SUDBURY
INTEGRATED NICKEL
OPERATIONS
A GLENCORE COMPANY

2019 Annual Report on the Action Plans

Site Specific Standard Approvals:
SO_2 (1 hr) #501-12-rv0
SO_2 (24 hr) #502-12-rv0
Cadmium (24 hr) #501-13-rv0
Nickel (annual) #501-15-rv0

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Submitted to Ministry of the Environment
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1. Introduction

This report provides a summary of progress to date (up to the end of the 2019 calendar year) on the action plans associated with the site specific standards approvals for Sulphur Dioxide (1 hr. and 24 hr.), Cadmium (24 hr.) and Nickel (annual) as follows:

- Sulphur Dioxide (1 hr) Site Specific Standard Approval #501-12-rv0
- Sulphur Dioxide (24 hr) Site Specific Standard Approval #502-12-rv0
- Cadmium (24 hr) Site Specific Standard Approval #501-13-rv0
- Nickel (annual) Site Specific Standard Approval #501-15-rv0

Although the action plans have been completed with respect to the Cadmium and Sulphur Dioxide Site Specific Standards, Glencore applied to amend the completion date of the action plans in early 2018. The SO_2 1-hour, 24-hour and Cadmium Site Specific Standard action plan completion dates have all been amended to July 31st, 2020.

Glencore submitted new 10-year site-specific standard applications for both sulphur dioxide and cadmium in April of 2018. After some consultation with MECP, Glencore is currently working on an Industry Standard with Vale for Sulphur Dioxide.

Detailed Engineering and execution for the Sudbury Smelter Process Gas Project Phase II is ongoing to complete the action plan outlined below. The Secondary Gas system was completed in the September 2019 maintenance shut down and has been operating since that time. The following equipment was installed in 2019:

- Secondary fan building.
- The new 65m stack.
- Secondary hooding for each vessel and for matte granulation.
- Re-routing of the granulation tank exhaust and matte granulation dryer exhaust to the 93m stack.

Controlled Furnace atmosphere (CFA) technology was installed during an extended maintenance shut down in 2015 and has been operational since Q4 of 2015. Several challenges were encountered with operating the furnace under CFA conditions. A team of several engineers worked through the challenges over the last three years. The challenges that the commissioning team faced were as follows:

- Equipment reliability (analyzers, burners, make up air fans).
- Flow management and optimization for oxygen levels – including tuning of suction on the furnace to minimize air ingress and run closer to neutral.

- Off-gas system blockages caused by high temperatures in the uptakes.
- Smelting rate in the Electric Furnace.

As with any new process it takes several months and even years to optimize related processes.

Site Specific Standard Project History

Glencore's Sudbury Integrated Nickel Operations operates a nickel-copper smelter in Falconbridge, Ontario (the Facility). The facility smelts nickel-copper concentrate from the Sudbury and Raglan mines and processes custom-feed materials. The process uses an electric furnace to smelt the concentrate into a high-grade matte containing nickel, copper, cobalt and platinum group metals. A by-product of the process is SO_2 emissions as well as Nickel and Cadmium fugitive emissions. The product, smelted and granulated matte, is transported to the Nikkelverk refinery in Norway. The facility has a maximum annual production rate of 135,000 tonnes of matte.

SO_2 emissions from the smelter were previously regulated by an Ontario Government Control Order, which placed an annual limit on emissions. The control order requirements are consistent with Ontario's Industry Emissions — Nitrogen Oxides and Sulphur Dioxide Regulation (O. Reg. 194/05) that places new annual SO_2 emission limits and intensity targets for the Sudbury Smelter as of 2015. To meet these limits, Sudbury INO has implemented significant improvements to its environmental performance, specifically by increasing sulphur capture in the Acid plant and via the reduction of SO_2 emissions from the electric furnace. The reduction of SO_2 emissions from the electric furnace is a result of the installation of Controlled Furnace Atmosphere (CFA).

Additionally, under O Reg. 419/05 for SO_2, emissions are continuously monitored and operations are interrupted or curtailed so that ground-level concentrations (GLCs) do not exceed target levels measured at monitoring stations in the community. In addition to the community monitors, Sudbury INO Smelter has installed three early warning SO_2 monitors on the Glencore property that Smelter operations use to curtail prior to SO_2 impacting the town site.

An Emission Summary and Dispersion Modelling (ESDM) Report (prepared separately) has documented, according to the maximum emission rates, that a Site Specific Standard is required for SO_2, Nickel, and Cadmium Point of Impingement (POI) from the Facility. The modeling techniques used are conservative by design, and represent the maximum operating scenario. These "worst case" predictions are then compared to the standard. The ESDM Report does not fully take into account the interruption of smelter operations under certain weather conditions (curtailment) or the intermittent nature of the operations.

Sudbury INO Smelter has implemented the use of an online particulate monitor that is used to curtail Smelter operations when particulate from the Smelter is impacting the town site. In May of 2019, a second online particulate monitor was added to the control strategy to further minimize the impact of smelter operations on the community.

The Emissions Summary Dispersion Model was used to prioritize sources of SO_2, Nickel and Cadmium and identify technologies to reduce emissions from the Smelter. As part of the Technical Benchmarking process, the Sudbury INO Smelter investigated both Process Change Technologies and Add-on Control Technologies.

The following Process Change Technologies were assessed:

- High Roast, Controlled Furnace Atmosphere, Secondary Hooding in Converter Aisle, Use of New Stack and Improved Finishing Vessel Operating Practices.
- High Roast, Controlled Furnace Atmosphere and Optimize Existing Acid Plant – Temperature.
- High Roast, Controlled Furnace Atmosphere and Optimize Existing Acid Plant – Increasing Sulphur Capture in the 4-pass Converter.
- New Smelting Process – DON Process.
- Continuous Converting in Finishing Vessels only.
- Continuous Converting for Entire Aisle.
- Converter Aisle Blowing to Acid Plant.
- Electric Arc Furnace Gas to Acid Plant.
- Electric Arc Furnace Gas to Roasters.
- Increase Iron Content of Final Matte.
- Reduce Annual Production.

All of these technologies were assessed through benchmarking or through piloting test work to assess whether or not they were feasible.

The following Add-on Control Technologies were assessed:

- Regenerative Scrubbers for all Streams and Secondary Hooding in Converter Aisle.
- High Roast, Controlled Furnace Atmosphere and Regenerative Scrubber – Finishing Vessel.
- New Double Absorption/Double contact Acid Plant.
- Wet Gas Sulphuric Acid Plant.
- Regenerative Scrubber – Electric Furnace.
- Non-regenerative Scrubbing – Caustic.
- Non-regenerative Scrubbing – Dual-alkali.
- Non-regenerative Scrubbing – Lime.
- Non-regenerative Scrubbing – Soda Ash.
- Paques BIODESOX Process.
- Dry Flue Gas Desulphurization.
- Sulfacid Process™.

- Modern Dust Collector Technology.
- Installation of stacks on Roaster Roof Fans.

All of these technologies were assessed through benchmarking or through piloting test work to assess whether or not they were feasible.

Technologies that passed through the TBR and Economic Feasibility Assessment were then included in the Action Plans for SO_2, Nickel and Cadmium Site Specific Standards.

Progress on the Site Specific Standard Action Plan for Sulphur Dioxide (SO_2)

Overall progress on the action plan for SO_2 is provided in Table 1, with detailed information presented in Tables 2 and 3 for High Roast and Controlled Furnace Atmosphere technologies, respectively.

Table 1: Summary of Progress on Action Plan for SO_2 (1 hr and 24 hr)

Technology	Action Plan	Timeline	Progress to end of 2019
High Roast (HR) and Controlled Furnace Atmosphere (CFA)	1. Acid plant upgrades (appendix A)	1. 2009-2015	1. Drying tower, 4-pass converter, absorbing acid cooler and converter heat exchangers replaced in 2013. New tail gas re-heater was installed in 2014.
	2. Development of SMC/SCV hybrid vessel (adaptation for change in furnace matte composition under high roast)	2. 2009-2015	2. Completed – Reconfigured 7 SMC in a Hybrid vessel in 2014. Installed a new 8 Hybrid Vessel in 2015.
	3. Improve feed blending systems to stabilize metallurgical control	3. 2010-2015	3. Construction of 013 filter feed tank was completed in 2014. The conversion of two settled storage to agitated tanks was completed in 2015.
	4. Furnace sealing systems	4. 2009-2015	4. Completed in 2015 as part of the CFA project.
	5. Pilot scale trial of DC electrical furnace (DC may be more suitable for CFA than current AC furnace)	5. 2011-2014	5. Pilot test and Scoping Study completed in 2011. Plant trial completed in 2014.

Technology	Action Plan	Timeline	Progress to end of 2019
	6. Install new ductwork system to distribute acid plant tail gas to electric furnace and control split between furnace and smelter stack	6. 2011-2015	6. Completed in 2015 with the installation of CFA.
	7. Commissioning and Training for Controlled Furnace Atmosphere	7. 2015-2019	7. A commissioning team has been working on the new process since late 2015 and optimization of the process continues. (on-going).
Improve Finishing Converter Vessel Practices (FV SOP)	1. Develop Semtech converter monitoring system	1. 2010-2015	1. The concept was tested and the technology was not reliable. Investigating a new technology called LIBS.
	2. Ensure reliability of stack analytical monitor	2. 2012	2. Completed in 2012.
	3. Operator training program	3. 2010 – 2015	3. Produced metallurgical training modules and rolled the training out in 2016.
	4. Implement turn up/turn down blast air control	4. 2010 – 2015	4. Completed in 2011 with Glencore Process Support.
Secondary Hooding in Converter Aisle and construction of a New Secondary Gas Stack	1. Laser mapping of existing plant	1. 2010-2011	1. Completed in 2012.
	2. Development of detailed flow model	2. 2010-2011	2. Preliminary flow model completed as part of Feasibility study. Detailed model completed during Detailed Engineering in 2015.
	3. Refurbish 137m stack or build a new stack (appendix B)	3. 2015-2019	3. A revised plan was developed in late 2015 for the installation of a new stack. A new 65 m stack was installed in 2018 as part of the secondary gas.
	4. Installation of secondary fan to direct secondary gas from the Converter Aisle to a new 65m stack. (appendix B)	4. 2016-2019	4. The fan building, the fan, and the 65m stack were installed in 2018. The full system was operational as of October 2019.

Technology	Action Plan	Timeline	Progress to end of 2019
	5. Installation of secondary hoods, secondary fan and stack	5. 2015-2019	5. Civil construction - secondary hood foundations completed in 2015. The full system was operational as of October 2019.
Investigate other options	1. Conduct a Furnace Technology Assessment to identify other opportunities for reductions	1. 2010-2011	1. Completed as part of Options Analysis in 2011.
	2. Conduct Acid Plant tail gas engineering study to compare double contact/absorption design with CanSolv regenerative scrubbing	2. 2010-2011	2. Evaluation completed including a pilot trial in 2009 and a CanSolv/ Double absorption tradeoff study in 2011.
	3. Re-evaluate switching to Double Contact/Double Absorption acid plant design	3. 2011	3. Completed as part of Options Analysis phase in 2011.
	4. Re-evaluate Cansolv regenerative scrubbing	4. 2011-2012	4. Evaluation completed including a pilot trial in 2009 and Cansolv/Double Absorption trade-off completed in 2011.
	5. Assess heat recovery options to generate energy for scrubbing systems.	5. 2011-2012	5. Completed as part of Cansolv/Double Absorption in 2011.
	6. SO_2 Monitoring network upgrades and curtailment software upgrades (appendix B)	6. 2010-2017	6. Several upgrades were made to the curtailment software in 2011-2012 including enhanced SO_2 concentration and meteorological real-time and predictive components.

Table 2: Summary of Progress on Detailed Actions to Implement High Roast

	Action	Timeline	Progress to end of 2019
Acid plant upgrades	1. Cooling tower fan upgrades	1. 2009-2015	1. Completed in 2014.
	2. Engineering scoping study	2. 2010-2011	2. Completed in 2011.
	3. Drying tower replacement	3. 2010	3. Completed in 2010.
	4. SO_2 to SO_3 converter replacement	4. 2012	4. Completed in 2013.
	5. Replacement of converter heat exchangers (see photos in Appendix A)	5. 2012	5. Completed in 2014.
	6. Absorbing acid cooler replacement	6. 2012-2013	6. Completed in 2013.
	7. Cooling tower upgrade (see photos in Appendix A)	7. 2013-2015	7. Execution complete in 2014.
	8. Cross-flow stripper installation	8. 2016-2018	8. The cross-flow stripper was commissioned during the May 2018 shut down.
	9. Wet Scrubber replacement	9. 2013-2018	9. Wet scrubber was tied in during the May 2018 shutdown.
Development of SMC/SCV hybrid vessel (adaptation for change in furnace matte composition under high roast)	1. Engineering and computer modelling study	1. 2009-2012	1. Completed in 2012.
	2. Plant trial of hybrid concept	2. 2010-2013	2. Three plant trials completed.
	3. Ensure low metal content maintained in discard slag	3. 2011	3. This was proven in the 2010 Hybrid Vessel plant trial.
	4. Plant trial of porous plug N_2 injectors	4. 2012-2013	4. Completed in 2014
	5. Modification of #7 slag make converter to hybrid vessel	5. 2012	5. Completed in 2014 (appendix 1).
	6. Modify bins & feeding system for converter aisle	6. 2014-2015	6. Completed in 2015.
	7. Modify slag hauler access to converter aisle (See photos in Appendix A)	7. 2014-2015	7. Completed in 2015.

	Action	Timeline	Progress to end of 2019
	8. Installation of #8 hybrid vessel complete with hooding (See photos in Appendix A)	8. 2014-2015	8. Completed in 2015 – Several plant trials were run before installing the Hybrid vessel (appendix 1).

Table 3: Summary of Progress on Detailed Actions to Implement Controlled Furnace Atmosphere

	Action	Timeline	Progress to end of 2019
Furnace Sealing Systems	1. Install sealing systems a. Need to keep air out of furnace for Controlled furnace atmosphere b. Computational modeling study with NRCan	1. 2009-2015	1. Project completed in 2015 as part of the CFA project.
Pilot scale trial of DC electric furnace (DC may be more suitable for CFA than current AC furnace)	1. Collect 40 tonnes of feed from smelter for test work on real material	1. 2011	**1.** Completed in 2011 – Two DC arc campaigns were conducted as well as a plant scale test at the Smelter in 2014.
Install new ductwork system to distribute acid plant tail gas to electric furnace and control system.	1. Install new ductwork system to add Acid plant tail-gas (low oxygen air) to the electric furnace. Control tail gas split between the furnace and the 93m stack	1. 2014-2015	**1.** Completed in 2015 (appendix 1).

3. Progress on Action Plan for Cadmium

Table 4: Summary of Progress on Action Plan for Cadmium (24 hr)

Technology	Action Plan	Timeline	Progress to end of 2019
Installation of fugitive Emissions collection hoods and installation of a new stack.	1. Installation of baghouse on slag tapping ventilation exhaust	1. 2010	1. Completed in 2011.
	2. Laser mapping of existing plant	2. 2010-2011	2. Completed.
	3. Development of detailed flow model	3. 2010-2011	3. Preliminary flow model completed as part of the Feasibility Study.
	4. Construct a new secondary gas stack. (appendix 2)	4. 2011-2019	4. A detailed Assessment of 137m stack was completed in 2012 as part of Feasibility Study. A new 65 m stack was installed in 2018.
	5. Installation of secondary fan and direct secondary gas from the Converter Aisle to a new stack. (appendix 2)	5. 2015 - 2019	5. The fan building, the fan, and the 65m stack were installed in 2018. The full system has been operational since October of 2019.
	6. Installation of secondary hoods	6. 2015-2019	6. Civil construction - secondary hood foundations completed in 2015. The full system will be commissioned in late 2019.
	7. Redirection of gas streams from matte granulation to the existing 93 m stack	7. 2015-2019	7. The full system has been operational since October of 2019.

4. Progress on the Action Plan for Nickel

Table 5: Summary of Progress on Action Plan for Nickel (annual)

Technology	Action Plan	Timeline	Progress to end of 2019
Update Emissions	1. Annual Emissions reduction	1. 2015-2026	1. Updated in the ESDM annually.
	2. Update converter aisle Emissions	2. 2015-2026	2. Based on future monovent testing update the converter aisle emission rates.
Matte Granulation Emissions Collection and secondary hooding in the Converter Aisle and directed to a stack	1. Laser mapping of existing plant	1. 2010-2011	1. Completed in 2012.
	2. Development of a detailed flow model	2. 2010-2011	2. Preliminary flow model completed as part of the Feasibility Study.
	3. Construct a new stack or refurbish the 137m stack (appendix 2)	3. 2013-2019	3. A revised plan was developed in late 2015 to install of a new 65m stack that meets requirements. Completed in 2019.
	4. Installation of secondary fan and new secondary gas stack. (appendix 2)	4. 2015-2019	4. The fan building, the fan, and the 65m stack were installed in 2018. The full system was commissioned in late 2019.
	5. Installation of secondary hoods	5. 2015-2019	5. Civil construction - secondary hood foundations completed in 2015. The framework of the secondary hoods was installed in 2018 and the system was operational as of October 2019.
	6. Redirect gas streams from matte granulation to the existing 93m stack	6. 2015-2019	6. Detailed engineering and planning continued through 2017. Ducting tied in to the 93m stack in September 2019.
Investigate Emissions from the Roaster Roof Fans	1. Internal Housekeeping Dust control	1. 2015-2022	1. Continual improvement projects underway. Sampling campaign to identify significant sources in 2017.
	2. Evaluate Technology options in Roaster Roof Fan area	2. 2015-2022	2. Study completed with improvements to be implemented in 2020. Monitoring system (cameras and dust measures) completed in 2017.

Technology	Action Plan	Timeline	Progress to end of 2019
	3. Engineering assessment of Roaster Roof Fan 3m stacks	3. 2018-2022	3. Engineering study to be completed in the future. Improvements made to furnace bin covers during Jan 2019 shutdown.

5. Voluntary Actions since Site Specific Standard Approval

Table 5: Summary of Voluntary Actions to Reduce Metals Emissions

Action Plan	Timeline	Progress to end of 2019
1. Replaced all the Internals on the ESP on the 93m stack	2010 - 2013	Replaced the high voltage electrodes with new design and replace all the collection plates (increased particulate collection).
2. Addition of a second Tymco "regenerative" vacuum/sweeper truck	2011	Sweeper is dedicated to the Custom feed areas preventing fugitive emissions and track out.
3. Full assessment on the main Cadmium dust collectors and source testing	2012	Continual improvement projects resulted from the assessment and projects have been completed.
4. Dust Collector Management Plan implemented	2012	DCMP includes preventative maintenance, continual improvement, critical spares, and training.
5. Installed a new bin vent on the matte silo and a new baghouse on the matte loadout conveyor gallery	2013 – 2014	Replaced old out-dated dust collectors with more efficient modern units (appendix 3).
6. Installed new Transformer rectifier sets on all units in the main stack ESP	2013 – 2016	Increased voltage on the new TR sets will increase collection efficiency of the ESP.
7. Installed on-line particulate monitors on the property line as early warning devices (appendix 3)	2013 – 2017	Initially there was only one monitor but recently two more monitors were added. Based on on-line particulate measurements activities around the Smelter will be curtailed when Particulate is impacting the town.
8. Continual improvement projects to develop administrative controls around activities that produce fugitive dust.	On- going	As much as possible custom feeds are unloaded inside, custom feed is stored in covered roll off bins, piles outside are tarped, and conditioning material with dust suppression.

Action Plan	Timeline	Progress to end of 2019
9. Upgrades/ Improvements to Raglan Receiving facility	On-going	Review of baghouse design and upgrade to fan and filter media. Completed in Jan 2019.
10. Enclosing Matte Load-out conveyor	2016 – 2019	Although the matte loadout conveyor is covered, fully enclosing the conveyor would eliminate fugitive emissions. Completed in September 2019.
11. Installation of new PLC controlled rapping equipment on the main stack ESP	2016 – 2017	The addition of a PLC controlled rapping system allows the rapping program to respond to ESP conditions to yield lower particulate emissions.
12. Particulate Emissions Project		
a. Construction of an indoor concentrate unloading facility for Railcars and Trucks	2019 - 2020	The movement of these activities inside a building will further reduce TSP and all metal emissions. The buildings will be fitted with a baghouse to ensure negative pressure
b. Construction of a new ball mill to re-slurry concentrate	2018 – 2019	The new ball mill is attached to the end of the concentrate receiving facility. This will allow concentrate to be handled and re-slurried indoors and pumped directly to the Smelter. This eliminates fugitive emissions from handling and transportation. Completed in October 2019.
c. Construction of a new Package feed Receiving and Sampling Building	2019 – 2020	The movement of these activities into a building will reduce fugitive TSP and metals emissions. The building will also be fitted with a baghouse to ensure the building is at negative pressure.
d. Construction of a new building to house Revert crushing activities	2020 – 2021	The movement of these activities into a building will reduce fugitive TSP and metals emissions. The building will also be fitted with a baghouse to ensure the building is at negative pressure. This baghouse will also service existing custom feed buildings in the area.
e. Installation of a three season truck wash	2021	The truck wash will significantly reduce track out from trucks travelling around the site and leaving the site.

APPENDIX A
PGP Completed Projects

Figure 1. - Above: New collection hood on the Slag launder

Figure 2. - Right: New dust collector servicing the slag end launder. (2010)

Figure 3. - New Tail Gas re-heater (2014)

Figure 4. - New 4-pass converter in the acid plant to increase sulphur capture. (2012)

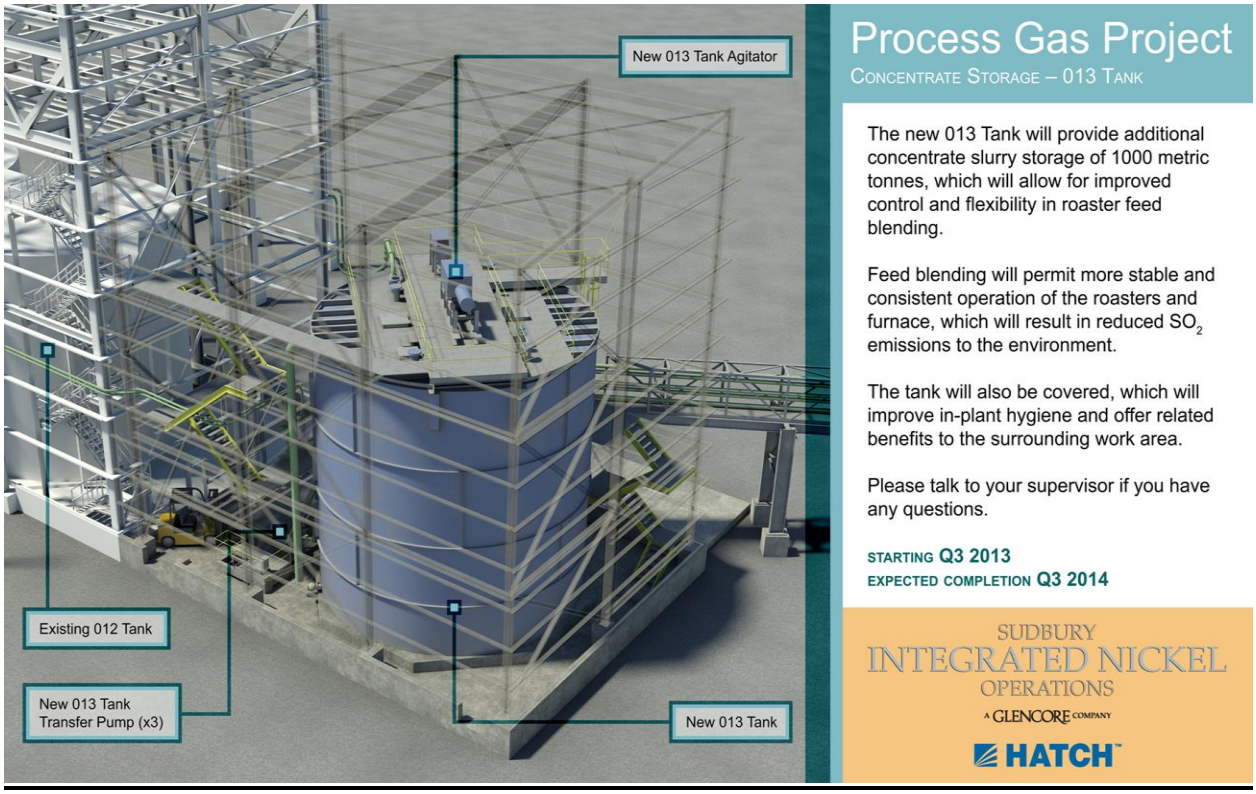

Figure 5 – New 013 Blend Tank – Complete in 2013

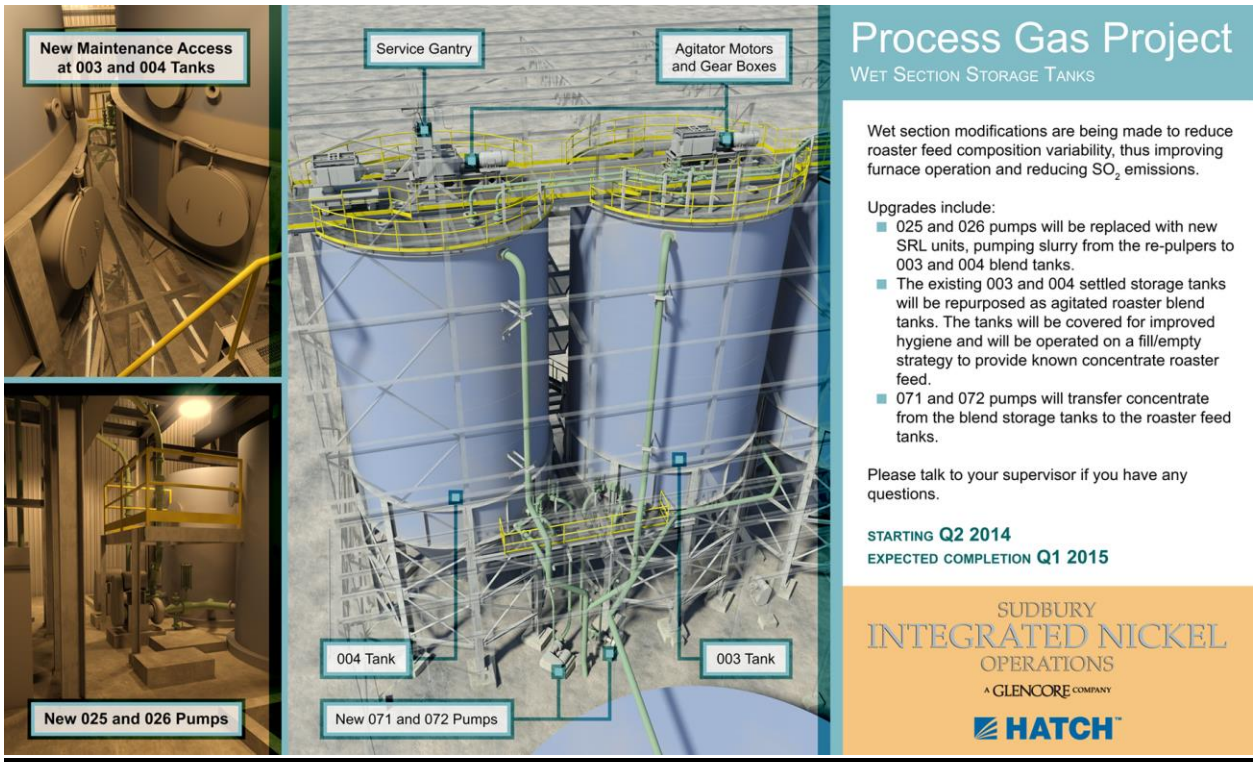

Figure 6. – New agitated storage tanks – Complete in 2014

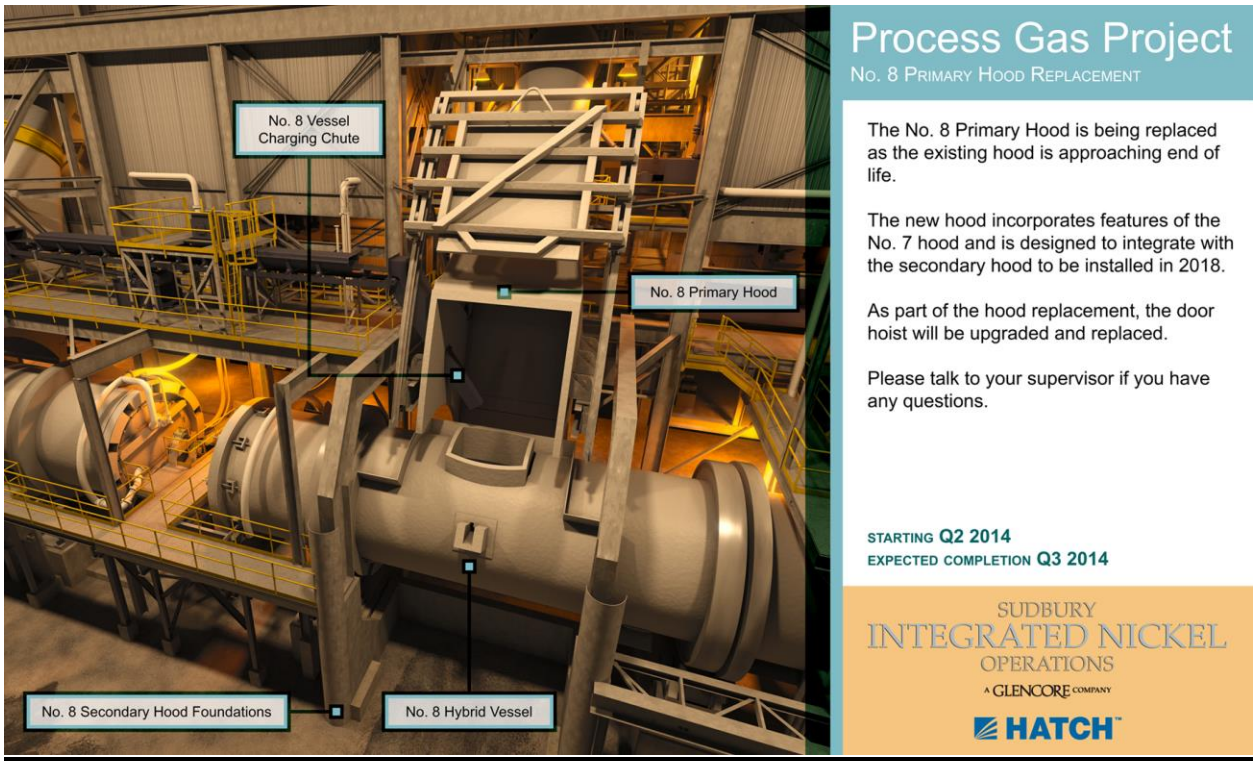

Figure 7. – New primary hood on #8 Hybrid Vessel – Complete in 2015

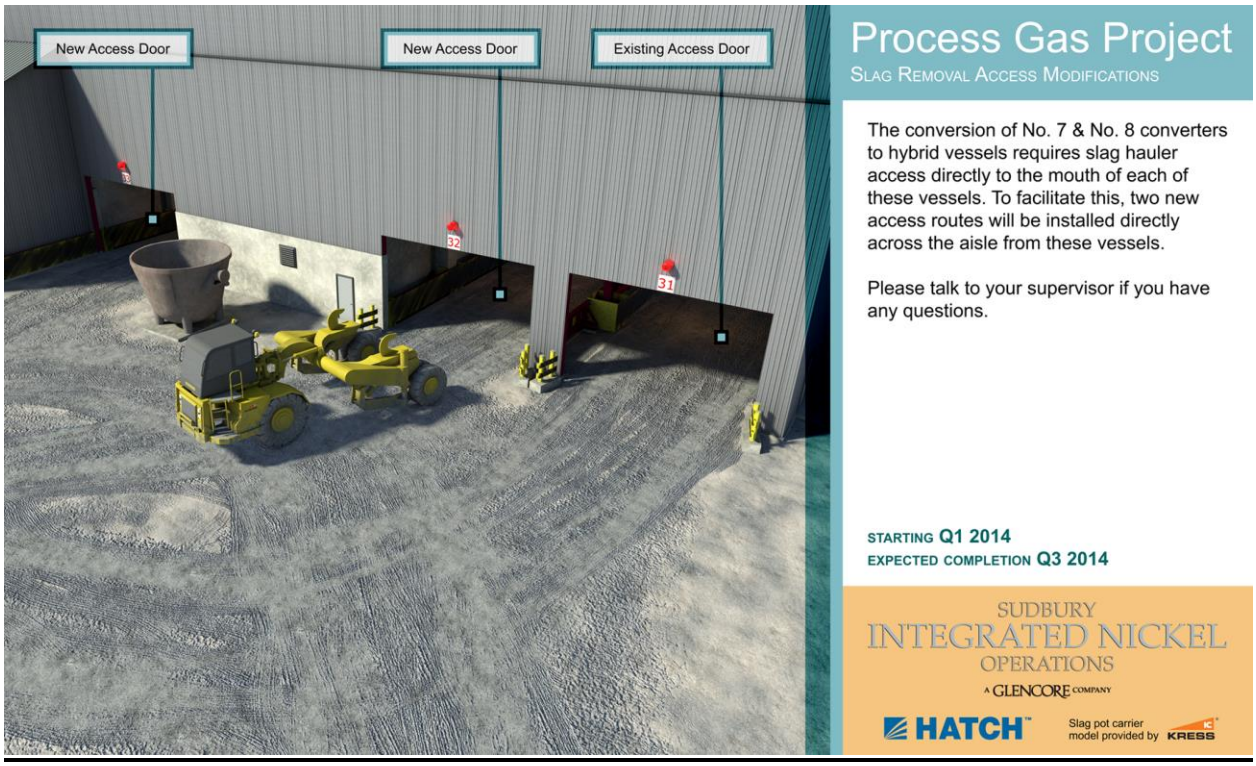

Figure 8. – New access to the Converter Aisle to remove slag – Complete in 2014

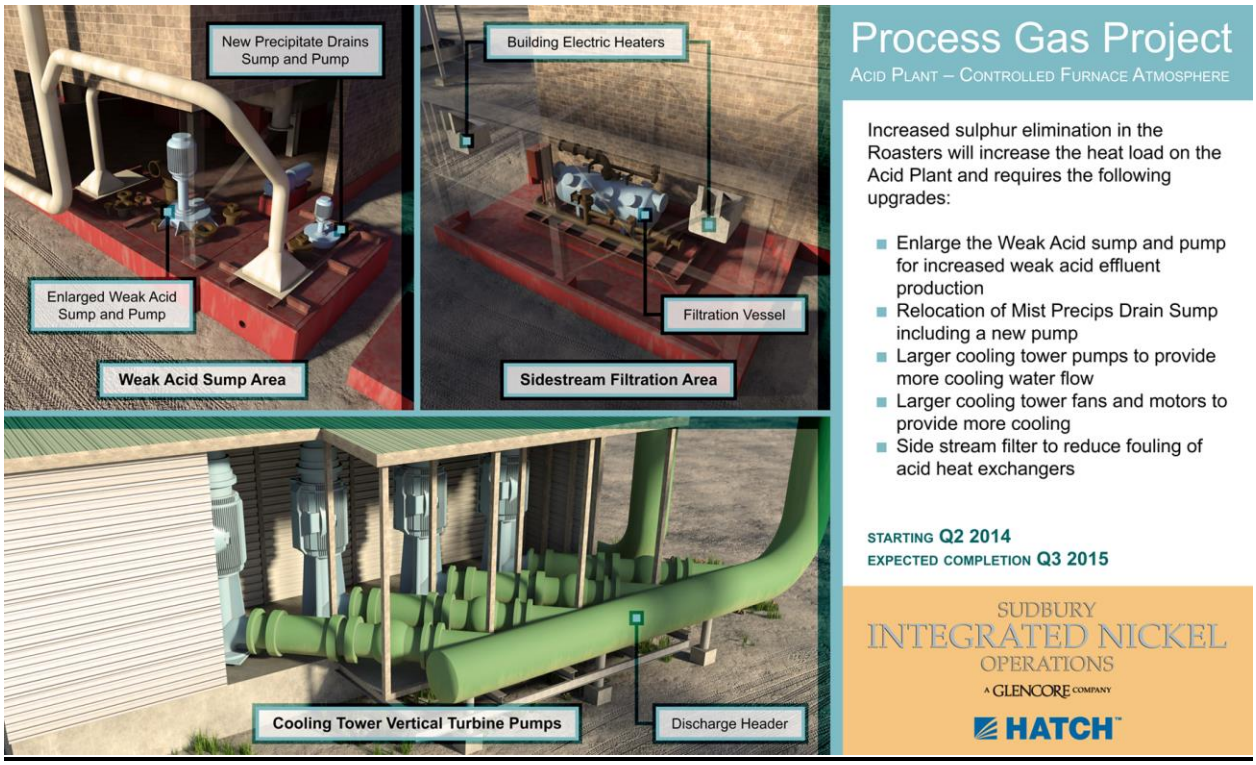

Figure 9. – Upgrades to the Acid Plant cooling – Complete in 2014

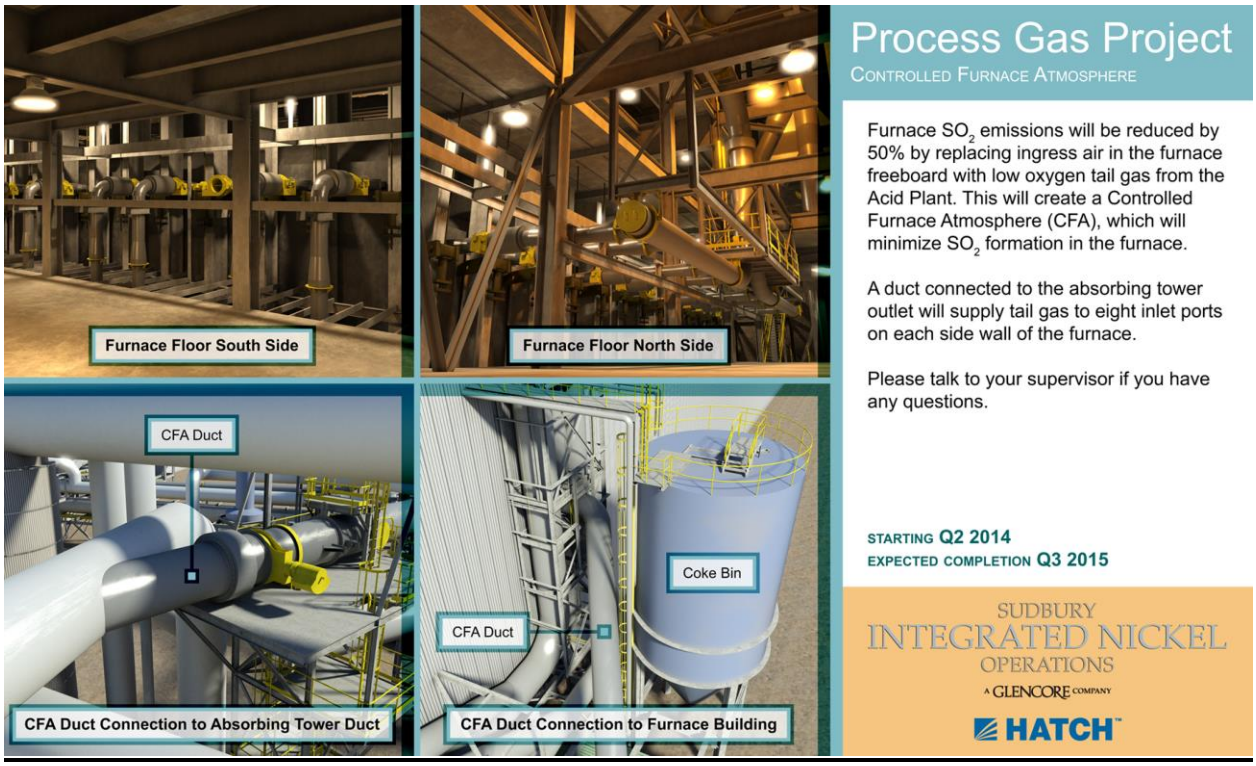

Figure 10. – Controlled Furnace Atmosphere installation – Complete in 2019

APPENDIX B
Future Site Specific Standard Projects

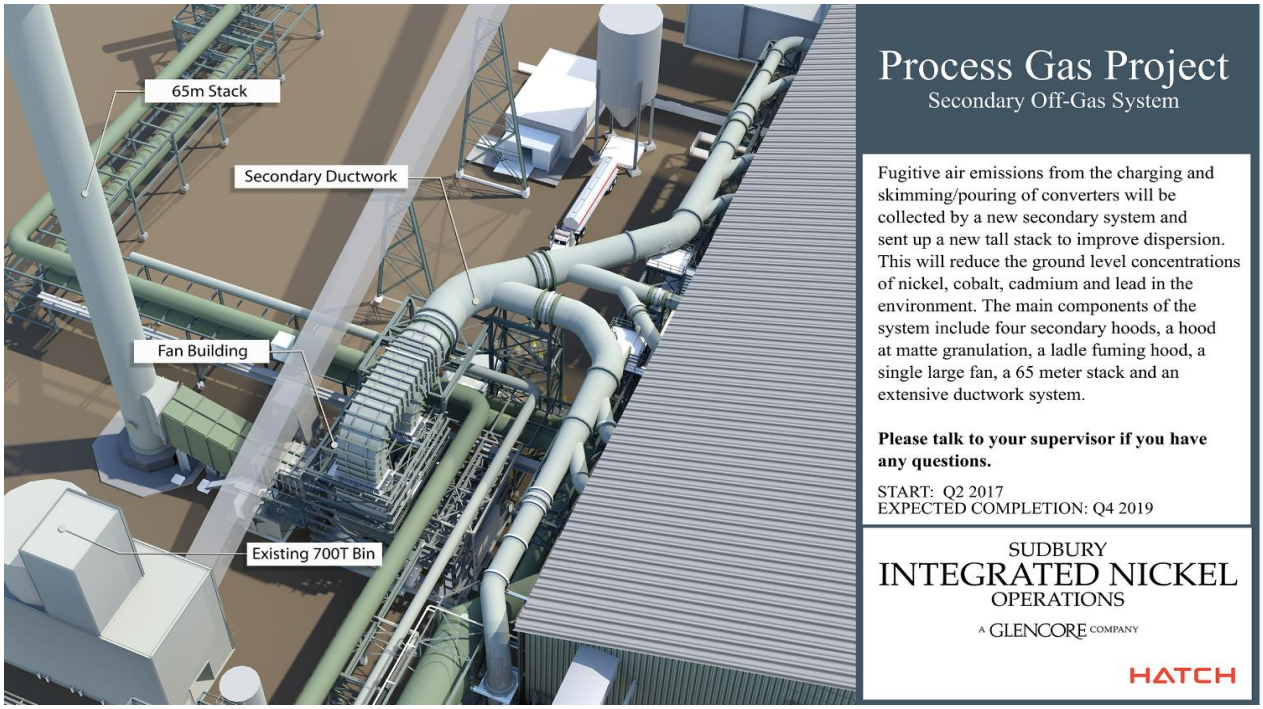

Figure 11. - Secondary Gas collection ducting – Complete 2019

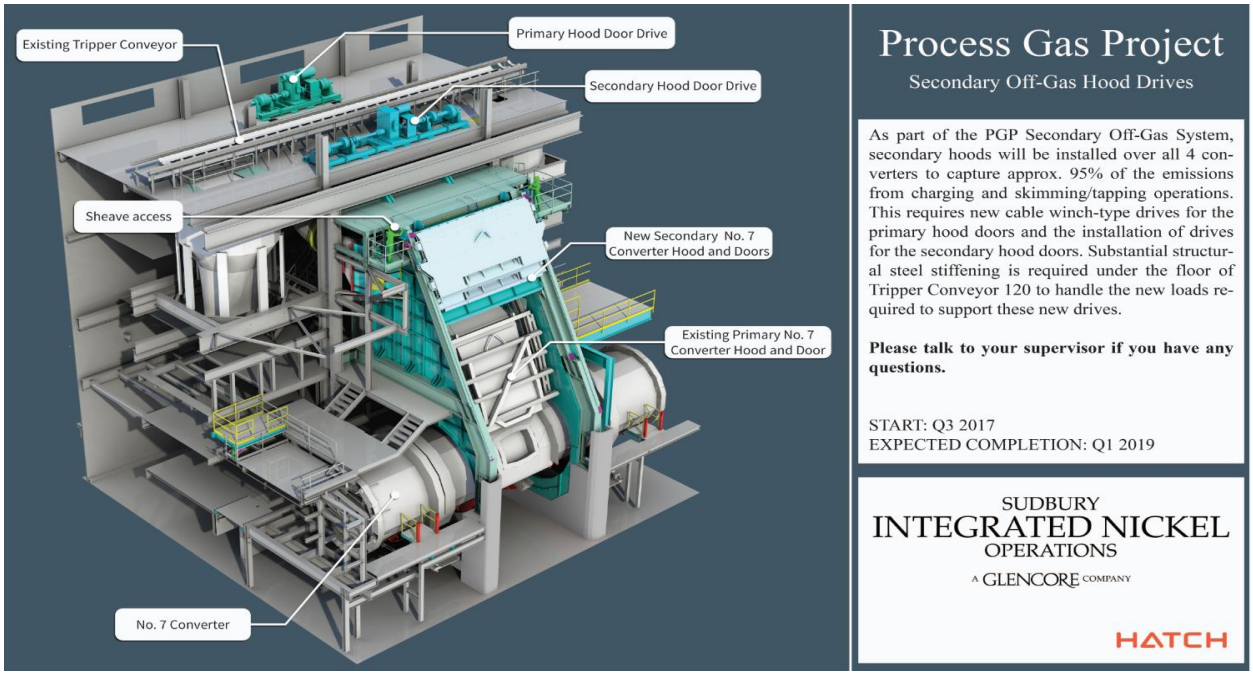

Figure 12. - Secondary Hoods – Complete in 2019

APPENDIX C
Future Particulate Emissions Reduction Projects

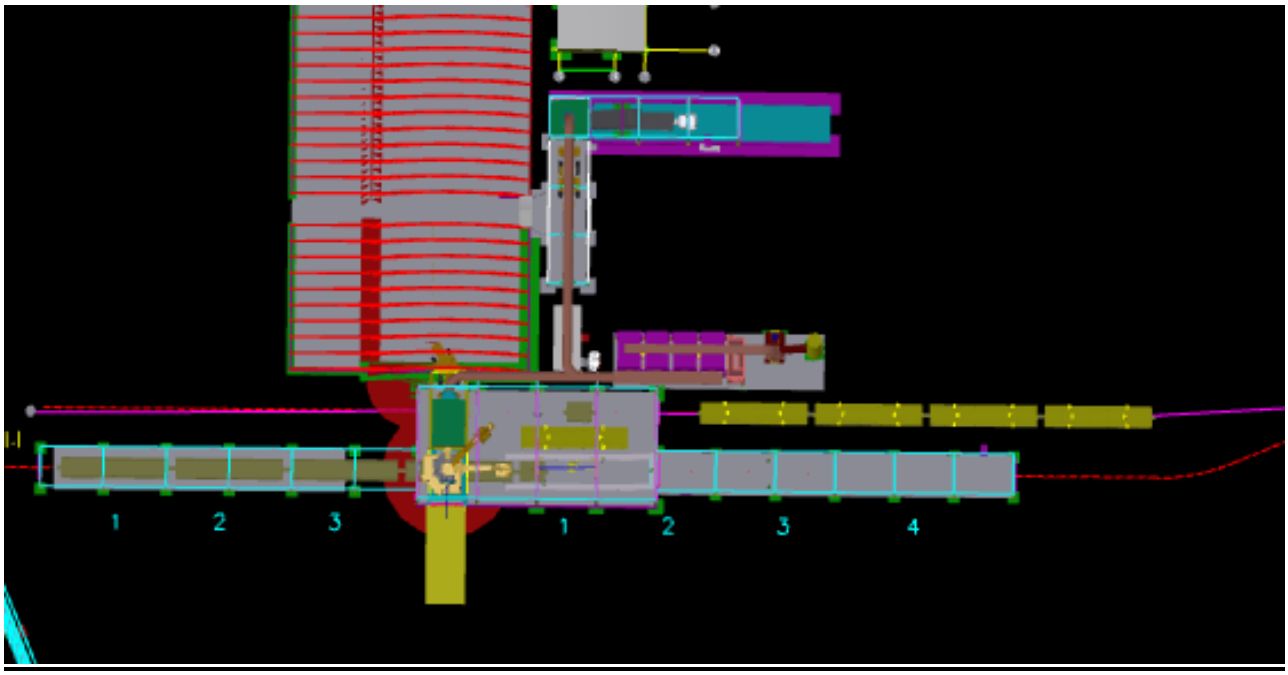

Figure 13 – Indoor Concentrate Unloading for Rail and Trucks

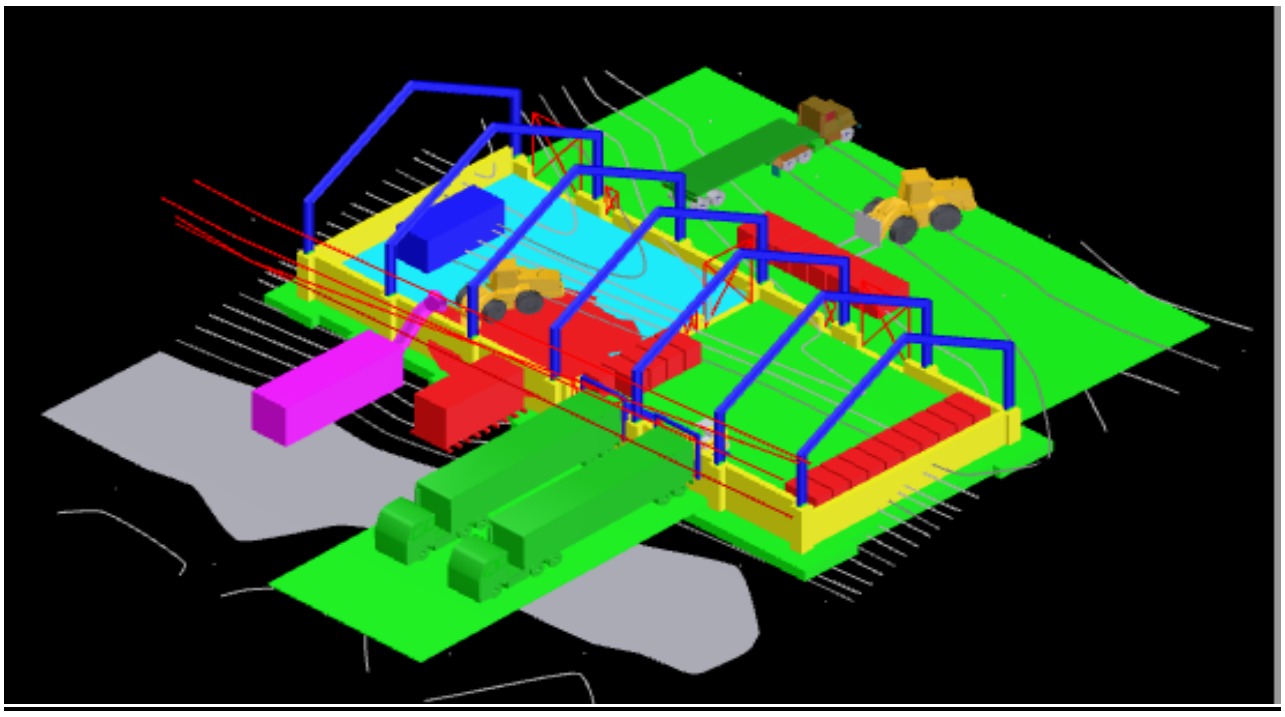

Figure 14 – Indoor Packaged Custom Feed Receiving and Sampling

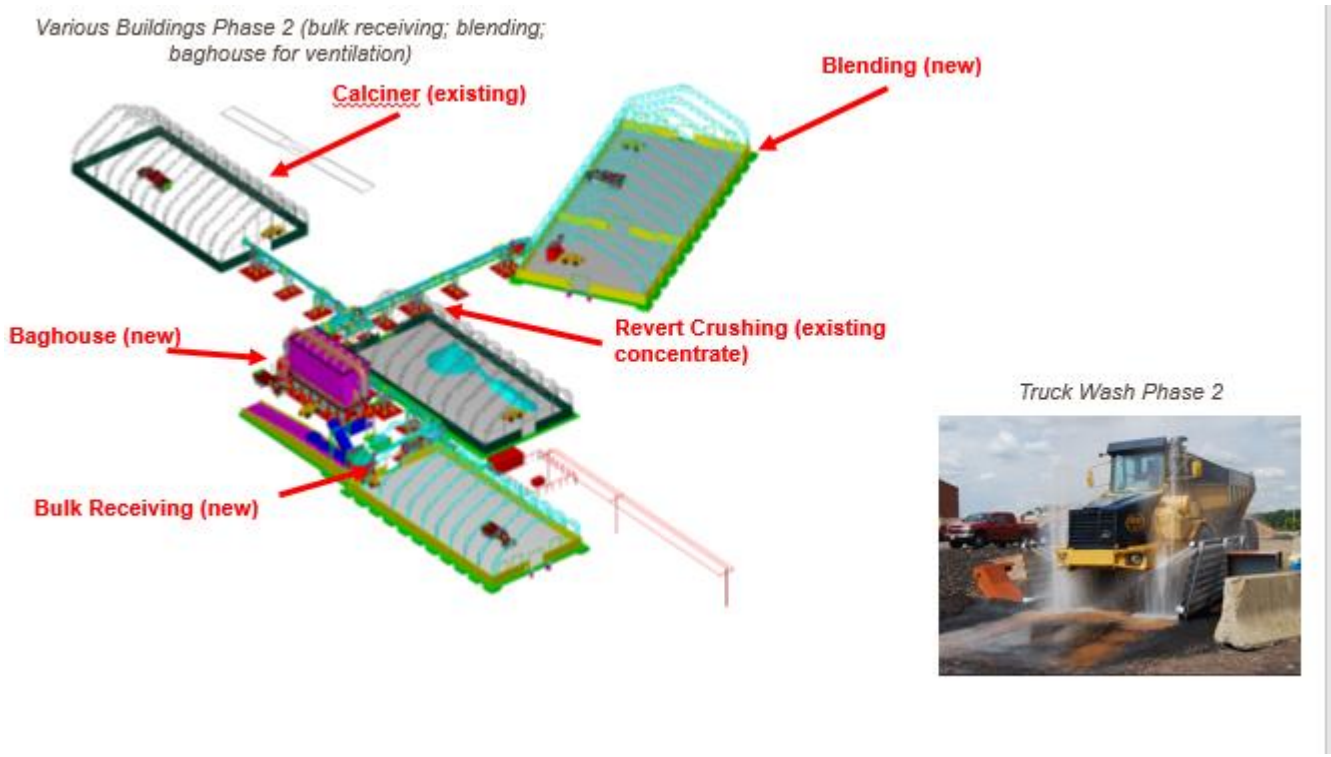

Figure 15 – New Revert Crushing Building with Baghouse and truck wash

APPENDIX D
Particulate and SO_2 Control Systems

Figure 16. - Glencore has installed SO2 and TSP monitors near the Property line between 2010 and 2017

Figure 17. - New Dust Collector on the conveyor (2015)

Figure 18. - New Bin Vent on the Matte Silo Matte (2014)

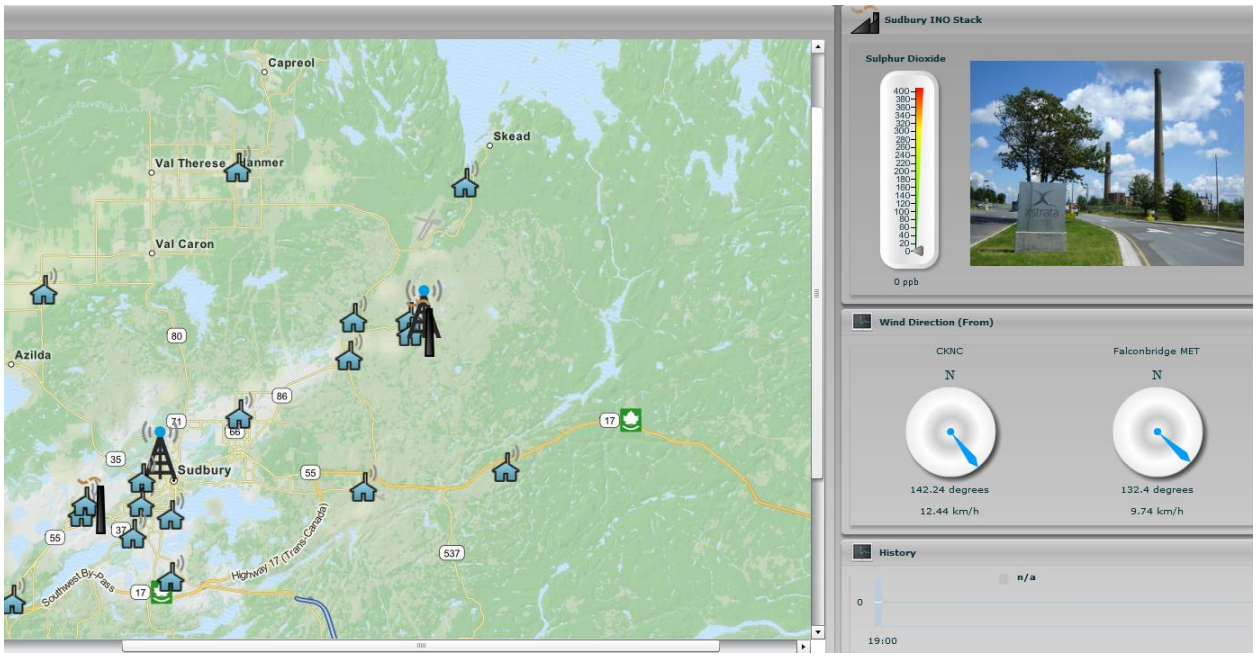

Figure 19. - Bestech Public Air Quality Website

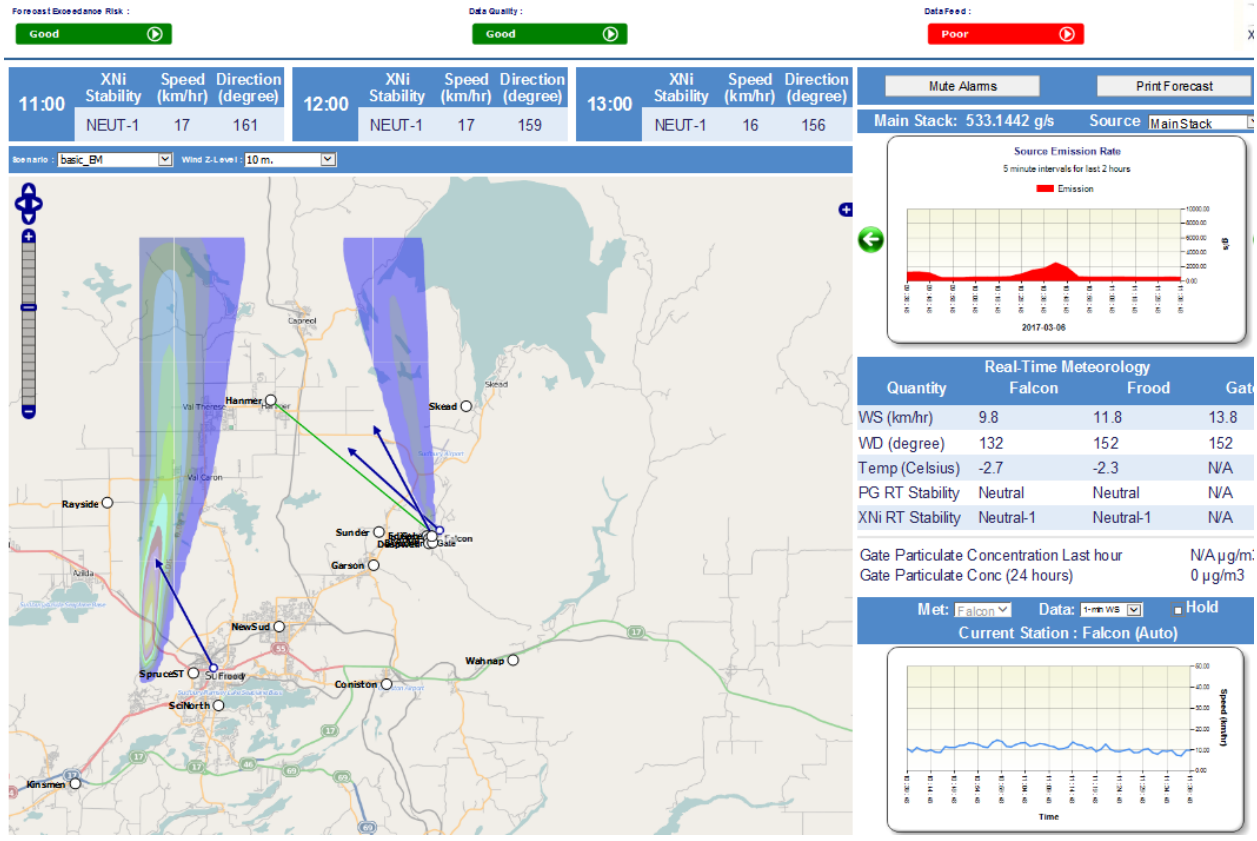

Figure 20. - CAPs 5 System Monitoring SO2 GLCs in the Community