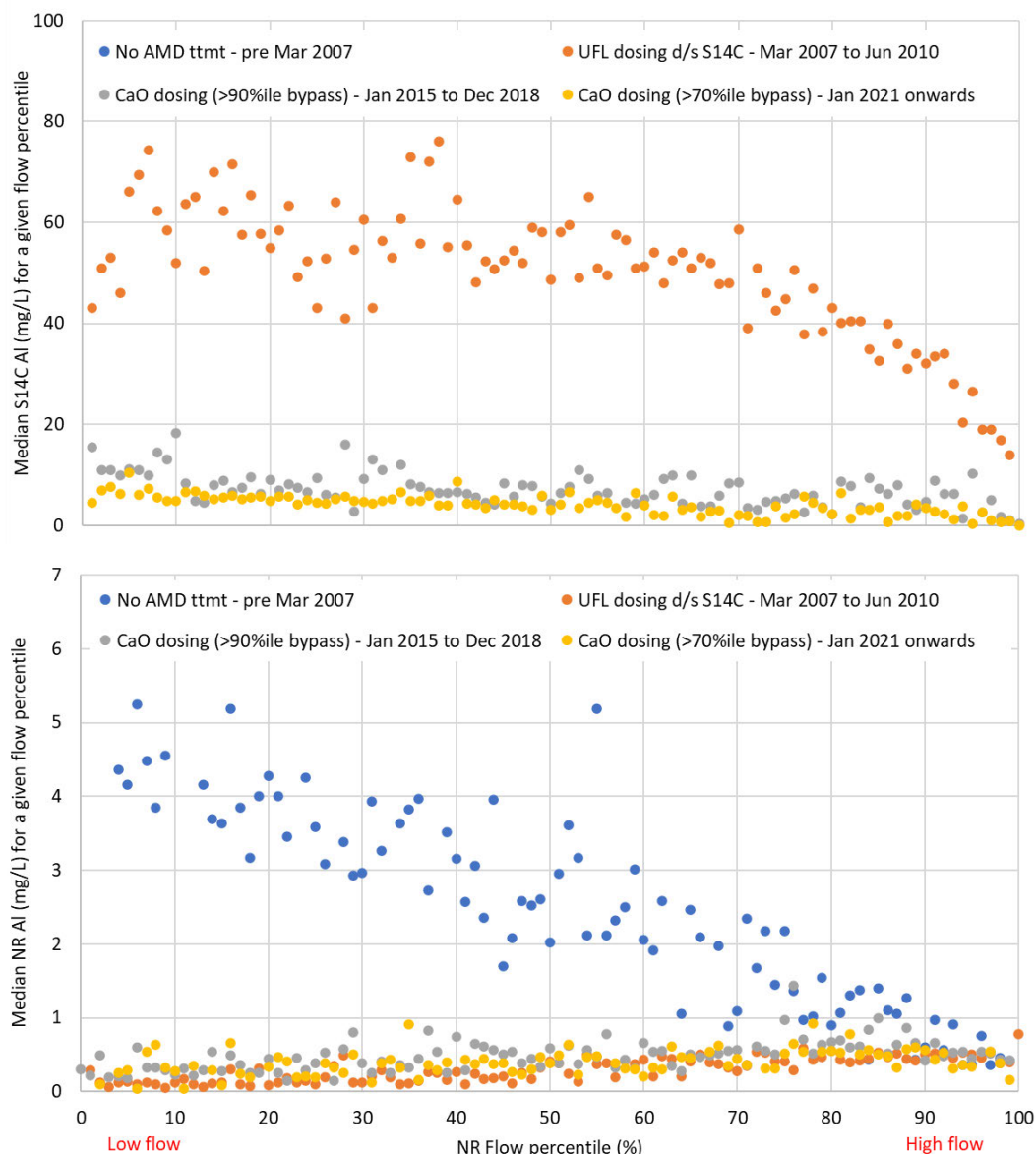


Figure 19. Relationship between flow percentile and median dissolved Al concentration

Key observations from Figure 19 are:

- S14C Al concentrations were significantly higher (40 – 80 mg/L) prior to alkaline dosing moving upstream of S14C in 2010. The S14C Al concentration showed a trend of high flow dilution, with concentrations decreasing at >70th percentile flows. The transition to alkaline dosing (Initially UFL but transitioning to CaO from Jan 2015 onwards) upstream of S14C from June 2010 onwards has resulted in a reduction in S14C Al concentrations through all flow ranges. Similar Al concentration values are reported for the >90th percentile bypass (Jan 2015 to Dec 2018 dataset) and >70th percentile bypass (Jan 2023 onwards) periods, indicating that the Mangatini Sump bypass threshold has had a minimal effect on S14C Al concentration.

NR Al concentrations were significantly higher (up to 5 mg/L) prior to alkaline dosing of Mangatini Stream commencing in March 2007 and showed a relatively linear trend of dilution with increasing flow percentile. Commencement of UFL dosing downstream of S14C in March 2007 resulted in a significant reduction in NR Al concentration, particularly during low to moderate flow conditions. Overall NR Al concentrations have remained similar throughout the UFL and CaO dosing phases, with similar values reported for both the >90th percentile bypass (Jan 2015 to Dec 2018 dataset) and >70th percentile bypass (Jan 2023 onwards) periods, indicating that the Mangatini Sump bypass threshold has also had a minimal effect on NR Al concentration.

7.2.2 Turbidity value effects

Trends in turbidity in available S14C, S14B, and NR water quality monitoring datasets are shown in Figure 20. It should be noted that the y-axis has been scaled to exclude some high values to provide better resolution of the majority datapoints.

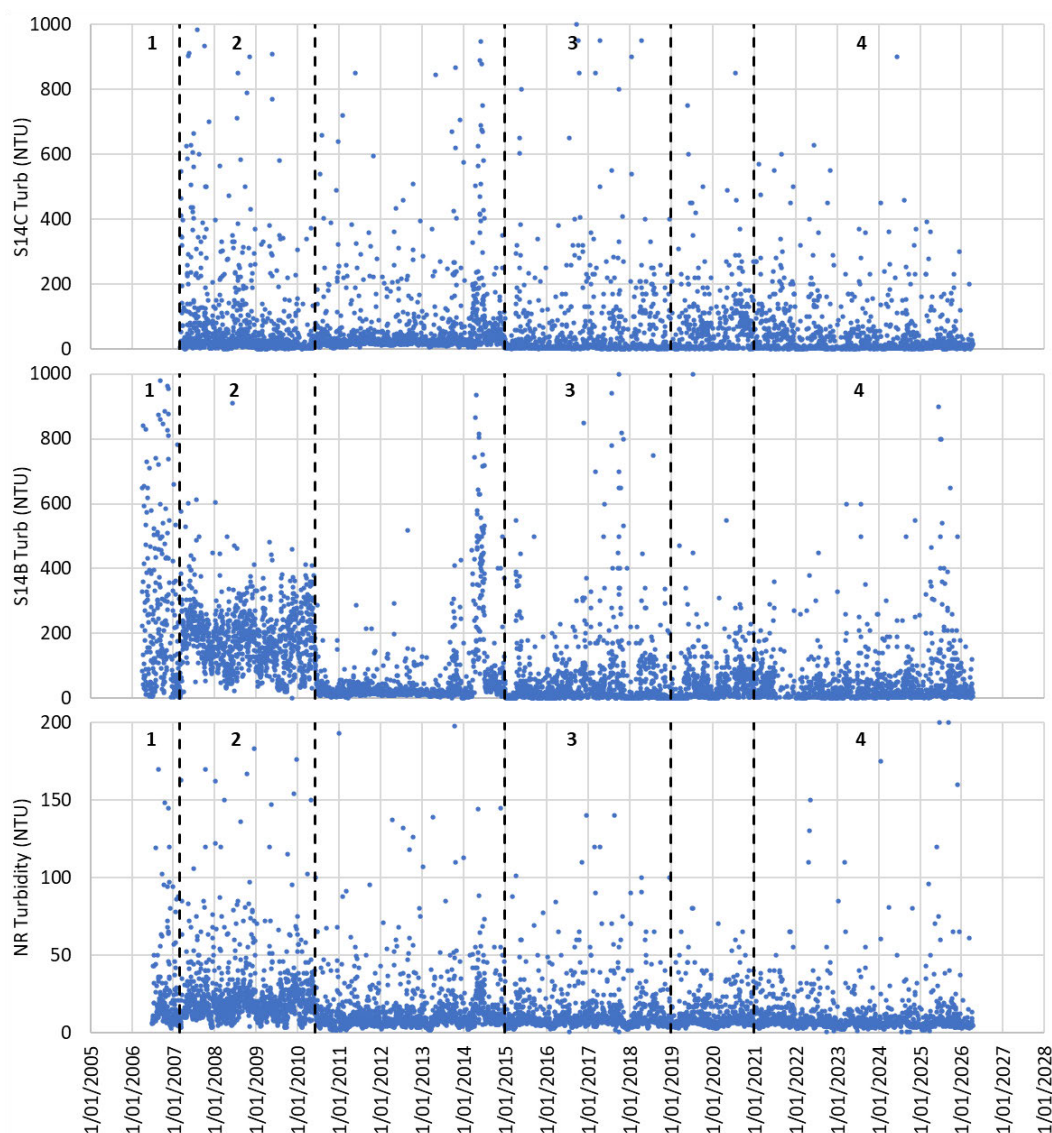


Figure 20. Turbidity data time series, with each phase (1-4) used for modelling identified

Critical milestones in the Turbidity datasets are:

- AMD treatment by UFL dosing directly to Mangatini Stream (downstream of S14C) commencing in March 2007;
- AMD treatment by UFL dosing upstream of Mangatini Sump (and also upstream of S14C) commencing in June 2010; and
- Transition to CaO dosing upstream of Mangatini Sump commencing in 2015 (to improve clarity issues associated with UFL dosing).

Available turbidity and flow rate monitoring datasets have been coupled for these sites and date ranges (as specified in Table 6) and sorted to show the typical (median) turbidity value for a specific flow percentile. This processed dataset is presented in Figure 21.

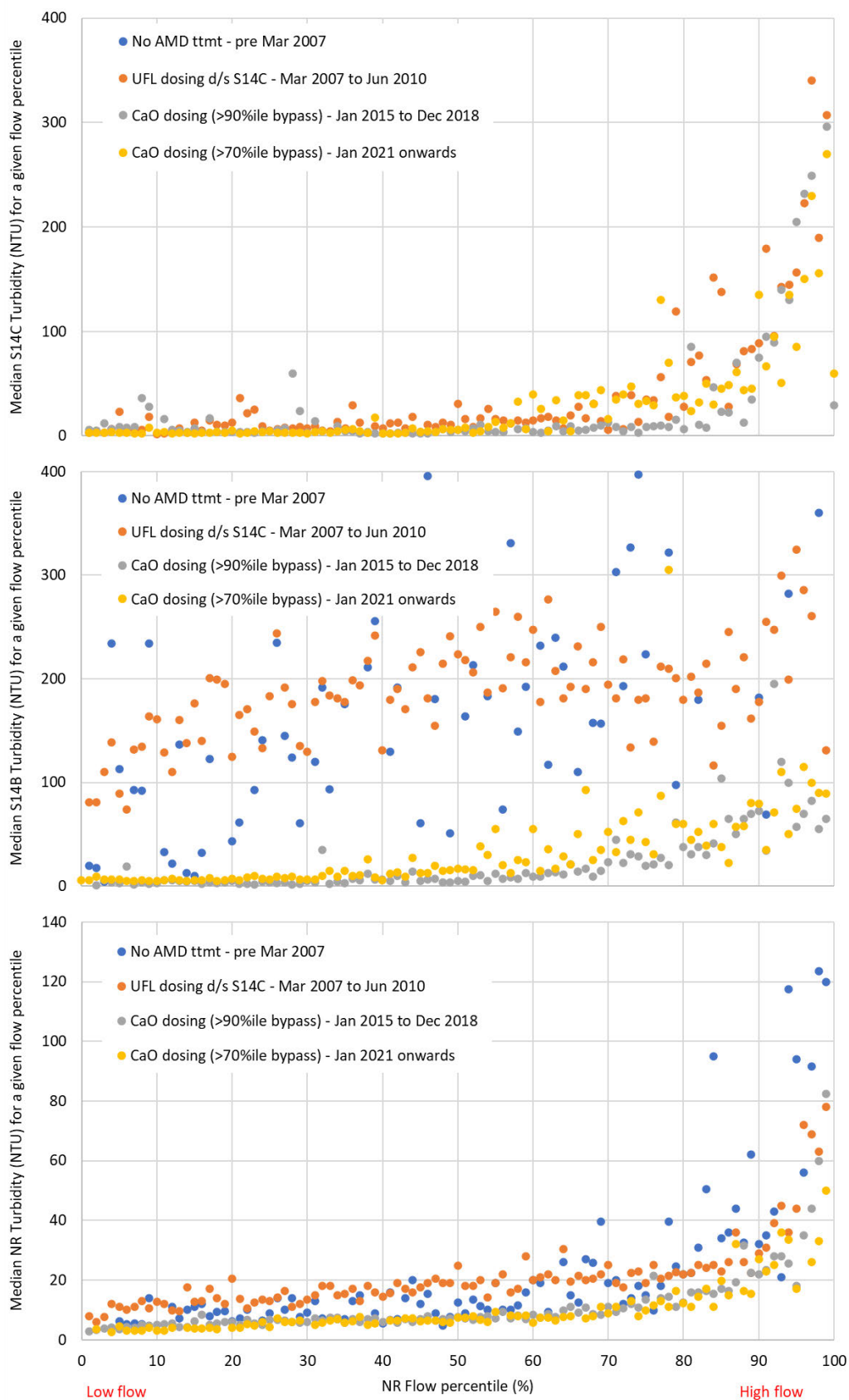


Figure 21. Relationship between flow percentile and median turbidity

Key observations from Figure 21 are:

- The relationship between S14C turbidity and flow rate has been relatively consistent throughout the available record. During the pre-June 2010 period when UFL dosing was downstream of S14C (i.e., S14C unaffected by LDS / AMD Sludge) the turbidity values were relatively low during low to moderate flow conditions (<70th percentile) and increased during high flow conditions (>70th percentile). This trend has largely remained since the alkalinity dosing point moved upstream of S14C. However, it is noted that there is some divergence in turbidity trends in the 60th to 90th percentile flow range between the two periods where bypass was less frequent (Jan 2015 to Dec 2018) versus more frequent (Jan 2021 onwards).
- The relationship between S14B turbidity and flow rate has been changed significantly at different times throughout the available record. This includes transitions from:
 - Highly variable turbidity values in the pre-March 2007 dataset (with scatter including multiple values of up to 1,000 NTU not shown by y-axis in Figure 21).
 - Consistently high turbidity values through the March 2007 – June 2010 period, when UFL was dosed directly to Mangatini Stream downstream of the S14C site without sedimentation, resulting in turbidity values in the 100 – 300 NTU range across most flow conditions.
 - Significant reduction in turbidity at S14B after the alkaline dosing point transitioned to above Mangatini Sump from March 2010 onwards. S14B turbidity values were relatively low during low to moderate flow conditions (<70th percentile) and increased during high flow conditions (>70th percentile). This trend has largely remained, though it is noted that the divergence in turbidity trends in the 60th to 90th percentile flow range observed at S14C is less evident at S14B, indicating the increased bypass frequency (between the ‘Jan 2015 to Dec 2018’ versus ‘Jan 2021 onwards’ periods) has a limited effect further downstream.
- The relationship between NR turbidity and flow rate has been relatively consistent throughout the available record NR turbidity. This includes transitions from:
 - Relatively elevated turbidity values in the pre-Mar 2007 dataset, particularly during high flow conditions (>70th percentile).
 - Relatively high turbidity values through the period where UFL was dosed directly to Mangatini Stream below the S14C site without sedimentation, particularly during low to moderate flow conditions with turbidity values in the 10 – 20 NTU range;
 - Significant reduction in turbidity at NR after the alkaline dosing point transitioned to above Mangatini Sump from March 2010 onwards. NR turbidity values were low (<10 NTU) through low to moderate flow ranges (<70th percentile). While NR turbidity values increased during high flow periods (>70th percentile), they remained lower than the equivalent NR Turbidity levels were in the pre-March 2010 dataset. There is also no observable divergence in turbidity trends

between the 'Jan 2015 to Dec 2018' versus 'Jan 2021 onwards' datasets, indicating the increased bypass frequency has a limited effect downstream.

This analysis was repeated for TSS effects with similar trends observed. The TSS analysis has been omitted from this report to reduce content.

7.2.3 Key observations

Overall, the operational performance monitoring data supports continuation of a high flow bypass threshold of 70th percentile flows by showing:

- Prior to any treatment, dissolved Al and turbidity values were relatively high throughout the full flow percentile range, including during low to median flow conditions.
- The current regime (CaO dosing with a nominal >70th percentile flow bypass threshold) is delivering NR turbidity values that are comparable to values seen in January 2015 to December 2018, when the high flow bypass threshold was nominally >90th percentile.
- The current regime is delivering relatively low NR Al concentrations and turbidity values compared to historic trends prior to AMD treatment and during the period where UFL was dosed directly to Mangatini Stream (without sedimentation).

These observations show that the LDS contribution to NR Turbidity is relatively minor, including during > 70th percentile high flow bypass periods. Overall, NR turbidity values are relatively low under the current Mangatini Treatment System configuration (including CaO dosing upstream of Mangatini Sump and high flow bypass from 2015 onwards), compared to historic values.

7.3 LDS contribution to downstream sediment loads – year 2020

An assessment of the total sediment loads discharged from Stockton mine has been provided to give context to the potential effects of LDS bypass and decant discharge. This includes the contribution from LDS derived sediment loads and clastic sediment loads (i.e., the non-AMD precipitate component of TSS). This assessment uses measured data (as opposed to model predictions) to show the LDS contribution to overall sediment loads in the Ngakawau River.

Stockton mine sediment load estimates are based on data for the year 2020. This year was selected as it:

- Represents an 'average' year from a rainfall perspective, with 5725 mm recorded; and
- Had an estimated pre-treatment acidity load of ~6,500 t/year, which is more representative of expected loads throughout the BPCP than current levels reporting to Mangatini Treatment System.

The 2020 monitoring data at Sites S14B (Mangatini Catchment) and NR (Ngakawau River) were reviewed to enable the mass balance calculation. Annual sediment loads based on telemeterised 15-minute

sensor measurements of flow rate and automatic turbidity, and daily TSS measurements have been estimated at S14B and compared with the total loads at NR (which includes contributions from all sediment sources within Ngakawau River Catchment upstream of site NR). These total sediment loads are presented in Table 8.

The sediment load contribution from LDS in bypass and decant discharges is quantified in the next two sub-sections.

7.3.1 2020 LDS bypass sediment load (bypassing Mangatini Sump)

The LDS bypass contribution to total sediment loads has been estimated based on the daily Mangatini acidity load versus flow exceedance percentile distribution. This assessment calculates the cumulative acidity load (pre-treatment) in the > 70th percentile flow range as 3,125 t/year in 2020 (Figure 22). This is the nominal high-flow proportion of Mangatini AMD that is dosed with CaO but flows down the bypass. The LDS sediment load associated with this bypass flow will be proportional to the ~3,125 t acidity load neutralised by CaO dosing. Assuming an LDS generation rate of 34 m³ LDS /t acidity neutralised and an LDS solids content of 2 wt%, this equates to an estimated LDS sediment load flowing down the bypass of 2,125 t/year.

Figure 22 also identifies the cumulative acidity load (pre-treatment) in the <70th percentile flow range as ~3,113 t/year in 2020. This is the low to moderate flow proportion of Mangatini AMD that is dosed with CaO and flows into Mangatini Sump for sedimentation. This acidity load equates to an estimated LDS sediment load flowing into Mangatini Sump of 2,117 t/year in 2020. This is the proportion of total Mangatini Treatment System LDS load managed by either decant discharge (discussed in Section 7.3.2) or pumped to filter beds for dewatering and disposal in slops cells.

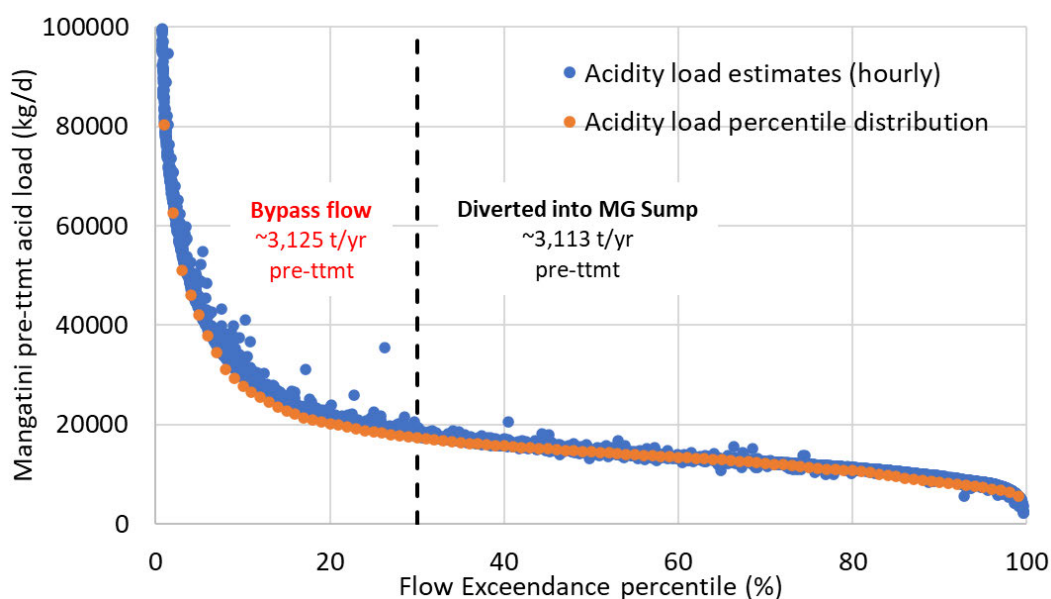


Figure 22. Proportion of year 2020 Mangatini pre-treatment (assessed at site MGIU) acidity load

Continuous flow monitoring sensor data have been reviewed to quantify the theoretical frequency that S14 flow rate exceeds the 70th percentile bypass threshold for a given time duration. The S14 dataset (which is analogous to S14C flow rate) including data from 2017 onwards was processed to quantify the percentage of events that both exceeded the 70th percentile flow rate threshold and lasted for greater than 24 or 48 hour periods. This assessment showed that:

- 22% of events that exceed the 70th percentile flow rate threshold lasted for longer than 24 hours; and
- 8% of events that exceed the 70th percentile flow rate threshold lasted for longer than 48 hours.

This analysis suggests that while bypass events nominally occur when flow rate exceeds the 70th percentile (i.e., 30% of the time) the majority of these bypass events are a relatively short duration. For example, Mangatini Sump bypass events nominally occur 30% of the time (i.e., flows > 70th percentile), with only 22% of those bypass events lasting longer than 24 hours. These two statistics combined indicate that there are approximately 24 separate Mangatini Sump bypass events per year that have a duration of greater than 24 hours.

Example plots of flow rate records for two events that exceeded the 70th percentile flow condition at S14 for periods of 24 and 48 hours are shown in Figure 23.

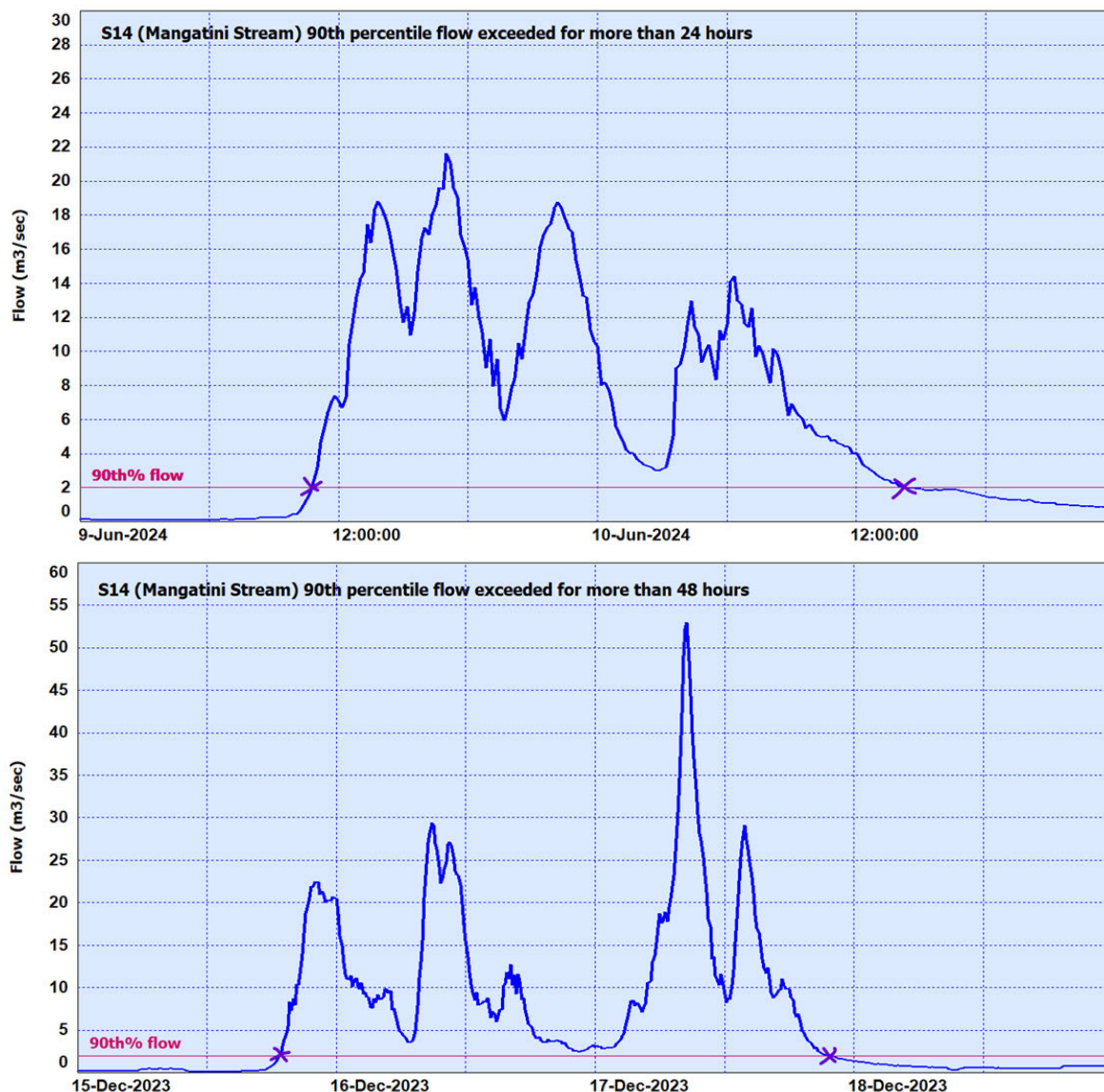


Figure 23. Example flow records for two events exceeding 70th percentile flow rate (for duration >24 and >48 hours, respectively) at Mangatini Stream flow rate monitoring site S14.

7.3.2 2020 LDS decant discharge sediment load

There were 6 reported decant discharge events from Mangatini Sump in 2020, with event duration and discharge volume recorded in Table 7. It should be noted that the bottom 3 discharge events were actually a sequence of infrequent discrete discharges during those date ranges, as opposed to a continuous discharge event that lasted multiple days.

A cumulative 72,267 m³ of LDS was discharged via Mangatini Sump decants through 2020. Assuming a discharge LDS solids content of 2 wt%, this equates to an estimated LDS sediment load discharged via the decants of 1,445 t/year.

Table 7. Controlled LDS decant discharge events from Mangatini Sump, 2020 (average rainfall year)

Discharge Start	Discharge End	LDS discharged from Mangatini sump (m ³)
12/06/2020	12/06/2020	765
21/07/2020	21/07/2020	1,953
23/07/2020	23/07/2020	1,449
18/08/2020	30/09/2020	40,920
4/12/2020	11/12/2020	13,590
22/12/2020	24/12/2020	13,590
Total 2% solids (m³)		72,267
Total dry Tonnes LDS (t)		1,445

7.3.3 Combined LDS contribution to 2020 NR and S14B sediment load.

As discussed, the 2020 total sediment loads at S14B and NR were calculated from monitoring records. These are presented in Table 8, along with the LDS contributions to sediment loads via Mangatini Sump decant discharge and bypass. These combined estimates indicate that Mangatini Sump LDS discharges contribute to 18.6 % and 6.9% of the total sediment load at S14B and NR, respectively.

Table 8. Percentage LDS discharge from Mangatini AMD Treatment to Annual Sediment Loads in Ngakawau River in 2020

Site	Total Sediment load* (t/year)	LDS decant discharge contribution (t/year)	LDS bypass contribution (t/year)	LDS % of total sediment load (%)
S14B	19,193	1,445	2,125	18.6
NR	51,740	1,445	2,125	6.9

* Calculated from continuous sensor measurements of flow rate and turbidity.

7.4 LDS effects assessment

To assess any adverse impact from LDS accumulating in sediments, a metals-in-sediment survey was undertaken by Instream (2026). This assessment has recommended that a metals sediment survey is undertaken every year at site NR to determine if there are any trends in metal concentrations as part of the 6-year reviews. This assessment and other proposed monitoring is described in Instream (2026).

7.5 Continuation of operational consent conditions

Instream (2026) have proposed compliance and performance monitoring that cover the effects of BPCP activities on downstream water quality. This includes aspects related to the effects of water and AMD management across the Stockton Plateau.

Additional LDS / AMD Sludge management activities are described in the following sections.

7.5.1 Mangatini Sump Management / LDS bypass and discharge

BRL seeks a continuation of the current consent conditions for operation of the Mangatini Treatment System, including high flow (>70th percentile) LDS management aspects. This includes adoption of additional conditions around monitoring effects proposed in Instream (2026) and a continuation of conditions around management of the Mangatini Sump and LDS bypass and discharge. Current operational consent conditions (RC06206) include:

- Adherence to the operating regime and monitoring procedure set out in the Mangatini Sump Management Plan, including the updates to the LDS discharge matrix in GHD (2023, Table 9); and
- Compliance with the turbidity limits (as surrogate for TSS as automatically monitored) as set out in Table 10.

Table 9. LDS discharge matrix presented in the 2022 Mangatini Sump Management Plan update (GHD 2023).

MGD Turbidity (NTU)				500	1,250	2,500	5,000	10,000	20,000
MGD TSS (wt% solids)				0.1	0.25	0.5	1	2	4
Flow Percentile (%)	S14B Flow Rate ^(b) (m ³ /s)	NR2 TSS ^(c) (mg/L)	NR2 Turbidity ^(c) (NTU)	Maximum LDS Decant Flow (L/s)					
95+	> 7.9	Unlimited	Unlimited	Max Decant ^(a)	Max Decant	Max Decant	Max Decant	Max Decant	Max Decant
90 – 95	3.6 to 7.9	150	100	Max Decant	Max Decant	1040 (970)	520 (480)	260 (240)	130 (120)
80 – 90	1.7 to 3.6	75	50	970 (890) ^(d)	390 (360)	190 (180)	100 (90)	50 (40)	20 (20)
70 – 80	1.1 to 1.7	37.5	25	170 (140)	70 (50)	30 (30)	20 (10)	10 (10)	- (-)
0 – 70	< 1.1	n/a	25	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)

Source: adapted from Table 7 in MWM (2021)

Notes:

(a) Max decant discharge rate applied is 1,900 L/s.

(b) Flow rate updated from NR to S14B

(c) NR2 TSS and Turbidity are assumed to be similar to NR given their close proximity.

(d) Allowable decant flows updated based on NR flow record from 2006 through 2022; values from previous update (MWM, 2021) shown in parentheses for comparison

Table 10. Turbidity consent criteria for LDS discharge from Mangatini sump

Flow Percentile band (%)	Flow rates S14B (m^3s^{-1})	LDS discharge to stream	Turbidity averaged over 8 hours NR Two (NTU)
95+	7.349+	Yes	n/a
90 – 95	3.373 to 7.349	Yes	100
80 – 90	1.672 to 3.373	Yes	50
70 – 80	1.139 to 1.672	Yes	25
0 – 70	0 to 1.139	No	25

7.5.2 McCabes consent conditions

BRL seeks a continuation of the current consent conditions for operation of the McCabes Treatment System, including high flow (>70th percentile) LDS bypass aspects and future expansion to include treatment of Plover Stream AMD. As discussed, LDS / AMD Sludge has not yet accumulated sufficiently for active management at McCabes Sump to be required. However, BRL have identified a site for an LDS dewatering filter bed adjacent to McCabes Sump. Active AMD Sludge management is expected to be required for a short period between 2030 to 2033. There is sufficient capacity in proposed slops cells for disposal of dewatered McCabes AMD Sludge.

A comparison of forecast AMD Sludge generation rates (after the transition to MgO dosing of AMD) versus sump storage capacity indicates that active long term AMD Sludge management at McCabes Sump is not required.

7.5.3 MW16 consent conditions

BRL seeks consent conditions for AMD treatment by alkaline dosing directly to MW16 Sump from 2047 onwards. A comparison of forecast AMD Sludge generation rates versus sump storage capacity indicates that active AMD Sludge management at MW16 Sump is not required.

8.0 Acronyms

Acronym	Definition
Acidity	Acidity to pH 7
AEE	Assessment of environmental effects
Al	Aluminium
AMD	Acid Mine Drainage
Bcm	Bank cubic metres
BPCP	Buller Plateau Continuation Project
BRL	Bathurst Resources Limited
CaO	Calcium Oxide – acidity neutralising agent
ELF	Engineered Landform

EOML	End of Mine Life
ESE	Escarpment sub-area
Fe	Iron
FTA	Fast Track Approval
LDP1	Lime Dosing Plant 1 – Mangatini Catchment
LDP2	Lime Dosing Plant 2 – St Patrick Catchment
LDS	Low Density Sediments
MFS	Mount Fred South sub-area
MgO	Magnesium Oxide – acidity neutralising agent
MSR	Mussel shell reactor
PAF	Potentially Acid Forming
RC	Resource Consent
TSS	Total suspended solids
UFL	Ultrafine Limestone – acidity neutralising agent
UWHR	Upper Waimangaroa Haul Road
VDT	Vegetation Direct Transfer

9.0 References

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10.0 Appendices

Appendix 1: Mangatini Sump Management Plan 2018

Executive summary

Overview

The Mangatini Sump (the Sump) is a key element of the Stockton Mine site water management system. The Sump provides settlement for both sediments and mineral precipitates entrained in the upper Mangatini Stream. The sediments are associated with upstream mining activity and the precipitates are unreacted lime and metal hydroxides formed by treatment of acid mine drainage (AMD).

The Sump has been in operation since July 2009 and in combination with upstream pH adjustment has been very successful in treating AMD runoff. This is evidenced by the water quality achieved at the water quality site NR in the Ngakawau River over time.

There have been a number of amendments to sump operation since it was commissioned. In particular in December 2014 the site changed the dosing reagent used for acid neutralisation from Ultra Fine Limestone (UFL) to Calcium Oxide (CaO). This change has improved the clarity of the treated water discharge; however the sludge generated is lower density than generated with UFL. This has resulted in sludge buildup in the Sump occurring more rapidly than anticipated in the design phase.

Since July 2016 the site has been investigating a wide suite of options to manage the accumulation of low density sediments (LDS) in the sump under the umbrella of the “Mangatini Sump Project” with key objectives being to retain the good water quality outcomes being achieved with CaO dosing upstream and to also keep the sump operational for the Life of Mine (LOM) and into the closure period. When the Sump was designed in 2007, active mining in the Sump catchment was expected to be finished by 2017

This Management Plan sets out how the Mangatini sump will be operated going forward based on the outcomes of the Mangatini Sump project to date, and responds to a request from the West Coast Regional Council (WCRC) in April 2017 to review consent conditions associated with sump operation (RC06206). Because Solid Energy had a number of trials underway in April 2017 associated with improving sump management, and a changed operating regime might require consent revisions or additions; WCRC agreed that the new owner BT could continue sump operation under existing consent conditions until June 2018.

This Management Plan supercedes previous documents relating to the Mangatini Sump operation and treatment performance; including as described in the Mangatini Sump Assessment of Environmental Effects (AEE) prepared by Solid Energy NZ Limited (Solid Energy) and submitted in support of resource consents in 2007.

[REDACTED]

[REDACTED]

[REDACTED]



Mangatini Sump Project

The options tested as part of the Mangatini Sump project can be grouped into the following categories:

- Disposal of LDS to land
- Sludge consolidation/densification
- Disposal to catchment

In addition to the above a number of tests have been performed on sludge characteristics to try and better understand settlement behaviour and hydroxide characteristics.

Results from this program of works have informed the proposed operating regime for the Mangatini Sump going forward. Elements of the program are still ongoing and will continue to inform how to optimise the sump performance. Based on the results of the Mangatini Sump Project the plan for sump operation going forward is summarised as:

- Continue and optimise dosing of the stream with CaO upstream of the Mangatini Sump;
- Diversion of the Mangatini stream into the sump for flows up to the 70th percentile flow event and bypass of partially treated flow for greater flows;
- Discharge of LDS from the decant to the stream in high rainfall conditions subject to controls developed by the project (refer Appendix B). Discharge rates of LDS will be subject to a matrix developed by O’Kanes Consultants (OKC) which draws on a contaminant load model described in Appendix C. LDS will also be discharged by pump when stream flows are in the 70th to 80th percentile range.
- Ongoing testing of options for sludge densification within the sump.
- Ongoing testing of LDS disposal to filter beds.
- Geo-tube bag use for LDS disposal retained as a contingency measure.
- Maintenance works and monitoring as described in the Management Plan to check performance of the sump and the operating regime applied.

The operating regime for the Sump is summarised in the following table where LDS management is linked to stream flow.

Flow Conditions at NR by Percentile %	Mangatini Stream diversion to Sump	LDS to Stream Discharge	Other LDS Management Methods
0 to 70%	Yes – all flow	No	¹ Potential disposal to land if freeboard is at risk/In sump densification
70% to 80%	Bypass partial	Yes	
80% to 90%	Bypass	Yes	² NA –
90% to 100%	Bypass	Yes	

1. Note Disposal to land and in sump densification options are still subject to further work

2. Not practicable to remove LDS in high flows, LDS discharge to stream and via bypass in these conditions.

Resource Consent Review

The improved quality of the water discharging from the Mangatini Sump has contributed to a long term improvement in Ngakawau River acidity and pH levels, under the current resource consent conditions. Discharge of LDS does not impact pH and is likely to be contributing alkalinity.

The focus for improving water quality in the Ngakawau River as agreed by Solid Energy in 2005 with the Stockton Community Consultative Group, is the health of the native fish populations in the river. The restoration of native fish populations in the river has been assessed at five year intervals through an extensive fish survey in the upper Ngakawau River and a selection of reference sites in adjacent catchments. A fish survey was completed in October 2017 and this showed the [REDACTED] remains significantly more abundant than recorded in 2005 however [REDACTED] were dominated by medium to large fish.

BT has have committed to a further fish survey in Nov /Dec 2018 to better determine the reason for the relative absence of [REDACTED] in the 2017 survey and proposes that annual fish surveys be carried out going forward.

Trials over the last 18 months of LDS discharge have complied with current consent conditions for both turbidity and pH. However while no additional adverse effects have been identified over the trial period, LDS discharge does have the potential to impact turbidity and clarity. For this reason it is proposed that discharges be limited to conditions when stream and river flows are high; when turbidity levels are naturally elevated. It is thus appropriate to apply specific conditions relating to the times when an LDS discharge is occurring to maintain turbidity at in the Ngakawau River at naturally occurring levels.

Going forward BT proposes that

- **The existing conditions 21 and 22 relating to both pH and turbidity be retained.** The current consent conditions for turbidity in the Ngakawau River were based on the paper by Richardson et al. (2001). The paper identifies that the [REDACTED] more sensitive to turbidity than other species of native fish and avoids turbidity levels greater than 25 NTU. The paper concluded that achieving turbidity levels of less than 25 NTU in the migration season helps to maintain upstream migrations and populations of [REDACTED] and therefore other native fish. The

rolling 30 day 25 NTU consent condition was developed on the basis of the above research and adopted by WCRC and Solid Energy. There has been no subsequent research that supports a move away from this condition.

- **Consent conditions will be augmented with this Management Plan** for the Mangatini Sump. The Management Plan will be updated every 2 years to take account of ongoing refinements and any changes to the LOM. Linking the Management Plan to resource consent conditions provides for an adaptive management approach.
- **New conditions for turbidity** will be applied when an LDS discharge is occurring. These conditions are proposed to be based on the CLM model developed by OKC (refer Table 12 Average 8 hour NR Turbidity During LDS discharge)

A key outcome of the trials BT has undertaken on LDS discharges is a check sheet that the site environmental team uses to prepare and undertake stream discharge. The check sheet includes checks and triggers for proceeding with and/or amending LDS discharge rates making use of rainfall forecast and real-time flow and water quality monitoring information. The monitoring plan also includes collection of water quality samples at a number of points along the Mangatini Stream at regular intervals during an LDS discharge and the data collected from this will be used going forward to re-calibrate the CLM model annually.

The approach BT has taken to developing an operating regime for discharge of LDS from the Mangatini Sump follows an Adaptive Management approach whereby procedures established in the check sheet (Appendix B) and the controls encompassed in the discharge matrix (Table 12) will be reviewed and improved on an ongoing basis.

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- Appendix A – Resource Consent Conditions
- Appendix B – Stream Discharge Check Sheet
- Appendix C OKC Discharge Matrix Report
- Appendix D – Monitoring and Evaluation Programme

1. Introduction

1.1 Overview

The Mangatini Sump (the Sump) is a key element of the Stockton Mine site water management system. The Sump provides settlement for both sediments and mineral precipitates entrained in the upper Mangatini Stream. The sediments are associated with upstream mining activity and the precipitates are unreacted lime and metal hydroxides formed due to Calcium Oxide (CaO) dosing; a treatment measure applied to address acid mine drainage (AMD).

The Sump has been in operation since July 2009. As detailed in later sections there have been a number of amendments to the Sump operation since it was commissioned, including changes to neutralisation dosing reagents and the catchment area.

This Management Plan presents the proposed operating and maintenance regime that owners BT Mining Ltd (BT) plan to apply to the Sump going forward. The proposed regime has been developed based on trials that BT has undertaken over the last year relating to dosing reagents, sludge characteristics, sludge disposal options and optimisation of the Sump performance. The planned operating regime aligns with discharge consent condition variations that BT are also seeking (refer section 1.3).

This Management Plan supercedes previous documents relating to the Mangatini Sump operation and treatment performance; including the Mangatini Sump Assessment of Environmental Effects (AEE) prepared by Solid Energy NZ Limited (Solid Energy) and submitted in support of resource consents in 2007.

The location of the Mangatini sump is shown in Figure 1.

1.2 Background

AMD management at the Stockton mine is complex due to its origins from multiple sources across the Stockton Plateau. The site has been mined for over a 100 years and AMD discharges are sourced from a combination of historic underground workings as well as runoff and seepage from historic and current waste rock stockpiles. AMD contributes to poor water quality in several streams that drain the plateau.

Previous mine owners Solid Energy committed to improving downstream water quality and embarked on the Surface Water Management Action Plan ("SWaMP") in 2005. Under SWaMP a number of treatment systems and waste rock management initiatives were established across the mine site; with the Mangatini Sump being one of these.

A key premise of SWaMP was that "brown water" (runoff impacted by waste rock contact) and "black water" (runoff in contact with coal fines) should be collected and treated separately. This was based on an assumption at that time that coal fines would be more difficult to remove. Resource consents, including those required for operation of the Mangatini sump were obtained progressively to cover each component of SWaMP. Over ensuing years the management system has changed (as described following) and the system then designed has now changed to a new regime. By December 2010, A-Drive Dam, Ford Creek Dam, Duncan's Sump, Mangatini Sump, No1 North Dam, the Black Water Treatment Plant (BWTP) and the temporary Limestone Dosing Plant were constructed and in operation. It was found through experience that in practise that there was minimal benefit from separating brown and black water, and the process of pH adjustment followed by settlement was equally efficient for both water streams. It also proved difficult to densify sludge generated from the BWTP and this was de-commissioned in November 2012.

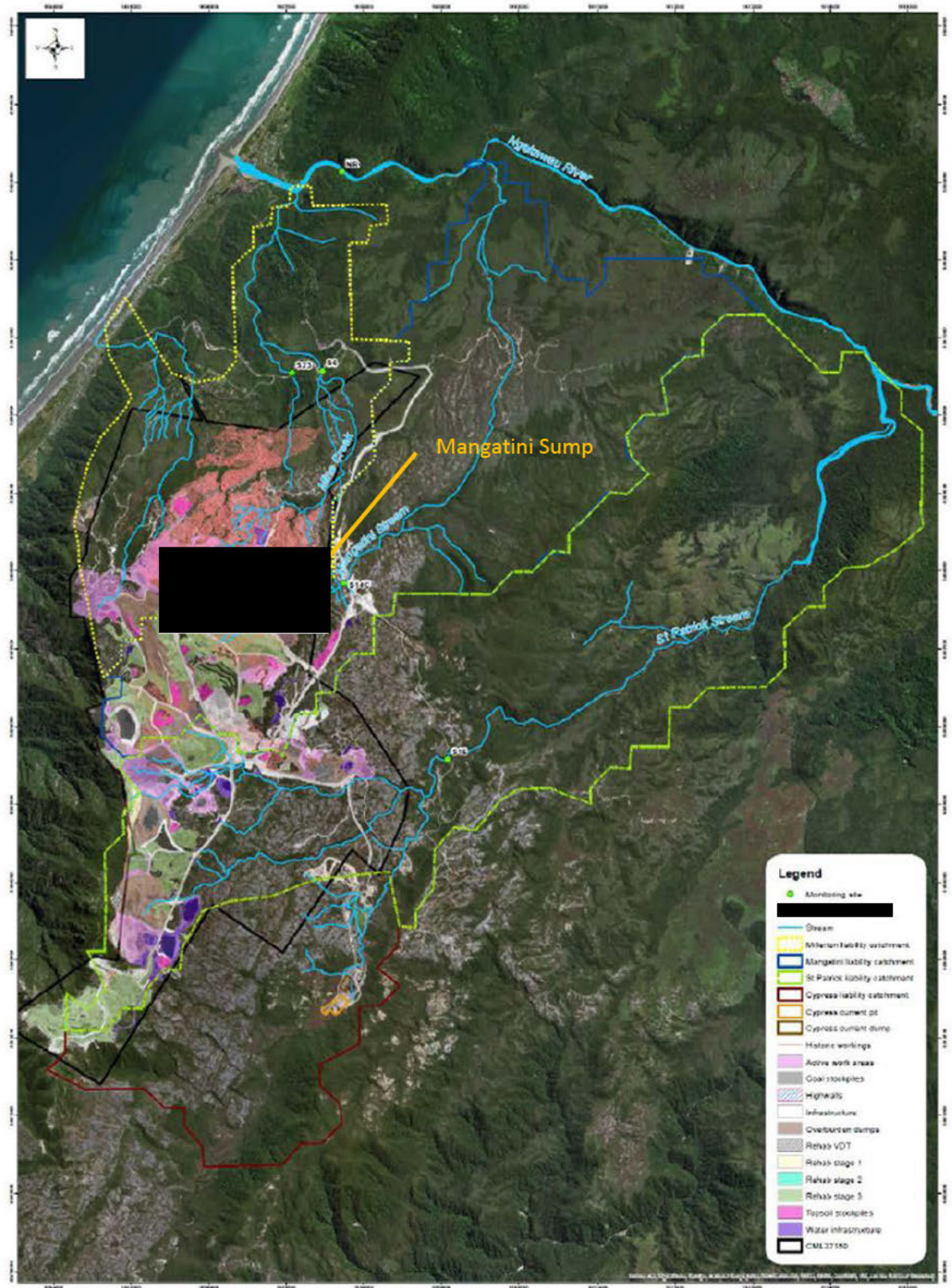


Figure 1 Mangatini Sump Location Plan

Both brown and black waters have now been treated in the Mangatini catchment by pH adjustment and settlement in the Sump since November 2012. There has been a marked

improvement in Ngakawau River water quality since 2010 due to the measures applied to improve discharge water quality from the Stockton mine as a whole. In addition to water treatment there has been an ongoing focus on rehabilitation and capping of waste rock stockpiles to reduce AMD.

The benefits of all of these activities is apparent in the monitoring records for the Ngakawau River at water quality monitoring site NR. Both pH and aluminium levels at site NR have stabilised to on average above pH 5 and below 1 g/m³ respectively. Water quality improvements and monitoring sites are described in section 3.3.

When the sump was first commissioned, ultra fine limestone (UFL) was the dosing reagent used to adjust pH upstream of the Sump. Using UFL target pH adjustment and associated metals removal rates were achieved; however clarity of the treated water was often poor.

This is illustrated in the photographs of the Sump provided in Figure 2 with UFL treatment (upper photo) and CaO (lower photo).

The change in dosing reagent was also made because UFL was found to be inefficient; with significant proportions of the UFL remaining un-reacted and present as layers within the sludge accumulating in the Sump. The change to CaO has improved both discharge water clarity and AMD treatment efficiency.

An unexpected consequence of the change to CaO is that the density of the sludge collected in the sump is lower than UFL. A layer of Low Density Sediments (LDS) in the order of 8 m in depth has developed since CaO dosing commenced. The development of this LDS layer impacts the capacity and hence longevity of the sump since sludge buildup is quicker.

Solid Energy commenced a series of trials to determine how to manage LDS in July 2016 and BT has continued with these. A key objective was to retain the excellent water treatment outcomes achieved through dosing with CaO while preventing uncontrolled release of LDS. These trials are co-ordinated as part of the Mangatini Sump project which is described in section 5.1.

The change to dosing with CaO was made in December 2014.

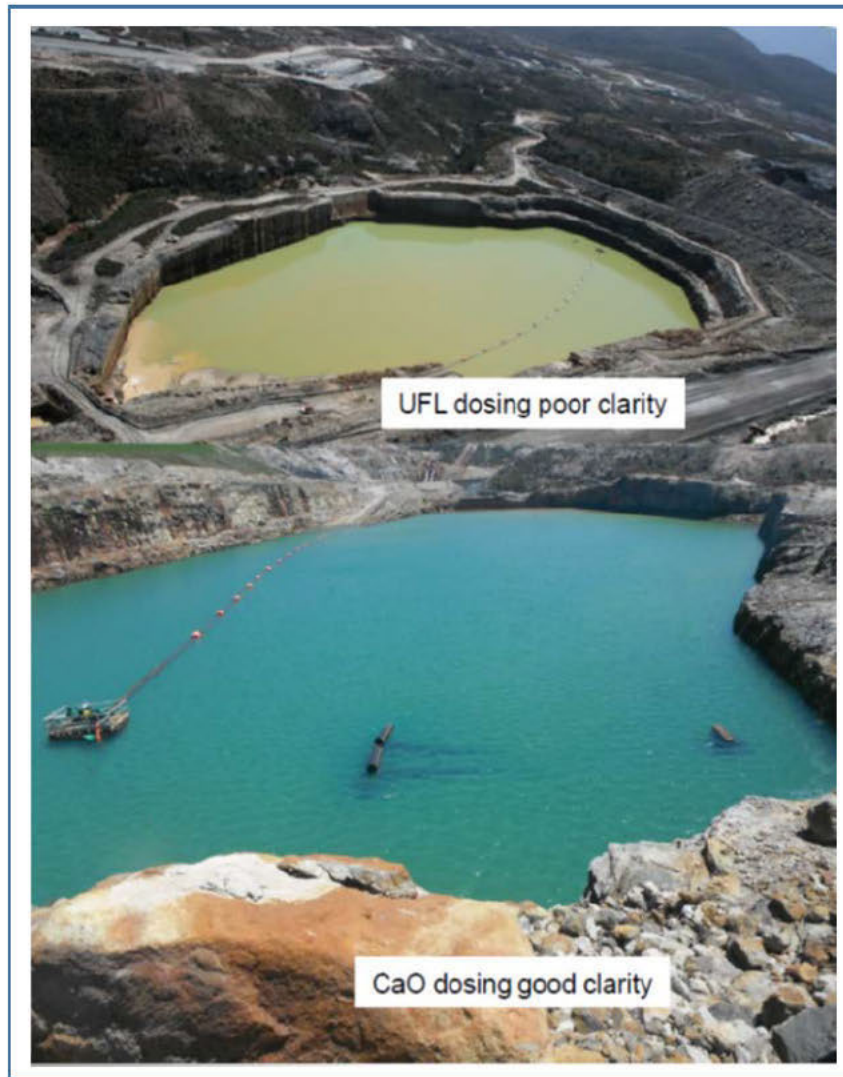
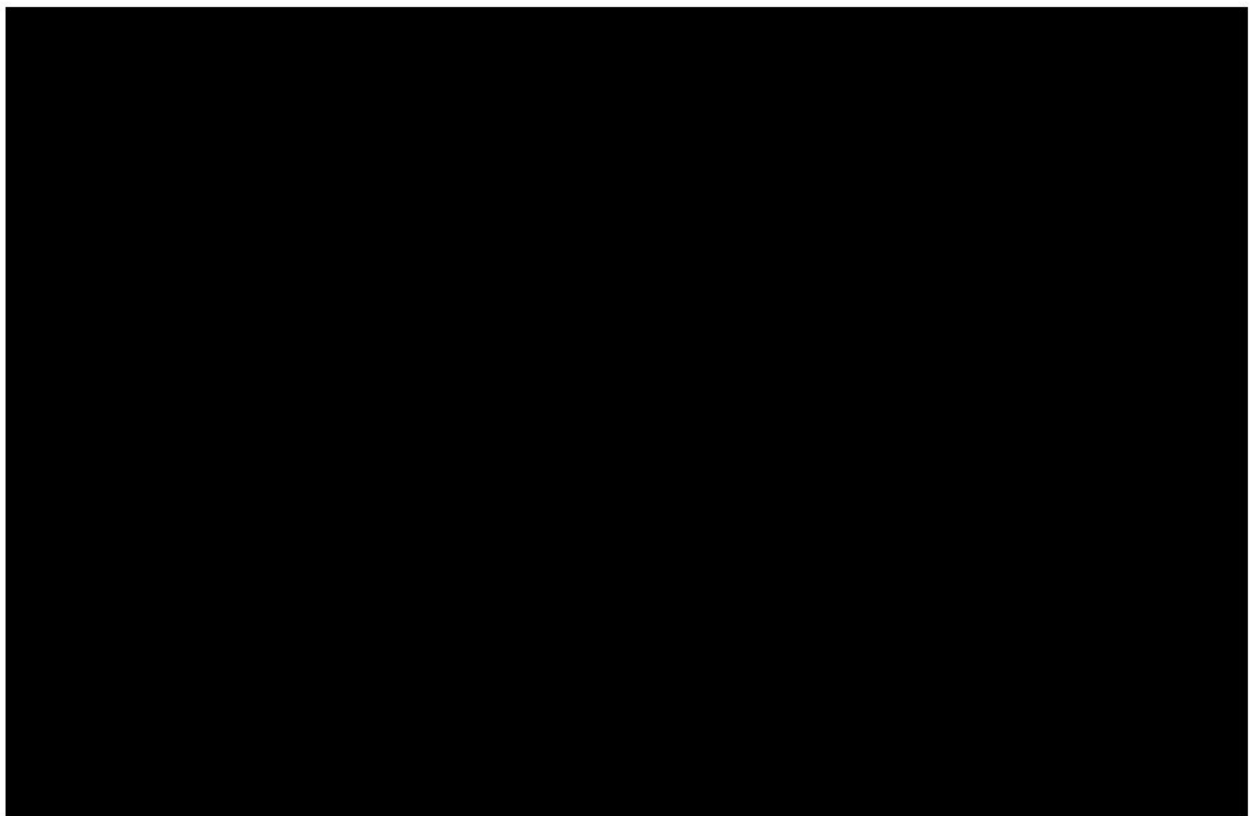


Figure 2 Comparison of Mangatini Sump water clarity with UFL and CaO dosing upstream



1.4 Resource Consents

The discharge of treated water from the Mangatini Sump is subject to resource consent RC06206. The associated consent conditions are reproduced in Appendix A for reference. In April 2017 the WCRC requested that Solid Energy review these consent conditions. New mine owner BT has taken over this responsibility.

Because Solid Energy had a number of trials underway in April 2017 associated with improving sump management processes, and a changed operating regime might require consent revisions or additions; WCRC agreed that BT could continue Sump operation under existing resource consent conditions until June 2018. The intent was that BT would then report on trial outcomes and at the same time respond to the resource consent review request.

The WCRC requested that Solid Energy review conditions 6, 21 and 22 with the key matters to be addressed summarized below:

- That annual fish surveys be carried out.
- That the 30-day rolling median condition for pH be reviewed.
- That upstream and downstream monitoring points are needed.
- That telemetry be adopted for continuous monitoring at such sites.
- That conditions 21 and 22 be revised to provide a higher pH minimum (currently pH 4.2) and to limit turbidity increases to a percentage of the period of base flow.

This management plan sets out how the Mangatini sump will be operated going forward and responds to the WCRC consents review request. The resource consent review by BT is outlined in Section 6.

1.5 Scope and Limitations

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2. Mangatini Sump Design Background

2.1 Original Design Basis

2.1.1 Model Development

The Mangatini Sump was developed as part of the Stockton site water management system, to treat run off from a catchment of 413 ha, with provision for a long term catchment reaching 532 ha.

The Sump was designed originally to treat brown water and it was intended that any black water generated in the catchment would be collected and pumped to the BWTP. The design basis of the sump was to allow settlement of suspended particles (sediment and AMD particles) in the brown water to occur, prior to water being discharged from the Sump via a floating decant system.

The original design basis for the Sump assumed that active mining in the Mangatini catchment would continue for 10 years (until 2017), and that the Sump would continue to treat AMD until the end of a 100 year design life covering post closure (Mangatini Sump AEE, Solid Energy, 2007).

The Sump was sized based on modelling work completed by MWH (Mangatini Sump Modelling of Water Quality Performance, MWH 2007). At the time, it was assumed that a 90th percentile discharge limit for suspended solids would be imposed. The model used a nominal 50 mg/L Total Suspended Solids (TSS) outflow water quality target as a basis for assessment of Sump performance, and was developed based on data collected at the S14 water quality monitoring site between March 2002 and January 2007. Key inputs in the development of the model included:

- Flow rates diverted to the Sump from the Mangatini Stream
- Surface area (dead water in reservoir)
- Sediment properties
- Inflow concentrations

The performance of the sump was shown to be highly sensitive to the design settling velocity of the suspended particles in the brown water. The performance of the Sump was reported by MWH to decrease significantly when altered settling characteristics were trialled through the model. A decreased design settling velocity resulted in 40 – 60% of outflows exceeding the TSS discharge target of 50 mg/L.

At the time, the model was believed to be conservative in the approach to settling velocity, since it was assumed that any black water generated in the catchment would be treated separately.

As would be expected, modelling indicated that the performance of the sump was also sensitive to the TSS concentration of the Sump inflows. The performance of the Sump increased when the TSS concentration of the inflows was decreased, and vice versa. The TSS inflow assumptions used to set the control case for the model were noted as being highly conservative to account for future mining in the catchment.

The design basis for the Mangatini Sump control case as defined by MWH is provided in Table 1, below.

Table 1: Control Case Parameters for Mangatini Sump

Parameter	2002 - 2003	2004 - 2005	2006
% of time outflow TSS > 50 mg/L	9.6	10.0	10.6
Max diverted flow to Sump (m ³ /s)	25.0	20.0	25.0
Optimum maximum decant flow (m ³ /s)	0.8	0.6	0.8
Mean outflow TSS (mg/L)	53.0	56.0	60.0

This control case was used to size the Sump and to provide the desired outflow TSS performance targets. The sizing characteristics of the sump as determined from the modelling work are provided in Table 2 below.

Table 2: Mangatini Sump Characteristics

RL	Volume (m ³)	Surface Area (m ²)
570.5	86,838	27,670
575.5	231,462	30,181
580.5	388,670	32,704
584.5	534,576	42,061
590.5	797,818	46,004
593.5	938,388	47,669

2.1.2 Model Relevance

Using the control case parameters and Sump design characteristics detailed in Section 2.1.1, the settling performance of the Mangatini Sump was predicted over a modelled period from June 2002 to January 2007. During this time interval, the Sump was found to meet the outflow TSS performance targets of 50 mg/L and 300 mg/L being met 90% and 95% of the time, respectively.

Performance was linked to stream flow through the diverted flow values shown in Table 1 above. These values correlate to a flow greater than the 95th percentile value for the Mangatini Stream (refer Table 5).

MWH considered that capturing all flows below 20 to 25 m³/s (depending on year modelled) in the sump resulted in optimum sump performance in relation to sediment removal.

The AEE prepared by Solid Energy to support consent applications for the Sump (2007) relied on the MWH study and reported that “*The current application will enable a large stormwater sump to be commissioned that will capture stormwater that currently flows down the Mangatini Stream for approximately 95% of the time.*”

2.2 Sedimentation Model Relevance to Current Operations

The MWH analysis does not now represent Sump operation. Key factors that have changed include:

- The sedimentation model did not account for the behaviour of AMD flocculants; the modelling used the settlement characteristics of sediment only. AMD flocculents settle at different rates to sediment and are subject to densification over time.
- The Mangatini Stream bypasses the Sump at around the 70th percentile flow condition.
- The MWH model performance targets (TSS of 50 mg/L and 300 mg/L being met 90% and 95% of the time) do not correlate directly with the resource consent conditions at NR (which are for turbidity – refer 4.1).

The changes to how the Sump is operated to what was originally envisaged have occurred over time with the site environmental team making adaptations to improve performance as well as respond to a changing mine plan.

As discussed in section 3.3 the water quality in the Ngakawau River has improved markedly with the Sump in operation.

2.3 Mangatini Sump Operation

2.3.1 Current Operation

The Mangatini Sump currently treats runoff from a catchment of 491 ha, as shown in Figure 3 below.

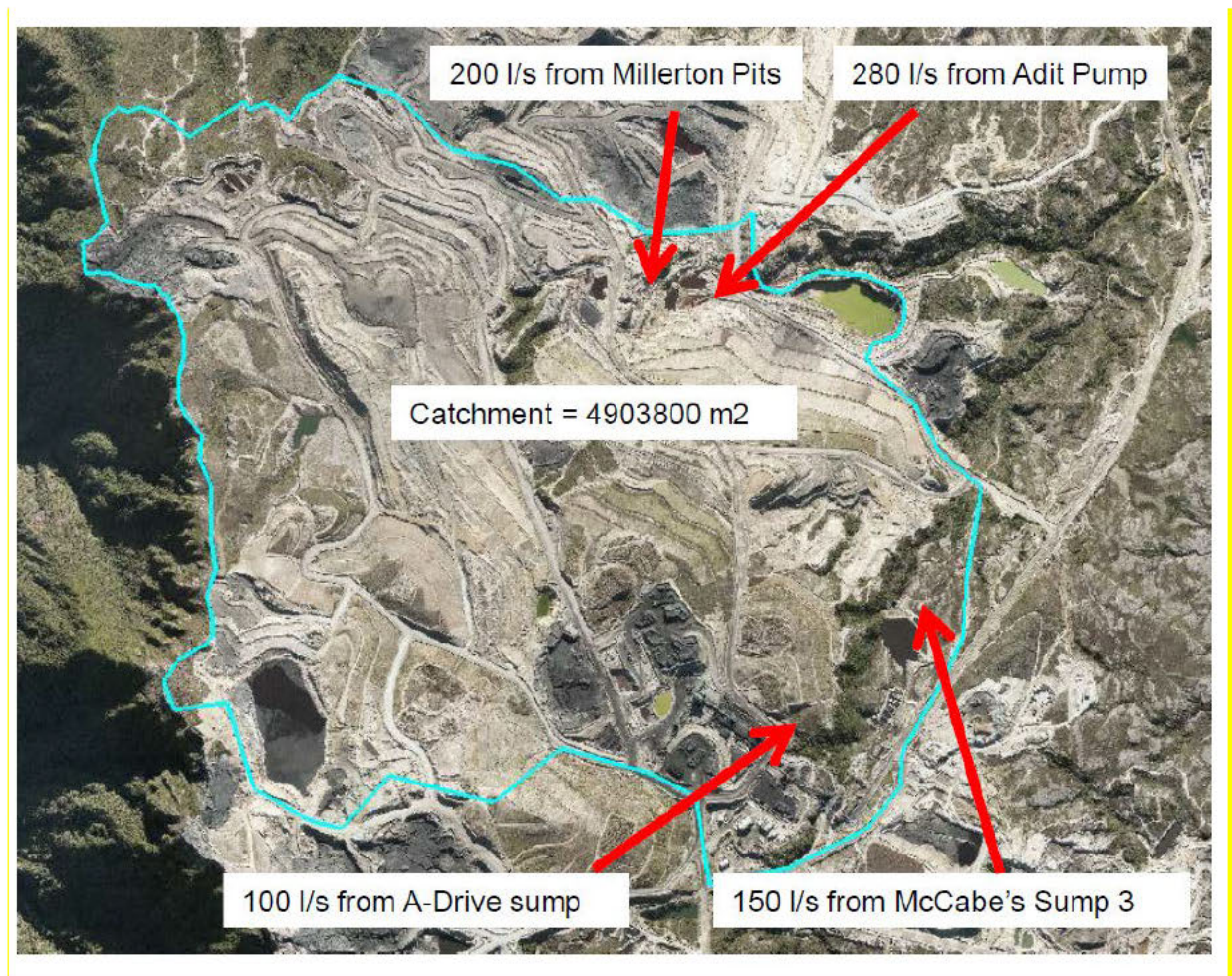


Figure 3: Current Catchment of Mangatini Sump

Up to 730 L/s can also be pumped to the Mangatini Stream for treatment from surrounding mine areas; noting that the adit pump is a contingency measure that has not been used to date. MWH (refer section 2.1.1) calculated that inflows to the sump would be in the flow range of 500 to 800 L/s for 80 percent of time for the predicted catchment area range of 400 to 532 ha.

Flow records maintained by BT indicated the 80th percentile inflow into the sump over the last 3 years is currently about 500 l/s; hence even with pumped inflows the inflow rates have

remained comparable to design assumptions, noting that more flow is bypassed than MWH envisaged..

The discharge water quality from the Sump has been generally of good quality (i.e. pH greater than 5.5, low turbidity and low aluminium content).. Figure 4 shows the sump in relation to the Mangatini Stream.

As a means of reducing sediment loads into the sump, where practicable flow is first passed through the upstream Mangatini (MG) Quarry sumps.

CaO is dosed directly into the stream downstream of the MG quarry sump.

CaO Dose Point



Figure 4 Mangatini Sump Treatment System

The Mangatini Stream is diverted into the Sump when flows are below about 3 m³/s; equivalent to the 70th percentile flow event. The inlet culvert can pass up to 15 m³/s but the inflow is restricted by the height of the water in the Sump. A minimum 2 m freeboard of clean water is generally maintained above the sludge and this is decanted off to the Mangatini Stream.

As flow increases and water level in the Sump rises above RL 593.5m, water begins to bypass the sump and discharge from the Sump spillway (located above the inlet to the sump).

2.3.2 Planned Catchment

Mining activities at Stockton Mine are expected to continue through to at least 2027 and it is planned that the Mangatini Sump will form a part of the water treatment system until mining ends. The expected future catchment (including pumped flows from other mine areas) will likely remain in the same order as that currently reporting to the Sump.

The current LOM plan contemplates a further 5-10 years of active mining in the catchment and in adjacent areas with water being pumped to the sump for treatment.

Mining in the next 5 years is planned to extend through the Millerton Block and incorporate the Rockies mine as shown in Figure 5. Since most of this future area is down gradient of the Sump, water requiring treatment will be pumped to the Mangatini Stream (upstream of MG Quarries).

Concurrent rehabilitation will occur within the current active areas to keep the overall open area within the sump's capability to treat and to reduce AMD discharges as much as is practicable.



Figure 5: Planned Future area to be treated using the Mangatini Sump

2.4 Design Storage Capacity

The modelling work completed as part of the original design of the Mangatini Sump indicated storage capacity of the Sump would be sufficient to provide adequate treatment to brown water inflows from the specified catchment over the design life of the Sump (100 years).

The 'as-built' capacity of the Sump was reduced by approximately 20%, partially due to the placement of the inlet culvert and upstream spillway. The capacity issues were further compounded by much higher than expected volumes of AMD sludge accumulation in the sump. Measures to manage sludge accumulation are described in section 5.

2.4.1 Height Storage

Figure 6 shows the original storage capacity estimates produced by MWH in 2007. Storage capacity of just under 1Mm³ was estimated to be available to the normal operating level of RL 593.5m. The decant was shown to operate between RL 584.5m RL and 593.5m RL.

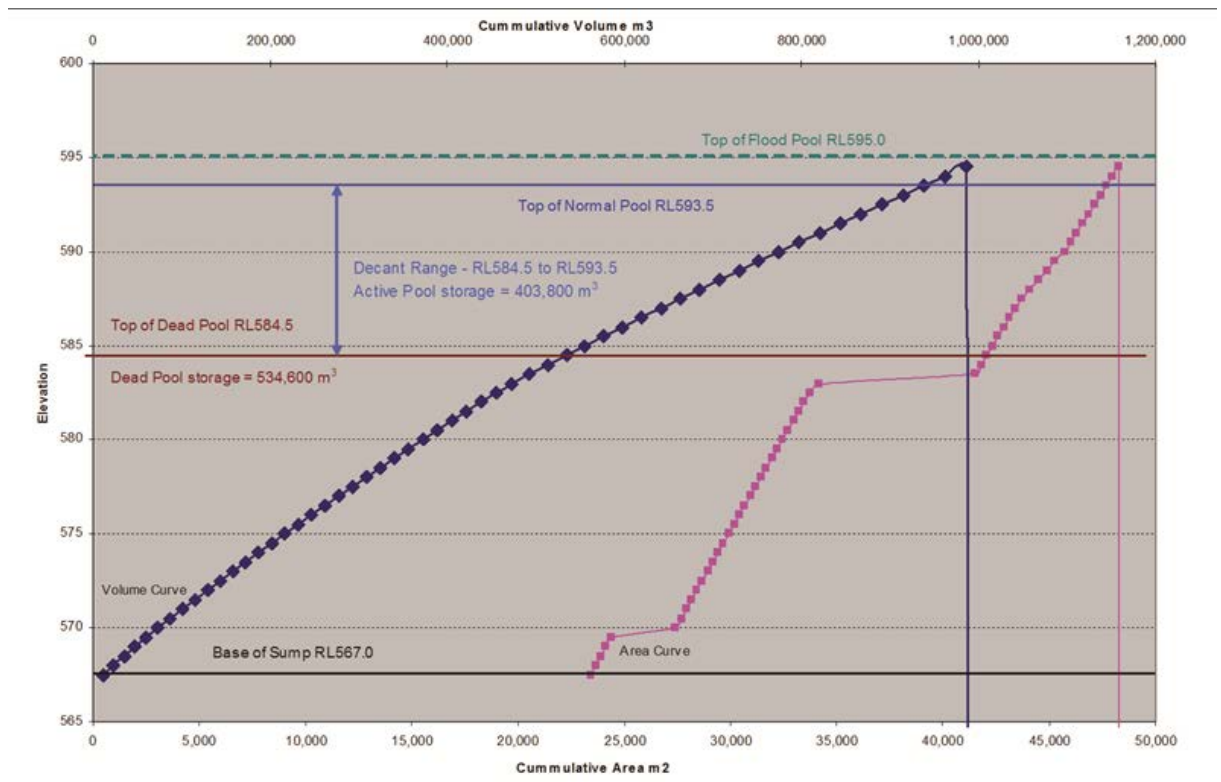


Figure 6 Active reservoir and sediment storage volumes of the Mangatini sump (MWH, 2007 (a))

The as-built elevation versus volume curve is shown in Figure 7.

In 2014 the floating decants were modified to lift them above the accumulated sludge level reducing the active storage to approximately 263,300 m³.

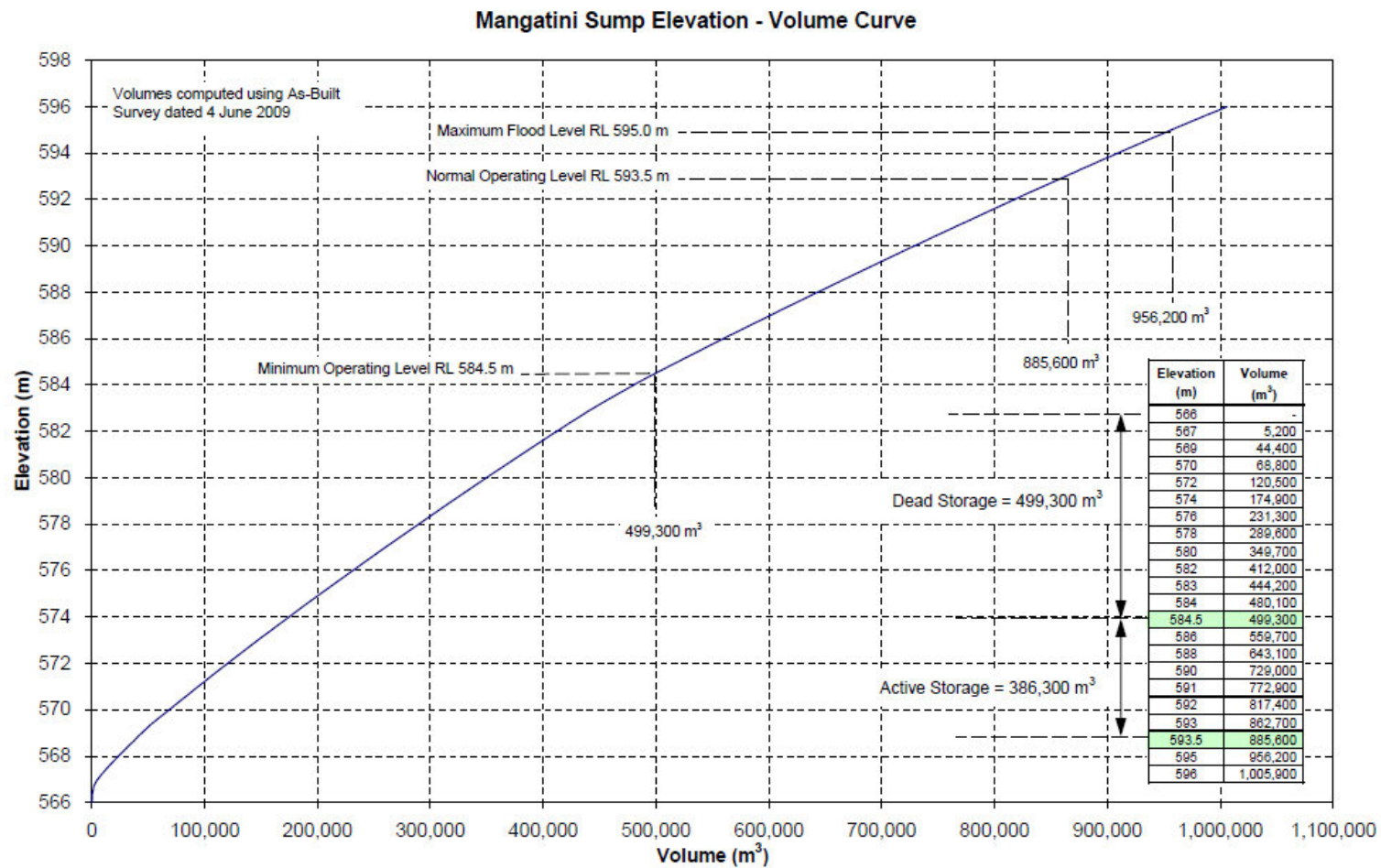


Figure 7 As- Built Height Storage Relationship for the Mangatini Sump

2.4.2 Sonar Survey 2018

The sump is regularly surveyed by sonar to assess the status of sludge accumulation. In addition with assistance from CRL Energy Ltd (CRL), there have been a number of surveys of sludge density. The latest sonar results provided by BT are shown following:

Table 3 Mangatini Sump Sonar Results

Sump sonar results 6 March 2018

LDS RL at decant – 589.5m

LDS RL in eastern half of sump – 590.0 m

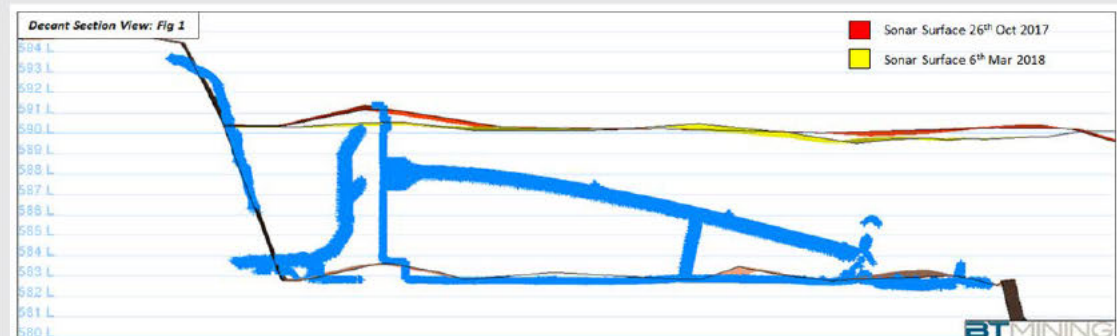
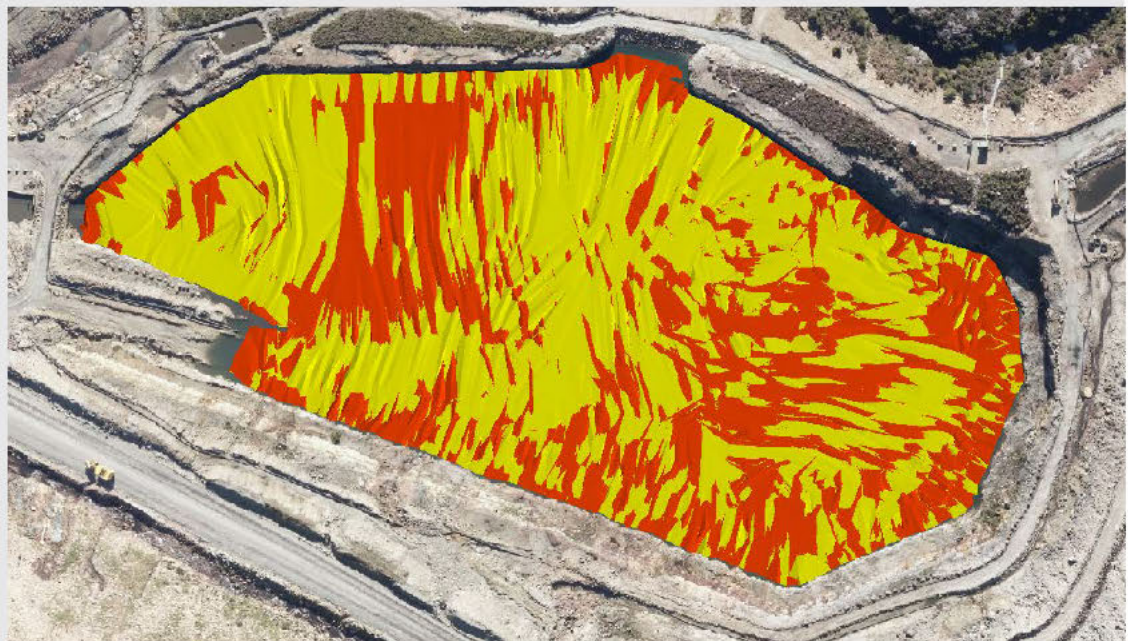
LDS RL in western half of sump – 590.5 m

Max. water level before sump spills over inlet weir – 593.5 m

In following survey outputs :

Yellow surface top of sludge – Sonar survey 6/3/18 – total sludge volume = 770,056 m³

Orange surface top of sludge – Sonar survey 26/10/17 – total sludge volume = 765,292 m³



The latest survey indicates a total sludge volume of 770,056 m³ and approximately 3 m of freeboard to the inlet weir. This sludge is of variable density as discussed in section 2.4.3.

2.4.3 Sludge Density profiles

Figure 8 shows the most recent density profile survey completed by CRL in October 2017.

The survey indicates LDS is generally between RL 590 m to ~RL 588 m. The profiles are somewhat variable below this depth.

Figure 8 Sludge/Sediment Profiles

shows where the samples were taken from. It is important to note that over a depth of about 22m metres of sludge in the Sump that consolidation and densification of sludge is occurring over approximately 40% of the sludge column with time. There is currently approximately 400,000 m³ of HDS and 300,000 m³ of LDS in the Sump.

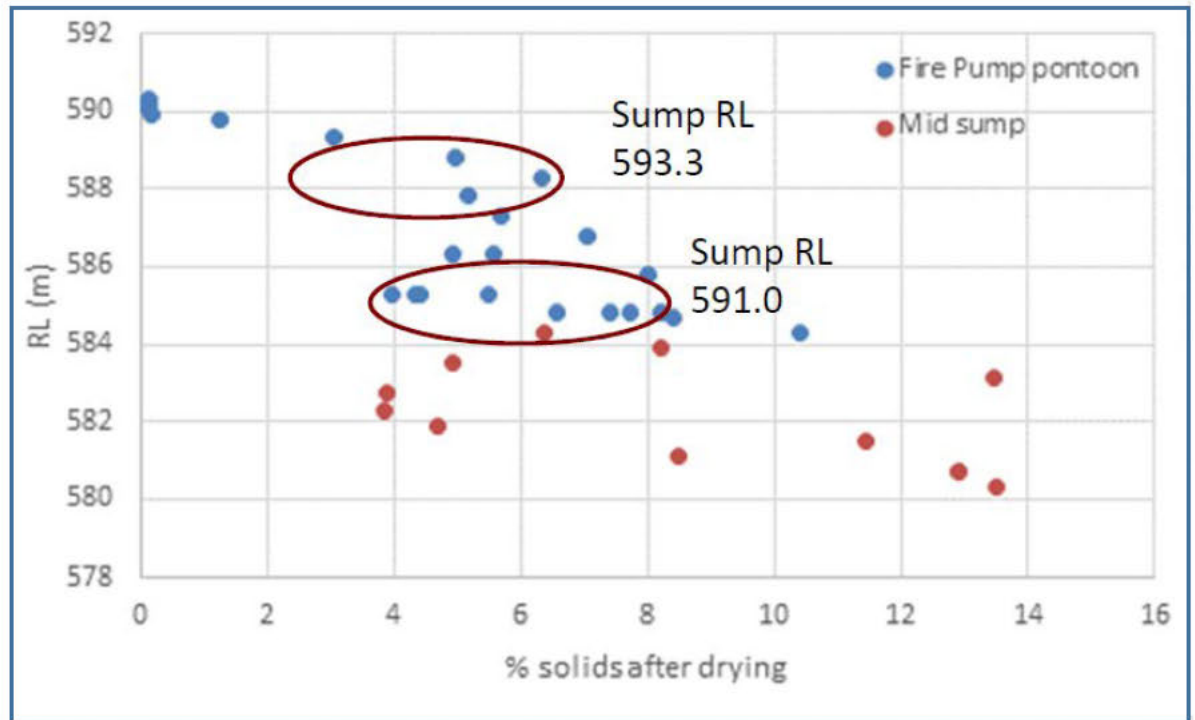


Figure 8 Sludge/Sediment Profiles



Figure 9 Sludge/Sediment Profile Sampling Locations

3. Receiving Environment

3.1 Ngakawau River Catchment

Figure 10 shows the receiving environment for the Mangatini Sump discharge. The Sump discharges to the Mangatini Stream which is a tributary of the Ngakawau River. Several other tributaries contribute to the Ngakawau River flow.

The Mangatini Stream makes up approximately 12 % of the river catchment by area at the ocean confluence.

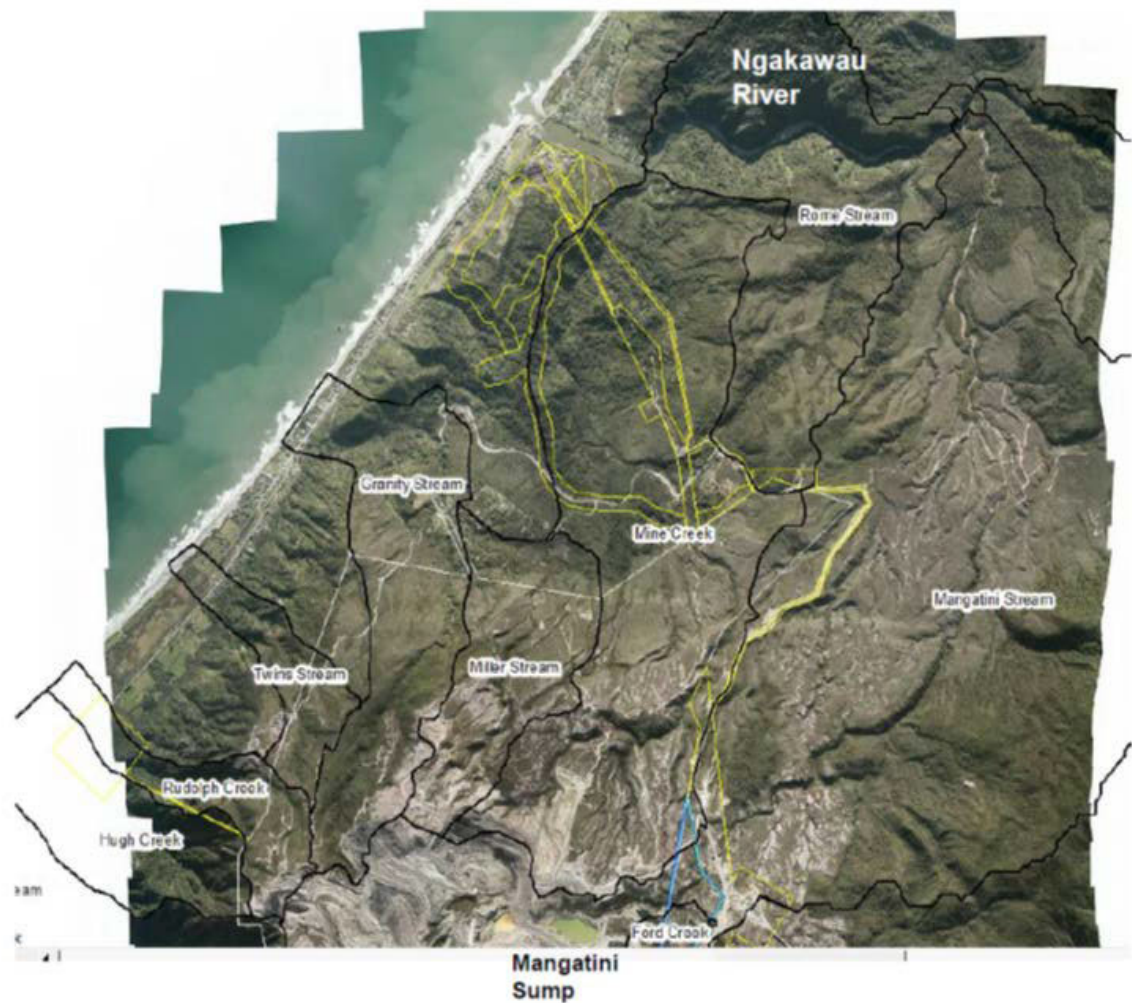


Figure 10 Mangatini Sump Receiving Environment

A summary of stream catchment areas from Stockton site is provided in Table 4 for reference.

Table 4 Ngakawau River Tributaries

Tributary	Catchment Area (km ²)
Mine Creek to Ngakawau Confluence	6.88
Mangatini Stream to Ngakawau Confluence	22.55
St Pats Catchment to Ngakawau confluence	43.0
Total at monitoring site NR	188

3.2 Flow

Flow gauge locations are shown in Figure 11.

Consent conditions primarily relate to site NR in the Ngakawau River.

Site S14B is used by BT as an internal monitoring site to assess impacts of site activities on the Mangatini Stream. As discussed in section 5.5.2 the flow gauge at S14B is an important control point for the proposed operating regime for the Sump.

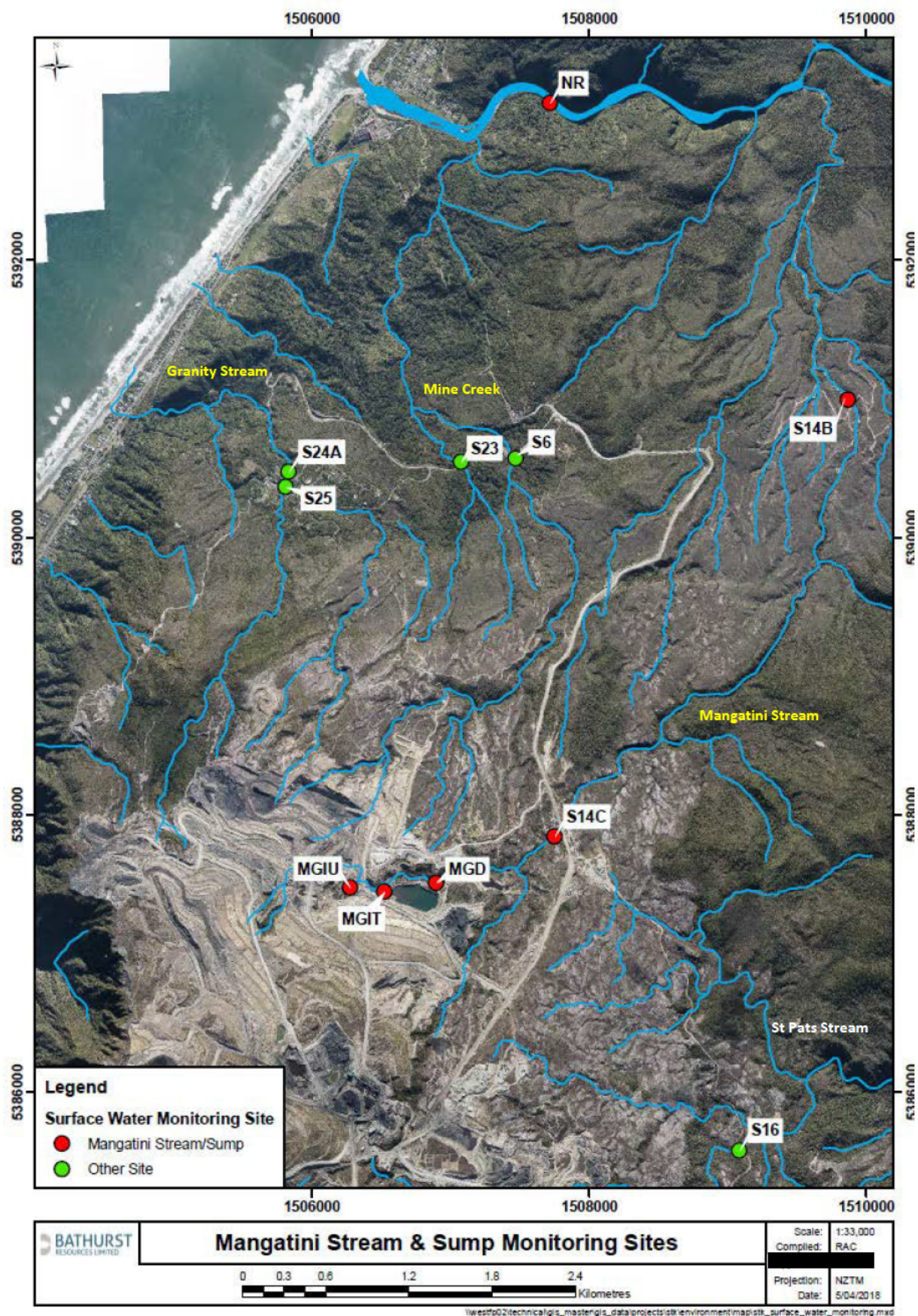


Figure 11 Flow Gauge Locations

Flow at NR and S14B for a range of flow conditions are compared in Table 5 . The flows at S14B generally provide a 6% contribution to flows at NR. Based on data review completed by BT there is an approximate timelag of 3 to 6 hours between peak flows at S14B and NR during rainfall events.

Table 5 Flow Comparison NR and S14

Non Exceedance percentiles	S14B Flow (m ³ /sec)	NR Flow (m ³ /sec)
100	195.04	907.55
95	7.08	105.31
90	5.75	90.29
85	4.83	79.10
80	4.19	70.17
75	3.69	62.76
70	3.27	56.66
65	2.94	51.29
60	2.68	46.76
55	2.47	42.80
50	2.28	39.26
45	2.13	36.15
40	2.00	33.31
35	1.89	30.86
30	1.80	28.70
25	1.72	26.73
20	1.64	25.03
15	1.58	23.52
10	1.51	22.16
5	1.45	20.93

3.3 Water Quality

A network of water quality monitoring sites are used by BT to check that site discharges are not causing an adverse effect on downstream water quality. These sites are shown on Figure 12. BT use a combination of automatic monitors and regular water quality sample collection for monitoring.

Water quality monitoring relevant to the performance of the Mangatini Sump is summarised in Table 6

Table 6 Water Quality Monitoring Summary

Monitoring Site	Parameter measured	Frequency
MGIU/MGIT	Turbidity/pH Metals/TSS	Continuous and daily samples Daily Samples
MGD	Turbidity/pH Metals/TSS	Continuous and daily samples Daily Samples
S14C / S14	Turbidity/pH Metals/TSS	Continuous and daily samples Daily Samples
S14B	Turbidity/pH Metals/TSS	Continuous and daily samples Daily Samples
NR	Turbidity/pH Metals/TSS	Continuous and daily samples Daily Samples

Note – Metals (Dissolved) tested include Aluminium, Arsenic, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Magnesium, Manganese, Nickel, Zinc, Sulphur and Sulphate



Figure 12 Water Quality Monitoring Sites

4. Mangatini Sump Performance

4.1 Discharge Water Quality

The Sump in combination with upstream pH adjustment has been very successful in treating AMD runoff. This is evidenced by the water quality achieved at NR over time.

The following suite of graphs present the measured values for pH, dissolved Aluminium, turbidity and TSS at NR over the period of Jan 2005 to March 2018. The benefit of water treatment is clear from the change in pH at NR since 2007.

Consent condition 22 (RC 62016-V6) requires that:

- a) The acidity of the Lower Ngakawau River is not to fall below pH 4.0; and*
- b) The 30-day rolling median turbidity based on daily sampling is not to exceed 25 NTU as a result of the discharge.*

The data shows consistent achievement of a pH value greater than 4 (refer Figure 13), and the rolling median turbidity requirement has also been met.

BT report that the only period of non-compliance of median turbidity occurred before they owned the site over May – June 2014 during the remediation of the decant when all water was diverted past the sump.

Achievement of the community target for aluminium of 1 mg/l has improved over time. This is shown in Figure 16 where the number of exceedances per year are recorded when pH is concurrently under 4.8 (Aluminium is not toxic when the pH is greater than 4.8).

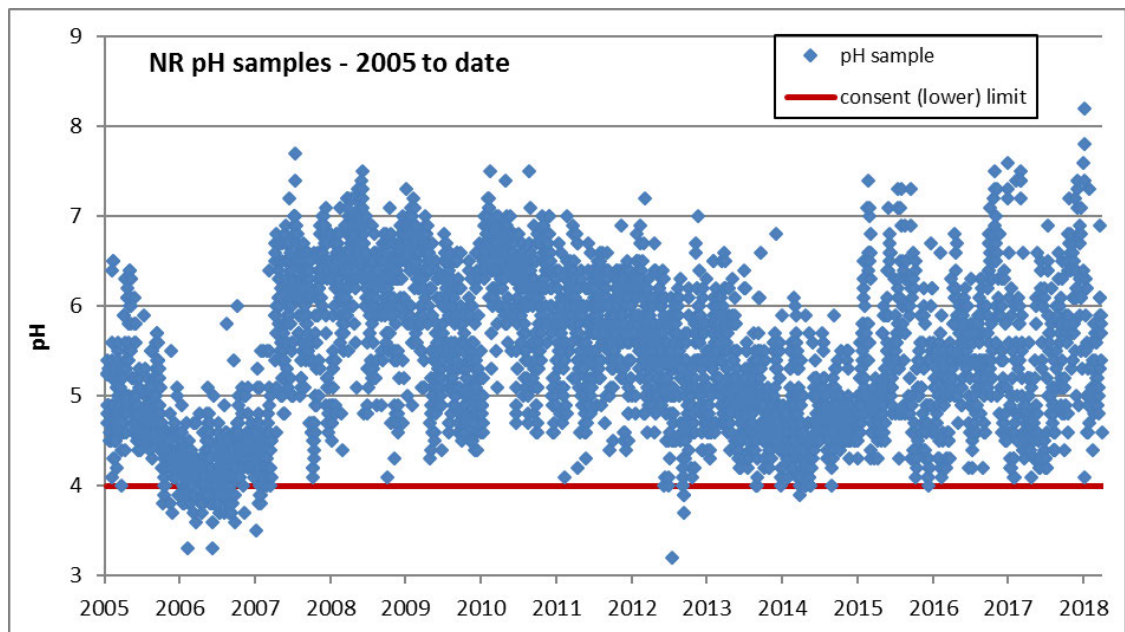


Figure 13 NR pH Samples 2005 to date (2018)

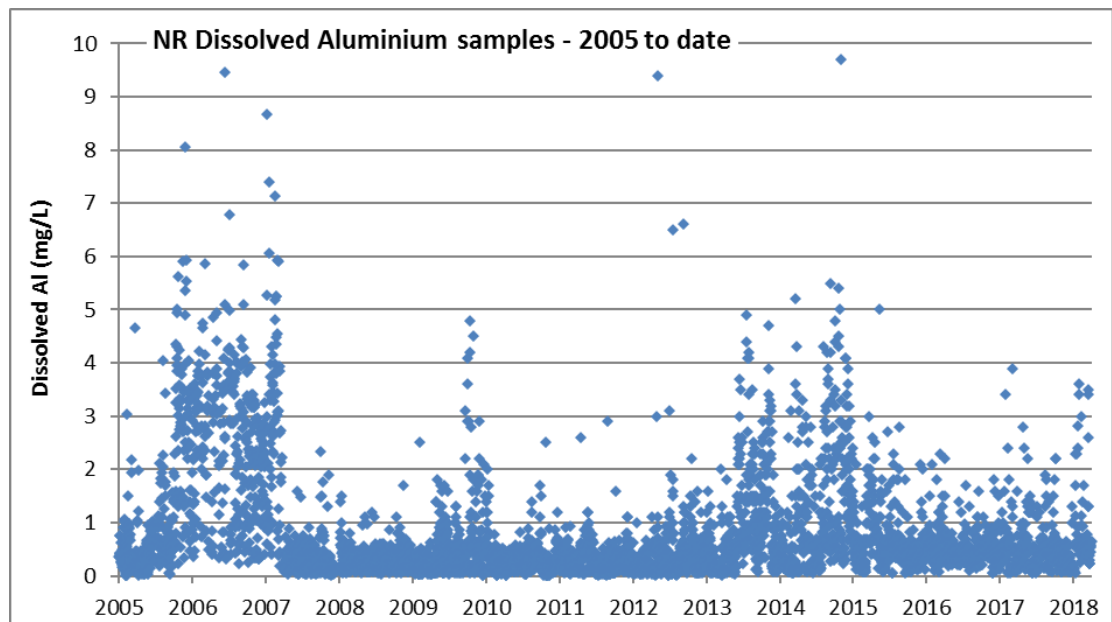


Figure 14 NR Dissolved Aluminium Samples 2005 to date (2018)

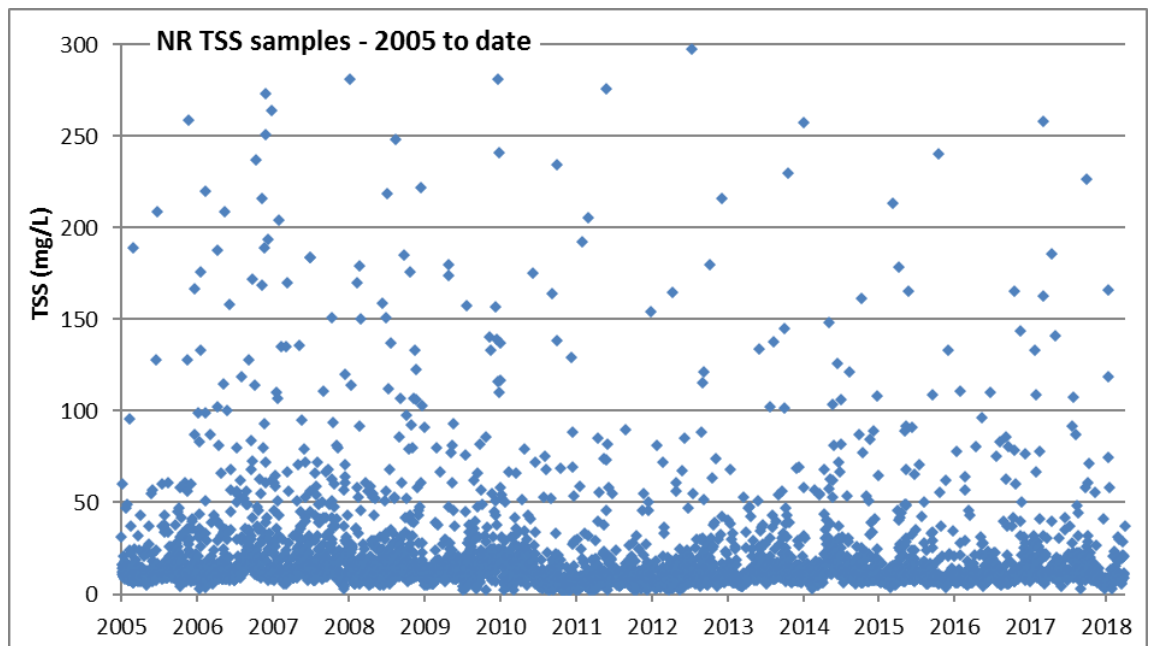


Figure 15 NR TSS Samples 2005 to date (2018)

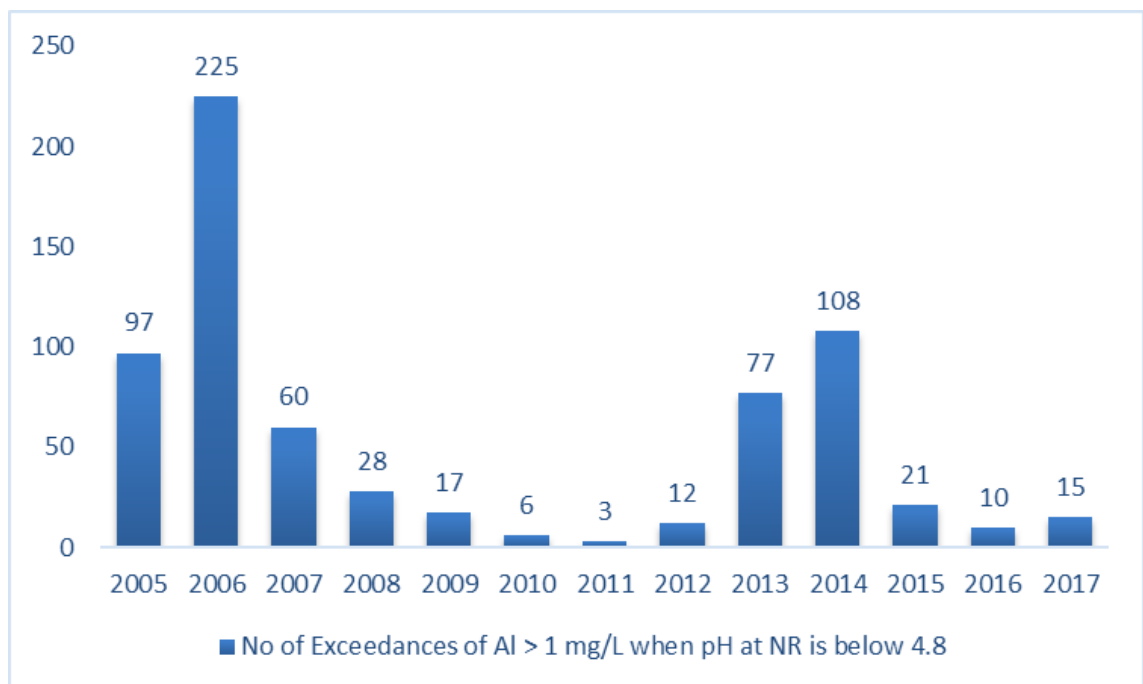


Figure 16 Count of Aluminium Community Target Exceedance

Note that values counted in Figure 16 are from daily samples.

4.2 Fish Survey Results

The focus for improving water quality in the Ngakawau River as agreed by Solid Energy in 2005 with the Stockton Community Consultative Group, is the health of the native fish populations in the river.

The treatment measures implemented over time have been designed to reduce sediments (TSS), raise the pH and remove Aluminium which is toxic to fish. The restoration of native fish populations in the river has been assessed at five year intervals through an extensive fish survey in the upper Ngakawau River and a selection of reference sites in adjacent catchments. Surveys completed include:

- November 2005 baseline survey carried out by the University of Canterbury, Freshwater Ecology Research Group (Harding et al. 2006).
- November 2011 by Golder Associates (Duncan Gray).
- November 2017 by Duncan Gray.

The results of the November 2017 survey are compared to the historic information collected in 2005 and 2011 in the report “Ngakawau fish survey 2017” prepared by Duncan Gray.

Figure 17 compares survey results from the three years they were completed.

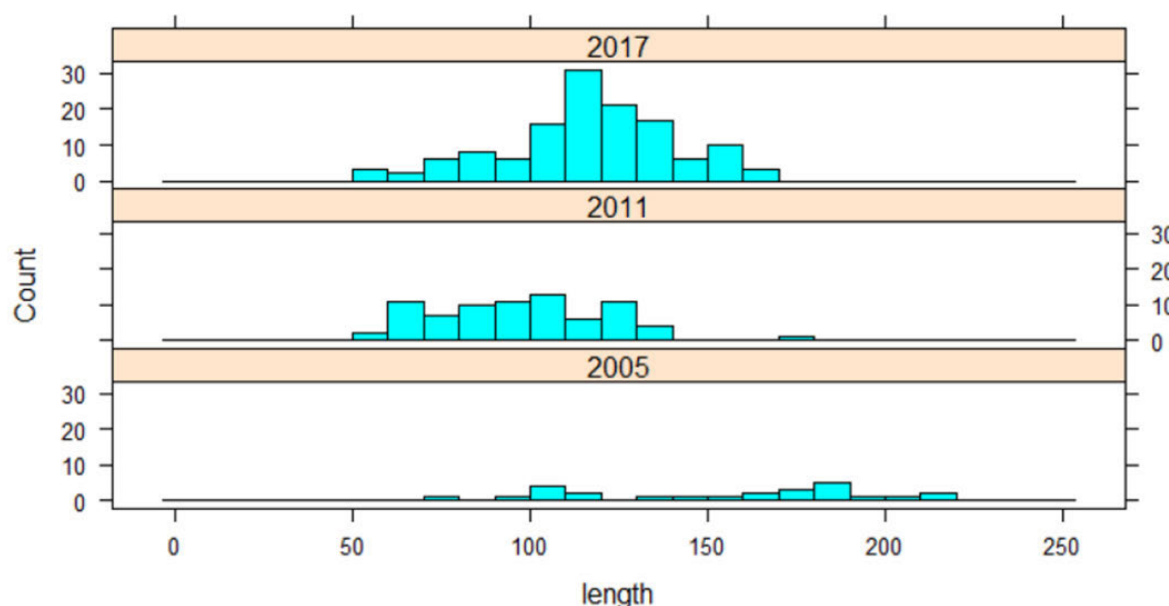


Figure 17 [REDACTED] - 2005, 2011 and 2017 survey results

The key findings of the Duncan Grey report are listed following:

- Water quality was variable, but remains significantly better than that recorded commensurate with the 2005 fish survey.
- There was no particular change in the species of fish observed in 2017 relative to previous years.
- The [REDACTED] significantly more abundant than recorded in 2005. [REDACTED] However, there was a relative absence of juvenile recruits in 2017 compared to 2011.
- There has been some juvenile recruitment through the Ngakawau River to headwaters in 2017.

- Recruitment of juveniles may have been affected by atypically low flows during the migration season in 2017, a decline in water quality or intraspecific competition between mature and juvenile fish in headwater streams.

Overall it is difficult to interpret from the most recent survey whether conditions for fish have improved, declined or been impacted by low flows or other factors. BT has have committed to a further fish survey in Nov /Dec 2018 to better determine the reason for the [REDACTED] in 2017 survey.

4.3 Stream Bypass

As discussed in section 2.1 the original design assumption was that all stream flow up to the 90th percentile flow event would enter the sump.

In practise flow bypasses more frequently; however as can be seen in the water quality data presented prior this has not had a detrimental effect on downstream water quality since the flow that bypasses is treated by the CaO dosing plant. The main reason that flow bypasses the sump more often is that sludge levels in the sump have risen faster than was anticipated at the design phase.

To prevent overflow of sludge and maintain a target depth of 2m of clean water above sludge; BT tends to operate the sump with water levels at about an RL of 592.5 m.

The impact of this is that in rainfall events if the sump water level rises up to 593.5m RL; stream flow cannot enter due to the relative head.

Monitoring indicates the point that flow bypasses the sump is when the stream is at about the 70th percentile flow equivalent. Flow that bypasses the sump has been dosed with CaO hence pH adjustment has occurred. The water quality monitoring data presented in section 3.3 does not indicate any detrimental impacts on receiving water from this bypass.

5. Proposed Operating Regime

5.1 Mangatini Sump Project Summary

Since July 2016 the site has been investigating a wide suite of options to manage the accumulation of LDS in the Sump; with key objectives being to retain the good water quality outcomes being achieved with CaO dosing upstream and to also keep the Sump operational for the LOM and into the closure period.

The options tested can be grouped into the following categories:

- Disposal of LDS to land;
- Sludge consolidation/densification; and
- Disposal to catchment

In addition to the above a number of tests have been performed on sludge characteristics to try and better understand settlement behaviour and sludge characteristics.

Collectively the various tests and trials have been carried out as components of the “Mangatini Sump Project”. Results from this program of works have informed the proposed operating regime for the Sump going forward and relevant results are reproduced in the following sections. Elements of the program are still ongoing and will continue to inform how to optimise the Sump performance.

Based on the results of the Mangatini Sump Project the plan for sump operation going forward is summarised as:

- Continue and optimise dosing of the stream with CaO upstream of the Mangatini Sump;
- Diversion of the Mangatini Stream into the sump for flows up to the 70th percentile flow event and bypass the partially treated flow for greater flows;
- Discharge of LDS from the decant to the Mangatini Stream in high rainfall conditions and discharge of LDS by pump when stream flows are in the range of 70th to 80th flow percentiles. as per the control matrix described in section 6.3.2 ,
- Ongoing testing of options for sludge densification within the Sump.
- Ongoing testing of LDS disposal to filter beds.
- Geo-bag use for LDS disposal retained as a contingency measure.

The following sections provide more detail on the above.

5.2 Management Approach

5.2.1 CaO Dosing

Dosing the Mangatini Steam with CaO has proven benefits in achieving good water clarity outcomes for treated water, as well as the required pH adjustment.

As part of the Laboratory trials CRL has been undertaking for BT, both treatment efficiency and coagulant settlement rates have been tested.

In laboratory trials, between 70 – 85 % of CaO added for neutralisation reacted with the acidity in the AMD, precipitating out >97 % of dissolved Fe and Al and raising pH above 5. Field trials performed in low flow, fine weather conditions had greater uncertainty in efficiency estimates due to variation in stream flow, and was estimated between 65 – 95 %. These results indicate there is potential to further optimise the CaO dosing process to achieve better utilisation of CaO.

BT has elected to continue assessing how treatment efficiency can be improved.

5.2.2 Stream Diversion

While a higher portion of stream flow than anticipated during the Mangatini Sump design phase is bypassing the sump, there are no apparent negative impacts on downstream water quality. This is based on monitoring of pH, turbidity and aluminium as summarised in section 4.1.

BT intend to continue to bypass flow around the Sump for approximately 30 % of the time. This will allow the site to maintain the current practise of operating the sump at a water level of RL 592.5 m providing low turbidity, high pH water for 70% of the time.

At this operating level there is generally at least 2 m of clean water for the decant to draw from, providing a buffer to sludge release and capacity to treat inflow for the majority of the time.

5.2.3 Stream Discharge

The decant is used to enable discharge of the treated water to the Ngakawau River. LDS can also be released through this decant if it is lowered into the sludge layer. Over the last 12 months the Stockton Mine site has tested discharging LDS during heavy rainfall events.

The basis for testing this approach is that the LDS content is not toxic to aquatic biota when the pH remains above 4.8 at NR and metals remain below target levels. The key consideration with discharge of LDS is that it must occur when river flows are high else the discharge provides noticeable discolouration.

This option has been trialled 6 times from August 2017 to April 2018 with all discharges being subject to a number of controls (refer Appendix B). Current consent conditions have been met throughout the trials.

The results from these trials indicate that stream discharge is an effective method of removing LDS and increasing the available freeboard in the sump. Maintaining freeboard is important to provide storage capacity for LDS in low flow conditions when it is not appropriate to spill LDS.

Table 7 provides a summary of the trials completed and the volumes of LDS removed.

BT estimate that current rates of LDS accumulation in the Sump is in the order of 100,000 to 200,000 m³ per annum by volume (at a dry solids density of 2% wt- refer section 5.7.) On this basis regular stream discharge will allow the majority of LDS generated to be discharged.

Table 7 LDS Stream Discharge Trials

DD	Date start	Date End	LDS RL @ start	Decant intake RL @ end	Volume LDS slurry removed (m3)
1	15/08/2017	18/08/2017	590.7	589.0	73680
2	6/09/2017	11/09/2017	589.6	589.1	21475
3	14/09/2017	18/09/2017	589.3	589.1	8590
4	3/11/2107	7/11/2017	589.4	589.3	4295
5	10/01/2018	18/01/2018	590.0	589.6	17180
Total Slurry removed					125220

During all discharge events, the water quality in the Ngakawau River was monitored to ensure the LDS did not exacerbate clarity issues in the receiving environment.

The decant became fixed in the LDS during the trials and could not be lowered further limiting the depth of sludge removed. Improvements in decant operation will continue to be tested.

Stream discharge requires minimal time and equipment, and reduces the interaction between mine operators and the LDS. However, as the Ngakawau River must be in high flow for discharge to occur, this option is reliant upon high rainfall events.

BT Mining has developed a check sheet of controls and actions that must apply for a stream discharge of LDS to occur. This has been modified over the last 12 months using learnings from the recent trials. The check sheet is included in Appendix B for reference. BT intend to further develop this sheet into a Trigger Action Response Plan (TARP).

Allowable rates of LDS release have been refined over the year through development of a contaminant load model (CLM) which is described in section 5.3. The CLM has been calibrated based on trial data and will continue to be modified over time as more data becomes available. Likely it will be updated annually or as required

It should be noted that acid mine drainage has been entering the Ngakawau River and estuary for over 130 years and this acid mine drainage is naturally neutralised by dilution with Ngakawau River and estuarine water. Hence the system has been dealing with LDS precipitates from dilution neutralisation for 130 years. Currently approximately 7500 tonnes of acid a year is being treated in the Sump; and approximately 7000 tonnes of acid discharging from historic and current mining in the Millerton/Mine Creek, St Patricks catchment and bypassing the Sump is not currently treated or only partially treated .

BT estimates that the 7000 tonnes of untreated acid equates to about ~500,000 m³ a year of LDS entering the Ngakawau River.

5.3 Contaminant Load Model

O’Kane Consultants (NZ) Ltd (OKC) were retained by BT to develop a LDS discharge matrix. This matrix defines the rate LDS could potentially be discharged to Mangatini Stream via the Mangatini Sump Decant (MGD), without exceeding Aluminium and turbidity/TSS concentration constraints in the Ngakawau River (at water monitoring site NR).

LDS discharge rates were calculated from potential additional Aluminium and TSS loads that could be released, being the difference between maximum load (based on Aluminium and TSS constraints at NR) and estimates for background loads based on available water quality and flow rate monitoring data.

Two matrices were developed; one for Aluminium constrained LDS discharge and one for TSS constrained LDS discharge. These constraints are shown in Table 8 for different flow percentile bands.

Table 8 Maximum NR Aluminium and TSS concentration during LDS discharge

Flow percentile band (%)	Flow rates (m ³ /s)	Max Al limit at NR during LDS discharge (mg/L)	Max TSS limit at NR during LDS discharge (mg/L)	Equivalent turbidity estimate (NTU)
95+	105+	1.0	No limit	n/a
90 - 95	90 to 105	1.0	150	100
80 - 90	70 to 90	1.0	75	50
70 - 80	57 to 70	1.0	37.5	25
0 - 70	0 to 57	1.0	n/a (no LDS discharge – 25 NTU rolling median applies)	25

The final combined LDS discharge matrix (Table 9) simply selected the lowest (either Aluminium or TSS constrained) LDS decant flow rate for a given NR flow rate and MGD TSS/turbidity at the time of discharge.

This matrix has been developed as a guide for LDS discharge to minimise potential effects and requires ongoing operational refinement and assessment of the process.

Table 9 Combined Aluminium and TSS Constrained LDS discharge Matrix

MGD Turbidity (NTU)*				500	1250	2500	5000	10000	20000
MGD TSS (wt% solids)				0.1	0.25	0.5	1	2	4
Flow percentile (%ile)	NR Flow (m ³ /s)	NR TSS (mg/L)	NR Turb* (NTU)	Maximum LDS decant flow (L/s)					
95+	>105	unlimited	unlimited	**Max.	Max.	Max.	Max.	980	490
90 - 95	>57	150	100	Max.	Max.	1,100	550	270	130
80 - 90	>25	75	50	1,160	460	230	110	50	20
70 - 80	>15	37.5	25	210	80	40	20	10	-
0 - 70	n/a	n/a	25	-	-	-	-	-	-

* MGD turbidity and TSS data show a 1 NTU : 2 mg/L TSS correlation as opposed to the 1 NTU : 1.5 mg/L TSS correlation at NR.

** Max decant discharge rate applied is 1900 L/s.

BT are conducting ongoing LDS discharge trials when flow conditions are appropriate.

Most of these trials have resulted in Aluminium and TSS concentrations below the NR constraints (for Al and TSS) used to develop the LDS discharge model (Figure 18). There are two exceptions that have been attributed to elevated background Aluminium concentrations (1) and/or excessive LDS discharge flow rates (2) as shown below (red circles). These exceptions would not occur with the discharge matrix applied.

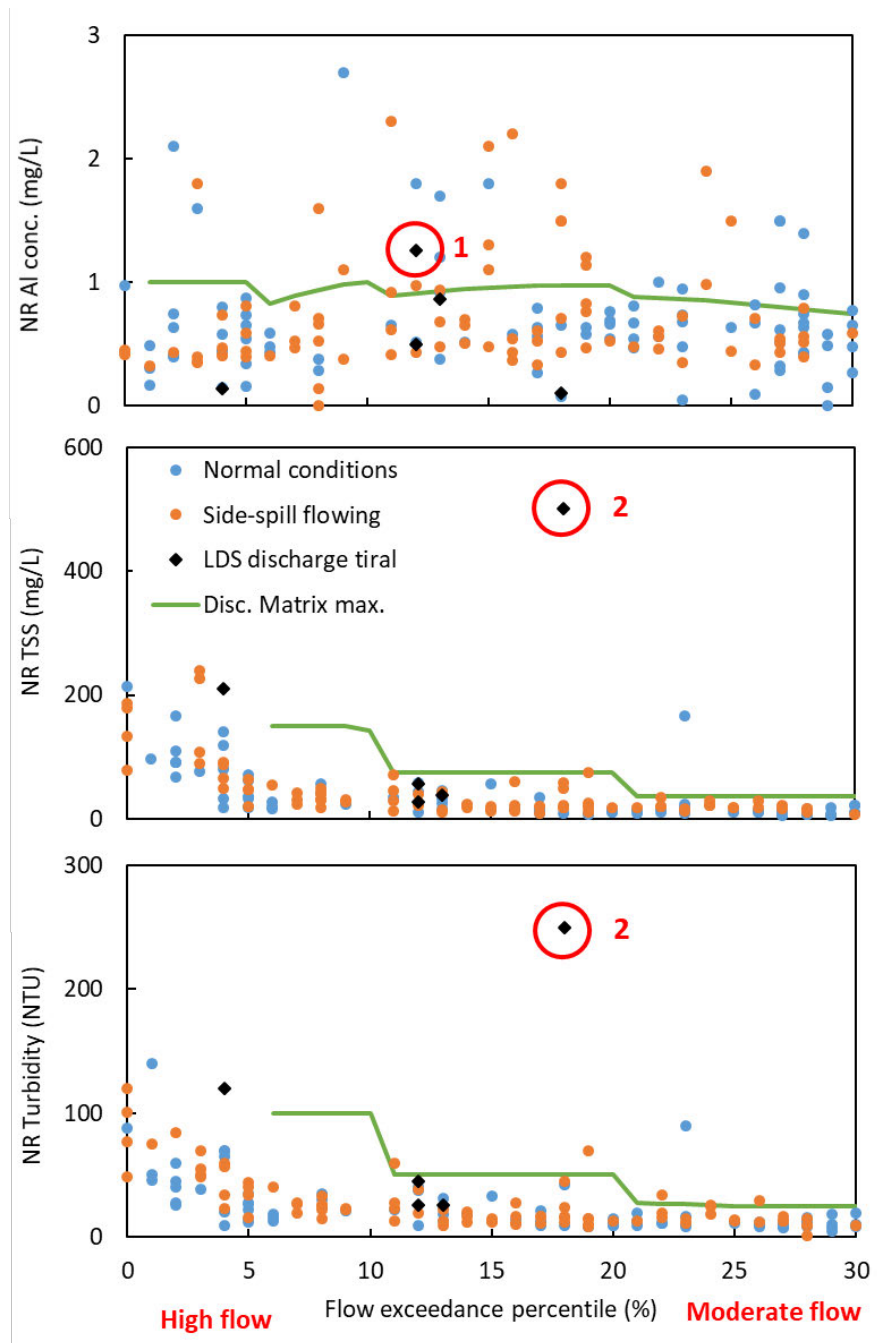


Figure 18 LDS Discharge Trial Water Quality at NR

There remains some risk of LDS discharge resulting in exceedance of NR concentration constraints, as has been observed in the field trial data. BT has indicated that these risks will be managed by:

- Limiting LDS discharge to relatively high NR flow conditions to maximise dilution;
- Limiting LDS discharge to when NR pH > 4.8 to minimise Aluminium remobilisation;
- Limiting the number of LDS discharge events per 30-day period, unless rolling median turbidity data indicate compliance is likely to be maintained; and
- Using 90th percentile background contaminant loads in matrix development.

Ongoing refinements to the LDS discharge matrix and operational procedures are likely to further reduce the risk of LDS discharge leading to elevated Aluminium and turbidity/TSS concentration at water monitoring location NR.

5.4 Sludge Densification

5.4.1 Overview

As shown in Figure 8; as a general trend there is increasing density in the sludge within the Sump as depth increases, however it is not linear. Facilitating an increased sludge density will increase the capacity and hence longevity of the Sump.

There are some unknowns around the behaviour of LDS, particularly whether it will eventually densify over time. BT, with assistance from CRL and OKC has undertaken a number of trials/tests relating to sludge generation, settlement and sludge characteristics. In addition site trials have been completed to test whether sludge recycle improves densification. The trials undertaken are summarised below and detailed in following sections:

- Column settling trials – Long term settlement testing of site AMD treated with UFL and CaO to test settlement rates over time. These tests also provided information on the treatment efficiency of reagents.
- Sludge recycle – on-site testing of the benefits of recycling treated water containing LDS back through the CaO dosing plant to assess whether there are benefits of increased sludge density and improved efficiency of the current treatment system. The basic premise of the tests is that recycled LDS particles will act as template particles on which further precipitation will occur.
- Dual dosing – Desk top study on the benefits of combining treatment of UFL with CaO.

The stream discharge option is based on LDS being low enough in density to facilitate release through the decant; and to retain mobilisation through the Mangatini Stream and out to sea. Densifying sludge in the upper levels of the sump where the decant operates must therefore be balanced with the need to retain LDS that can be discharged and will not impact downstream water quality.

5.4.2 Column Settling Tests

Column settling trials were undertaken to test:

- Relative sludge volumes generated by treatment with CaO, UFL and dual dosing treatments;
- Effect of aging on sludge density – i.e. how much denser does CaO generated sludge become over time compared to UFL generated sludge; and
- The efficiency and neutralising agent dissolution kinetics.

Settlement over time is important when considering the longevity of the sump.

Testing was undertaken initially by CRL at a beaker level and then in larger scale columns.

Testing shows a clear distinction in initial sludge volumes, where CaO sludge occupies more than four times the volume of UFL sludge after a 24 hour settling period with a greater than 50% difference in sludge density achieved with UFL dosing within a short period of time (<24hrs). After 3 months of settlement the sludge generated by CaO had reduced in volume by 30 %. This supports the densification behaviour observed within the sump, and continued monitoring of the column will observe further change.



Figure shows site AMD treated with UFL to the left and with CaO to the right

Figure 19 Cylinder settling trials

Testing also supports site experience that CaO is a more efficient dosing agent with treatment efficiencies of 71 – 86 % versus 29 – 59 % with UFL being achieved under laboratory conditions.

Testing is ongoing as BT optimises treatment processes.

5.4.3 Sludge Recycle

One trial has been completed on site where LDS was pumped back through the CaO dosing plant and discharged back to the Mangatini Stream. The trial was completed in March 2018 over a week of dry weather and the test results are still being compiled.

There is insufficient data available at this point in time to confirm whether sludge recycle should be adopted at full scale. BT propose to continue reviewing this option once all test data has been analysed and will then make a decision on whether to trial this further.

5.4.4 Dual Dosing

A desktop study was undertaken completed by OKC for BT looking at the potentially benefits in dual dosing the Mangatini Stream with both UFL and CaO. These benefits are associated with:

- Reduced treatment costs since UFL is cheaper than CaO; and
- Reduced sludge volumes and hence sludge management costs.

OKC completed a cost benefit analysis assuming that the primary objectives of dual reagent dosing would be:

- Neutralisation of AMD to pH 4.2 using lower cost UFL; and
- Transition (at pH ≥ 4.2) to neutralisation using CaO when UFL dissolution kinetics become less favourable.

A secondary objective was to consider the benefits of the UFL tendency to produce denser sludge, thus reducing overall sludge volumes reporting to the Mangatini Sump (or upstream sedimentation structures).

The study concluded that the proportion of acidity that could be managed efficiently by UFL is relatively minor at 35% of total acidity. This naturally limits the potential benefits of dual reagent dosing both from a reduction in reagent and sludge management opex perspective.

The analysis further concluded that:

- Water chemistry significantly influences the potential for dual reagent use as only 35% of the acidity load is < pH 4.2 due to significant Al acidity above pH 4.2;
- From a reagent opex perspective, dual reagent dosing is unlikely to be more cost effective than CaO only dosing and may be only marginally better than CaCO₃ only dosing; and
- From a sludge management opex perspective, dual reagent (or UFL only) dosing may be less costly than CaO only dosing, though this is very sensitive to sludge management costs (cost per m³ and total annual quantities) and UFL neutralisation efficiency.

Dual dosing was included in the laboratory column settling trials at CRL, where sludge from the dual dosing treatment had 15 % less volume than Calcuim Oxide treatment sludge after 24 hours of settling.

It was decided by BT to not progress this option at this stage.

5.5 Disposal to Land

5.5.1 Filter Beds

Filter beds have been trialled as an option for reduction of LDS volumes in the sump through land disposal. To trial this option, pilot scale filter beds were constructed on site, using reject material from the coal washing process re as the filter media. LDS was pumped up to the filter beds and sprayed over the filter surface. Figure 20 shows the LDS layer on the surface of the filter bed and a close up of the dried “cheesecake” like layer that formed.



Figure 20 Filter Bed Trials

The filter cake formed on the bed was dewatered to approximately 10 wt% solids, which is sufficient to enable removal and disposal. The trial results indicate that this option is effective in densifying the LDS, however there are unresolved issues relating to the clean water discharge and disposal of densified sludge from the filter beds.

During the trials, the discharge water quality from the filter beds was negatively affected by filtering through overburden material i.e. water quality monitoring indicated a low pH. This indicates that in order to retain the benefits of treatment; the filter bed discharge must be isolated from material that could result in contamination.

The disposal of the dewatered LDS (10 %wt solids) is also potentially problematic. Direct disposal to a waste dump would be the most efficient disposal option in terms of equipment and time. However, in the waste dump the LDS will be exposed to acidity from acid forming waste rock, which will potentially cause remobilisation of metal hydroxides (e.g. aluminium) present in the sludge. BT is currently testing the impact of LDS disposal with waste rock under laboratory conditions. If full containment of dewatered LDS is required the practicality of the filter beds becomes marginal due to the material handling involved.

Overall the current status with the filter bed option is that they show some merit as a means of LDS removal. On this basis BT intends to continue testing them as an option to operate in conjunction with stream disposal of LDS.

5.5.2 Geo-tube Bag Trials

BT has also trialled geo-tube technology as a means of disposing of LDS. A geo-tube bag is estimated to have capacity for approximately 300 to 550 m³ of sludge once dewatered. The trial undertaken by BT has involved pumping LDS up to a polymer dosing plant, and then injecting the polymer dosed LDS to a geo-tube bag. Over time the LDS dewateres and repeat applications can be made. The LDS needs to be dosed with polymer else it will discharge directly back out of the bags.

Though trial and error BT has now successfully filled a bag and achieved very good water quality outcomes in the water discharged from the geo-tubes (see Figure 21). Successful completion of the trials was achieved after making multiple adjustments to the system, particularly to polymer dose rates. While the trials have been successful many bags would be needed to keep pace with the volume of LDS generated (30 to 50 per year) and this is not practicable given the areas needed for bags to operate and the costs. The bags must also be disposed of and BT are still testing whether containment cells would be needed to prevent remobilisation of metals in the sludge through contact with AMD in waste rock dumps.

BT plan to retain geo-tube bags as a contingency disposal method if either filter beds are not workable and/or sustained low flow conditions limit the opportunity to dispose LDS by stream discharge.



Figure 21 Geotube Bag Trials

5.6 Operating Regime

The management approach applied by BT on a daily basis is subject to a number of conditions including stream flows, predicted weather conditions and sludge levels. The general approach outlined in section 5.1 applies; however daily review of actions by the site team is implemented as an additional control.

Table 10 summarises the flow conditions and associated actions that will be considered at differing flow rates.

Note that as per the check sheet provided as Appendix B there are a number of actions and checks that precede a stream discharge including review of the weather forecast, sump drawdown and blockage of the sump inlet.

Table 10 Mangatini Sump Operating Regime Summary

Flow Conditions at NR by Percentile %	Mangatini Stream diversion to Sump	LDS to Stream Discharge	Other LDS Management Methods
0 to 70%	Yes – all flow	No	¹ Potential disposal to land if freeboard is at risk/In sump densification
70% to 80%	Bypass partial	Yes	
80% to 90%	Bypass	Yes	² NA –
90% to 100%	Bypass	Yes	

1. Note Disposal to land and in sump densification options are still subject to further work

2. Not practicable to remove LDS from sump in high flows, LDS discharge to stream and via bypass in these conditions.

Figure 22 illustrates how this regime is applied through the differing levels of the sump. In essence there are four levels summarised as follows:

- Level 1 - Treated clean water above LDS, discharged by decant.
- Level 2 – LDS layer (RL 591m to 588m), density generally less than 2 wt%, discharge to stream in high flow conditions
- Level 3- LDS layer subject to ongoing consolidation. Ongoing assessment of opportunity to consolidate and potential draw-off for land disposal.
- Level 4- HDS – remains in sump

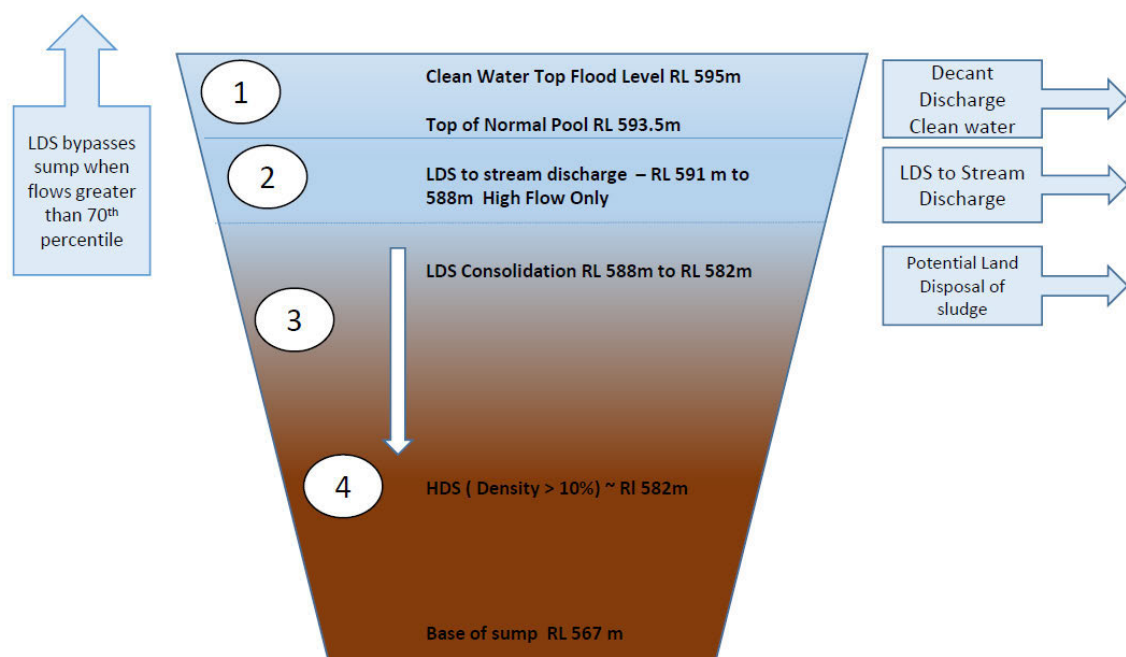


Figure 22 Mangatini Sump Operating Regime

5.7 Sump Capacity

The Mangatini Sump project was initiated due to concerns that sludge levels were rising much faster than originally predicted.

The early years of the Mangatini catchment development were characterised by the rapid formation of significant overburden dumps contributing large volumes of sediment to the Sump. UFL treatment was in the order of 40% effective and as such the unreacted UFL accumulated in the sump. Another factor contributing to sludge levels rising faster than expected include the settlement behaviour of metal hydroxides not being included in original design estimates for storage (refer section 2.1). Since December 2014 when the reagent changed from UFL to CaO the key issue has been accumulation of a lower density sludge than that generated with UFL.

Over the last 12 month sludge levels appear to have stabilised due to stream discharge of LDS.

Understanding the volumes of LDS likely to be generated over time and comparing this to potential volumes removed by stream discharge and retained within the Sump is important to estimating Sump longevity.

OKC has prepared an estimate of LDS generation rates for BT (April 2018). LDS generation rates were estimated based on MGIU iron (Fe) loads, which were used to derive the amount of LDS based on the known ratio of Fe: LDS.

OKC has estimated the LDS volume accumulating in the Sump (Figure 23) using solids contents of between 2 and 8 wt%.

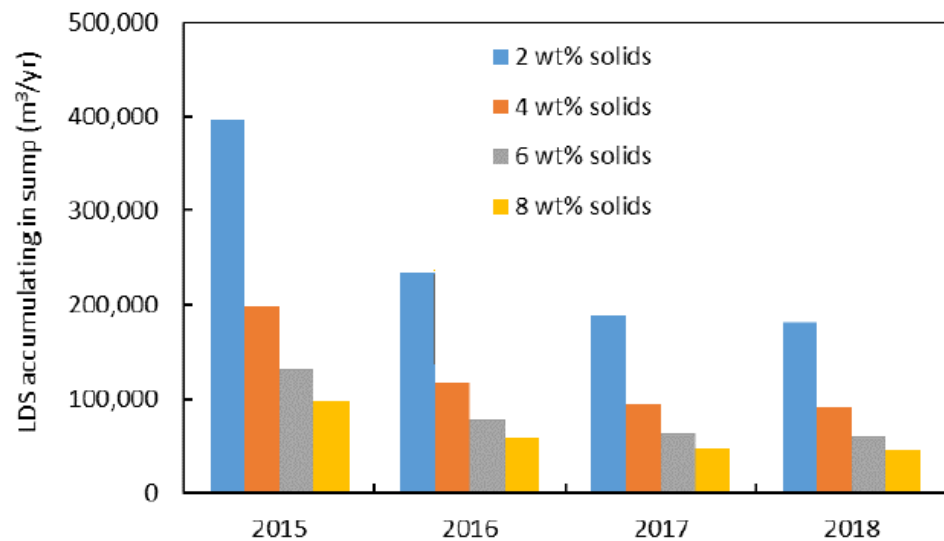


Figure 23 Estimate of LDS accumulating in the Sump

Sludge profiling work by CRL has shown that LDS solids content typically varies between 2 and 4 wt% in the upper LDS zone (refer section 2.4.3). This range of solids content corresponds to accumulation of 100,000 to 200,000 m³/yr of LDS in the Sump per year for 2017.

This equates well with the LDS stream discharge trials which indicate that in the order of 125,000 m³ of LDS has been discharged to stream, and the net effect of this discharge is that the sludge top level has been maintained at a constant level.

MGIU acidity load data was also reviewed by OKC. These data indicate that 2015 MGIU acidity load was ~10,000 t/yr. This is significantly higher than the 2016 and 2017 acidity loads which were 7,083 and 5,328 t/yr, respectively. The difference is potentially due to mining of Millerton high PAF rock which was disposed in the Mangatini catchment in 2013/14. The significantly higher LDS accumulation derived for 2015 may therefore be representative but the limited 2015 MGIU Fe load dataset reduces confidence in this estimate.

The contribution of Aluminium, TSS, and other constituents to LDS accumulation has been incorporated into this analysis indirectly by using the ratio of Fe to LDS. Total digest of LDS indicated an average of 8.8 wt% Fe content. The remaining 91.2% non-Fe material in those LDS samples are attributable to Aluminium, TSS, and other constituents (including Fe/Al associated oxyhydroxide groups, etc.).

This analysis does not include bed load or saltation sediments accumulating in the Mangatini Sump. However, it is possible these relatively dense particles would settle through the LDS layer and accumulate in underlying higher density zones.

Based on this assessment the sump is expected to provide settlement capability through the LOM and beyond if discharge of LDS to the stream continues in high flow events as has been trialled.

As the understanding of LDS behaviour is further developed the estimates of sludge accumulation in the sump will be refined. In particular the “net gain” future value can be better estimated once there is better understanding of whether LDS does eventually densify and/or if a means is confirmed (e.g. LDS recycle) to accelerate this.

5.8 Operations and Maintenance

BT has an operations and maintenance manual for the Sump that details the key activities and associated frequency of the activities required to maintain Sump performance. The manual is reviewed annually and adjusted based on learnings over the year and to recognise any changes made to the Sump operation to improve performance.

The use of the manual is to:

- Concisely record and communicate the relevant details of the design, construction and operation of the Sump structure.
- Assist in the training of personnel involved the Sumps s ongoing operation and monitoring.
- Act as a reference document to assist in the ongoing performance monitoring of the Sump and regular checking of the performance against the design assumptions.

There are four main areas that need to be managed correctly to ensure the ongoing successful operation of the sump, namely:

- The decant and outlet tunnel
- The intake.
- The catchment reporting to the reservoir; and
- Embankment and dam wall monitoring.

Key activities associated with these are tabled below and a full summary of activities is included as Appendix E.

Table 11 Operation and Maintenance Activity Summary

Area	Primary Activities	Frequency
Decant and outlet tunnel	Regular inspection	Quarterly
Intake	Sediment clean-out	As required – planned to be undertaken following a decant discharge when water levels in the sump are low
Catchment	Rehabilitation as soon practicable once mining complete	Ongoing
Embankment and wall monitoring	Regular inspection	Quarterly

5.8.1 Sediment clean-out of Intake

There is an ongoing build-up of sediment at the Sump inlet both within the inlet channel and in the entry to the Sump. In order to maintain operation BT will need to clean-out the channel and entry area from time to time. Where practicable BT will remove accumulated sediment

that is not in contact with flowing water with an excavator and in low flow conditions to prevent release of sediment downstream.

It is proposed to undertake this clean out following a decant discharge when water levels in the sump are as low as possible. This will remove the need to divert the flow over the inlet spill weir during low flow conditions (trialling this mid April).

If maintenance works are required during flow rates that may cause the consent conditions to be breached, the WCRC will be consulted.

5.9 Monitoring

5.9.1 Water Quality

Water quality monitoring as listed in Table 6 will continue. In addition BT will carry out additional water quality monitoring whenever an LDS discharge is made to the stream in line with the checklist included as Appendix B

BT also proposes that weekly water samples collected at Site NR will be analysed to provide the baseline acidity at NR to compare against pH. In addition, Lewis acidities at Site NR will be derived from daily pH and dissolved Aluminium results. This will allow the daily acidity baseline at Site NR to be compared against LDS discharge periods. Acidity measurements are more stable than pH readings and hence are more reliable to assess water chemistry impacts on aquatic life.

5.9.2 Compliance Reporting

BT are required to provide an Annual Monitoring report to WCRC for the mine site as a whole. This report compares monitoring data to consent conditions at all relevant sites.

It is intended that this reporting will continue and in addition BT will continue to advise WCRC before any stream discharges occur as per the LDS discharge check sheet.

5.9.3 Fish Surveys

Fish surveys are planned to be carried out annually which is more frequent than required by the new consent condition 6A (every 6 years). Please refer to section 6.2 for detail.

5.9.4 Sonar survey

BT currently undertakes sonar surveys bi-annually and the intent is to continue with this frequency. These surveys are important to monitor whether sludge levels are changing.

5.9.5 CLM Calibration

BT intend that the CLM will be calibrated on an annual basis for the next 2 years. Calibration will consist of review of water quality and flow data for all stream discharges and associated decant discharge rates. The matrix developed by OKC will be checked and adjusted as required.

6. Resource Consents

6.1 Current Consent Conditions

The WCRC advised Solid Energy in May 2017 of its intention to review resource consent conditions relating to RC06206. The letter invited the company to propose amendments or new consent conditions.

Because Solid Energy had a number of trials underway at that time associated with improving sump management, and a changed operating regime might require consent revisions or additions; WCRC subsequently agreed that Solid Energy (and now BT) could continue sump operation under existing consent conditions 21 and 22 until June 2018. The intent was that BT would then report on trial outcomes and at the same time respond to the consent review request.

A variation to consent condition 6 which relates to fish surveys was requested to be actioned immediately and this is now in place (refer section 6.2 for detail).

The key matters remaining to be addressed in the consent review included:

- That the 30-day rolling median condition for pH is too lenient.
- That upstream and downstream monitoring points are needed.
- That telemetry be adopted for continuous monitoring at such sites.
- That conditions 21 and 22 be revised to provide a higher pH minimum (pH 4.2) and to limit turbidity increases to a percentage of the period of base flow.

These items are covered in following sections.

Of note Solid Energy and subsequently BT committed to delivery of a Management Plan (this document) for the Mangatini Sump as part of the response to a consents review.

As outlined in section 5.0 there are still a number of studies underway that will continue to inform how to optimise the operating regime for the Sump.

Having a Management Plan linked to consent compliance provides a means to incorporate an adaptive management approach, whereby amendments to the operating regime management can be incorporated into updates.

6.2 Amendments in Relation to Fish Surveys - Condition 6

Following a review of the consent conditions of RC60206 in June 2017 Solid Energy proposed to add a new condition 6A requiring fish surveys to be carried out at six sites in the upper Ngakawau River and to monitor those sites six-yearly in future. The view of ecologists is that annual surveys are unlikely to add any value due to the seasonal variability in fish migration. A better test is to assess the range of ages in the 6 yearly-survey (assessing the success of juveniles returning).

The purpose of the monitoring is to establish whether water quality in the Ngakawau River is such that a normal age distribution of native fish species is being developed and maintained (and thus demonstrating that the discharge from Stockton Mine allowed by RC06206 is having no significant adverse effect on aquatic life).

The following consent condition was proposed and has now been adopted:

Single pass electric fish surveys by experienced freshwater ecologists are undertaken at 6 sites [REDACTED] confluence in 2017 and every 6 years following at the sites noted on Figure 1 and as listed below:

- [REDACTED]

The first survey is to be undertaken in between 1st October and 31st December 2017. Fish species, density and fork length information will be recorded and compared in a report with the 2005 and 2011 results to update records and assess for any change in juvenile migratory native fish species and/or abundance.

This report will be supplied to WCRC within 3 months of the survey being undertaken.



Figure 24 Fish Survey Site Location Plan

To tie in with the previous surveys it was proposed that the first survey be undertaken in November 2017 and data from this completed survey is reported previously in section 4.2.

Due to inconclusive results of the Nov 2017 fish survey BT are proposing a repeat survey in Nov 2018 and this will include [REDACTED] and will also place fish traps to confirm/quantify juvenile fish recruitment

6.3 Proposed Amendments in Relation to pH and Turbidity, Conditions 21, 22

6.3.1 Approach

In their letter of May 2017, WCRC raised concern that a rolling median over 30 days allows for one off or repeated drops in pH below 4.0 hence conditions 21 and 22 are too lenient. Further the letter requested that a condition relating turbidity to flow conditions be considered (e.g. for NR – *“Turbidity not to be increased by more than 60 NTU for more than 20% of the time of the base flow period ($< 0.6 \text{ m}^3/\text{s}$)”*)

The improved quality of the water discharging from the Mangatini Sump has contributed to a long term improvement in Ngakawau River acidity and pH levels, under the current resource consent conditions. Discharge of LDS does not impact pH and is more likely to be contributing alkalinity. However LDS discharge does have the potential to impact turbidity and clarity and hence needs to be limited to conditions when stream and river flows are high. It is appropriate to apply specific conditions relating to the times when an LDS discharge is occurring. Going forward BT propose that:

- **The existing conditions 21 and 22 relating to both pH and turbidity be retained.** The current consent conditions for turbidity in the Ngakawau River were based on the paper by Richardson et al. (2001). The paper identifies that the [REDACTED] more sensitive to turbidity than other species of native fish and avoids turbidity levels greater than 25 NTU. The paper concluded that achieving turbidity levels of less than 25 NTU in the migration season helps to maintain upstream migrations and populations of [REDACTED] and therefore other native fish. The rolling 30 day 25 NTU consent condition was developed on the basis of the above research and adopted by WCRC and Solid Energy. There has been no subsequent research that supports a move away from this condition.
- **Consent conditions will be augmented with this Management Plan** for the Mangatini Sump. The Management Plan will be updated every 2 years to take account of ongoing refinements and any changes to the LOM. Linking the Management Plan to resource consent conditions provides for an adaptive management approach.
- **New conditions for turbidity** will be applied when an LDS discharge is occurring. These conditions are proposed to be based on the CLM model developed by OKC and are summarised in the following section.

6.3.2 LDS Discharge Specific consent conditions

The following limits for turbidity linked to river flow conditions are proposed when LDS discharge occurs. These values are proposed as an average over an 8 hour period due to the time lag between the Mangatini Stream and the Ngakawau River. It is difficult to exactly match decant discharge rates with flow rates at NR. These values are based on the matrix developed by OKC for BT and presented in section 5.3

Table 12 Average 8 hour NR Turbidity During LDS discharge

Flow percentile band (%)	Max Turbidity limit at NR during LDS Discharge (NTU)
95+	n/a
90 - 95	100
80 - 90	50
70 - 80	25
0 - 70	n/a (no LDS discharge – 25 NTU rolling median applies)

The approach BT has taken to developing an operating regime for discharge of LDS from the Mangatini Sump follows an Adaptive Management approach whereby procedures established in the check sheet (Appendix B) and the controls encompassed in the discharge matrix (Table 12) will be reviewed and improved on an ongoing basis.

6.4 Continuous Monitoring

WCRC has suggested the use of continuous readings for compliance monitoring for turbidity. Daily sample test results are nationally considered more reliable and repeatable than sensor data which is the process adopted by BT.

With sensor data there is the problem around fouling and the uncontrolled, unobserved, environment in which monitoring is undertaken (e.g. was a leaf wrapped round sensor during high flow event that caused several hours of high NTU readings, which could be mistaken for the actual turbidity reading).

BT propose that the continuous monitoring of turbidity continues as an internal check with compliance based on daily samples measured at the lab.

6.5 Upstream and Downstream Monitoring

WCRC has requested upstream and downstream telemetered monitoring points in the Ngakawau River. BT has telemetered monitoring in place downstream at site NR already.

Previous mine owner Solid Energy has in the past tried a number of upstream installations at site NAM (just upstream of the bridge at Mangatini Falls) but has been unsuccessful as meters have been washed away or damaged in floods.

BT does not support upstream monitoring because of the difficulties in maintaining equipment.

7. References

Effects of turbidity on the [REDACTED] in a natural stream, New Zealand Journal of Marine and Freshwater Research, 35(1):191-196, March 2001.

Mangatini Sump Modelling of Water Quality Performance, MWH 2007

Mangatini Sump Assessment of Environmental Effects (AEE) prepared by Solid Energy NZ Limited, 2007.

1103-1-5 Estimate of LDS accumulation in Mangatini Sump, Memorandum from OKC to BT, April 2018

Appendices

Appendix A – Resource Consent Conditions



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 The West Coast, New Zealand
 Telephone (03) 768 0466
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RESOURCE CONSENT

Pursuant to Part VI of the Resource Management Act 1991 The West Coast Regional Council hereby grants to:

SOLID ENERGY NEW ZEALAND LIMITED
PO BOX 1303
CHRISTCHURCH 8140

A Resource Consent for the term and upon the conditions hereinafter set forth:

FILE No.: RC06206
RESOURCE CONSENT No.: RC06206/1, RC06206/2, RC06206/3 & RC06206/4
DATE OF ISSUE: 25 January 2007
VARIATIONS: Variation 1: 3 March 2008 - Map Reference & Condition 3
 Variation 2: 18 March 2008 - Conditions 7, 21 & 22
 Variation 3: 1 July 2013 - Conditions 1 & 7
 Variation 4: 5 June 2015; Conditions 1 & 17
 Variation 5: Conditions 1 & 13
 Variation 6: Conditions 1 & 6A
TERM: 21 years from date of issue
LOCATION: Stockton
MAP REFERENCE: At or about NZMS 260 L29: 159 – 492 (discharges 1 and 2), 157 – 491 (discharge 3) and 159 – 492 (discharge 4).

RESOURCE CONSENTS:

<u>RESOURCE CONSENT NO.</u>	<u>TYPE OF RESOURCE CONSENT</u>	
RC06206/1	Discharge Permit	To discharge minewater containing contaminants to the Mangatini Stream via a spillway channel and stormwater sump.
RC06206/2	Discharge Permit	To discharge stormwater containing contaminants to the Mangatini Stream.
RC06206/3	Discharge Permit	To discharge limestone for water treatment purposes to the Mangatini Stream.
RC06206/4	Discharge Permit	To discharge treated water from a water treatment plant to the Mangatini Stream.

CONSENT CONDITIONS

Pursuant to section 108 of the Resource Management Act 1991 the resource consents include the following conditions:

1. The discharges shall be carried out in general accordance with the details contained in the consent application and the applications for change or cancellation of consent conditions dated 18/1/2007, 30/11/2007, 10/5/2013, 20/05/2015, 26/08/15 and 20/07/17) submitted to the Consent Authority, except where inconsistent with these conditions. Any change or cancellation must be made in accordance with section 127 of the Resource Management Act 1991.
2. The Consent Holder shall supply any agent or contractor working under these consents with a copy of the consents.
3. The Consent Holder shall only discharge at the three locations labelled as 'Discharge 1', 'Discharge 2' and 'Discharge 4' on the attached aerial map entitled "**Annexure 1: RC06206v – Solid Energy NZ (Ltd) - Location of the four discharge points and the monitoring locations (S14b and NR)**", and at the location labelled "**Proposed Lime Dosing Location**" on the attached aerial map supplied with the application and entitled "**Figure 10: Layout of Mangatini sump and diversion**"; unless otherwise approved in writing by the Consent Authority.

• *Advice Note: This condition allows for **minor** changes to the discharge locations.*

4. Pursuant to section 128 of the Resource Management Act 1991, the Consent Authority may review the conditions of these consents by serving notice within a period of one month following every anniversary of the date of issue of the consents, for the following purposes:
 - a) To change the standards imposed by the conditions of the consents or to impose additional conditions in relation to standards or monitoring in order to avoid, remedy or mitigate and adverse effects on the environment which may arise from the exercise of the consents, and which it is appropriate to deal with at a later stage.
 - b) To change the standards imposed by conditions of the consents to standards that are consistent with any relevant Regional Plan, District Plan or Act of Parliament.
 - c) To require the Consent Holder to adopt the best practicable option to remove or reduce any adverse effect on the environment.
 - d) To assess the appropriateness of imposed compliance standards, monitoring regimes and monitoring frequencies and to alter these accordingly.

5. The Consent Holder shall pay to the Consent Authority such annual administration, supervision and monitoring fees as are fixed from time to time by the Consent Authority in accordance with section 36 of the Resource Management Act 1991.

CONSENT CONDITIONS FOR RC06206/1 and 2 (Mine water and stormwater discharges into the Mangatini Stream)

6. The discharge shall not give rise to the following effects at or beyond 200 metres downstream of the discharge point:
 - a) Any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
 - b) Any visual sedimentation on the bed of the Mangatini Stream;
 - c) Any conspicuous change in the colour or visual clarity;
 - d) Any emission of objectionable odour; and
 - e) Any significant adverse effects on aquatic life.

- 6A. Single pass electric fish surveys by a suitability qualified freshwater ecologist are to be undertaken at 6 sites upstream of the Ngakawau River-St Patricks stream confluence in 2017 and at no more than 6 yearly intervals following at the sites noted on Figure 1 in the AEE within the application (received 20/07/2017) and listed below:

- Ngakawau (above St Pat);
- McHugh St G tributary;
- St George;
- Blackburn;
- Budge; and
- Upper Ngakawau.

The initial survey is to be undertaken between 1 October and 31 December 2017. The survey shall include fish species, density and fork length information will be recorded and compared in a report with the 2005 and 2011 results to update records and assess for any change in juvenile migratory native fish species and/or abundance.

The results together with its interpretation shall be supplied to the Consent Authority within 3 months of the survey being undertaken.

CONSENT CONDITIONS FOR RC06206/3 (Alkalinity dosing discharge)

7. Alkaline dosing agents to be discharged to the Mangatini Stream must be approved by the West Coast Regional Council. Where ultrafine limestone is used the following specifications shall be met 90% of the time:
- a) Calcium carbonate content (dry weight) $\geq$ 85%; and
 - b) Particle size $<$ 100 μ m.
8. The Consent Holder shall provide to the Consent Authority as part of the annual work plan required by Coal Mining Licence 37 – 150:
- a) Verification (test results) that Condition 7 is being complied with; and
 - b) An assessment of any adverse effects associated with the ultra fine limestone quality that is outside of the specifications specified in Condition 7a) and 7b).
9. The discharge rate of ultrafine limestone shall not exceed 4 tonnes per hour, unless otherwise approved in writing by the Consent Authority.

- *Advice Note: This condition allows for **minor** changes to the dosing rate.*

CONSENT CONDITIONS FOR RC06206/4

10. The discharge rate from the water treatment plant into the Mangatini Stream shall not exceed 400 litres per second.
11. The Consent Holder may use flocculant(s) or water treatment chemical(s) for water treatment purposes provided that they are used in accordance with the manufacturer's specifications.
12. The Consent Holder shall notify the Consent Authority at least 5 working days in writing prior to using:
- a) The flocculant(s) or water treatment chemical(s) it initially proposes to use for water treatment; and
 - b) Any 'new' flocculant(s) or water treatment chemical(s) it proposes to use for water treatment that were not identified pursuant to Condition 12(a).

DISCHARGE MONITORING CONSENT CONDITIONS AT THE MANGATINI STREAM FOR RC06206/3 and 4

13. The Consent Holder shall undertake daily monitoring for the discharge from the limestone dosing plant and the water treatment plant into the Mangatini Stream, located downstream of the discharge, at the monitoring location labelled as 'S14b', as indicated on the attached aerial map entitled: "**Annexure 1: RC06206 – Solid Energy NZ (Ltd) - Location of the four discharge points and the monitoring locations (S14b and NR)**", for the following parameters:
 - a) Turbidity measured in Nephelometric Turbidity Units (NTU);
 - b) Total suspended solids;
 - c) Conductivity;
 - d) Temperature;
 - e) pH;
 - f) Hardness; and
 - g) The flow rate of the Mangatini Stream at S14b when samples are collected.
14. The Consent Holder shall undertake at least one macroinvertebrate ecology survey, each year for the duration of the Consent (during the months **October – February** inclusive), at the sampling location labelled **S14b**, as indicated on the attached aerial map entitled: "**Annexure 1: RC06206 – Solid Energy NZ (Ltd) - Location of the four proposed discharge points and the monitoring locations (S14b and NR)**".
15. The Consent Holder shall undertake a macroinvertebrate ecology baseline survey carried out prior to ultra fine limestone dosing in the Mangatini Stream (Site S14b). This survey shall be undertaken during the months of **October – February** inclusive.
16. Each macroinvertebrate ecology survey shall be undertaken at base-flow conditions, using no fewer than five replicates per sampling occasion, and the samples shall be analysed by an aquatic ecologist experienced in macroinvertebrate sampling and identification.

DISCHARGE MONITORING CONSENT CONDITIONS AT THE LOWER NGAKAWAU RIVER FOR RC06206/3 and 4

17. The Consent Holder shall undertake daily monitoring (Monday to Friday excluding public holidays) and randomly on three separate days during a calendar year on either Saturday, Sunday or a public holiday as chosen by the Consent Authority and notified to the Consent Holder not less than 5 days prior to the day of monitoring of the Lower Ngakawau River, at the monitoring location labelled as 'NR', as indicated on the attached aerial map entitled: "**Annexure 1: RC06206 – Solid Energy NZ (Ltd) - Location of the four proposed discharge points and the monitoring locations (S14b and NR)**", for the following parameters:
 - a) Turbidity;
 - b) pH;
 - c) Daily flow rate of the Ngakawau River when samples are collected.

The Consent Holder shall undertake monthly monitoring for hardness of the Lower Ngakawau River, at the monitoring location labelled as 'NR', as indicated on the attached aerial map entitled: "**Annexure 1: RC06206- Solid Energy NZ (Ltd) – Location of the four proposed discharge points and the monitoring locations (S14b and NR)**" unless the pH increases to greater than 7.5 in which case hardness will be measured and reported for four consecutive days. Once the 4-day rolling mean hardness is below 500mg/L then hardness sampling will revert to monthly.

18. The Consent Holder shall undertake at least one macroinvertebrate ecology survey, using artificial substrates for the collection of macroinvertebrates, each year for the duration of the

Consent (during the months **October – February** inclusive), at the sampling location labelled '**NR**' as indicated on the attached aerial map entitled: "**Annexure 1: RC06206 – Solid Energy NZ (Ltd) - Location of the four proposed discharge points and the monitoring locations (S14b and NR)**".

19. Each macroinvertebrate ecology survey shall use no fewer than five replicates per sampling occasion. Each artificial substrate sampler shall be deployed for a minimum of four weeks (during the months **October – February** inclusive) and the macroinvertebrate samples shall be analysed by an aquatic ecologist experienced in macroinvertebrate sampling and identification.
20. The Consent Holder shall undertake a baseline macroinvertebrate ecology survey (**sampling location NR**) prior to the ultra fine limestone dosing discharge in the Mangatini Stream.

Discharge Compliance Limits – Mangatini Stream, monitoring location 'S14b'.

21. The 30-day rolling median pH in the Mangatini Stream based on daily sampling shall not fall below 4.0 as a result of the discharge.

Compliance with Condition 21 is to be achieved no later than 1 month after the Lime Dosing Plant is commissioned and tested.

Discharge Compliance Limits — Lower Ngakawau River, monitoring location 'NR'.

22. The Consent Holder shall comply with the flowing parameter set below:
 - a) The acidity of the Lower Ngakawau River is not to fall below pH 4.0; and
 - b) The 30-day rolling median turbidity based on daily sampling is not to exceed 25 NTU as a result of the discharge.

REPORTING OF RESULTS

23. The results of the monitoring shall be forwarded to the Consent Authority monthly within 12 working days from the end of each month.
24. Notwithstanding Condition 23, the Consent Holder shall notify the Consent Authority within 48 hours of receiving any water monitoring results that exceed the discharge compliance limits specified in Conditions 6, 21 and 22, and of the actions taken by the Consent Holder to reduce the contaminant levels in the discharge.
25. All discharge, water quality monitoring results and, the ultra fine limestone quality details as required under Condition 8, shall be included in the annual work plan required by the Coal Mining Licence 37-150, and/or provided to the Consent Authority upon written request.

NOTE TO THE CONSENTS

The Consent Holder is advised that **the consents do not confer a right of access** to the proposed sites for the laying of a pipeline to carry minewater and for the installation of power poles to carry electricity to the pumps west of the "Department of Conservation triangle" and that this will require permission of the Department.



CONSENTS & COMPLIANCE MANAGER

Appendix B – Stream Discharge Check Sheet

CHECK SHEET FOR LDS DISCHARGE - DECANT
Mangatini Sump Project

Trial Reference	
Date	

Stage 1 – Pre LDS discharge					
Task	Task by	Initial	Date & Time	To Record	
Initiate LDS Decant Discharge Procedure after the identification of a significant period of rainfall.				<i>Estimated period of forecast event and rainfall depths:</i>	
Information to be collated prior to trial start				<i>Estimated clean water volume in sump (m³)</i>	
				<i>Estimated time to reach LDS layer (hrs)</i>	
				<i>Estimated LDS level RL (m)</i>	
				<i>Estimated peak flow for flow event at S14B</i>	
				<i>Estimated duration of event (hrs)</i>	
				<i>Target LDS Discharge Rate (l/s)</i>	
				<i>Target LDS Discharge Duration (hrs)</i>	
Management approval to proceed				<i>Approval by email to proceed from:</i>	
Advise of trial as a minimum to WCRC, Site Environmental Manager, Mine Manager				<i>List who emails sent to:</i>	
CHECK 1 - Check Stage at S14B prior to closure of inlet. A minimum stage of 9.3 m (30 th percentile) is required for blocking of inlet culvert				<i>Stage height at S14B and note if sump is already overflowing:</i>	

CHECK SHEET FOR LDS DISCHARGE - DECANT
Mangatini Sump Project

Trial Reference	
Date	

Task	Task by	Initial	Date & Time	To Record
Close the Mangatini sump inlet following the steps outlined in JHA				
Commence decanting of clean water withholding a 0.2 m layer				<i>Note start and stop times to dewater:</i>
CHECK 2 - Check stage at S14B has reached 9.39 m (70 th percentile)				
Commence discharge of LDS as per table 2 included in the LDS Decant Discharge Procedure				<i>Note rate of discharge:</i>

Stage 2 – During LDS Discharge				
Task	Task by	Initial	Date & Time	To Record
Obtain samples during LDS discharge				A minimum of 1 sample per day capturing LDS at each of the sites outlined in the LDS Decant Discharge Procedure
CHECK 3 - Check stage or flow at MGD, S14B and NR throughout discharge				<i>Reduce / cease discharge if flow and / or stage exceeds triggers in Table 2 of LDS Decant Discharge Procedure</i>
CHECK 4 - Check pH readings at MGD, S14, S14B and NR				<i>Cease discharge if pH exceeds triggers in Table 3 of LDS Decant Discharge Procedure</i>
CHECK 5 - Check turbidity readings at MGD, S14B and NR				<i>Reduce / cease discharge if turbidity exceeds triggers in Table 3 of LDS Decant Discharge Procedure</i>
Stop LDS discharge				<i>Time discharge stops:</i>

CHECK SHEET FOR LDS DISCHARGE - DECANT
Mangatini Sump Project

Trial Reference	
Date	

Stage 3 – Post LDS Discharge				
Task	Task by	Initial	Date & Time	To Record
Record sump water level				
Close sump decants				
Remove barrier at Mangatini Sump inlet culvert				
Monitor telemetry for 24 hours post discharge				
Obtain 3 days of samples as per standard daily water run (Monday –Friday)				
Record above information and sampling results in the LDS discharge spreadsheet				
Undertake sonar survey of sump to determine new LDS layer				
Report trial results to WCRC and mine management team				Email report issued to:

Notes:

Appendix C OKC Discharge Matrix Report

Stockton Coal Mine Low Density Sediments Discharge Matrix

21 May 2018



BATHURST
RESOURCES LIMITED



*Integrated Mine Waste Management and Closure Services
Specialists in Geochemistry and Unsaturated Zone Hydrology*

Stockton Coal Mine Low Density Sediments Discharge Matrix

1103-1-4

21 May 2018

Prepared for:

Bathurst Resources (NZ) Limited

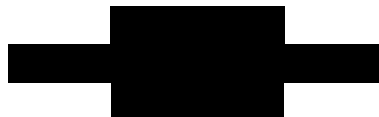
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Civil / Environmental Engineer



O'Kane Consultants (NZ) Ltd



Rev. #	Rev. Date	Author	Reviewer	PM Sign-off
Rev0	10-4-18	Will Olds	Paul Weber	Paul Weber
Rev1	21-5-18	Will Olds	Paul Weber	Paul Weber

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3. OKC did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referred to in the OKC proposal. If a service is not expressly indicated, the client should not assume it has been provided. If a matter is not addressed, the client should not assume that any determination has been made by OKC in regards to that matter.
4. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation, or information provided by the client or a third party and which have not therefore been taken into account in this document.
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6. The investigations undertaken and services provided by OKC allowed OKC to form no more than an opinion of the actual conditions of the site at the time the site referred to in the OKC proposal was visited and the proposal developed and those investigations and services cannot be used to assess the effect of any subsequent changes in the conditions at the site, or its surroundings, or any subsequent changes in the relevant laws or regulations.
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EXECUTIVE SUMMARY

O’Kane Consultants (NZ) Ltd (OKC) were retained by Bathurst Resources Limited (BRL) to provide ongoing support for sludge management at the Stockton Coal Mine. OKC project 1103/1 includes development of a low-density sediments (LDS) discharge matrix. This matrix defines the rate LDS could potentially be discharged to Mangatini Stream via the Mangatini Sump Decant (MGD), without exceeding AI and turbidity/total suspended solids (TSS) concentration constraints in the Ngakawau River (at monitoring site NR). LDS discharge rates were calculated from potential additional AI and TSS loads being the difference between maximum load (based on AI and TSS constraints at NR) and estimates for background loads based on available water quality and flow rate monitoring data.

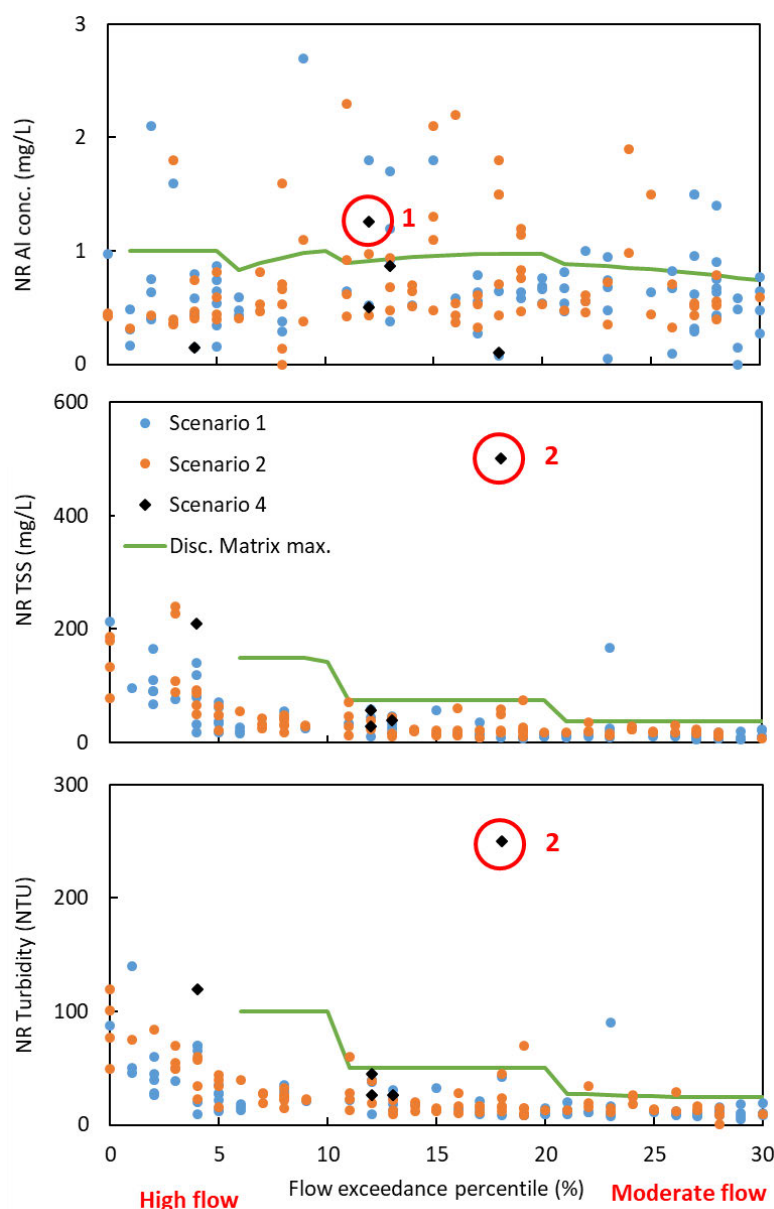
Two matrices were developed; one for AI constrained LDS discharge (AI concentration at NR < 1.0 mg/L) and one for TSS constrained LDS discharge (TSS at NR constraints shown in table below for a given flow percentile band). The final combined LDS discharge matrix simply selected the lowest (either AI or TSS constrained) LDS decant flow rate for a given NR flow rate and MGD TSS/turbidity at time of discharge. This matrix has been developed as a guide for LDS discharge to minimise potential effects and requires ongoing operational refinement and assessment of the process.

Combined AI and TSS constrained LDS discharge Matrix

MGD Turbidity (NTU)*				500	1250	2500	5000	10000	20000
MGD TSS (wt% solids)				0.1	0.25	0.5	1	2	4
Flow percentile (%ile)	NR Flow (m³/s)	NR TSS (mg/L)	NR Turb* (NTU)	Maximum LDS decant flow (L/s)					
95+	>105	unlimited	unlimited	Max.**	Max.	Max.	Max.	980	490
90-95	>57	150	100	Max.	Max.	1,100	550	270	130
80-90	>25	75	50	1,160	460	230	110	50	20
70-80	>15	37.5	25	210	80	40	20	10	-
0-70	n/a	n/a	25	-	-	-	-	-	-

* MGD turbidity and TSS data show a 1 NTU : 2 mg/L TSS correlation as opposed to the 1 NTU : 1.5 mg/L TSS correlation at NR, ** Maximum decant flow rate of 1,900 L/s.

BRL are conducting ongoing LDS discharge trials when flow conditions are appropriate. Most of these trials have resulted in AI and TSS concentrations below the NR constraints (for AI and TSS) used to develop the LDS discharge model. There are however two exceptions that have been attributed to elevated background AI concentrations (1) and/or excessive LDS discharge flow rates (2) as shown below (red circles).



LDS discharge trial water quality at NR

There remains some risk of LDS discharge resulting in exceedance of NR concentration constraints, as has been observed in the field trial data. BRL has indicated to OKC that these risks will be managed by:

- Limiting LDS discharge to relatively high NR flow conditions to maximise dilution;
- Limiting LDS discharge to when NR pH > 4.8 to minimise Al remobilisation;
- Limiting the number of LDS discharge events per 30-day period, unless rolling median turbidity data indicate compliance is likely to be maintained; and
- Using 90th percentile background contaminant loads in matrix development.

Ongoing refinements to the LDS discharge matrix and operational procedures are likely to further reduce the risk of LDS discharge leading to elevated Al and turbidity/TSS concentration at NR.

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1 INTRODUCTION

O’Kane Consultants (NZ) Ltd (OKC) were retained by Bathurst Resources Limited (BRL) to provide ongoing support for sludge management at the Stockton Coal Mine. OKC project 1103/1 includes development of a low-density sediments (LDS) discharge matrix. This matrix defines the rate LDS could be discharged via the Mangatini Sump Decant (MGD) without exceeding Al and turbidity/total suspended solids (TSS) constraints in the Ngakawau River (at water monitoring site NR). The discharge matrix was developed using available contaminant load data from January 2015 to March 2018, including LDS discharge trial data. This coincides with period CaO has been used as the neutralant by the Lime Dosing Plant.

This report has been divided into the following sections:

Section 1 – Introduction

Section 2 – Background

Section 3 – LDS Discharge Matrix Development

Section 4 – LDS Discharge Trial Data

Section 5 – Conclusions

2 BACKGROUND

2.1 Key Monitoring Sites

A review of background water quality has been undertaken for a range of exceedance percentile flow conditions. This review establishes background water quality, flow rates, and contaminant loads at the sites under investigation. Data have been compiled for key sites (MGIU, MGD, S14C, S14B, and NR) within the Mangatini Stream-Sump system. The relative positions of these sites are shown in Figure 2.1.

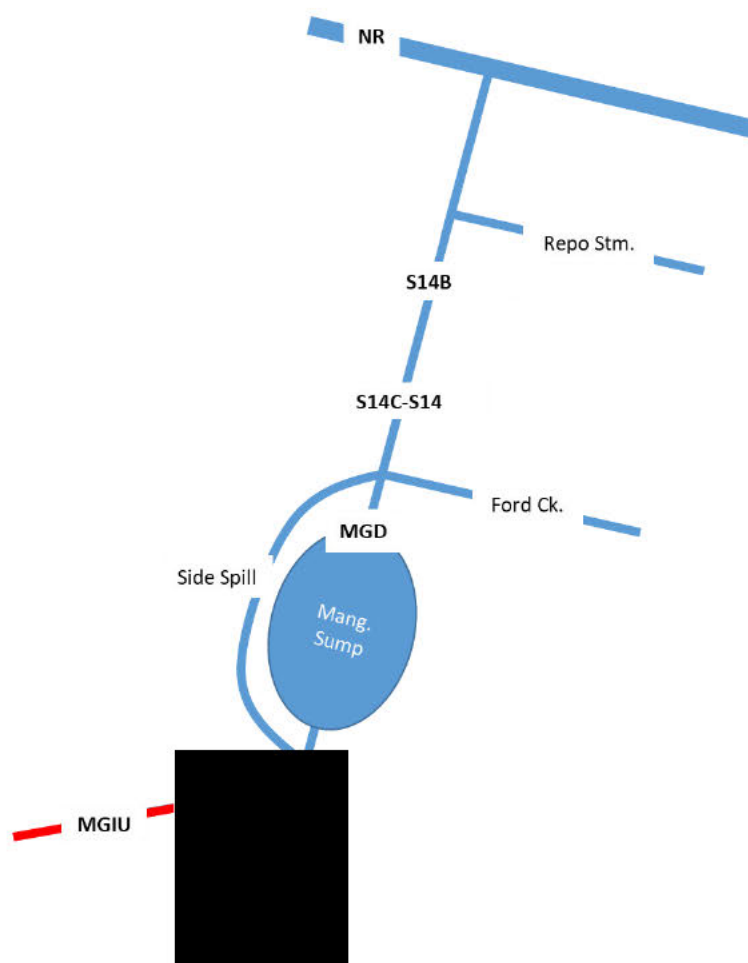


Figure 2.1: Mangatini Stream schematic

2.2 Contaminant Load Scenarios

The Mangatini Stream/Sump catchment is relatively complex, containing a large (~514 ha) catchment, the Mangatini Sump, and a side spill channel for high flows. Additional waters are also diverted / pumped into the catchment from other parts of the mine (e.g., Millerton and McCabes mining areas). To address some of this complexity available contaminant load data have been separated into four different scenarios:

Scenario 1 – Baseline (no LDS discharge or side spill flow);

Scenario 2 – Side spill discharge (no LDS discharge);

Scenario 3 – LDS discharge (no side spill); and

Scenario 4 – Side spill and LDS discharging.

These scenarios were developed to delineate the effect of controlled LDS discharge (Scenario 4) on downstream water quality as opposed to baseline (Scenario 1) and side spill (Scenario 2) effects.

Scenario 3 conditions typically coincide with moderate to low flows at NR. As such, Scenario 3 discharge trials were not undertaken as it was considered highly likely discharged LDS would trigger non-compliance downstream due to relatively low dilution flows. One exception was the LDS discharge event of 27th February – 3rd March 2017.

2.3 Flow Data

Flow rate data for the Mangatini Stream-Sump are shown in Figure 2.2. The upper Mangatini Stream flow rate (S14C) is typically 2 to 5% of total flow at NR in the Ngakawau River. These flow proportions are consistent across the flow spectrum. During normal flow conditions (no LDS discharge) there would be relatively consistent dilution of any contaminant load discharging the Mangatini Stream-Sump upstream of NR.

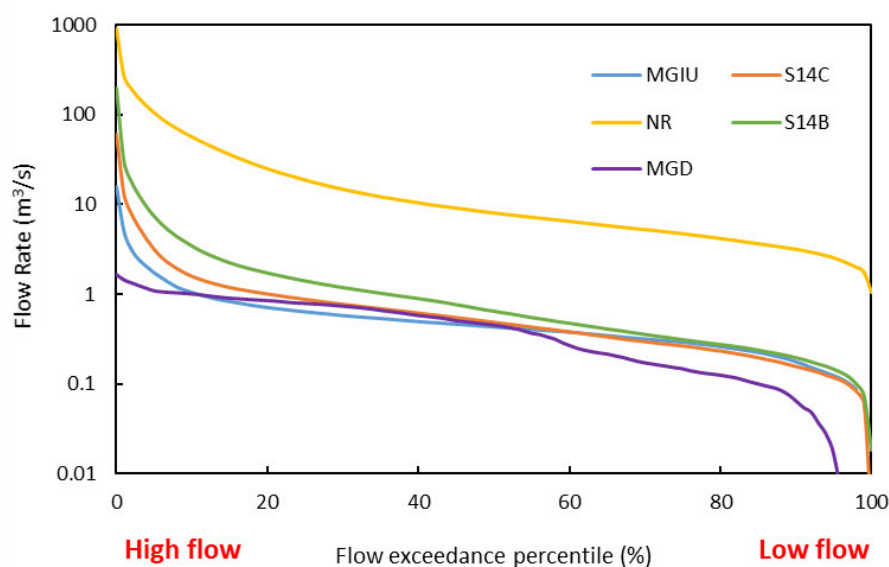


Figure 2.2: Mangatini Stream and Ngakawau River flow exceedance percentiles

Most flow rate data have been presented as **flow exceedance percentiles** as opposed to percentile flows to assist with data trendline fitting. For example, a 5% exceedance percentile flow represents a high flow that has been exceeded only 5% of the data record. The same 5% exceedance percentile flow rate corresponds to a 95-percentile flow. This relationship is shown for NR in Table 2.1.

Table 2.1: Exceedance percentile vs percentile flows at NR

Exceedance Percentile (%)	Percentile (%)	NR Flow Rate (m³/s)
0	100	908
5	95	105
10	90	56.7
15	85	36.2
20	80	25.0
25	75	18.8
50	50	8.1
75	25	4.7
100	0	1.0

2.4 Water Quality and Contaminant Loads

Data presented in this report are limited to those directly relevant to LDS discharge constraints and contaminant load calculations, including:

- Dissolved aluminium;
- Total Suspended Solids (TSS);
- Turbidity; and
- Flow rate.

2.5 LDS Discharge Constraints

The LDS discharge matrix was derived within the following constraints:

- Al concentration at NR should not exceed 1 mg/L;
- 30 day rolling median turbidity at NR should not exceed 25 NTU; and
- Maximum TSS at NR during LDS discharge should not exceed limits in Table 2.2.

Table 2.2: Maximum TSS limit at NR during LDS discharge

Flow percentile band (%)	Max TSS limit at NR during LDS discharge (mg/L)	Equivalent turbidity estimate (NTU)
95+	No limit	n/a
90-95	150	100
80-90	75	50
70-80	37.5	25
0-70	n/a (no LDS discharge – 25 NTU rolling median applies)	25

An additional constraint to minimise contaminant remobilisation in potentially acidic downstream environments is that LDS discharge events will be limited to when pH >4.8 at NR, to limit remobilisation of Al.

Typically water quality at NR complies with these criteria. This implies there is some capacity for additional LDS discharge (and subsequent increase in Al and TSS loads) while remaining below these constraints.

BRL intend to manage the 30-day rolling median turbidity constraint by limiting LDS discharge events to less than five per 30-day period, unless monitoring data show that further LDS discharge events are unlikely to affect compliance. Figure 2.3 shows the 30-day rolling median NR turbidity was significantly less than 25 NTU, including over the 2017 period when the LDS discharge trials occurred.

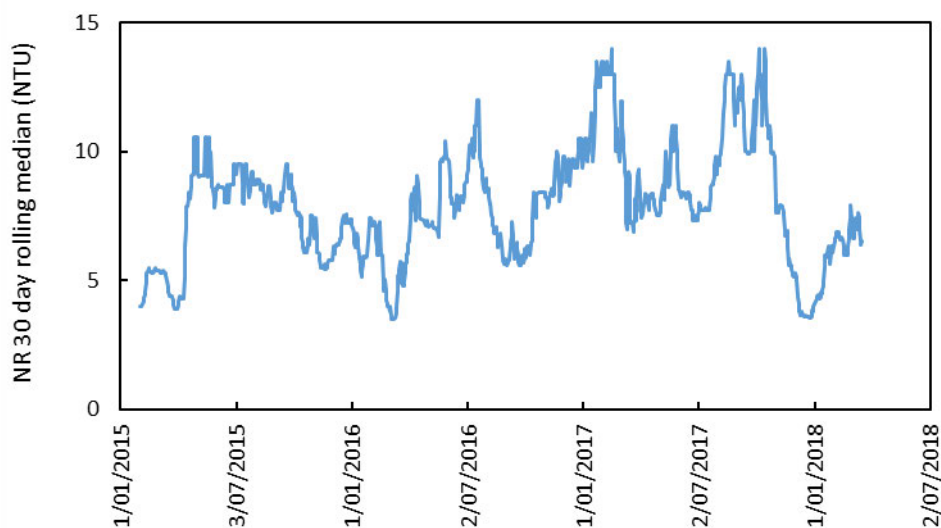


Figure 2.3: NR 30 day rolling median NTU

3 LDS DISCHARGE MATRIX DEVELOPMENT

Two LDS discharge matrices were developed; one based on Al concentration constraints at NR and one based on TSS/turbidity constraints at NR. Matrix development involved:

- Calculating maximum permissible NR Al and TSS loads:
 - Equivalent to an Al concentration of 1 mg/L; or
 - Maximum TSS as shown in Table 2.2.
- Calculating baseline NR Al and TSS loads over a range of flow exceedance percentiles;
- Calculating capacity (envelope) for additional Al and TSS loads at NR – Difference between maximum permissible NR load and baseline load; and
- Converting additional Al and TSS load to equivalent LDS discharge rate for a range of percent solids concentrations.

Two key assumptions have been made in the calculations for converting additional Al loads to LDS discharge rates:

- The LDS has an Al content of 10 wt%; and
- The Al dissolution rate between MGD and NR is a function of pH at NR with:
 - 2% dissolution of total LDS Al load (10% of TSS load) for NR pH greater than 4.8.

It should be noted that Scenario 1 (baseline) and Scenario 2 (side spill only) contaminant load data at NR were grouped together for the purposes of developing the discharge matrix to maximise the size of the dataset. This was considered appropriate as trends in Scenario 1 and 2 contaminant loads are similar at NR (Figure 3.1).

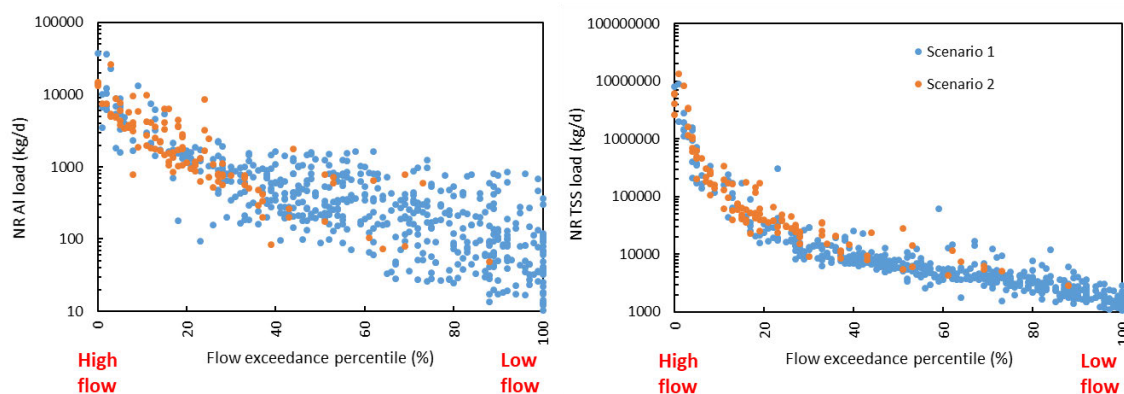


Figure 3.1: Al and TSS loads at NR during Scenario 1 and 2 conditions

3.1 AI Constrained Discharge Matrix

3.1.1 AI discharge envelope

The additional AI load envelope is shown in Figure 3.2 where LDS discharge could potentially be appropriate. The green hatched 'LDS AI envelope' is the area between the red 'Max AI' load curve and the black 'Background AI' load curve.

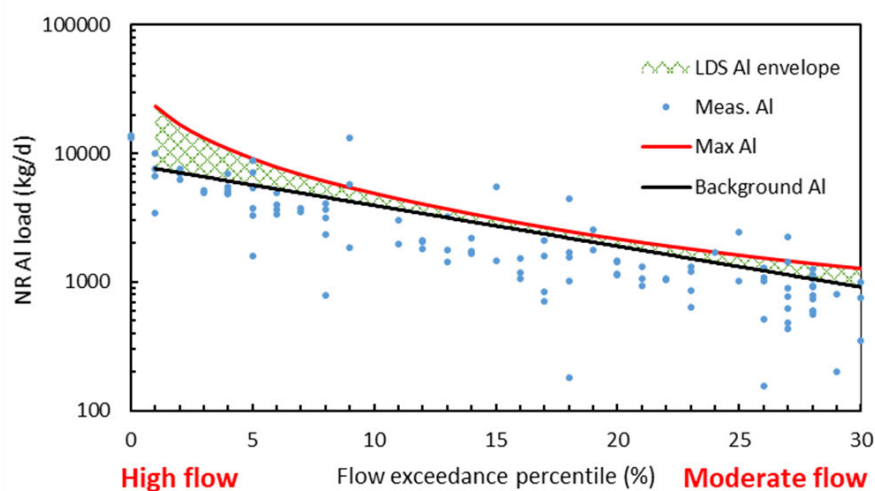


Figure 3.2: NR AI load envelope

The maximum AI load ('Max AI') at NR is derived simply by multiplying the flow rate (for a given flow exceedance percentile) by the target AI concentration of 1 mg/L.

The background AI load ('Background AI') at NR was derived by analysis of the NR AI load dataset as follows:

- 1) AI load data with $\text{pH} \leq 4.8$ was removed from dataset as LDS discharge will target NR $\text{pH} > 4.8$ conditions. This involved removal of data shown with red crosses in Figure 3.3.

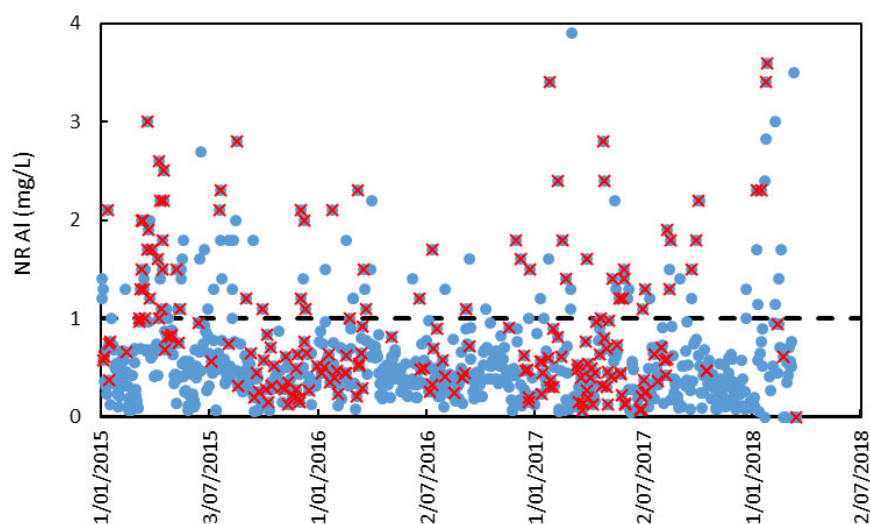


Figure 3.3: NR AI data showing samples with $\text{pH} \leq 4.8$

- 2) Remaining Al load data grouped by flow exceedance percentile (e.g. 0%, 1%, 2%, etc. flow exceedance percentile - Figure 3.4).

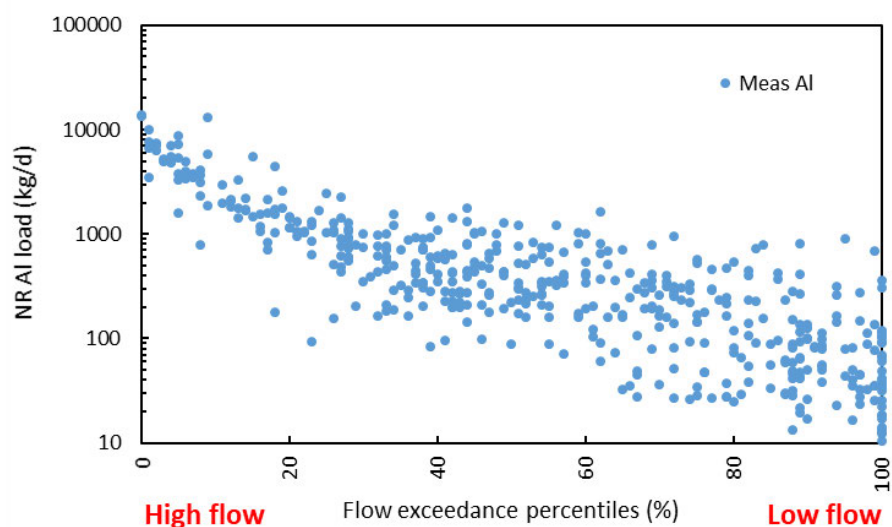


Figure 3.4: NR Al load data grouped by flow exceedance percentile

- 3) The 90th percentile measured Al load for each exceedance percentile was then calculated, plotted against the flow exceedance percentile, and fitted with two exponential trendlines in the 0 - 30 and 30 - 100 flow exceedance percentile ranges (Figure 3.5).

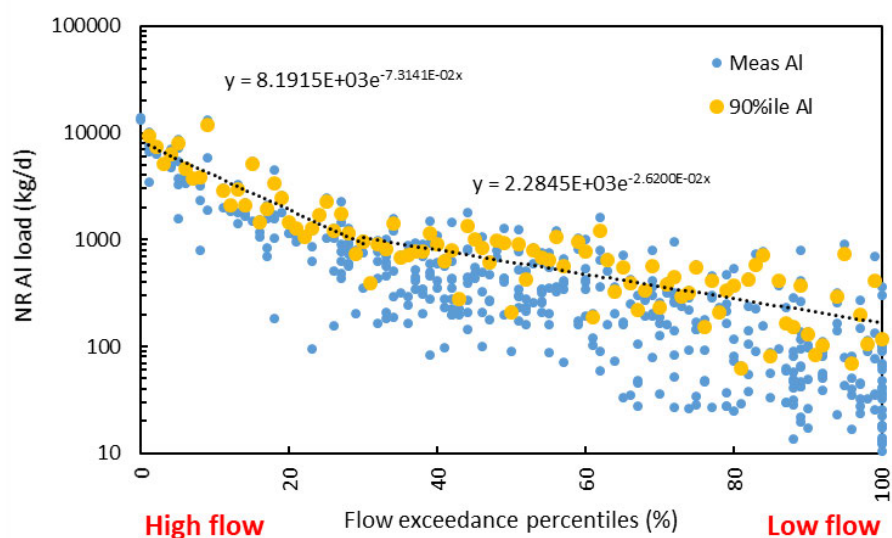


Figure 3.5: NR 90th percentile Al loads and fitted exponential trendlines

The exponential trendline fitted to the 0 - 30 flow exceedance percentile range was used to estimate the 'Background Al' line shown in Figure 3.2.

The difference between the red 'Max Al' load curve and the black "Background Al' load curve is the potential additional Al load at NR. As an example, this analysis showed that at the 5% flow exceedance percentile (NR = 105 m³/s) the maximum Al load at NR would be 9,099 kg/d. The

corresponding background Al load is estimated at 5,683 kg/d. Thus, there was capacity for an additional 3,416 kg/d Al load.

3.1.2 Al load to LDS load conversion

To develop the LDS discharge matrix it was necessary to convert this additional Al load capacity (e.g. the “LDS Al envelope”) into an equivalent additional LDS load (as a TSS load), which was required for operational management. This conversion is governed by two factors:

- The Al content of the LDS; and
- The degree of Al remobilisation as LDS moves downstream from MGD to NR.

Total recoverable Al data are available from LDS pumping trials and early MGD stream discharge trials that indicate an average 8.8 wt% Al content (dry basis) of discharged LDS (Figure 3.6). A nominal 10 wt% was used in model calculations to be conservative.

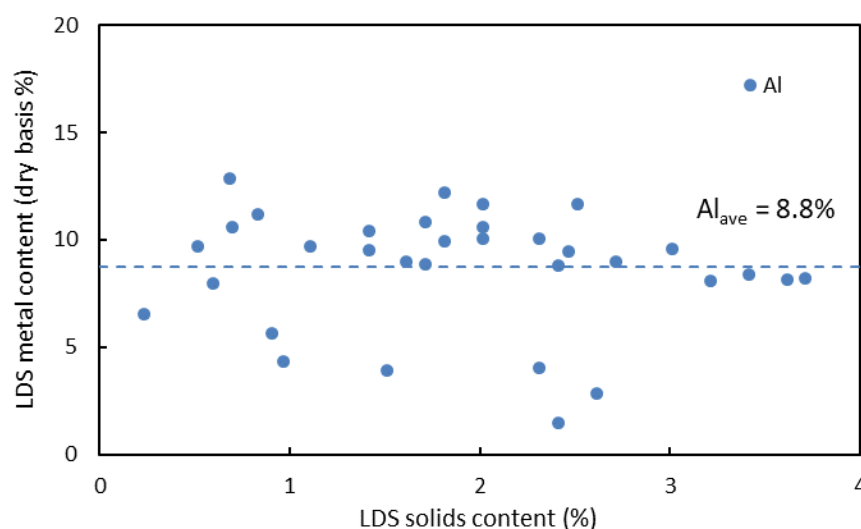


Figure 3.6: LDS Al content (wt% on a dry basis)

Dissolution of LDS in downstream acidic environments and the subsequent release of Al to solution was identified as a key risk for LDS discharge to the Mangatini Stream. LDS acidification trials were undertaken by CRL Energy Ltd (CRL) to quantify contaminant remobilisation in increasingly acidic environments. This involved titrating two LDS samples with a range of sulfuric acid (H₂SO₄) volumes such that pH after mixing ranged from pH 3.3 to 6, replicating the potential range of pH at NR and S14C.

Two LDS samples were titrated; one with 1.9 wt% solids and one with 0.3 wt% solids. Both LDS samples had an initial pH of approximately 6.5. Addition of H₂SO₄ resulted in an initially rapid decrease in pH (Figure 3.7). Buffering below pH 4.8 is likely due to dissolution of Al precipitates.

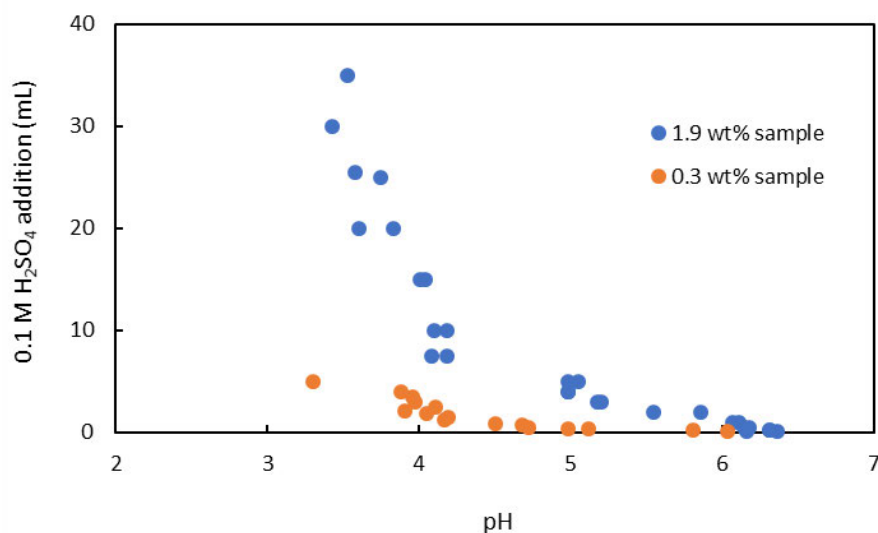


Figure 3.7: LDS pH following a given H₂SO₄ titration

For the purposes of developing the LDS discharge matrix the Al remobilisation rate (on a percent of total recoverable Al) was derived for a given pH (Figure 3.8). OKC have assumed a total recoverable Al content of 10 wt% in the LDS until total recoverable Al data are available from the laboratory. The nominal 2 wt% LDS sample would have a total solids content of 20,000 mg/L. Assuming this was 10 wt% Al equates to 2,000 mg Al/L in the LDS sample. The percent remobilised can then be calculated based on Al leach concentrations reported by CRL for a given pH (data not shown). For example, the Al leach concentration after acidification to pH 4.01 for the 1.9 wt% sample was 207.5 mg/L. This equates to remobilisation of ~10% of the 2,000 mg Al/L present in the LDS.

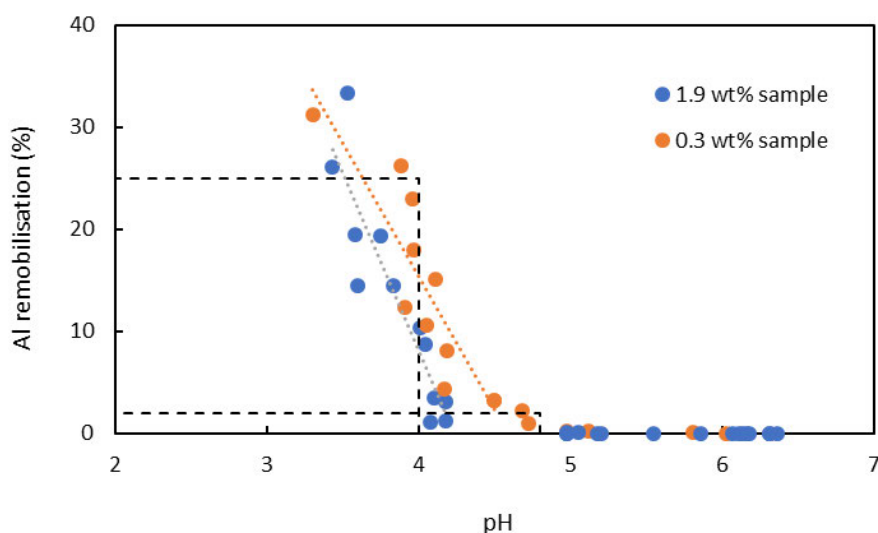


Figure 3.8: Proportion of Al remobilised as a function of pH

Figure 3.8 shows there is a significant difference in the Al remobilisation at pH 4 vs pH 4.8, as would be expected due to Al buffering of acidity and subsequent dissolution. Data indicate that if a downstream pH of greater than 4.8 is maintained, less than 2% of Al will be remobilised. However,

if downstream pH decreases to 4 then Al remobilisation could increase to 25%. Thus, to manage Al remobilisation BRL have committed to targeting LDS discharge when pH at NR is above 4.8. However, based on previous experience it is noted that at circum-neutral pH (5-8) Al can still be reported as being elevated by conventional laboratory analysis due to fine grained colloidal Al passing through 0.45 µm filter paper.

As the model assumes an LDS Al content of 10 wt% and that 2% of that Al will be remobilised as LDS moves from MGD down to NR, the LDS discharge load (equivalent to the LDS Al Envelope; Figure 3.2) is equivalent to the Al load scaled up by a factor of 500 (Figure 3.9). The 5 % flow exceedance percentile capacity of an additional 3,416 kg/d Al load therefore correlates to an additional LDS capacity of 1,708,000 kg/d before an Al concentration of 1 mg/L at NR would theoretically be exceeded.

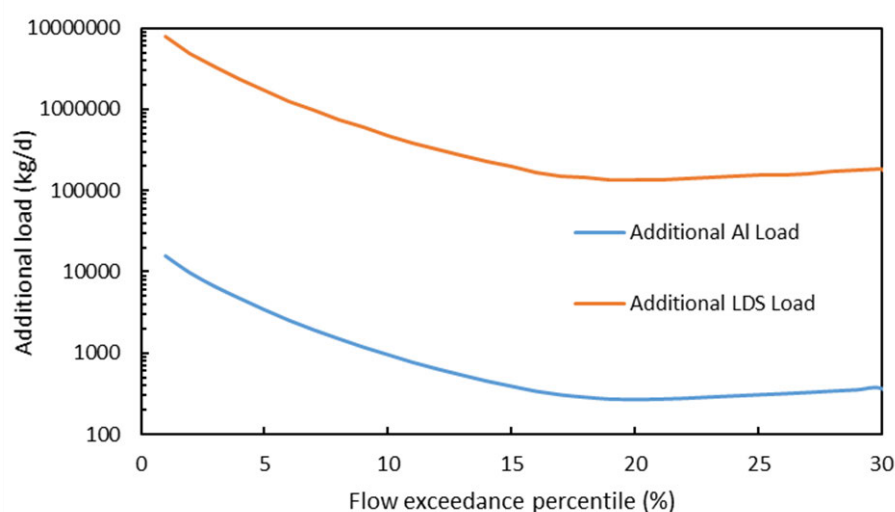


Figure 3.9: Additional LDS load scaled up from Al load

3.1.3 Al constrained LDS discharge matrix

Additional LDS loads in Figure 3.9 have been converted to MGD discharge flow rates for a range of NR flow exceedance conditions and decant turbidity/TSS concentrations to form the Al constrained LDS discharge matrix (Table 3.1). A maximum MGD flow rate of 1,900 L/s has been assumed.

It should be noted that the discharge matrix was developed for 1 to 30 percent flow exceedance percentiles but only 1 to 15 percent flows are shown in the report for brevity.

Table 3.1: AI constrained LDS discharge matrix

MGD Turbidity (NTU)			500	1250	2500	5000	10000	20000
MGD TSS (wt% solids)			0.1	0.25	0.5	1	2	4
Flow exceed. (%ile)	NR flow (m³/s)	NR AI (mg/L)	Maximum LDS decant flow (L/s)					
1	270	1	Max	Max	Max	Max	Max	Max
2	194	1	Max	Max	Max	Max	Max	1,402
3	152	1	Max	Max	Max	Max	Max	954
4	125	1	Max	Max	Max	Max	1,364	682
5	105	1	Max	Max	Max	Max	989	494
6	90	1	Max	Max	Max	1,459	729	365
7	79	1	Max	Max	Max	1,115	557	279
8	70	1	Max	Max	1,738	869	435	217
9	63	1	Max	Max	1,369	685	342	171
10	57	1	Max	Max	1,106	553	276	138
11	51	1	Max	1,779	889	445	222	111
12	47	1	Max	1,472	736	368	184	92
13	43	1	Max	1,236	618	309	154	77
14	39	1	Max	1,044	522	261	130	65
15	36	1	Max	902	451	225	113	56

3.2 TSS Constrained Discharge Matrix

3.2.1 TSS discharge envelope

The additional TSS load capacity is shown in Figure 3.10 where LDS discharge could potentially be appropriate. The green hatched 'LDS TSS envelope' is the area between the red 'Max TSS' load curve and the black 'Background TSS' load curve.

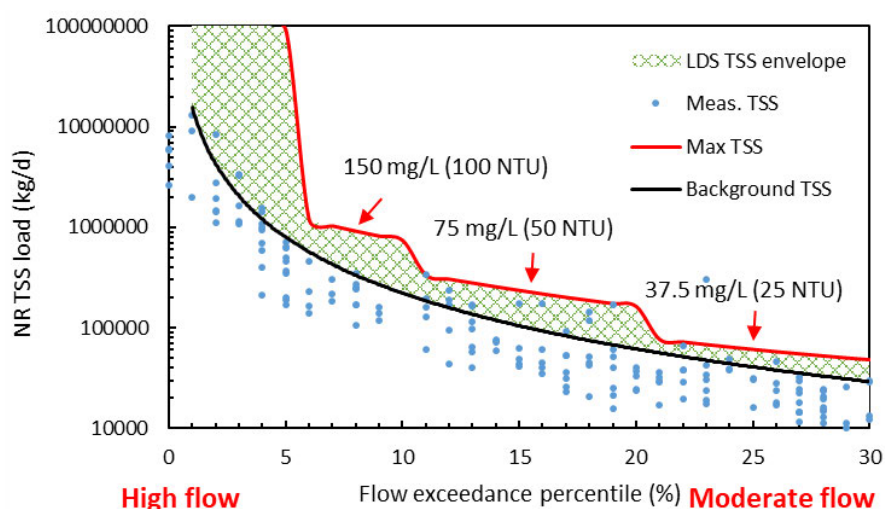


Figure 3.10: NR TSS load envelope

The maximum TSS load ('Max TSS') at NR is derived by multiplying the flow rate (for a given flow exceedance percentile) by the target maximum TSS concentration applicable to each flow percentile band (Table 2.2).

The background TSS load ('Background TSS') at NR was derived from the NR TSS load dataset:

- 1) TSS load data grouped by flow exceedance percentile (e.g. 0%, 1%, 2%, etc. flow exceedance percentile groups - Figure 3.11);

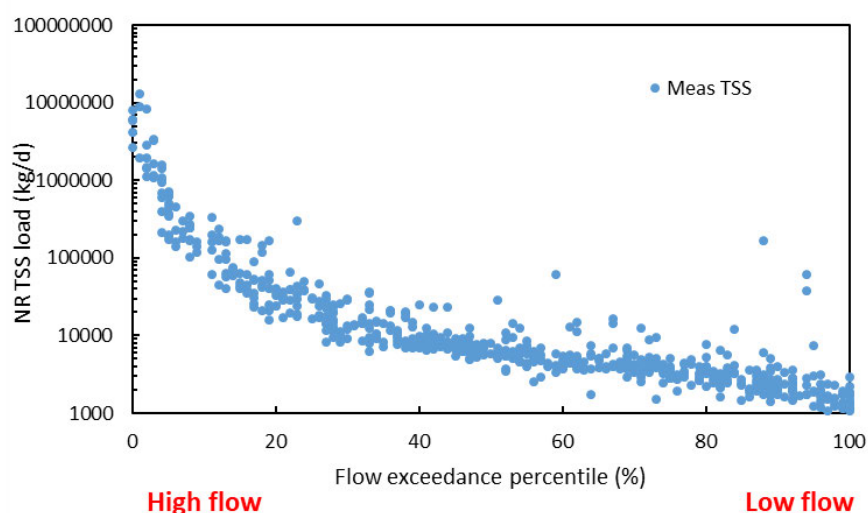


Figure 3.11: NR TSS load data grouped by flow exceedance percentile

- 2) The 90th percentile measured TSS load for each exceedance percentile was then calculated, plotted against the flow exceedance percentile, and fitted with two power trendlines in the 0 - 30 and 30 - 100 flow exceedance percentile ranges Figure 3.12.

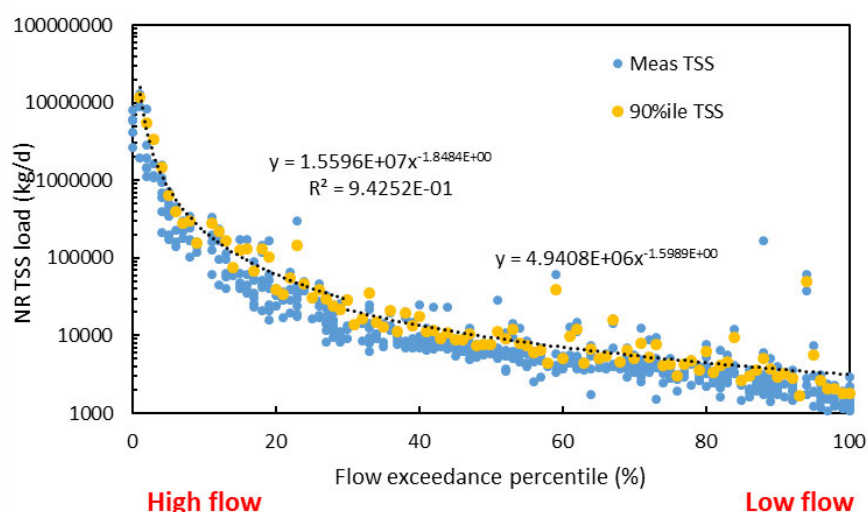


Figure 3.12: NR 90 percentile TSS loads and fitted power trendlines

The power trendline fitted to the 0 - 30 flow exceedance percentile was used to estimate the 'Background TSS' line shown in Figure 3.10.

The difference between the red 'Max TSS' load curve and the black "Background TSS' load curve is the potential additional TSS load at NR. As an example, at the 10% flow exceedance percentile the maximum TSS load at NR would be 735 t/d. The corresponding background TSS load is estimated at 221 t/d. Thus, there is potential capacity for an additional 513 t/d TSS load while theoretically remaining below the 150 mg/L TSS constraint at water monitoring site NR.

3.2.2 TSS constrained LDS discharge matrix

Additional LDS loads have been converted to MGD discharge flow rates for a range of NR flow exceedance conditions and decant turbidity/TSS concentrations to form the TSS constrained LDS discharge matrix. Again, a maximum MGD flow rate of 1,900 L/s has been assumed.

Table 3.2: TSS constrained LDS discharge matrix

MGD Turbidity (NTU)			500	1250	2500	5000	10000	20000
MGD TSS (% solids)			0.1	0.25	0.5	1	2	4
Flow exceed. (%ile)	NR Flow (m³/s)	NR TSS (mg/L)	Maximum LDS decant flow (L/s)					
1	270	150	Max	Max	Max	Max	Max	Max
2	194	150	Max	Max	Max	Max	Max	Max
3	152	150	Max	Max	Max	Max	Max	Max
4	125	150	Max	Max	Max	Max	Max	Max
5	105	150	Max	Max	Max	Max	Max	Max
6	90	75	Max	Max	1,393	697	348	174
7	79	75	Max	Max	1,384	692	346	173
8	70	75	Max	Max	1,333	666	333	167
9	63	75	Max	Max	1,262	631	315	158
10	57	75	Max	Max	1,189	594	297	149
11	51	50	1,702	681	340	170	85	43
12	47	50	1,681	673	336	168	84	42
13	43	50	1,635	654	327	164	82	41
14	39	50	1,571	629	314	157	79	39
15	36	50	1,502	601	300	150	75	38

3.3 Combined LDS Discharge Matrix

The combined LDS discharge matrix (Table 3.3) simply selects whichever of the AI or TSS constrained matrices has the lowest LDS decant flow rate (for a given NR flow rate and MGD turbidity/TSS concentration). LDS decant flow rates are rounded down to the nearest 10 L/s.

The combined discharge matrix has been further simplified for operational purposes by presenting flow conditions in bands. The LDS discharge rate for a given band corresponds to the lowest discharge rate within that band. In addition, bands are presented as 'Flow percentiles' rather than exceedance percentiles.

Table 3.3: Combined AI and TSS constrained LDS discharge Matrix

MGD Turbidity (NTU)*				500	1250	2500	5000	10000	20000
MGD TSS (% solids)				0.1	0.25	0.5	1	2	4
Flow percentile (%ile)	NR Flow (m ³ /s)	NR TSS (mg/L)	NR Turb* (NTU)	Maximum LDS decant flow (L/s)					
95+	>105	unlimited	unlimited	Max. Decant**	Max. Decant	Max. Decant	Max. Decant	980	490
90-95	>57	150	100	Max. Decant	Max. Decant	1,100	550	270	130
80-90	>25	75	50	1,160	460	230	110	50	20
70-80	>15	37.5	25	210	80	40	20	10	-
0-70	n/a	n/a	n/a	-	-	-	-	-	-

* MGD turbidity and TSS data show a 1 NTU : 2 mg/L TSS correlation as opposed to the 1 NTU : 1.5 mg/L TSS correlation at NR, ** Maximum decant flow rate of 1,900 L/s.

3.4 TSS and Turbidity Correlations

Compliance criteria at NR are currently based on turbidity rather than TSS. To include turbidity in the discharge matrix and present estimates of turbidity at NR it was necessary to derive correlations between TSS and turbidity. Separate correlations between TSS and turbidity have been developed for MGD and NR as the relationship is site specific.

3.4.1 MGD TSS vs turbidity

The LDS discharge matrix is derived based on TSS loads. The 1 NTU : 2 mg/L TSS correlation (Figure 3.13) at MGD is used to define turbidity corresponding to a given MGD TSS concentration at the time of discharge. This allows site staff to set LDS discharge rates based on turbidity or TSS data, whichever is available enabling real-time operational management. It should be noted that this correlation is limited to the LDS discharge trial dataset and does not necessarily represent the TSS vs turbidity correlation during normal (no LDS discharge) conditions.

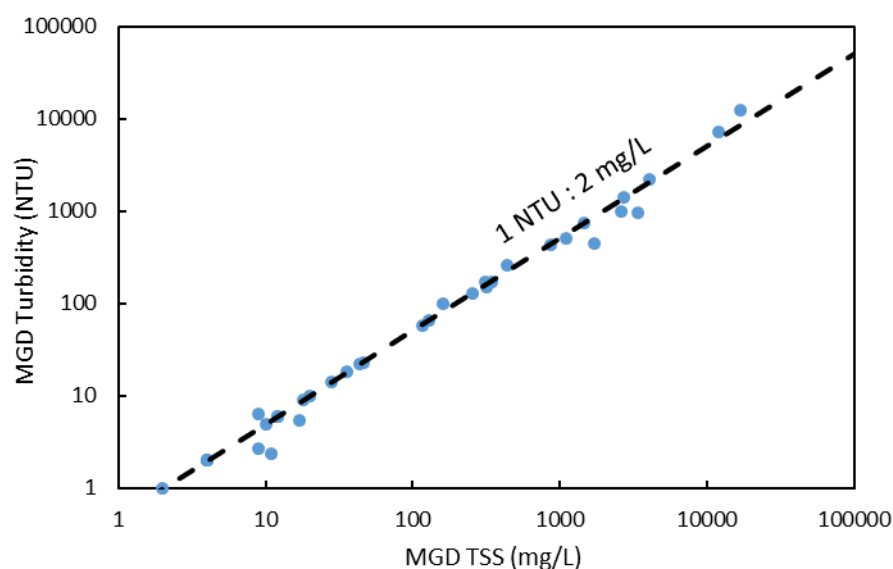


Figure 3.13: MGD turbidity vs TSS correlation

3.4.2 NR TSS vs turbidity

Current resource consent conditions use turbidity as a measure of water quality at NR (as opposed to TSS concentration). The 1 NTU : 1.5 mg/L TSS correlation (Figure 3.14) at NR was used to estimate turbidity at NR for a given TSS load.

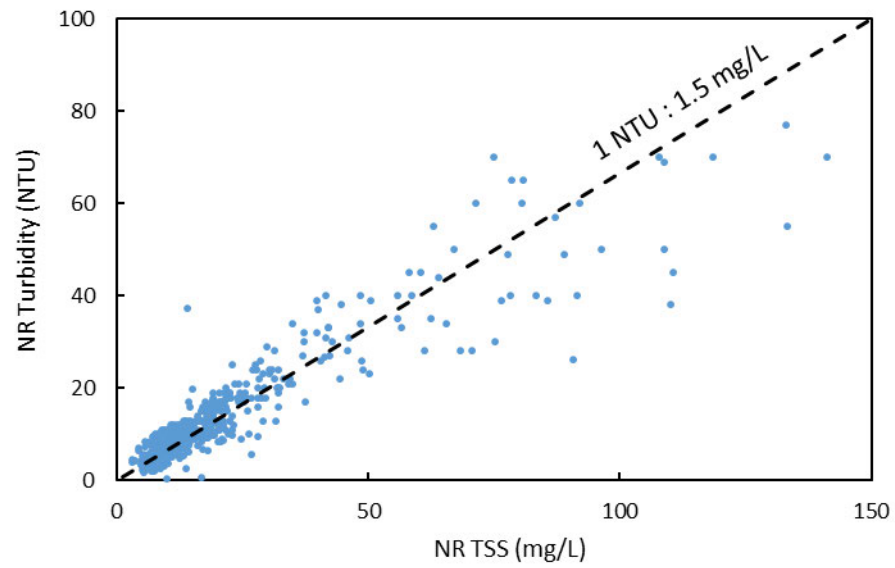


Figure 3.14: NR turbidity vs TSS correlation

4 LDS DISCHARGE TRIAL DATA

4.1 Trial Data

As part of the LDS discharge trials, BRL have been discharging LDS when flow rates are likely to be greater than 30% exceedance percentile. NR LDS discharge (Scenario 4: Side spill and LDS discharge) AI and TSS load data are plotted with scenario 1 and 2 data in Figure 4.1. Scenario 3 (LDS discharge no side spill) data (from 27/2/2017 to 3/3/2017) are also presented but are discussed in section 4.2.

Data show that NR Scenario 4 TSS and AI loads typically fall within the natural range observed at NR. The NR data show that BRL are managing to discharge the bulk of LDS at flow rates higher than the 20% exceedance percentile.

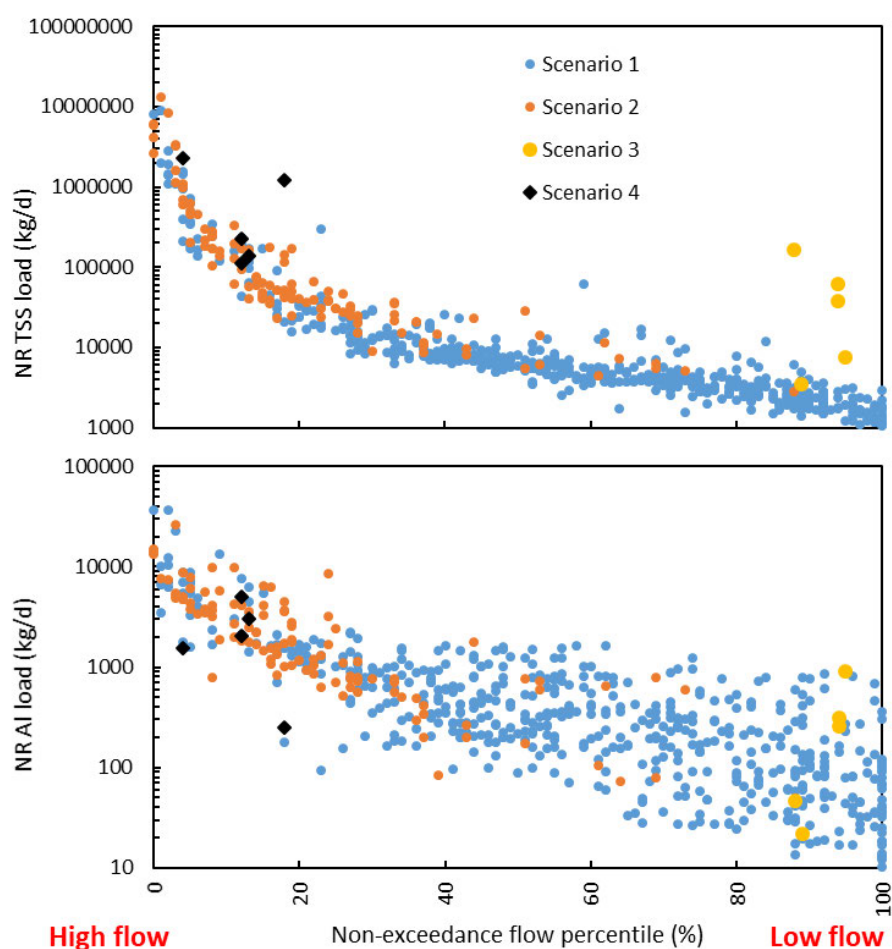


Figure 4.1: NR contaminant loads

More detailed AI, TSS, and turbidity data are shown in Figure 4.2 for the 0 - 30 flow exceedance percentile range. Also plotted are curves for expected maximum AI, TSS, and turbidity based on the combined LDS discharge matrix.

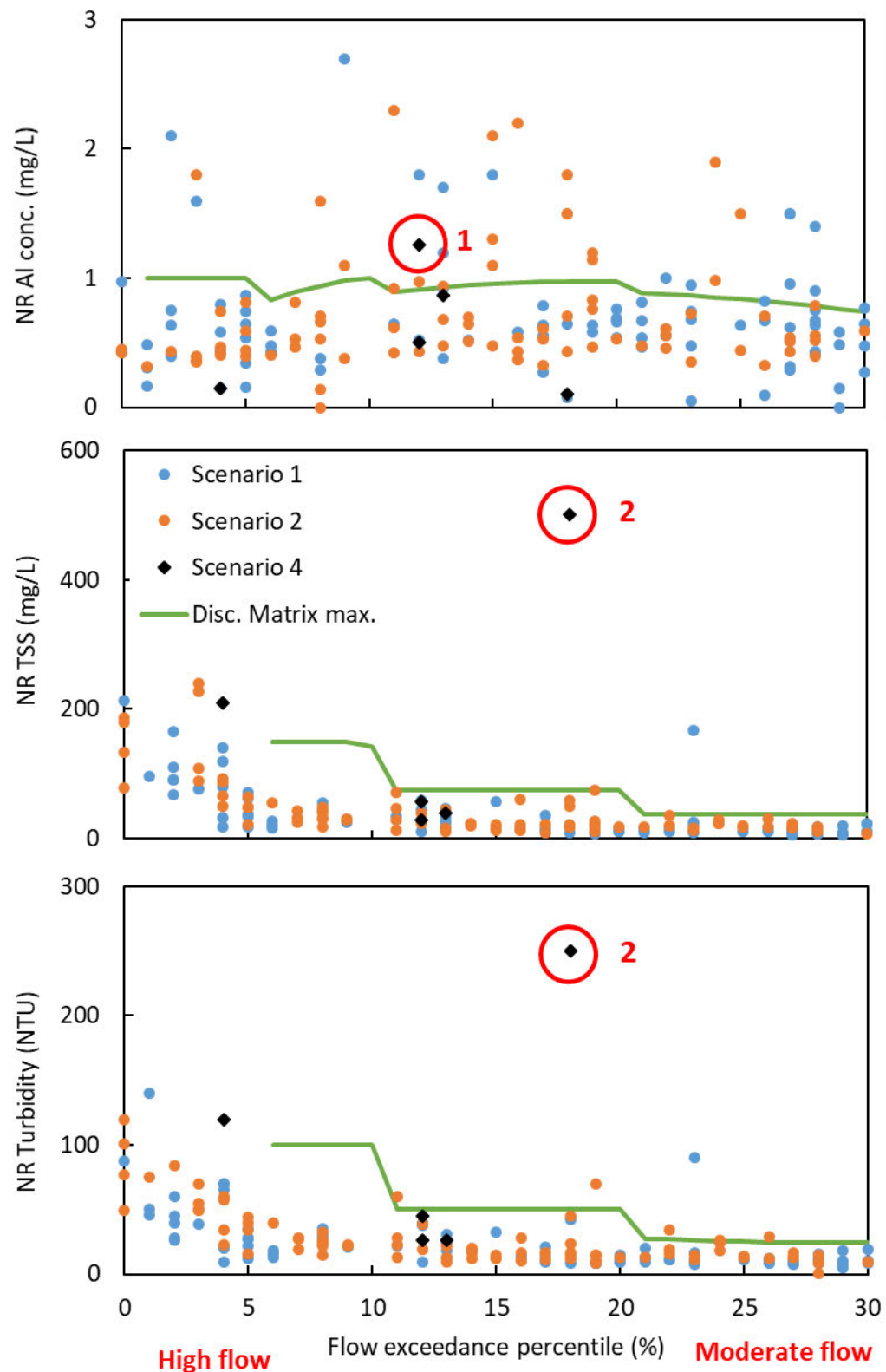


Figure 4.2: LDS discharge trial water quality at NR

Theoretically, if the combined LDS discharge matrix were adhered to, there should be at least a 90% chance that all Scenario 4 data plot below the green lines in Figure 4.2. However, two of the Scenario 4 LDS discharge trial data exceed the green line values.

Point 1 – MGD data indicate LDS discharge of ~1,702 L/s at ~440 mg/L TSS. When the slug of LDS reached NR flow conditions were equivalent to ~12% exceedance percentile. Based on the receiving NR flow rate and TSS concentration discharging at MGD, the recommended combined matrix discharge flow rate would be ~1,160 L/s, ~30% lower than the actual LDS discharge rate. Decreasing LDS discharge rate by 30% may have been sufficient to decrease NR Al concentration to less than 1 mg/L. However, for the 80-90 percentile flow band the combined discharge matrix flow rate is actually constrained by TSS load (rather than Al). The NR TSS was only 28 mg/L, significantly lower than the 75 mg/L limit for that flow band, indicating elevated background Al concentration may have contributed to the high Al concentration (rather than excessive LDS discharge alone).

Point 2 – MGD data indicate LDS discharge of ~550 L/s at ~18,000 mg/L TSS. When the slug of LDS reached NR flow conditions were equivalent to ~18% flow exceedance percentile. Based on the receiving NR flow rate and TSS concentration discharging at MGD, the recommended combined matrix discharge flow rate would be ~50 L/s. This is lower by a factor of 11 and may have been sufficient to reduce the observed 500 mg/L TSS concentration at NR to below the 50 mg/L TSS constraint.

4.2 Low Flow LDS Discharge Event

LDS was discharged between 27/2/2017 to 3/3/2017 to reduce the sump water level for maintenance purposes. This LDS discharge event coincided with relatively low flow conditions in Mangatini Stream and the Ngakawau River. The resulting accumulation of LDS in the Ngakawau River and Estuary was the subject of an investigation between Stockton staff and the WCRC.

A summary of key water quality and flow exceedance percentile data for NR and S14C are shown in Table 4.1. Data show the slug of LDS discharged from MGD was detected at NR, with turbidity values of 20-320 NTU reported over the LDS discharge period. Elevated Al concentrations, of up to 3.9 mg/L were also observed, though the increase in Al is not proportional to the increase in turbidity/TSS, indicating this may have also coincided with elevated background Al concentrations and may be a function of fine-grained colloidal Al being analysed as the dissolved fraction..

Table 4.1: NR and S14C turbidity/TSS during low flow LDS discharge event

Date	Ngakawau River at NR					Mangatini Stream at S14C		
	TSS (mg/L)	Turbidity (NTU)	Flow ex. Percentile (%) [*]	pH	Al (mg/L)	TSS (mg/L)	Turbidity (NTU)	Flow ex. Percentile (%) ^{**}
27/2/2017	12.4	4.9	89	6	0.08	474	230	100
28/2/2017	578	320	88	7.2	0.16	-	-	-
1/3/2017	258	120	94	7.4	1.3	-	-	-
2/3/2017	163	90	94	7.5	1.1	2236	850	99
3/3/2017	32.2	20	95	7.4	3.9	5123	1400	99
6/3/2017	6.5	5.1	89	5.6	0.17	6.5	6.2	100

* Corresponds to NR flow rates between 2.7 and 3.4 m³/s, ** corresponds to S14 flow rates between 0.05 and 0.08 m³/s.

Flow rates at NR and S14C were very low when the LDS was discharged. This shows that during low flow conditions even a small amount of controlled LDS discharge is likely to result in deterioration in water quality at NR.

It should be noted that pH at NR was relatively high (up to pH 7.5) during the discharge event, suggesting LDS discharge has a neutralising effect at NR. This reduces the risk of Al remobilisation from LDS as discussed in Section 3.1.2.

5 CONCLUSIONS

The combined LDS discharge matrix was developed based on maximum Al and TSS concentration constraints at NR. The matrix is developed as a guide and suggests that significant LDS could be discharged via the sump decant, with discharge flow rates limited by the size of the decant in some circumstances.

There remains some risk of LDS discharge resulting in exceedance of NR concentration constraints, as has been observed in the field trial data. BRL have made several commitments to manage that risk, including:

- Limiting LDS discharge to relatively high NR flow conditions to maximise dilution;
- Limiting LDS discharge to when NR pH > 4.8 to minimise Al remobilisation;
- Limiting the number of LDS discharge events per 30-day period, unless rolling median turbidity data indicate compliance is likely to be maintained; and
- Using 90th percentiles (as opposed to average) background contaminant loads in matrix development.

Ongoing refinements to the LDS discharge matrix and operational procedures are likely to further reduce the risk of LDS discharge leading to elevated Al and turbidity/TSS concentration at NR.



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Appendix D – Monitoring and Evaluation Programme

The following monitoring and evaluation programme will be followed to ensure the Mangatini Sump continues to function correctly. Records of these inspections will be kept by the Environmental Engineer – Water. A proforma inspection sheet has been developed to facilitate the systematic inspection of the facility and collection of monitoring data (not included here).

Item	Activity/Element	Criteria and evaluation	Person Responsible	Frequency
Decant	Floating intake & lanyard lines	No blockages or damage that will inhibit performance.	Water Engineer	Bi-monthly
	Motorised control valves	Visual check of operational response	Water Engineer	Monthly
	Access ladders & landings	No damage, deterioration or hazards	Staff accessing the ladder / Fixed Plant	Prior to entry / annually
	Tunnel groundwater inflow	No increased leakage	Geotechnical	Quarterly
	Tunnel rock condition	No instability	Geotechnical	Quarterly
Rock Dam Wall	Crest rim	No cracking or slumping	Geotechnical	Quarterly
	Sump walls and benches	No cracking or deterioration	Geotechnical	Quarterly
	Mangatini escarpment	No change in groundwater patterns	Geotechnical	Quarterly
Intake	Channel and culvert	No sedimentation or blockages	Water Engineer	Weekly
	pH meter	No blockage or damage, regular cleaning	Water Engineer	Daily (Mon-Fri)
	Upstream sediment ponds	Excavate sediment build up	Water Engineer	As required
Yawar embankment	Upstream face	No slumping, cracking, loss of riprap	Geotechnical	Quarterly
	Downstream face	No slumping, cracking, seepage, erosion damage	Geotechnical	Quarterly
	Crest	No cracking or slumping	Geotechnical	Quarterly
	Spillway	No cracking or slumping	Geotechnical	Quarterly or after operation
Catchment	610 drain	No blockage or damage	Water Engineer	Monthly
	Stormwater inflows	No uncontrolled inflows	Water Engineer	Quarterly
Sump Monitoring	Reservoir level	Monitor reservoir level and adjust decant flow	Water Engineer	Twice daily or as required
	Sediment level	Sonar survey and sediment volume calculation	Water Engineer	Bi-monthly

Item	Activity/Element	Criteria and evaluation	Person Responsible	Frequency
	DMP's	No significant change in line or level from baseline	Survey	Quarterly
	Piezometers	No change in trend	Water Engineer	Quarterly
	Inclinometers	No significant change from baseline	Water Engineer	Quarterly
	Camera boreholes	No identifiable change, displacement or inflow	Water Engineer	Only if other instruments indicate change
	Seepage Monitoring Weir	No significant change in historical readings or sign of discoloured water	Water Engineer	Monthly.

In addition to the above regular inspection regime the embankment and appurtenant structures should be inspected following any significant event, such as:

- Earthquake above a M5.5 occurring within the region;
- Rainfall event where the rainfall intensity exceeds 66 mm/hr or 233 mm in a 24 hour period i.e. following a 1 in 10 year event, or when the spillway has been discharging;
- Landslide, slope failure or significant rockfall into the reservoir;
- Any other event that could impact on the operation of the reservoir. This would include any significant operational changes in the catchment, which would be expected to occur as part of the usual mine ATM process.

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