

2023 BC MEND ML/ARD 30<sup>th</sup> Annual Workshop



**MAVEN**  
WATER & ENVIRONMENT

# Water Treatment Gains with a Gravel Bed Bioreactor at Rainy River

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December 7, 2023



# Outline



The site



The technology



Implementation



Early Operation



Enhancement



Current Operation

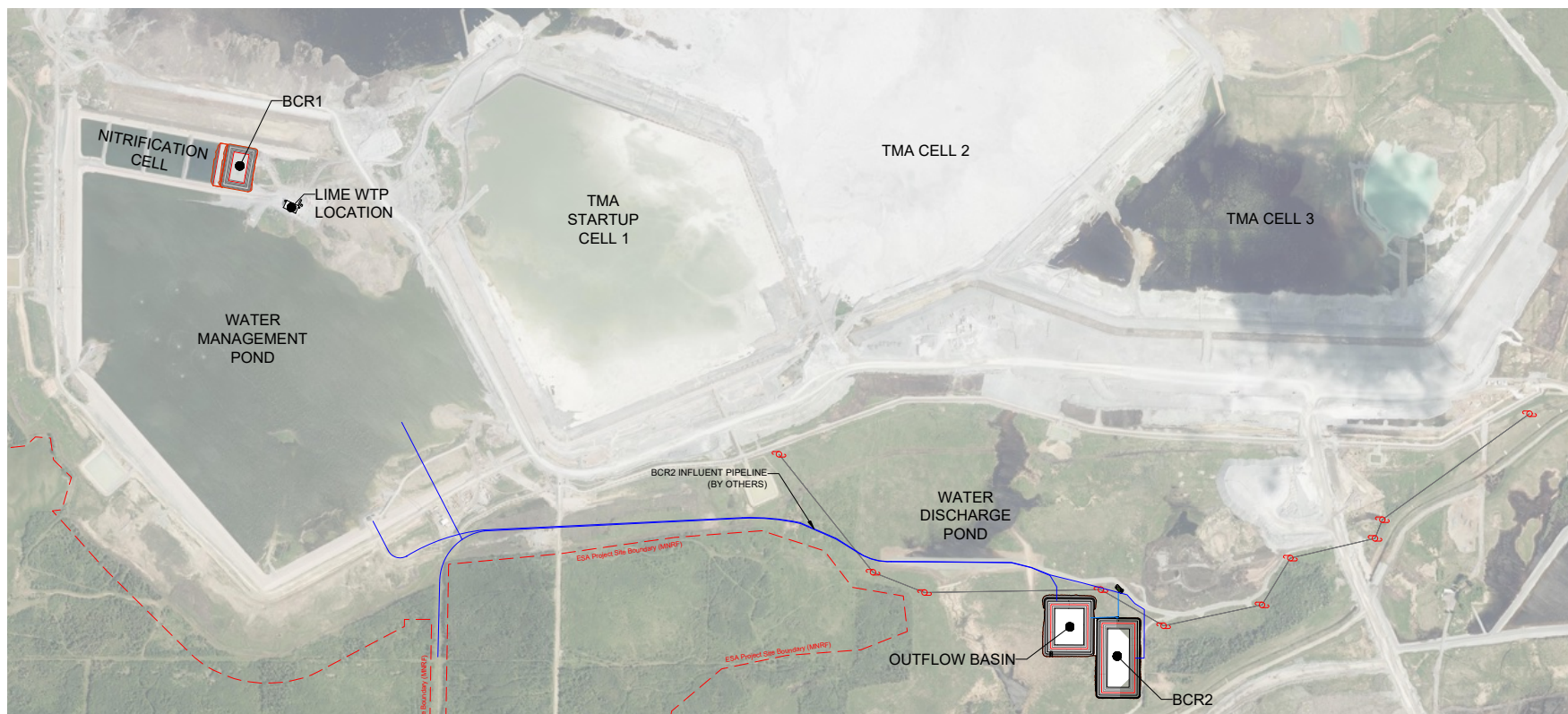
## Mine Location



- Rainy River Mine (RRM), owned by New Gold Inc., is a gold mine located in the Rainy River District of northwestern Ontario.



# Site Map





# Advancing Technology Readiness Level (TRL)

From  
TRL-6 to  
TRL-8 in  
2 years

Technology  
Maturation  
Plan was key

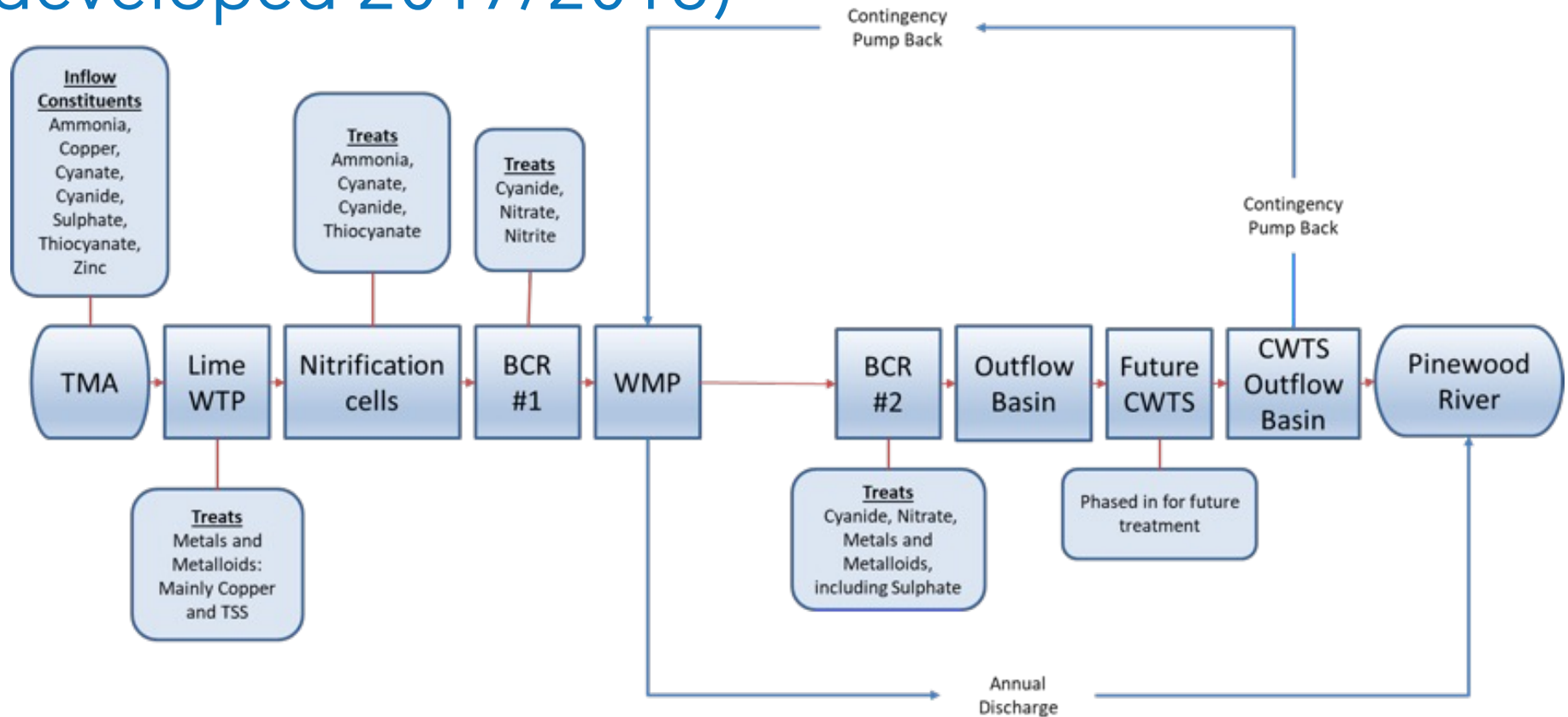


# How the Gravel Bed Bioreactor (GBBR) Works

- Fixed bed, vertical upflow
- 90% gravel, approx 10% peat or wood chips
- Electron donor (carbon source) = glycerol
- Phosphorous = monopotassium phosphorus (MKP)
- Nitrogen = from water source
- Iron = ferrous (as needed)
- Coupled biogeochemical process
  - Direct reduction (nitrate, sulphate)
  - Coupled removal of metals (co-precipitation with sulphide and iron)
  - Chemical removal by biogenically formed amorphous iron sulphides (AVS)

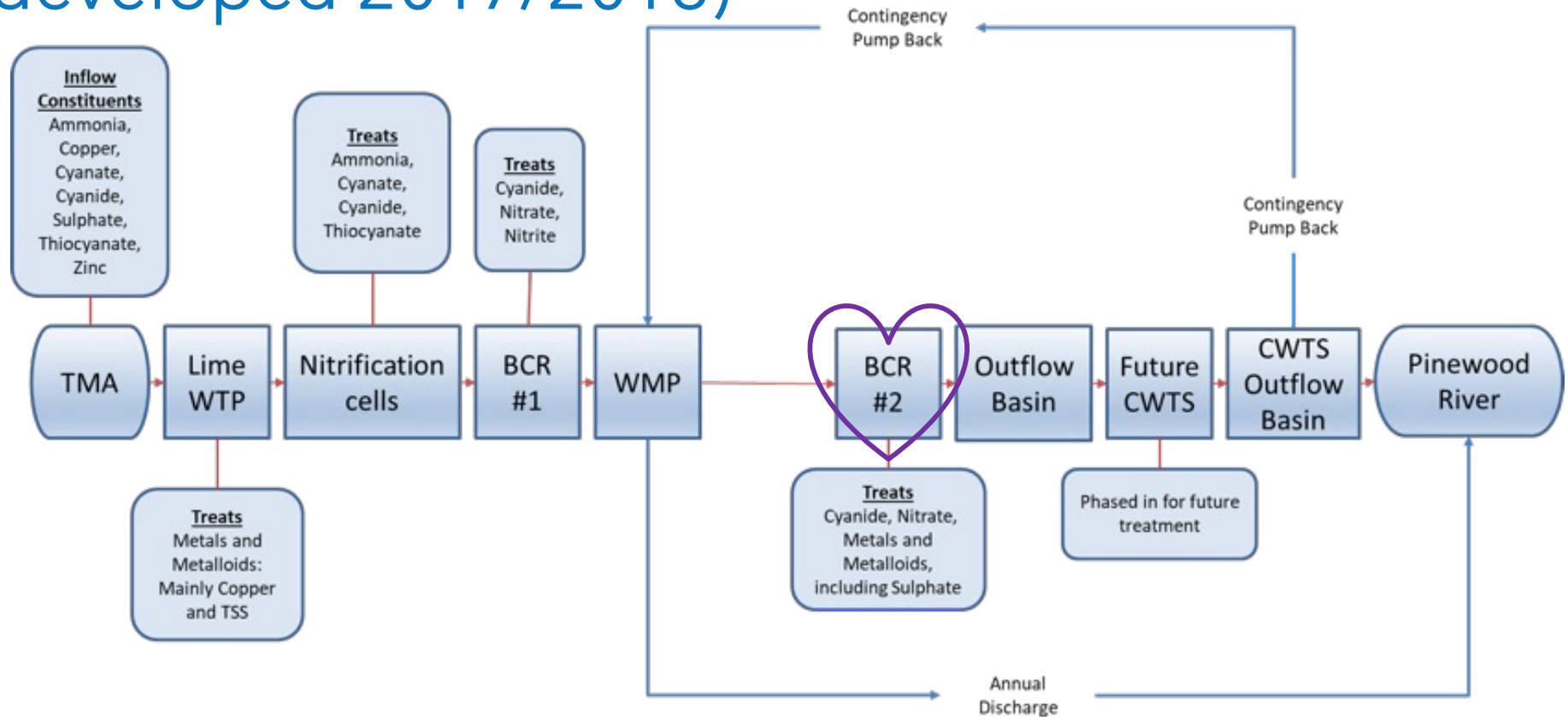


# Treatment Train – Initial Plan (developed 2017/2018)



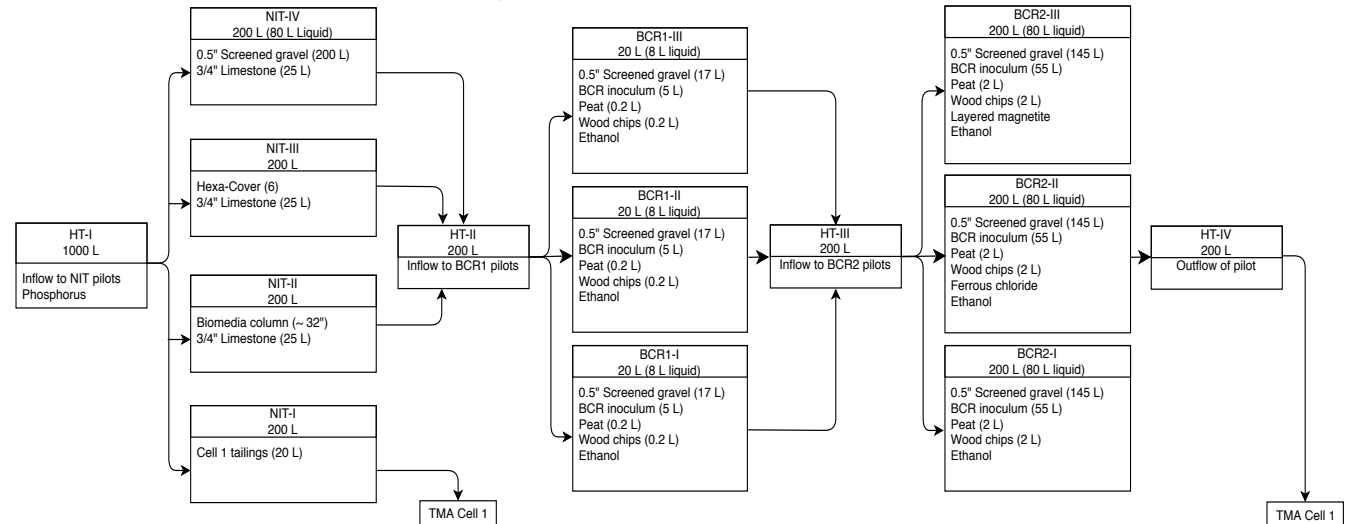


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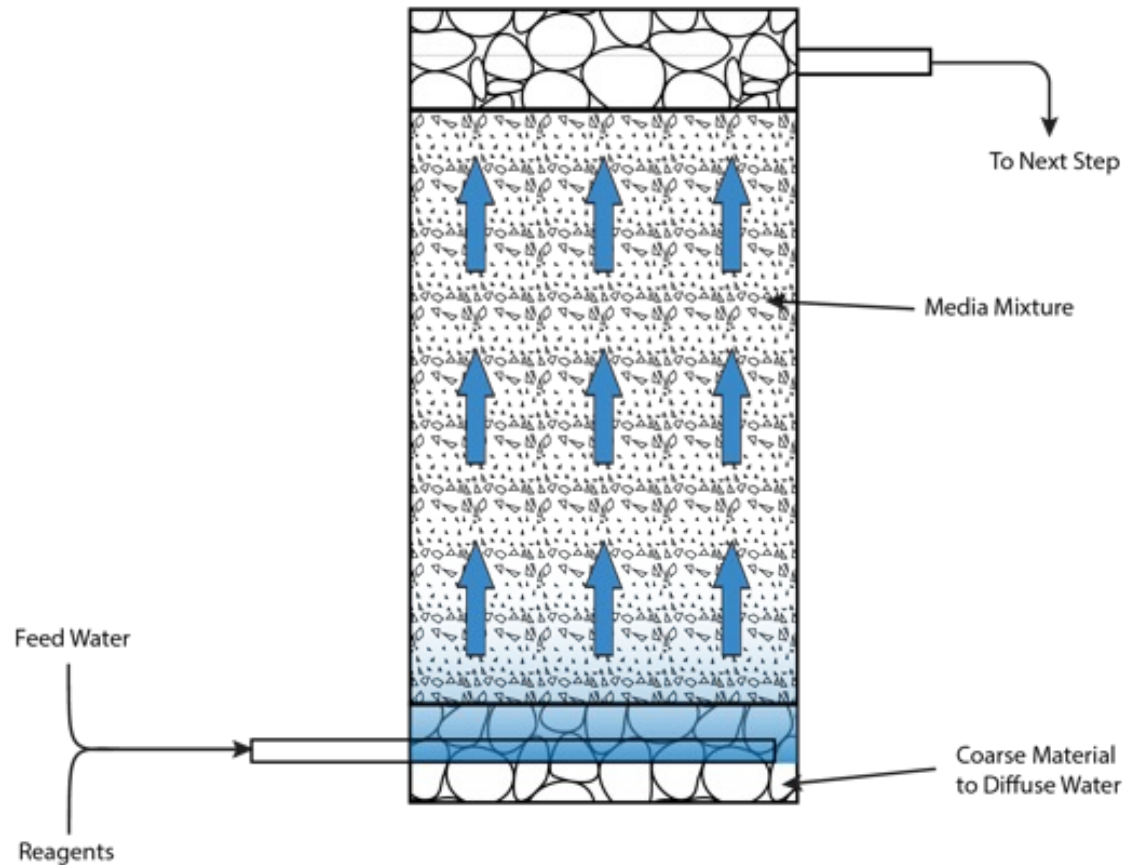


# Advancing the TRL - Pilot System - 2018

- Both BCR1 and BCR2 are GBBRs.
- Tested tailings water directly.
- Ethanol used for ease of access.
- Different ammonia treatment media and controls.
- Evaluated inclusion of iron in BCR2.
- BCR 'inoculum' is tailings water incubated with the media before adding to the BCRs.



# GBBR Concept Diagram





# Construction Winter 2019-2020

- Footprint: 220 m x 100 m  
Base: 160 m x 60 m  
Depth: 5 m
- Total Volume Gravel:  
72,700 m<sup>3</sup>
- Total Water Volume (est):  
18,175 m<sup>3</sup>
- Max Design flow rate:  
20,000 m<sup>3</sup>/day  
(approx. 1-day HRT)



## 2020-2021 Operations

- Used as a polishing step in 2020 and 2021.
- Treated the small amounts of nitrate and copper that came to it from the water management pond.

## 2022 – Extreme Wet Year - Water Management

- In 2022 Rainy River Mine experienced a 1 in 100-year precipitation event.
- Needed to treat as much water as possible to environmental discharge compliance.
- GBBR was previously underutilized and not being used to its design capacity.
- Could be decoupled from the rest of the treatment process to treat metals and metalloids
- Higher water treatment capacity
  - 10,000 m<sup>3</sup>/day through the GBBR
  - Less water to TMA

	2021 Treated Volume (m <sup>3</sup> )	2022 Treated Volume (m <sup>3</sup> )
WTP and BCR1	819,414	1,987,734
GBBR (BCR2, MRP Water)	0	619,463
TMA Cell 1 water	0	486,077
Total treated	819,414	3,093,274

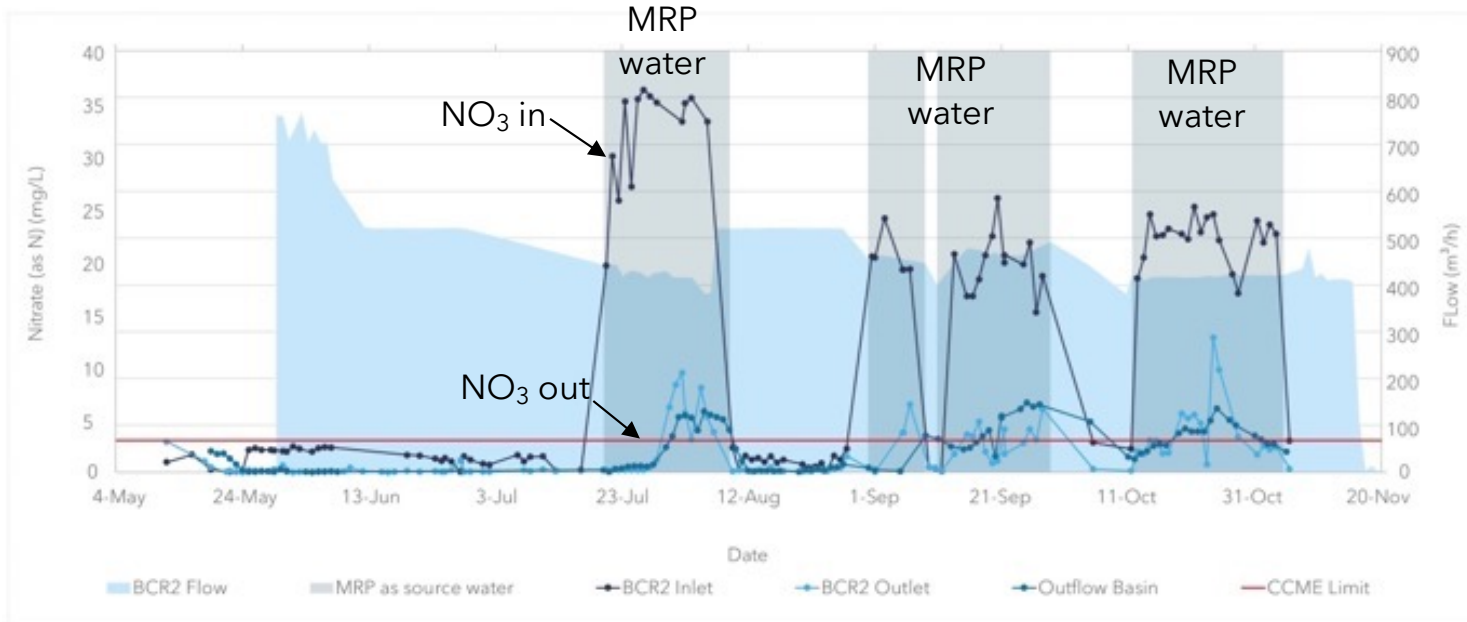
3.6x more!



## 2022 Limited Operational Flexibility (LOF) trial

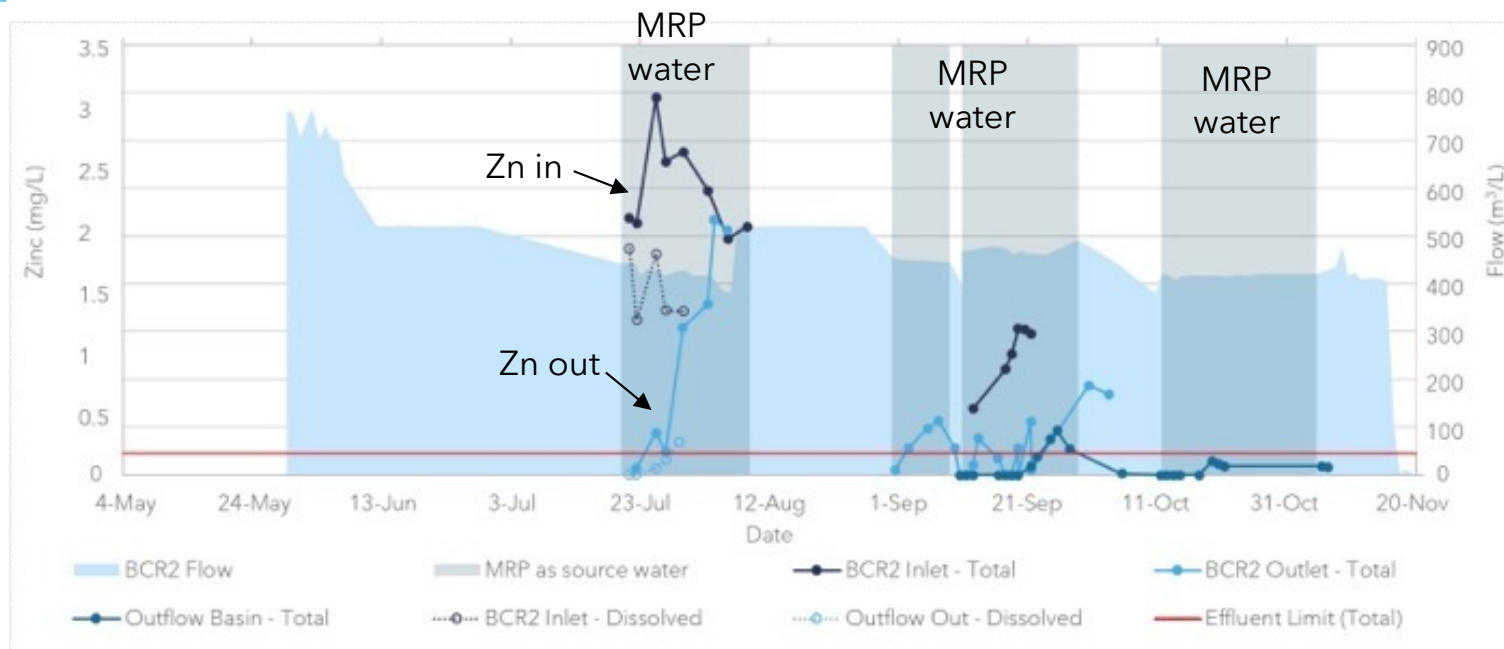
- An LOF trial was applied for and performed.
- Mine Rock Pond water treated by GBBR to expand water treatment capacity by 10,000 m<sup>3</sup>/day.
- Key Constituents for treatment:
  - Zinc-D: 1-3 mg/L
  - Nitrate-N: 20-35 mg/L

# Nitrate Treatment 2022



Nitrate-N mg/L			
	Min	Max	Avg
In	15	36	24
Out	0.06	13	3.4

# Zinc Treatment in 2022



Solid lines: Total Zn

Dot lines: Dissolved Zn

Zinc-Total mg/L			
	Min	Max	Avg
In	0.54	3.1	1.8
Out	<0.01	2.1	0.45



Early 2022



# End of 2022 – Optimization Opportunities

1. Reagent overdose
2. Changes made between design and construction

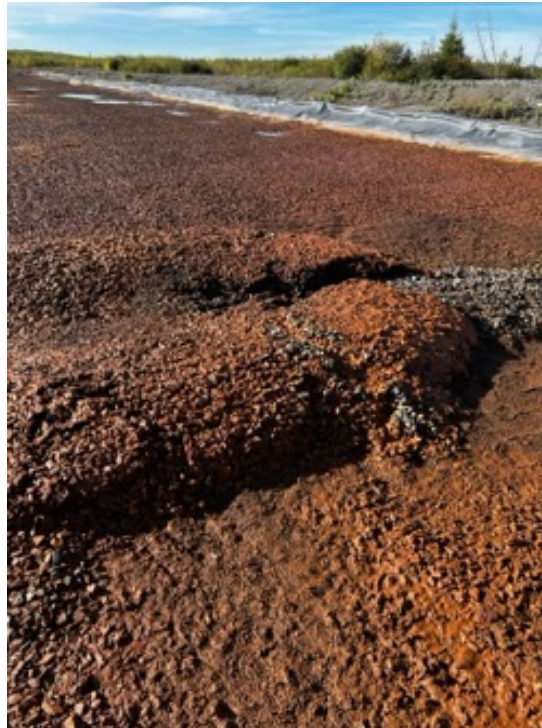


# Short Circuiting

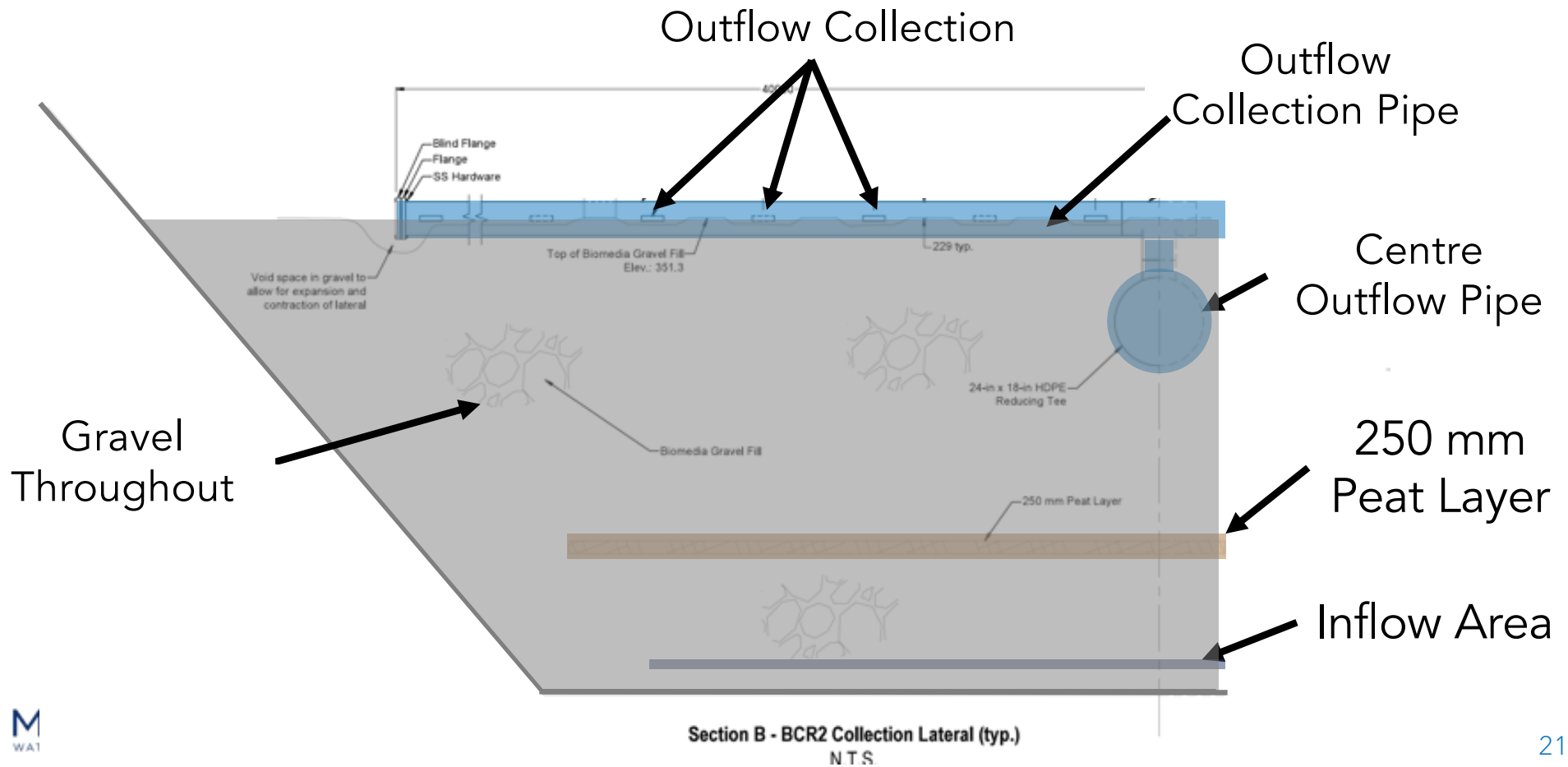




# Assessing the Challenge

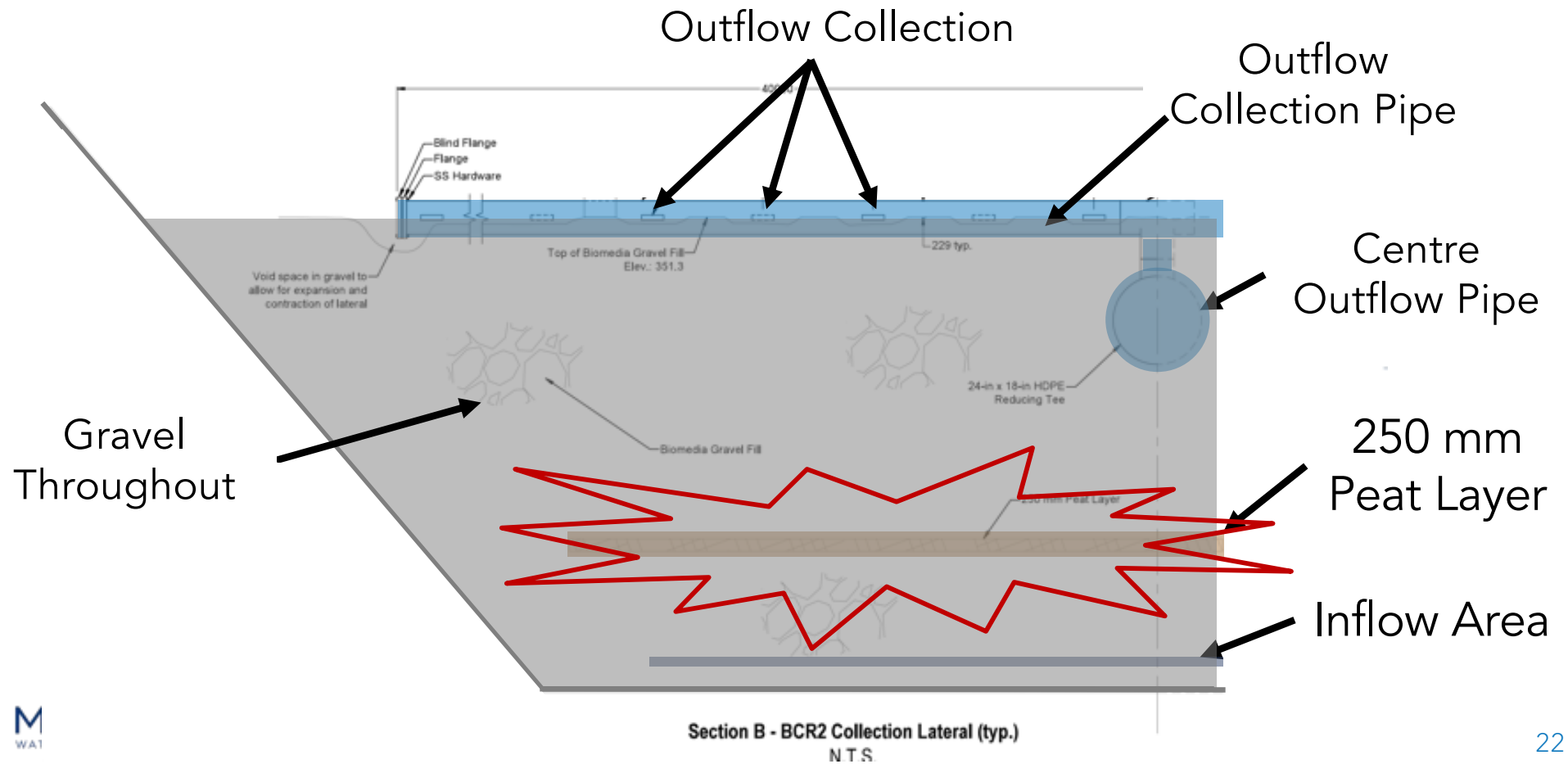


## Revisiting the "As Built"

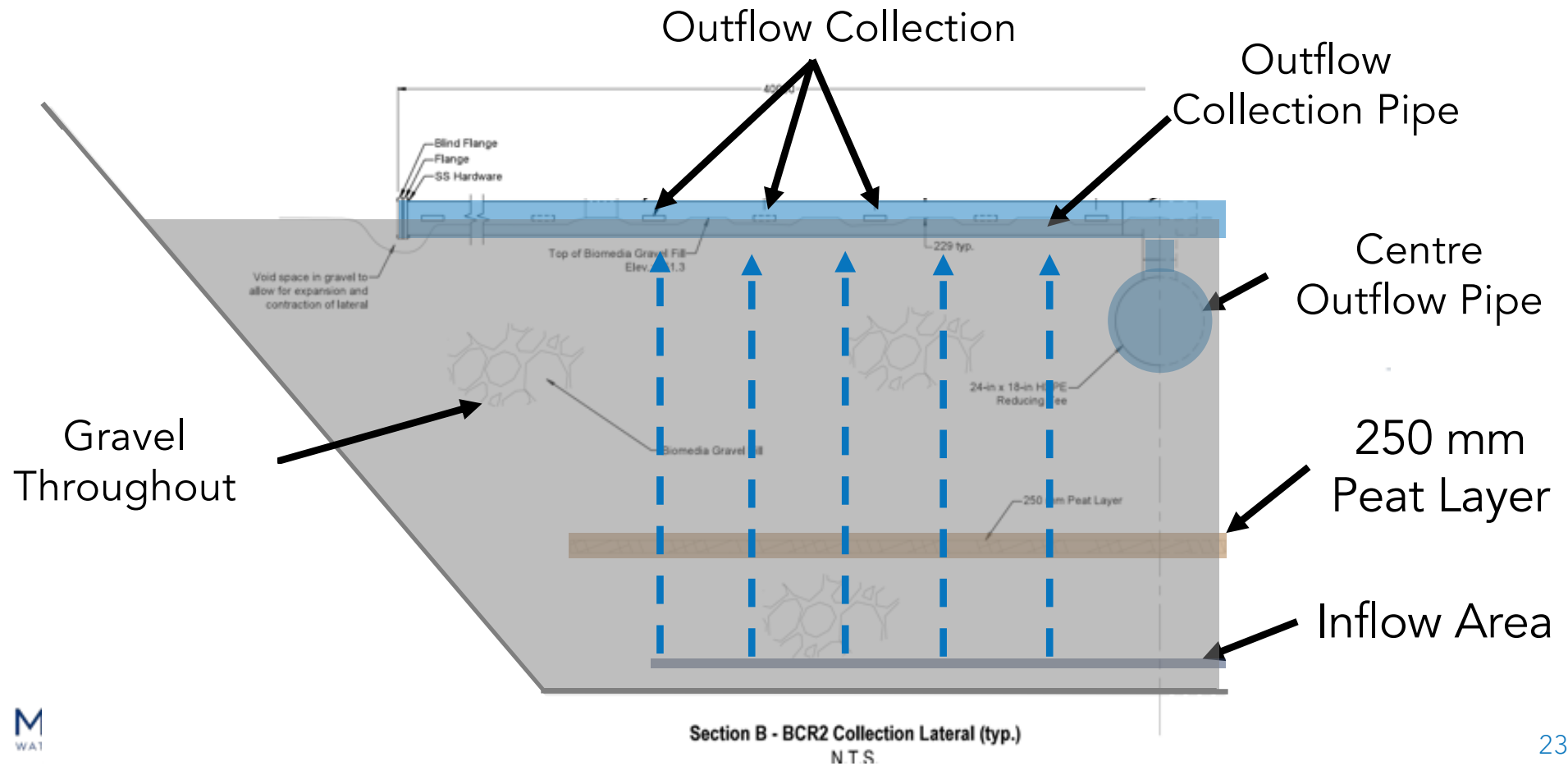




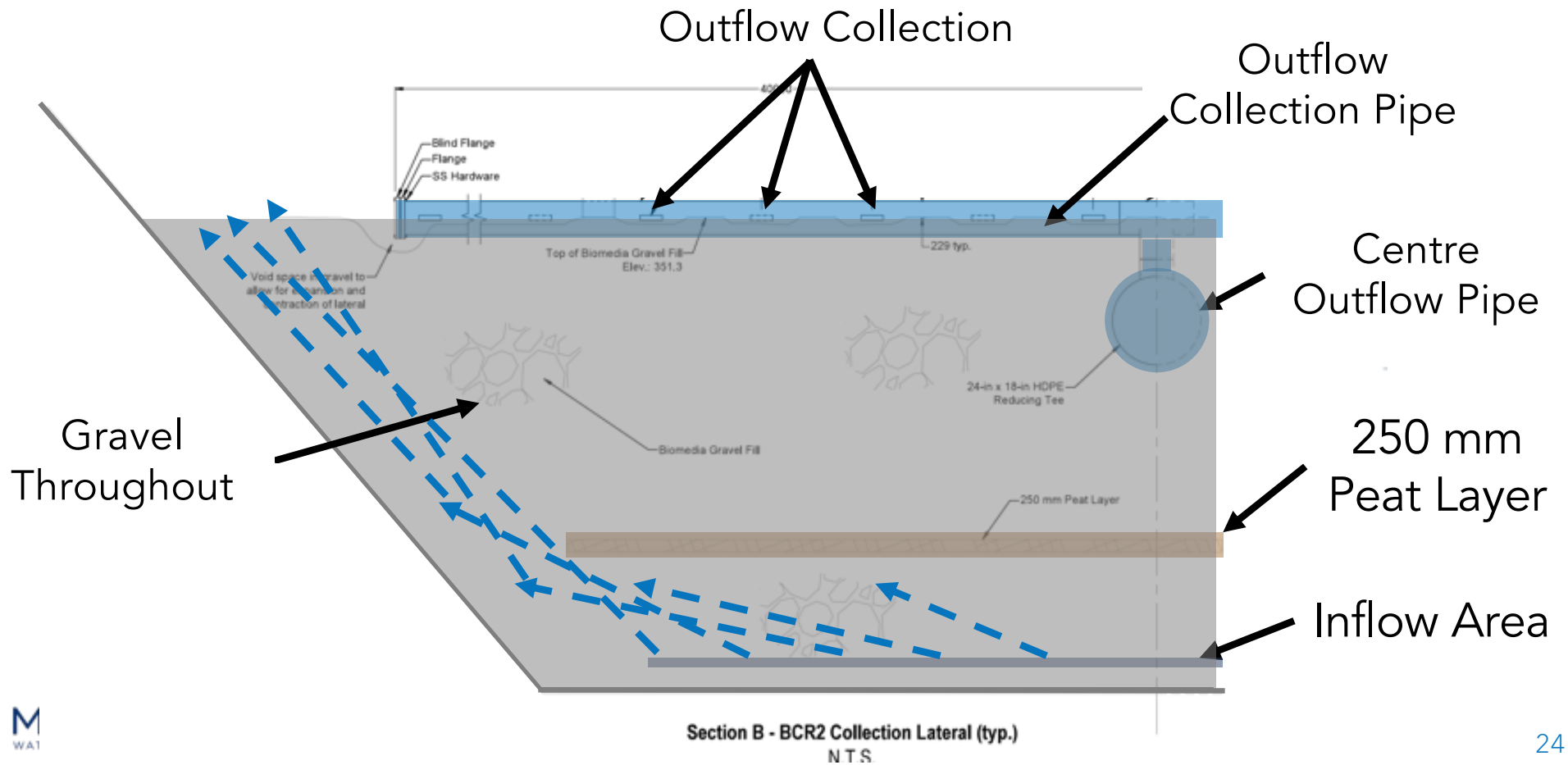
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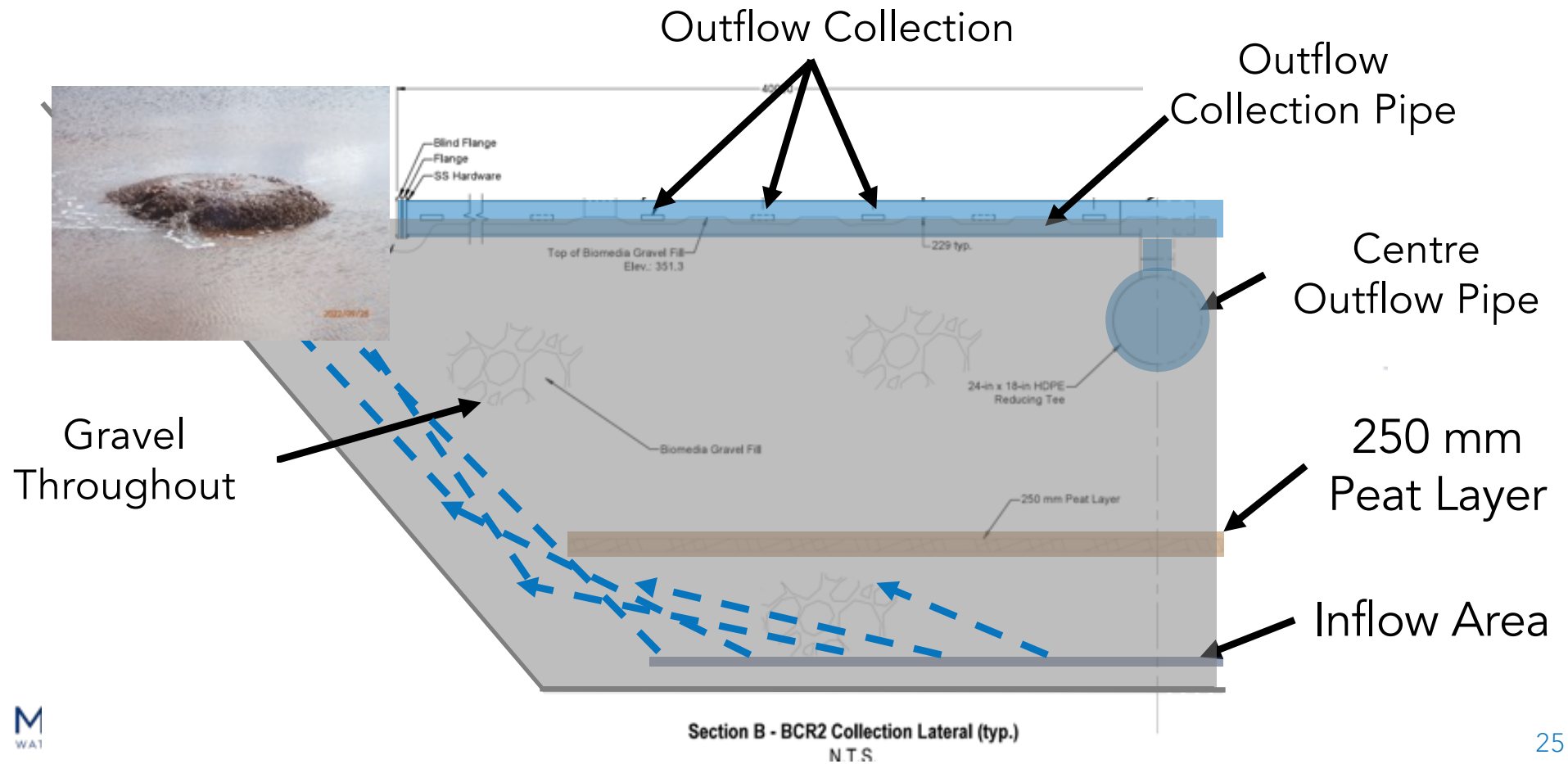
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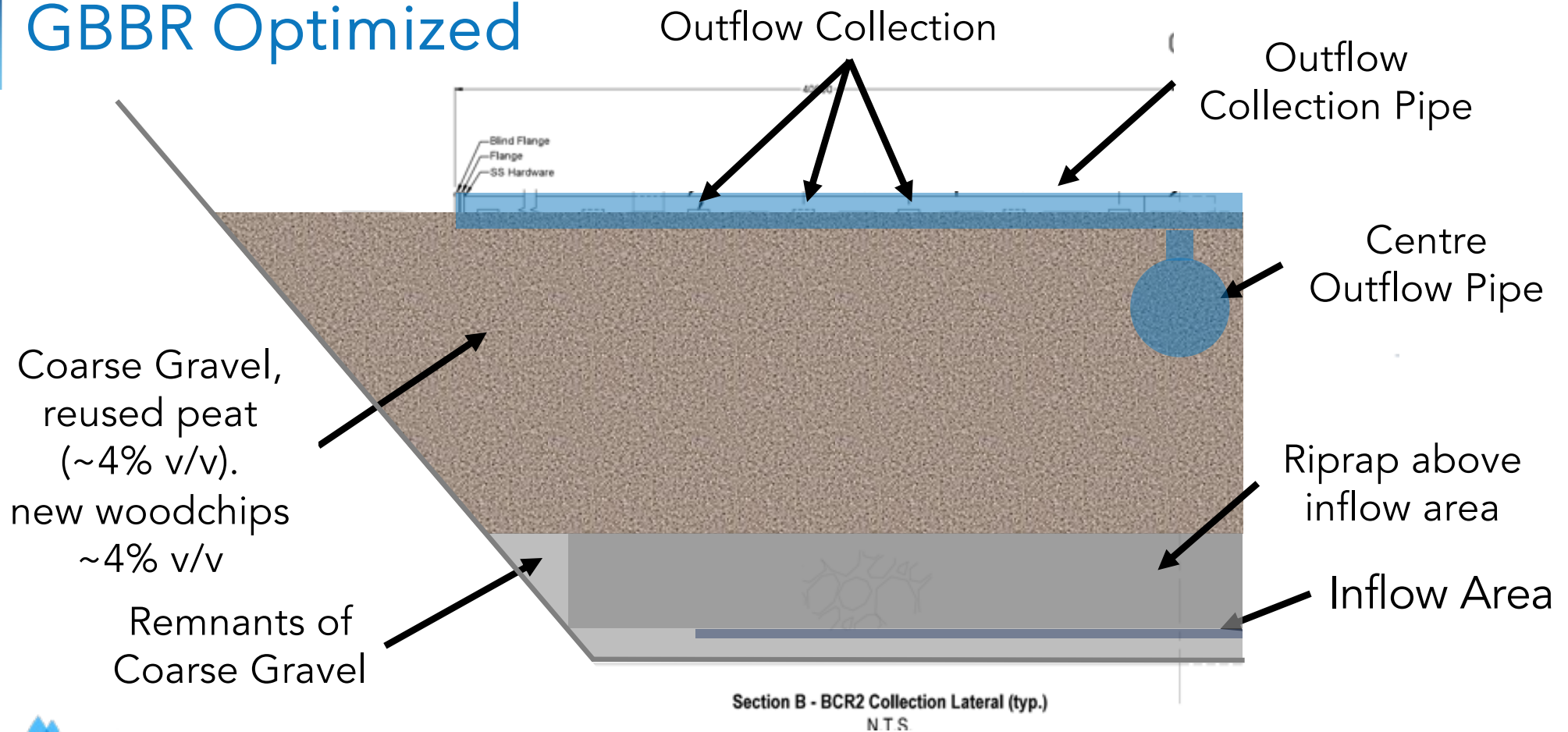
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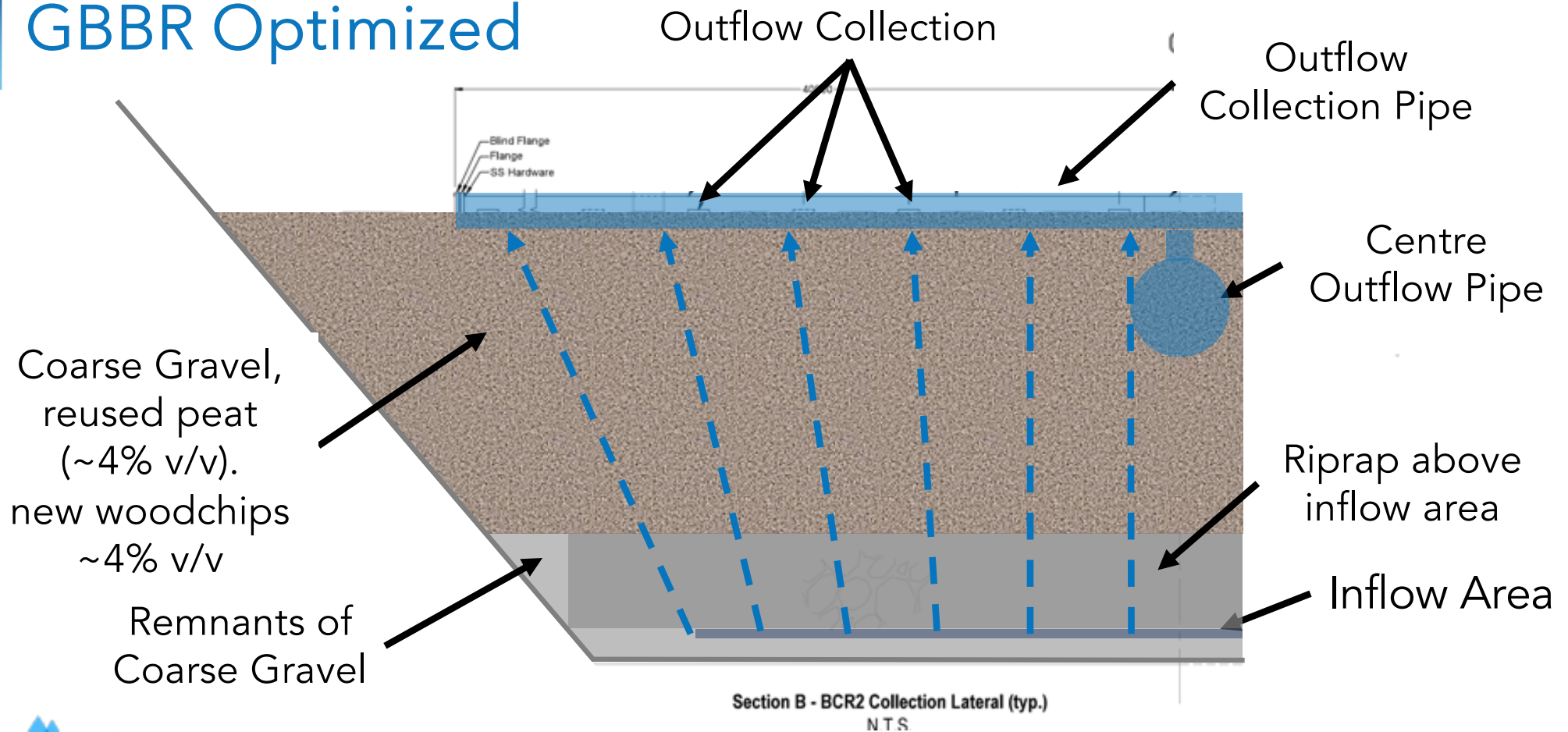


# GBBR Optimized





# GBBR Optimized



# Renovations



# Renovation





# Renovation



# Renovation - Final

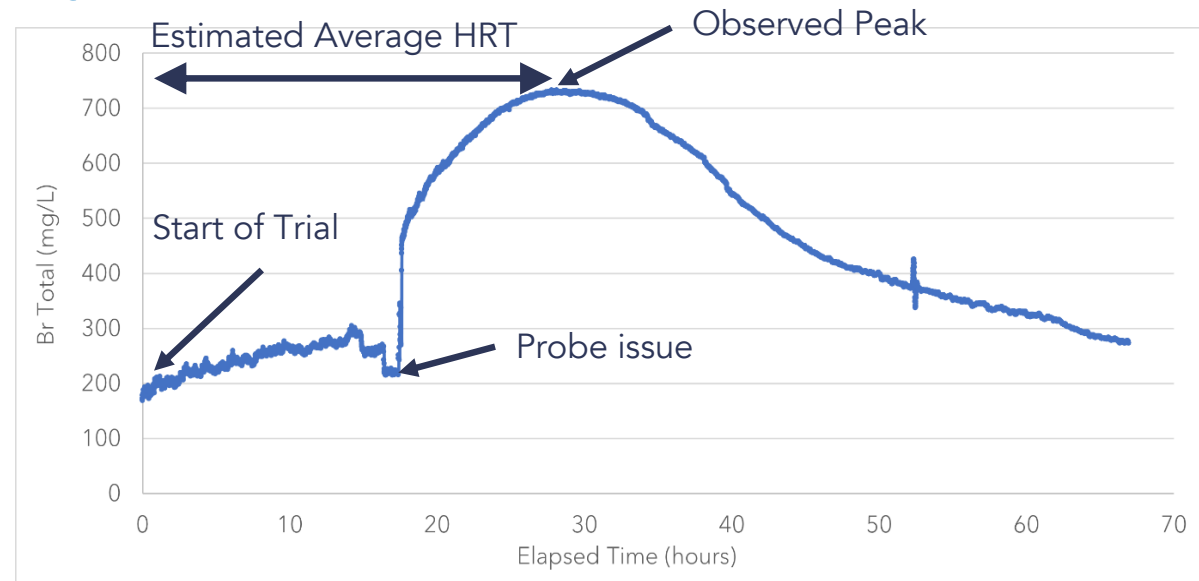




# 2023 Tracer Study

Confirm HRT and flow paths in the GBBR.

Repeat periodically (e.g., annually) to guide preventive maintenance for clogging or short-circuiting.

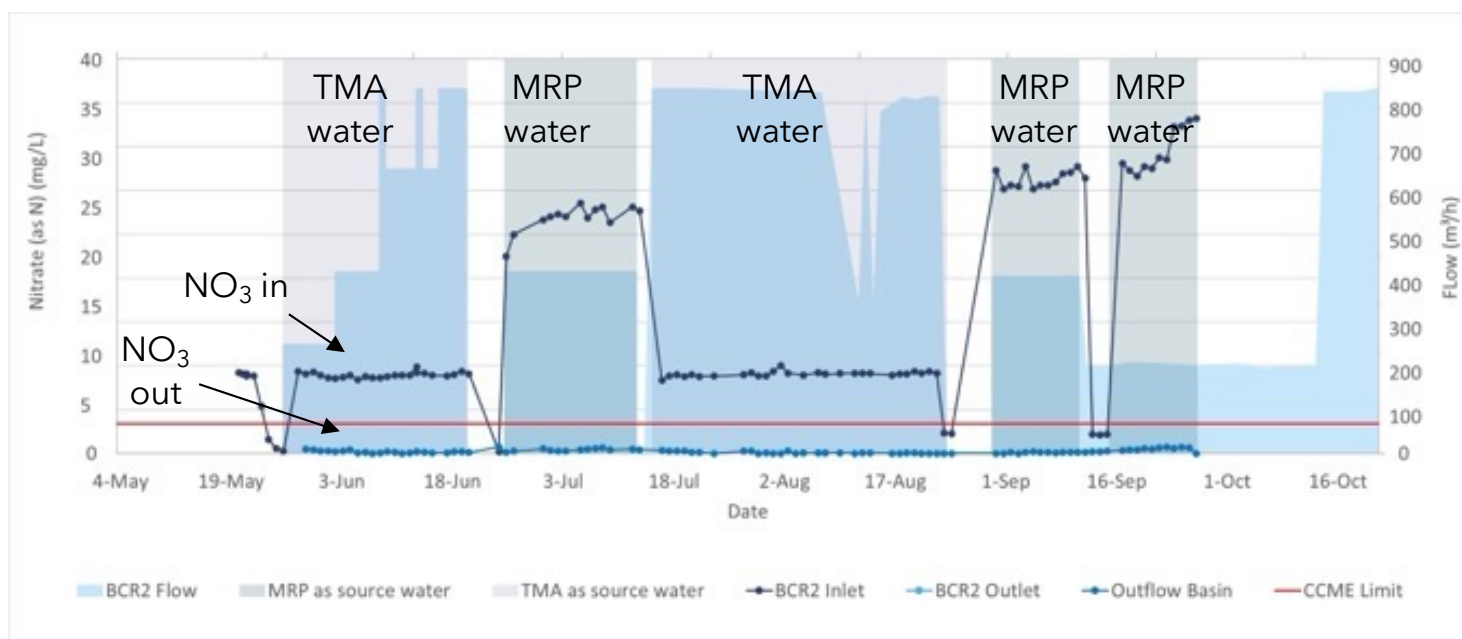


	Est Water Volume (m3)	HRT (hours)
Calculated from Design	18,175	22
Estimated from Tracer (preliminary data analysis)	23,324	28

# 2023 Operations



# Nitrate Treatment 2023

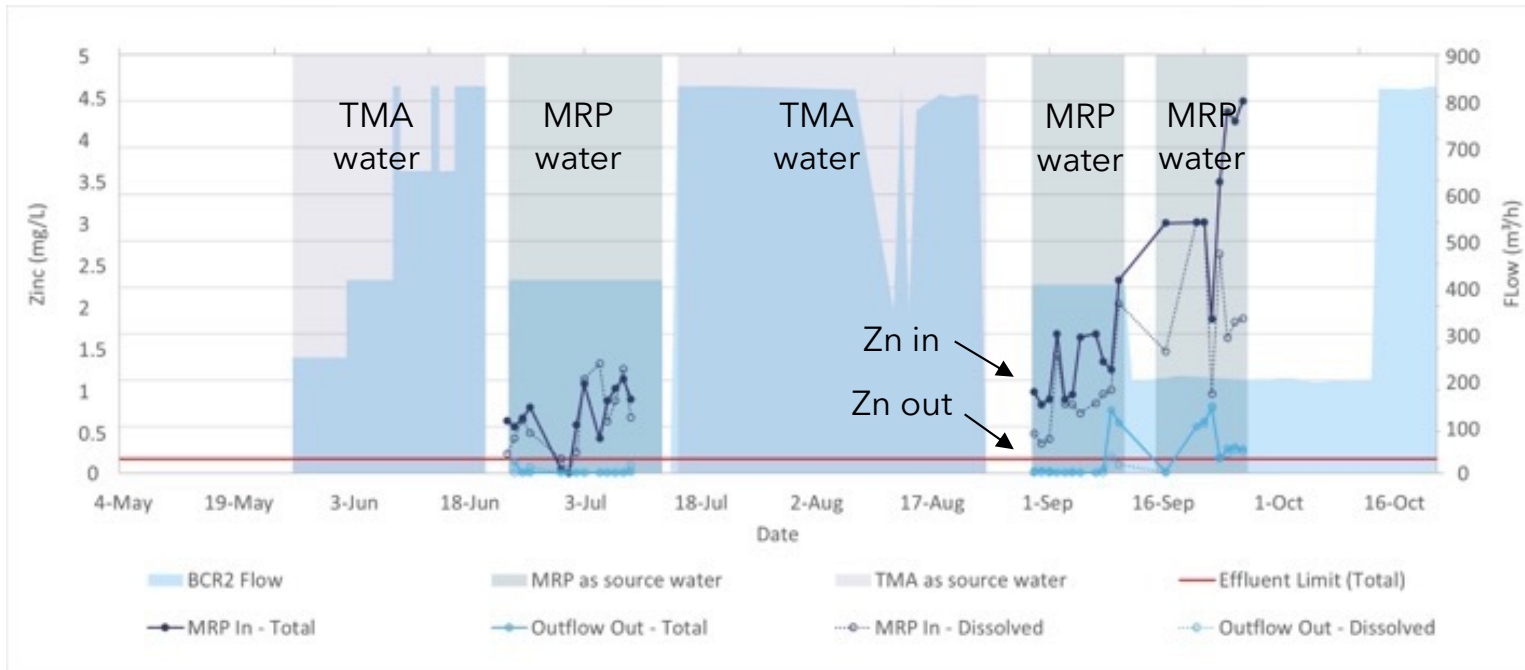


When MRP water is used:

Nitrate-N mg/L			
	Min	Max	Avg
In	20	34	27
Out	<0.01	0.64	0.30

# Zinc Treatment 2023

TMA = tailings management area  
MRP = mine rock pond



Zinc-Total mg/L			
	Min	Max	Avg
In	<0.01	4.5	1.6
Out	<0.01	0.78	0.16

Optimized  
reagent dosing  
improved vs  
2022

Solid lines: Total Zn

Dot lines: Dissolved Zn

# Copper Treatment 2023

TMA = tailings management area  
MRP = mine rock pond

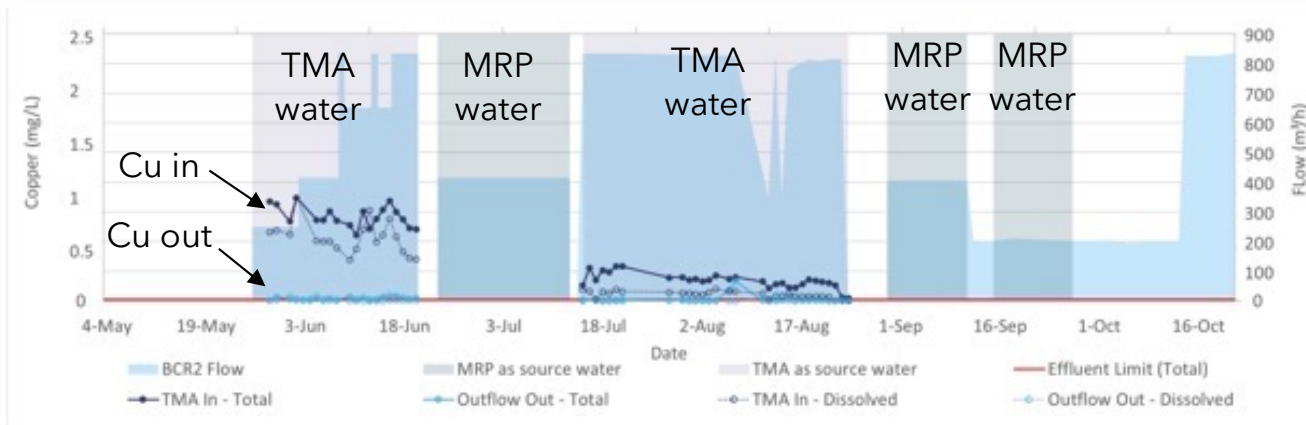
Low  
Density  
Sludge



When TMA water is used:

Sample Location	Copper Total (mg/L)		
	Min	Max	Avg
In	0.026	0.983	0.406
LDS Out	<0.001	0.588	0.164
GBBR Out	<0.001	0.189	0.020

GBBR



GBBR treats  
Cu-CN  
complexes  
that Low  
Density  
Sludge (LDS)  
cannot



## Summary (2023 treatment)

	Gravel Bed Bioreactor (GBBR)		Low Density Sludge (LDS)	
	In	Out	In	Out
<b>Reagents</b>	Glycerol, Phosphorus, sometimes Ferrous		Lime, Ferric, Polymer	
<b>Flow (m<sup>3</sup>/day)</b>	20,000	20,000	~17,800	~15,000
<b>Nitrate-N</b>	27 (max 34)	0.30	Not treated	Not treated
<b>Copper-T</b>	0.406 (max 0.983)	0.02	0.406 (max 0.983)	0.164
<b>Zinc-T (50% flow)</b>	1.6 (max 4.5)	0.16	Not tested	Not tested
<b>GHG Estimate</b>	57 tonnes/year CO <sub>2</sub>		2,423 tonnes/year CO <sub>2</sub>	

## Summary (2023 treatment)

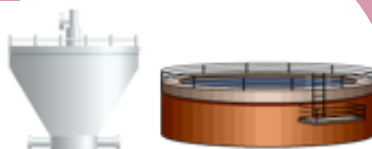
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### SCOPE 1

21 tonnes CO<sub>2</sub> (Nitrate reducing bioreactor).

01

02



**WTP with lime for  
metals + nitrate  
reducing bioreactor**

03

### SCOPE 1

57 tonnes CO<sub>2</sub> (Nitrate reducing + sulphate reduction).

01

02



**GBBR treating both  
metals and nitrate**

03

### SCOPE 3

GBBR not required reagents using the dominant reaction. No minor/ very specific ones considered in the calculations.

### SCOPE 3

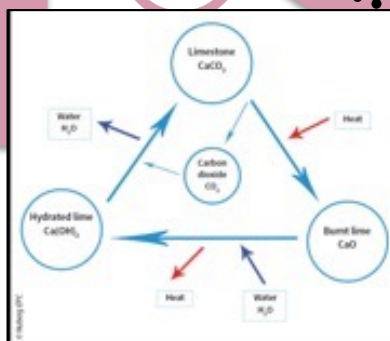
Considering only the reagent as manufactured by third party:  
2402 tonnes CO<sub>2</sub>e.

Production  
15%

Combustion  
85%

### MAIN ASSUMPTIONS

Operating half of the year for the lime system and full year in the bioreactor.



VS

### SCOPE 2

No impact comparison, the upstream and downstream of the process will be the same for both options.

WTP flow 15,000 m<sup>3</sup>/water into the system.

Fuel consumed for heating in calcination reaction:  
Diesel.

20 mg/L nitrate-N, targeted.

50 mg/L sulphate targeted for reduction.

**DATA INPUT**

## Next Steps for Rainy River GBBR

- Permitting for permanent source water changes.
- Consider increasing flows to reach treatment capacity (estimated to be approximately 2-3x higher than design basis).
- Consider adding ammonia treatment nitrification cell to fully decouple treatment.
- Continue preventive monitoring and maintenance.

## GBBR's in BC – further advancing the TRL

- Maven's mFlex pilot system on-site through 2022.
- Paired with climate-controlled trials.
- Nitrate and Copper treatment as expected (TRL-8).
- Advancing Selenium and Molybdenum treatment (TRL-7).



# Thank you!



**newgold**<sup>TM</sup> Rainy River Mine



# Questions?

