Projects

HYDRO

REPORT

Internal Task Force

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Page:	1 of 25

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CONTENTS

1 Background

In the region of Barcarena, Brazil, where Alunorte Alumina Refinery is located, a heavy rainfall occurred on the night of the 16th of February 2018 followed by significant rainfall over the next 10 days.

The rainfall led to flooding in the area and public surveillance authorities inspected Alunorte's alumina refinery and surrounding areas, following reports of water contamination and possible leakage from the bauxite residue deposits. Residents in Alunorte neighboring communities claimed that Hydro was responsible for the reported water contamination.

1.1 Internal Task Force

An internal Task Force was appointed by President and CEO on February 24th to execute a comprehensive review following the heavy rainfall and flooding.

The Task Force scope has been to establish an overview of the relevant facts and circumstances to establish the effects of the heavy rainfall in February, and furthermore to prepare recommendation for improvement of systems, processes, and organization in the short and longer-term perspective. According to the mandate, the Task Force has concentrated its work on the following issues:

- The operational integrity of the Red Mud Deposits.
- Alunorte´s ability to treat and dispose of excess water in a compliant manner.
    - From the Red Mud Deposits
    - Plant and Infrastructure Areas
- The environment inside and outside the perimeters of Alunorte.
- Any non-compliance with any of Alunorte's relevant licenses.
- Emergency Preparedness related to extreme rainfall.

1.1.1 Task Force organization

The Task Force has been headed by Senior Executive Tom Røtjer reporting directly to President and CEO Svein Richard Brandtzæg. Jan Arild Berget; Senior HSE Manager has been appointed Project Manager for the Task Force. In addition, Vice President Pia Magnussen; Vice President Bernt Malme have been core team members.

A support group with Hydro and Alunorte employees and external consultants has worked closely together with the Task Force.

1.1.2 Task Force schedule and milestones

To meet the original report milestone, March 23rd, the Task Force has worked according to the following overall plan:

- Week # 9: Preparation, organizing resources and developing detailed program.
- Week #10 & 11: Presence at Alunorte site.
- Week#12: Conclusions and reporting.

Later, presentation of Task Force report was re-scheduled to April 9th.

1.2 Task Force approach

Through interviews with Alunorte management and key discipline resources, meetings with external consultants, field visits to critical areas inside the plant, review of documents (both controlling documents and records from the event), calculations and review of relevant licenses; the Task Force has arrived on the conclusions and recommendations presented in this report.

- Field visits have been made by the Task Force to:
  - Plant perimeter areas
  - Area 45
  - Area 82 – Effluent Treatment Plant (ETP)
  - DRS1 & DRS2 – including basins
  - Mixing Box and Holding pond area
  - Canal Velho
  - Canal Novo
  - Albras Channel
  - Sanitary Wastewater Treatment Plant
  - Concrete pipes route from DRS1 to ETP

1.2.1 Issues not included by the Task Force

Due to several parallel initiatives (“Work Streams”) initiated by Norsk Hydro the following has not been included in the Task Force data collection:

- Sampling and laboratory analysis of water and soil samples inside and outside the plant (executed by external consultant SGW).
- Visit to the area where wastewater streams are discharged into the Pará River.
- Visits to neighboring communities.

2 Alunorte Refinery

Alunorte - Alumina do Norte do Brasil S.A is located in Barcarena, a municipality situated 123 km from Belém in the state of Para.

The factory started its operations in July 1995. From 1995 until today, Alunorte has undergone three major expansions and is now the world's largest alumina producer.

The first refinery expansion project started in 2000 and was completed in 2003. With the expansion, production capacity increased from 1.6 to 2.45 million tons of alumina per year, a capacity increase of 50%.

The second expansion from July 2003 to early 2006, increased the production capacity to 4.4 million tons of alumina per year.

In 2006, Alunorte began the third expansion, completed in August 2008, which enabled the company to produce 6.26 million tons of alumina per year, an estimated 7% of the world alumina production.

In 2011, the bauxite mine in Paragominas and a majority stake in the Alunorte refinery was acquired by Hydro, the acquisition also included 51% of the Albras aluminium smelter making Hydro the largest aluminum company in South America.

In 2014, Alunorte sanctioned the Press filter and DRS2 project to replace the drum filters with build press filters and the new deposit area to reduce the environmental footprint of red mud deposit area. The press filter material is dryer, less caustic than the drum filter material, and can be compacted. This project also included a new effluent treatment plant.

In addition to major investment projects, there are continuous improvements and sustaining projects ongoing both in execution and study phase.

3 Layout

Figure 3.1 Overview of Alunorte

4 Task Force – Main Findings and Recommendations

4.1 Summary

- Extreme rainfall resulting in large amounts of water needing treatment upon release.
- Internal power outage due to lightning reducing water treatment capacity.

- An external power voltage dip led to interruptions of production equipment in the refinery. This caused a spill of process water containing caustic soda in the process area going to the Effluent Treatment Plant (ETP). This impacted the effluent water treatment plant capacity.
- No overflow from the Bauxite residue deposits.
- Not fully treated effluent was released through Canal Velho into the Para River. Average effluent concentration was within the prescribed limits.
- Recommendations have been identified to improve the robustness of the operations. The most important recommendations are:
  - To implement increased effluent treatment capacity.
  - To ensure good dialogue with relevant authorities to ensure timely authority approvals.

4.2 Rainfall event in Alunorte

The event of intense rainfall which began on the night of the 16th of February 2018 resulted in a rainfall occurrence of 231mm in 12h, and 239mm in 24h followed by significant rainfall over the next 10 days. This contributed to the flooding of plant areas, overflowing from the Canal Novo to the Canal Velho and filling of ETP collection basins. This resulted in a need to divert rainfall run-off from the refinery to the Canal Velho and into the Para River.

There were other unexpected events which complicated the management of the event including an internal power outage, due to lightning, reducing the water treatment capacity and an external power voltage dip which led to interruptions of production equipment in the refinery. This caused a spill of process water containing caustic soda in the process area going to the ETP which contributed to the ETP basins remaining at high levels for a period of 4 to 5 days. This further complicated the situation resulting in the need to again use Canal Velho to divert rainwater to the Para River.

The detailed sequence of events is given below.

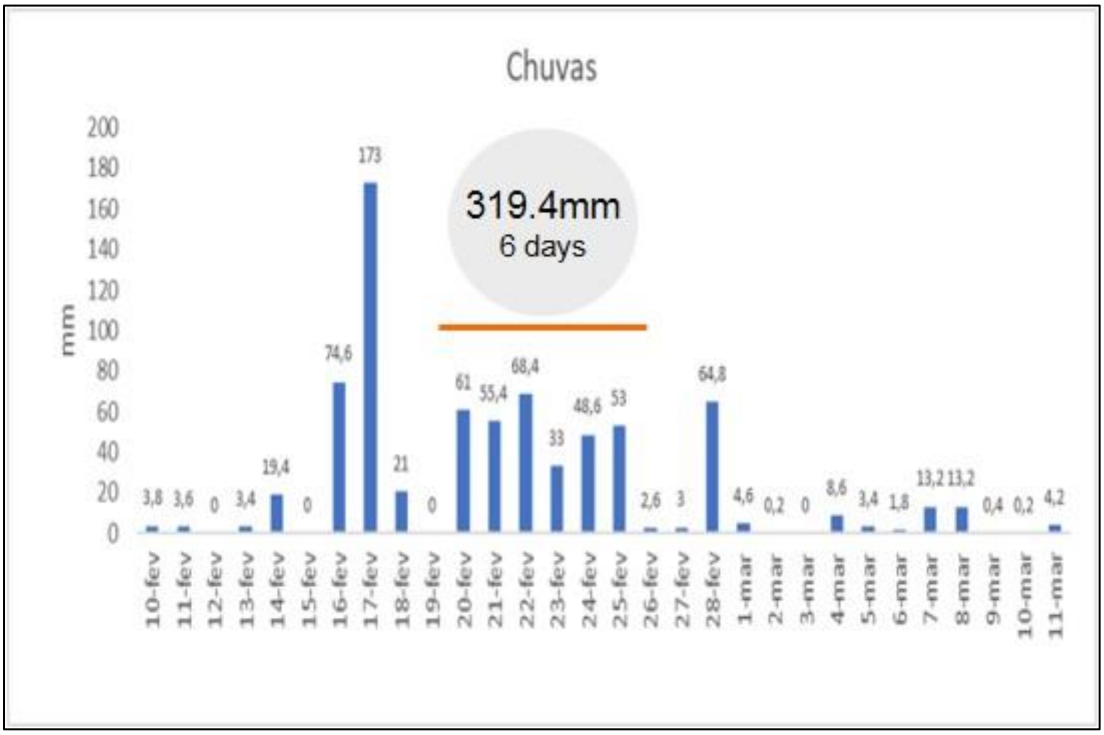

Figure 4.1 Rainfall event

4.3 Sequence of Events

The operational sequence of events below indicates the approximate timeline of events from February 16th to March 3rd as determined by the Task Force. This is based on information given by Alunorte operational areas. Note that the times given are indicative to the best knowledge of the Task Force.

February 16th:

- 23:30, Alunorte: Heavy rainfall started.
- Around 24:00, Area 82: Lightning struck the substation feeding the effluent treatment plants 82 C/D/E. The capacity in the Effluent Treatment Plant (ETP) was lowered, but maintenance resources were mobilized and returned the ETP to normal operation at 01:00.

February 17th:

- 00:00, Area 45: The sump in area 45 went up to 100% in less than one hour, and the sump was flooded at around 01:00. The area remained flooded for six days. The Task Force has not found any signs of overflow to the outside.
- 06:20, Area 82A – Mixing box: Canal Velho was opened until 13 00.
- Time before 07:00 Area 82A: The plant effluent circuits coming to the mixing box showed low caustic concentrations.
- 07:00 (Approximately) Area 82: The collecting basins in the effluent treatment area were rising and reached a critical level of 98% (no freeboard)

- Overflow from Canal Novo into Canal Velho
- The sedimentation basins in the Bauxite Storage area overflowed to Canal Velho because of low capacity of the pumps.
- 13:30, Alunorte: There was a voltage dip in the power supply from outside Alunorte. This voltage dip led to power failure/problems in different parts of the refinery. It took around 12 hours before all lines and equipment were back in operation.
- Around13:30, Area 82A Mixing box: Overflow in spent liquor tanks from the refinery Area. Caustic concentration levels in the overflow were up to a max of 133.9 g/l. and went through the process effluent circles to the holding pond in the mixing box area. Failure in mixing box: The return lines to return the overflow from the process caustic to the plant did not work properly.

February 17th to 21st:

- The subsequent contamination of the drainage circuit and failure of the return system from collection box to mud circuits caused a significant reduction in the flow rate to the ETP.
- The heavy rainfall the 16th and 17th reduced the freeboard level from 3.25 m on February 15th to 1.0 m on February 18th.
- Due to the high levels in A82, pumping was limited from DRS1 BC1 & BC2 until the 22nd of February causing low freeboard in DRS1 BC1& BC2.
- February 17th from around 15:00, DRS1: Flow from BC 1 and 2 in DRS1 was restricted due to the high levels and capacity restrictions in area 82 C/D, and this lasted until February 22nd. In the period between 17th and 22nd DRS1 was pumping on some occasions, but with reduced flow.
- February 20th 23:40, Area 82A: Canal Velho was opened and kept open for 6,5 hours until 06:10 the 21st.
- February 21st 21:30, Area 82A: Canal Velho was opened and kept open for 10 hours until 07:45 the 22nd.

February 22nd:

- 04:00, DRS1: Flow to Area 82 C/D/E started through the two concrete pipes and the steel pipe, the effluent treatment capacity was back to full capacity

February 25th:

- 00:20, Area 82A: Old channel was opened and kept open for 11,5 hours until 12:00

March 3rd:

- Pumping from the holding ponds in DRS2 to effluent treatment started

4.4 DRS1 and DRS2

4.4.1 Solid residue deposit number 1 - DRS1

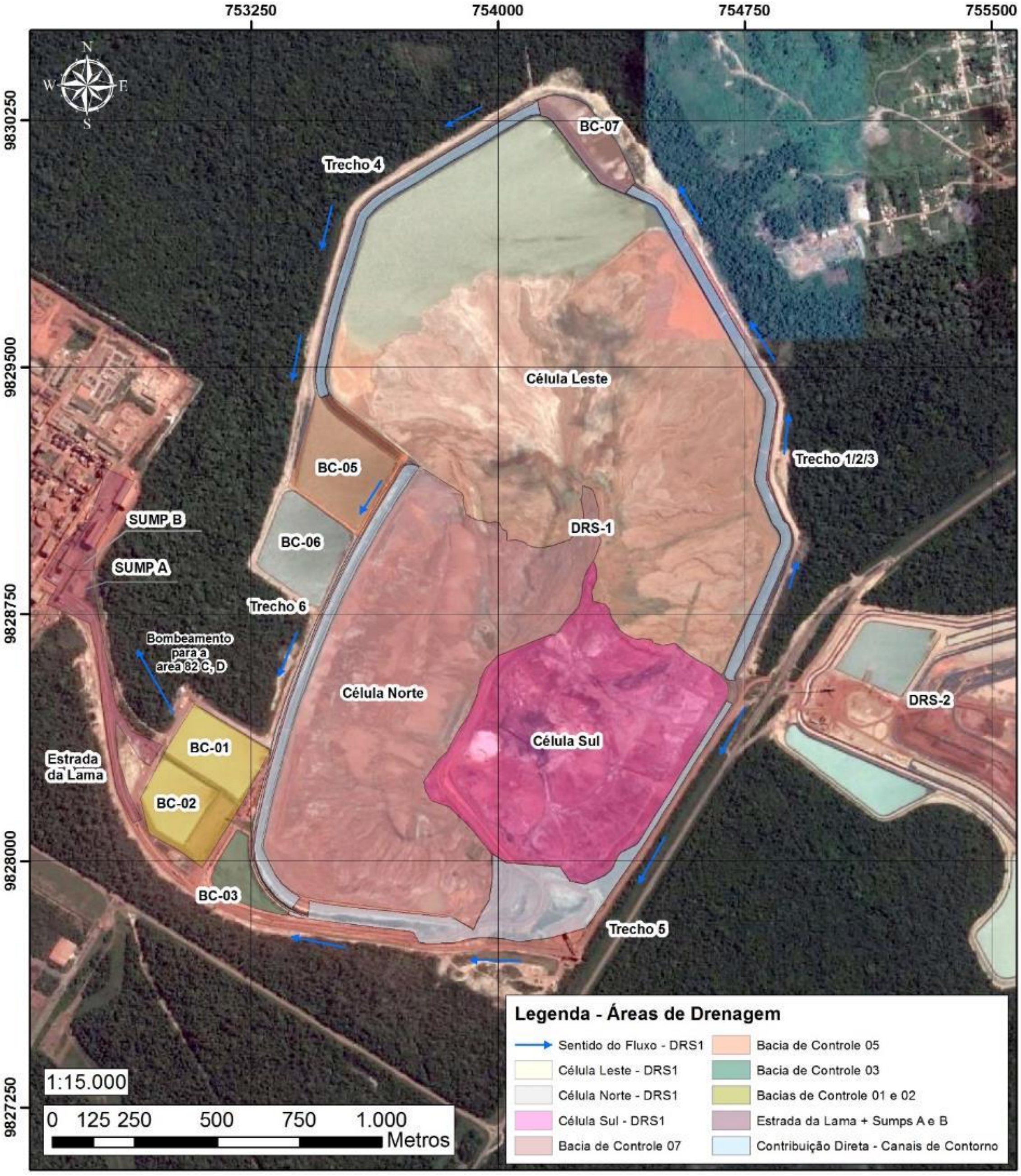

Figure 4.2 DRS1 deposit areas and Control Basins 2018.

DRS1, Solid Residue Deposit number 1, is the first deposit area of Alunorte.

The deposit area in DRS1 is built with a geomembrane (HDPE) in the bottom. Around the whole perimeter of DRS1, there is a HDPE lined contour channel to collect effluents from the deposit area and lead these into the different control basins (BCs).

The effluents from DRS1 are routed from the control basins in DRS1 in two ways, either through BC1 and BC2 to Area 82C/D by gravity flow through concrete pipes, or through the control basins BC5 and BC6 to Area 82E by pumping.

The control basins BC5 and BC6, originally dedicated for DRS1 and DRS2 respectively, were built in 2013 and 2015.

The current DRS1 deposit area is around 3 km^2. It is composed of storage cells for bauxite residue and control basins for effluent run off. The contour channels around DRS1 collect the water from the cells and lead this to the Control Basins (BCs).

The eastern cell, including the storage cells CL2 and CL3 are the last cells in operation in DRS1, and they are currently used for mud storage from the old drum filters. The effluents from these areas are drained via the contour channel to control basin BC5. A connection to BC6, originally designated to DRS2, was made in 2016.

The effluents in the older southern and northern cells are drained to the contour channel and further to BC3, BC2 and BC1. In this area, press filter material is currently placed on top to level and compact the area for the planned DRS1 closing.

Control basins BC1 and BC2 can - through the contour channel - receive effluent from the entire system that makes up DRS1. In BC1 and BC2 there are pumping systems that direct the effluents into the feed boxes and concrete pipes, which then by gravity lead the flow to the industrial effluent treatment plant in Area 82 C and D.

The Control basin BC6 was originally dedicated to the runoff from only DRS2, but since the DRS2 is in commissioning phase, it has the possibility to serve both deposit areas. From BC6, the effluents are pumped to Area 82E through a 24-inch steel pipe.

Around midnight (00:00) February 17th, the flows from BC1 and BC2 were stopped due to the reduced ETP capacity. The freeboard of DRS1 is shown in Figure 4.3: The variations in the freeboard (borda livre) in DRS1 as measured (taken from the Alunorte Plant Operations system - blue is actual, grey is forecast for extreme situation) Figure 4.3. The heavy rainfall the 16th and 17th reduced the freeboard level from 3.25 m on February 15th to 1.0 m on February 18th.

The freeboard level was below minimum requirement of 1 m from around February 18th to 26th.

Pumping from DRS1 via BC1 and BC2 to area 82 started February 22nd at around 04:00 when the levels in DRS1 were high. DRS1 utilized the full volume of BC6 since there was no problem with effluent levels in DRS2.

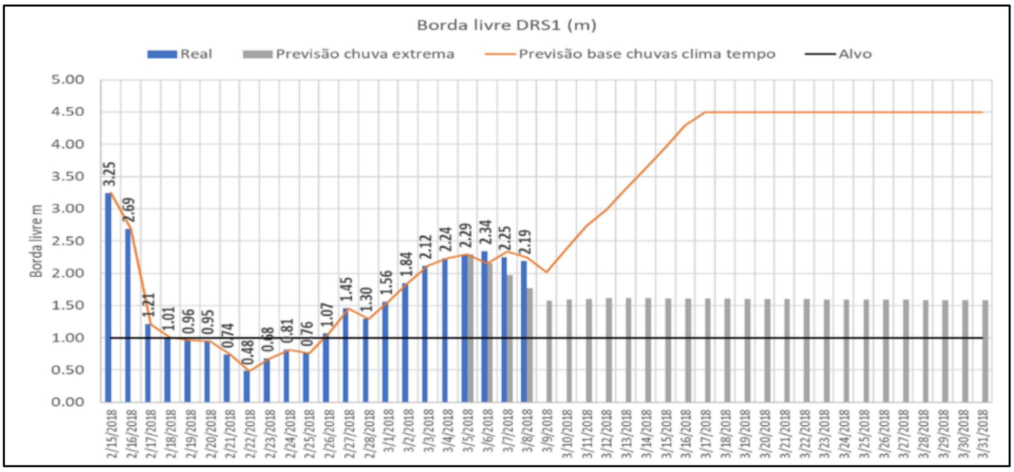

Figure 4.3: The variations in the freeboard (borda livre) in DRS1 as measured (taken from the Alunorte Plant Operations system - blue is actual, grey is forecast for extreme situation)

February 22nd Operations started emergency works to place out sand bags and heighten levels around DRS1, to avoid overflow as a safety measure.

The Task Force has concluded that DRS1 did not overflow during the entire rainfall event. Site inspection along the full perimeter of DRS1 and inspection of drone photos and videos confirm this conclusion.

<u>Recommendation:</u>

Chapter 4.5.1.

Figure 4.4 DRS1 Drone photo 24.02.2018 – DRS1 seen from north west.

Figure 4.5 DRS1 east zone and west part of DRS2. Highway PA-481 separating the deposit areas.

Figure 4.6: DRS1 (front) and Industrial plant (behind) – showing situation February 24th.

4.4.2 DRS1 Closure/Decommissioning

The closure planning of DRS1 has been initiated. This closure will have a material impact on future water management since DRS1 is over 50% of the water shed for the entire site. Alunorte has developed a draft closure plan which has been through a review in October 2017.

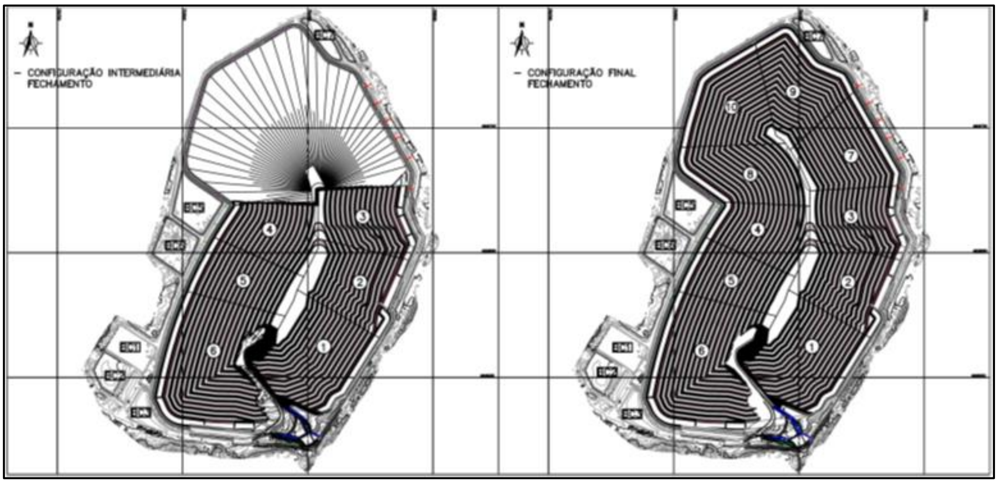

Figure 4.7 DRS1 closing

The review showed that it was necessary to improve and mature the project. The feasibility study is key since it will form the basis for selecting the most sustainable closure method.

The closure scenario has investigated the safety of the anticipated slope angle of the residue deposit. It has been checked and confirmed that the minimum safety factor is between 1.6 (profile north) and 3.1 (profile south) at end of construction, compared to a minimum safety factor in Brazil of 1.5.

An expert advisory group has been established, and a workshop was held on February 26th and 27th, 2018, to provide input to formulating a feasibility study from which a concept selection and a recommendation for how to proceed can be derived.

The expert team advised to test 4 different approaches. (Variations of method from Press-filter/soil mix and vegetation over into composite design using drainage layers and seepage collection).

By reducing the total water shed through gradually closing DRS1 and diverting clean run off outside the "system where water needs treatment" will release more capacity to manage extreme rainfall events on site.

<u>Recommendation:</u>

Progress closure project for DRS1.

4.4.3 Solid residue deposit - DRS2

DRS2, Solid Residue Deposit number 2, shall be the next deposit area in Alunorte. The DRS2 deposit has a lower footprint compared to the old DRS1.The press filters deliver residue to DRS2 with less caustic and water content compared with the drum-filtered material historically having gone to DRS1.

The residue area is estimated to last for around 10 years of deposit storage with the regular production level.

The entire DRS2 area is covered with a HDPE geomembrane. DRS2 is designed to receive dry residue from the press filters through a pipe conveyor. Commissioning of the press filters started in 2016, and the first material was placed in DRS2 in July 2017.

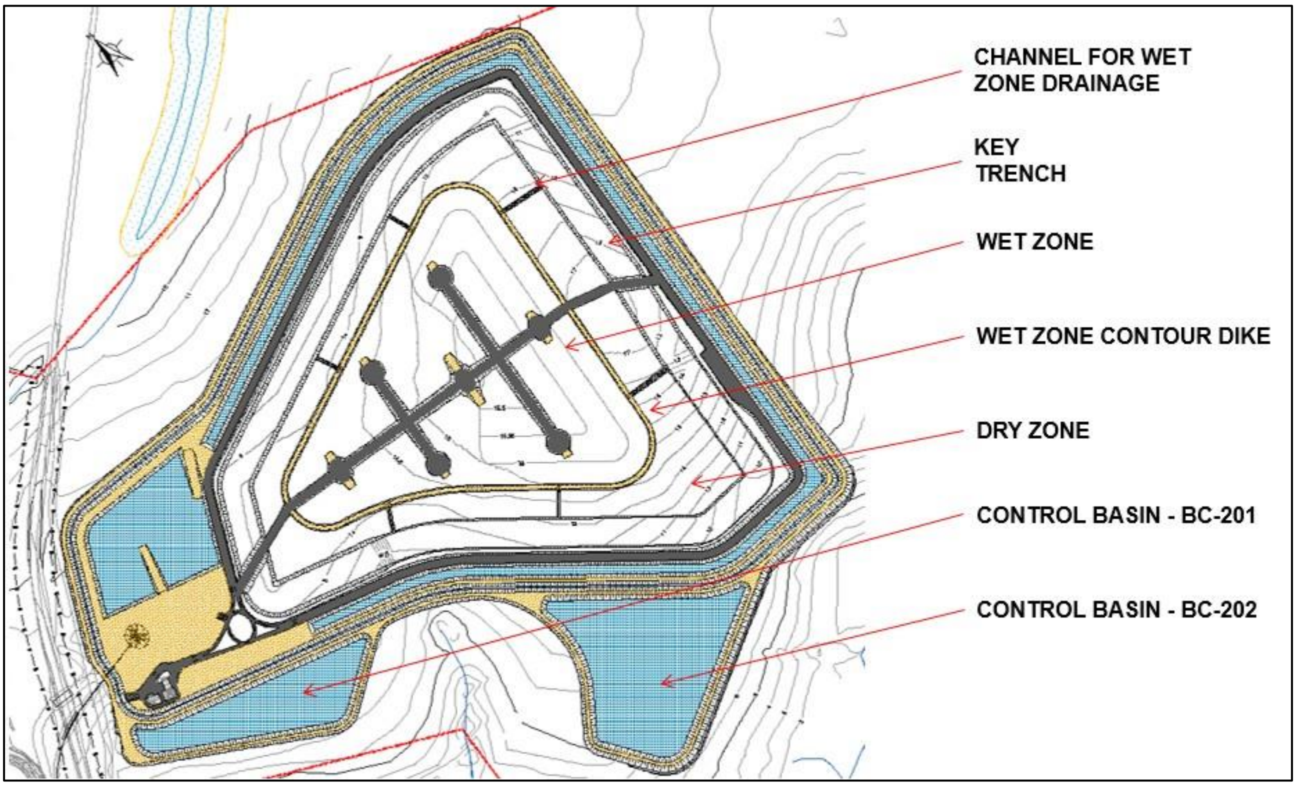

Figure 4.8 DRS2 design

The waste deposit area of DRS2 (press filter material) is composed of a single contributing area that drains the effluent volume into the internal channel by means of surface drainage when the waste reaches a certain elevation. The external channel further receives the effluent from the internal channel and leads the water to the control basins.

From the control basins, the effluents are directed to BC6 in DRS1, and from there to the effluent treatment plant 82E through a 24inch steel pipe. The pipe is dimensioned for the full capacity of DRS2.

The Task Force has concluded that DRS2 did not overflow during the rainfall. Site inspection along the full perimeter of DRS2 and inspection of drone photos and videos made available show no signs of overflow. Figure 4.9 shows the free board curve for BC201 and 202 from the Operational system, shows that the free board is decreasing from 4.1 m February 16th to 1.4 m March 2nd due to the rainfall. During this period, no pumping out of the reservoir was performed, the water was kept in the reservoir to utilize BC-6 for DRS1 effluents. Pumping to BC-6 started March 3rd.

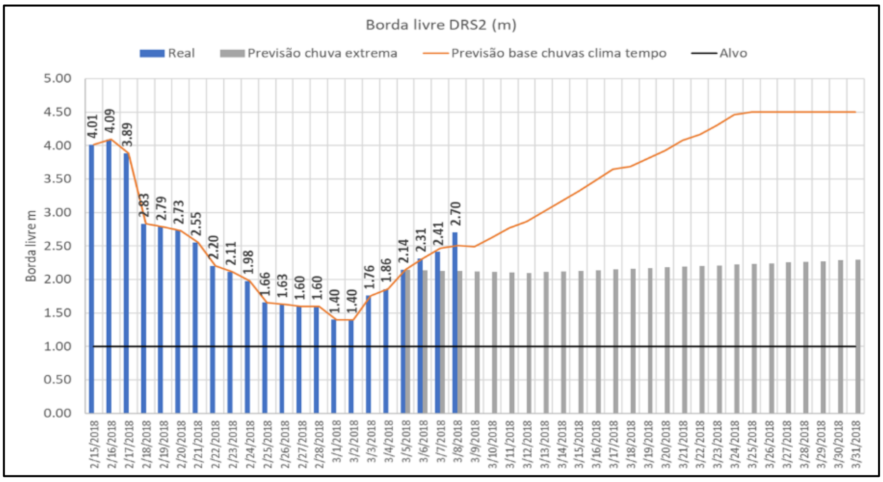

Figure 4.9: Free board of BC201 and 202 in DRS2 during the rainfall event; blue is actual, grey is forecast for extreme situation

Figure 4.10: DRS2 drone photo March 2nd, 2018 –DRS2 when the free board was the lowest during the event.

The picture below shows a flow through a dedicated low point from the waste reservoir according to design.

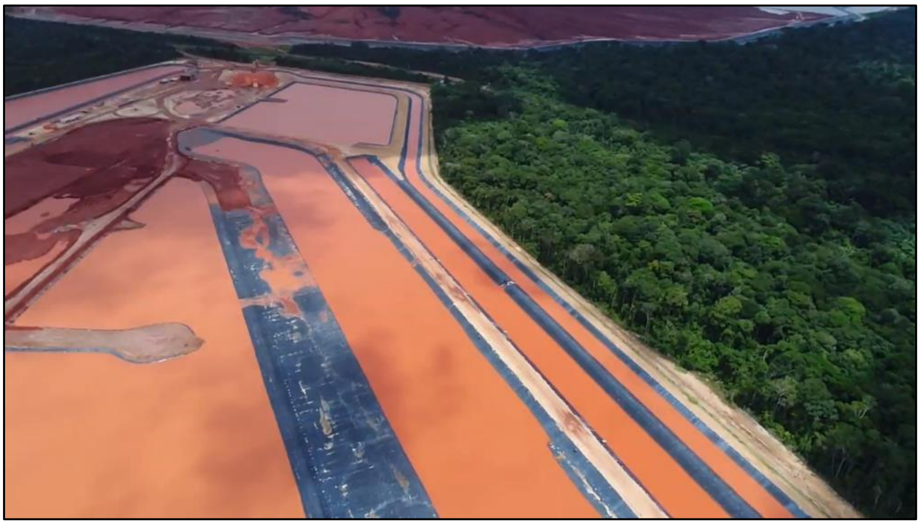

Figure 4.11: Section of DRS2 – Drone photo March 06th, 2018

Recommendation:

See Chapter 4.5.1.

4.4.4 Effluent transport system from DRS1 and DRS2

Two concrete pipes, each one with a diameter of 1m, provide transfer of effluent waste water by gravity flow from DRS1 to the Effluent Treatment Area 82 C/D. The start of the pipes are two collecting ponds next to BC1 and BC2. The boxes are filled with effluents by pumping.

Figure 4.12 Effluent box in DRS1 showing permanent and mobile pumping into the box

The pipes are buried at the start of the pipe route in DRS1, and the routing is then above ground until the last stretch into ponds in Area 82 C/D, where the pipes are again buried.

A stretch in Area 45 is higher than the ground level in the area, and during the rainfall it worked as a barrier to keep the storm water in Area 45 within the plant perimeter.

Figure 4.13 Effluent pipes from DRS1, picture facing towards DRS1

Figure 4.14 Effluent pipes in Area 45, steel pipe from DRS2 shown in the middle

The pipes have been inspected for cracks on a regular basis and cracks are repaired as soon as they are discovered. All repairs are documented in reports.

Figure 4.15 Example of small repairs of concrete pipes

Recommendation:

Install new transfer pipes and pumping facilities from the DRS1 to Effluent Treatment Plant. This has already been sanctioned by Alunorte as part of the Water Management Improvement Project.

4.5 Alunorte Effluent Treatment System

4.5.1 General

The total rain catchment area of Alunorte is around 5.5 km². The water management system must be able to control and treat the effluent waters from the process and storage areas. The industrial plant contributions to the rain catchment area is around 1.5 km².

The site has allocated the water management responsibilities for various sections to different organizational units. The operation of the system is not centralized.

DRS1 is capable to manage a major rainfall event.

Holding basins at DRS1 are accumulating sediments to about 50% of the capacity of the basins towards the end of the 2-year maintenance schedule.

DRS1 and DRS2 represent the major part of the Alunorte water shed. The DRS2 with pumps and treatment is built according to the latest standards.

The Task Force has identified a need for upgrading the drainage pipes within the plant area in order to separate clean water from water needing treatment

The power outage showed that there is a need for a more robust system to avoid high concentrate liquor going to the ETP.

Recommendation:

- Conduct a new Water Balance Study and re-establish design parameters for the whole system design.

- Upgrade Alunorte drainage system to facilitate better separation of clean storm water from water needing treatment including control systems.
- Integrate the holding basins at the Bauxite Residue deposits (DRS1 and DRS2) as one system utilizing total capacity.
- Reduce external water consumption through reuse of internal water.

4.5.2 Area 82 – Effluent treatment area

All the effluent streams from DRS2, DRS1 and process areas including storm water are controlled and treated in the effluent treatment plant as illustrated in figure 4.16. Discharges are monitored out of the ETP and discharged to Para River.

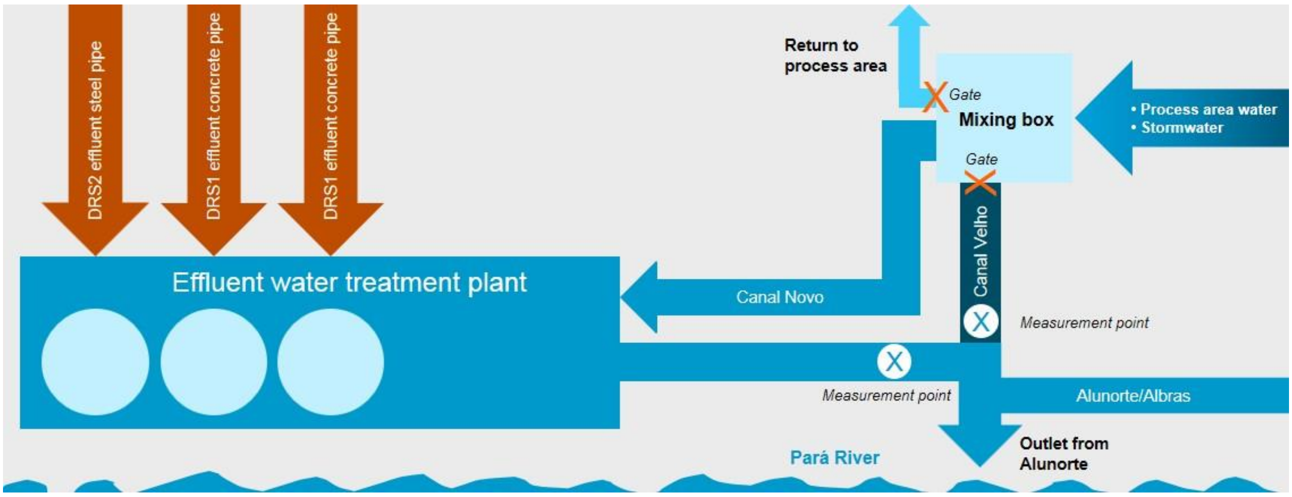

Figure 4.16 Principle of effluent treatment plant at Alunorte

The effluents from sources within the process areas in the plant, including storm water, are led to the "mixing box", a system to classify the effluent in terms of caustic content and pH. No clean waste water is separated in the mixing box area, and all effluent water going through to the ETP in Area 82 is treated in the effluent treatment plant. After treatment, the water is measured and discharged to the Para River. I.e. all collected storm water and surface drainage water is going through this area of the plant.

Figure 4.17 Drone photo of Area 82 March 6th, 2018

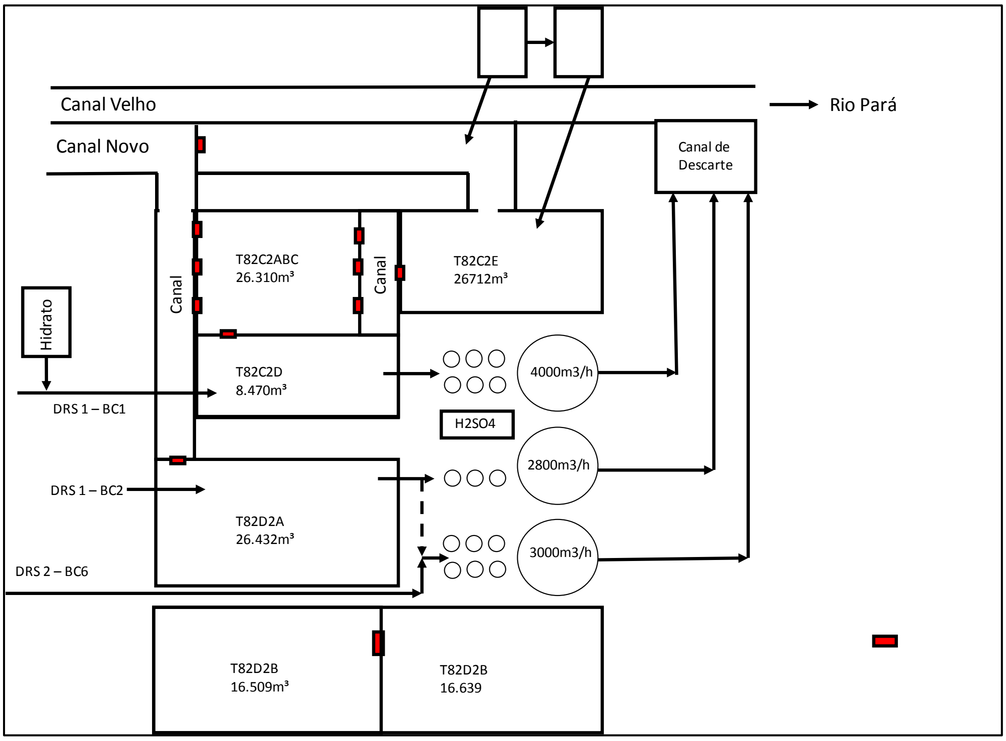

Figure 4.18 Area 82 B/C/D/E

In the inlet to the "mixing box" system, the 7 refinery effluent circuits CC1-CC7 are continuously monitored by conductivity instruments and with floodgates that in case of contamination, pH above 9, could be able to divert each current from the normal circuit box, to the collecting pond (contaminated solution), and from this collecting pond are pumped into the process circuit (mud circuit).

The pipes routed to the mixing box are buried concrete pipes with 1500 mm diameter.

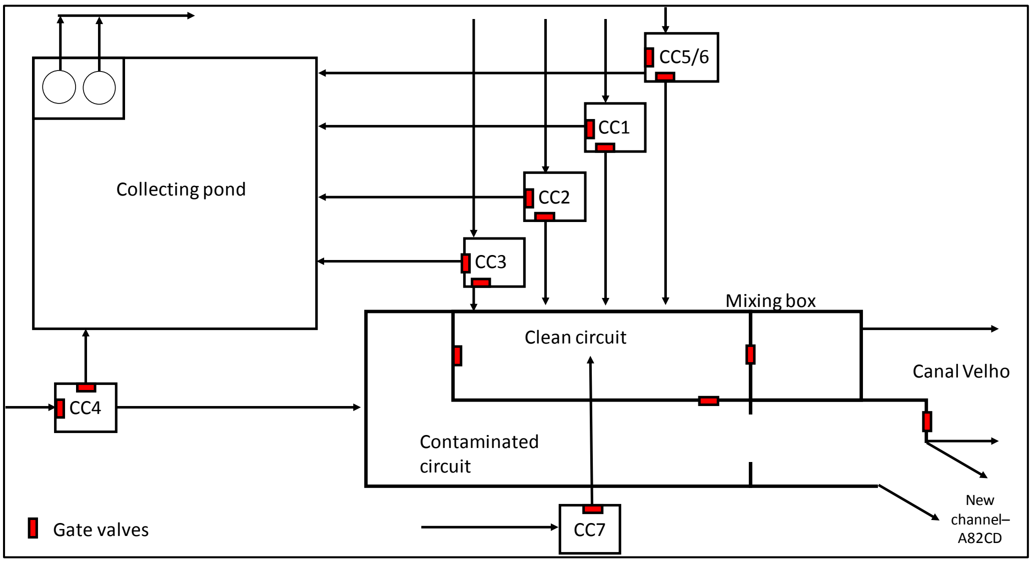

Figure 4.19 Mixing box Area 82 A.

<u>Recommendation:</u>

- Increase effluent treatment capacity by 50% before next rainy season. This is already sanctioned by Alunorte.
- Upgrade mixing box system to prevent process effluents from plant to impact the Effluent Treatment Plant negatively.
- Establish one control room for the total water effluent treatment system with improved rainfall prognosis, alerts, communications, modelling capability and instrumentation devices.
- Improve capacity in the whole effluent water system by removing silt more frequently and avoiding pumping silt from the DRS1 and DRS2 to the Effluent Treatment Plant.

4.5.3 Area 45

Area 45 has been used as a plant laydown and storage area (not waste related) as well as for contractor offices and temporary workshops.

This area was flooded after one hour of the rainfall and remained flooded for six days.

The reason for this was that the pumps in the drainage sump in area 45 did not have sufficient capacity to pump away the water.

Following the flooding, the area was drained using mobile pumping equipment. The task force has been informed that the sump pumps are now in normal service.

<u>Recommendation:</u>

Build more holding basin capacity in the old lay down area (Area 45). This is already sanctioned by Alunorte. A new storm water system including holding pond capacity and sufficient pumping system will be constructed.

Figure 4.20 Area 45 during the flooding

4.6 Environment

4.6.1 External Environment

Stakeholders have expressed concerns with regards to the environmental impacts from ongoing operations and unintended incidents such as extreme rainfall events. This includes effect to humans, air, water, soil, vegetation and groundwater.

To address these concerns a scoping study for a holistic baseline and effect study was initiated in 2017.

Several water streams originate at Alunorte premises. One of these is Murucupi which is being monitored bimonthly both from two sampling points (Figure 4.23).

Figure 4.21 Monitoring stations in Murucupi River

The Al and Fe concentration in the Murucupi upstream and at Estação Conhecimento, which is in an urban area, suggest natural occurrence of Al and Fe in concentrations which are typical for a lateritic environment, (B.I.Kronberg1W.S.Fyfe1O.H.LeonardosJr.2A.M.Santos3, 1977)

After the events of February 2018, Instituto Evandro Chagas (IEC) and FUNASA (Fundação Nacional de Saúde) took samples for chemical analyses inside and outside Hydro boundaries. The Task Force does not comment on the results of the IEC.

FUNASA report shows contamination by coliforms in shallow wells in the community. Among the metals, only Al, Fe and Mn were analyzed and Al and Mn were not detected in any well. All metal concentrations are below drinking water limits.

The Bom Futuro community is located to the northeast of Alunorte and close to a landfill. Information indicates that some of the houses have shallow wells extracting water from the highest near surface aquifer. There is a chance that the aquifer is already contaminated with leachate generated in the upgradient landfill considering it is an open pit without liner or containment.

In the Bom Futuro village coliforms can be present in the wells since there is no sewer collection system or basic sanitation in this village.

Coliforms in these shallow wells are not related to the industrial effluent from Alunorte. All sanitary wastewater generated at the Alunorte plant is treated in an onsite sewage treatment plant. The treated effluent is discharged into the ETP and enters the Para River.

The regular monitoring in the Para River is bi-monthly. During the heavy rainfall event, the monitoring was intensified to several samples per day both in the exit canal and in the Para River, weather permitting. In the discharge channel, where water was led out, the monitoring data demonstrates the pH limit was marginally surpassed for very short periods. However, on average effluent concentration was well within the prescribed limits between pH 6 - 9.

To put this into perspective, since the estuary is brackish water (water influenced by the sea) the near shore pH in sea-water can go to 8 – 9 naturally.

<u>Recommendation:</u>

- Initiate and perform a baseline and effect study for the operations to create an overall overview of the status as basis for future monitoring. The investigation to cover the larger Barcarena area.
- Invite academia in Para Brazil/Norway to participate in designing and performing a high quality environmental R&D program – comparable to the Biodiversity Research Consortium Brazil – Norway.

4.6.2 Internal Environment

The site operates a number of groundwater monitoring wells which surrounds the plant site, the DRS1 and DRS2.The wells are sampled bimonthly and analyzed.

Figure 4.22 Overview of monitoring wells at Alunorte, excluding DRS2

Figure 4.23 Monitoring wells at DRS2

<u>Recommendation:</u>

Review and improve the environmental monitoring so it becomes more representative, frequent, with higher quality and for more parameters.

4.6.3 Permits and licensing and regulatory follow up

This review has focused on licenses relevant for the extreme rainfall event. It was not conducted as a systematic compliance review.

The Task Force has observed the use of Canal Velho without a permit issued by the environmental authorities.

There is one effluent channel from Albrás which is discharged into the Alunorte discharge channel before it reaches the Pará River. Albras is responsible for the channel environmental permit as well for the effluent discharge quality. Alunorte has also discharged storm water from the coal shed area into the Albras Channel This practice has been discontinued.

<u>Recommendation:</u>

Review relevant permits and licenses.

4.7 Risk and Vulnerability Analysis - Emergency Management

During heavy rainfalls, the emergency focus at Alunorte is on preventing overflow from DRS1 and DRS2.

The heavy rainfall event in combination with other unexpected, cascading events led to reduced capacity in the ETP which led to challenges in managing effluent waters at Alunorte.

On an operational level, the events were mitigated through technical and operational actions, minimizing environmental consequences, and protecting the integrity of the bauxite waste deposits.

Recommendation:

Evaluate emergency practices and exercises associated with potential combinations of multiple cascading effects.