Regenerable IX Resin for PFAS Treatment - 4+ Years Later... What We’ve Learned...

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The PFAS Challenge

- PFAS substances are everywhere
- Few treatment case studies available

A Proven Solution: Regenerable IX

- Effective and sustainable
- Minimizes waste
- Scalable
- Compounding cost savings over time
- Future-proof
Agenda

- Regenerable IX process overview
- Case study – RAAF Base
  - Treatment effectiveness
  - Resin capacity trends
  - Waste generated
  - Leveraging data to optimize performance
- What we’ve learned – is Regenerable IX a silver bullet?
Regenerable IX Process

Water Treatment
Regenerable IX Process

Key to Processes
- Water flow
- Solvent flow
- Vessel rotation process
- Potential/future process
- Waste generation

RESIN

Resin Regeneration

OFF-RAMP TO DESTRUCTION

SOLID WASTE

SuperLoading™

STILL BOTTOMS (very high PFAS concentration)

DISTILLATION

REGENERANT SUPPLY (low PFAS concentration)

SPENT REGENERANT (very high PFAS concentration)

REGENERANT SUPPLY (low PFAS concentration)

RIEX Vessel Regeneration
Stage 1: Pre-treatment
Stage 2: REIX Treatment
Stage 3: Resin Regeneration

Key to Processes:
- Water flow
- Solvent flow
- Vessel rotation process
- Potential/future process
- Waste generation

REGENERATION HUB:
- OFF-RAMP TO DESTRUCTION
- SOLID WASTE
- SuperLoading™
- STILL BOTTOMS (very high PFAS concentration)
- DISTILLATION
- DISTILLATION
- REGENERANT SUPPLY (low PFAS concentration)
- SPENT REGENERANT (very high PFAS concentration)
- RIEX Vessel Regeneration
Regenerable IX Hub-and-Spoke Model

Transportable Regenerable IX Vessel
Regenerable IX Case Study
RAAF Base, AU

- Legacy AFFF-impacted groundwater
- 12.6 L/s (200 gpm) treatment since 2019
- Influent: $\Sigma$PFAS up to 60 µg/L; mean: 14 µg/L
- Treatment criteria: Australian HBGVs
  - PFOS + PFHxS 0.07 µg/L
  - PFOA 0.56 µg/L
- 26 regenerations
- 19+ kg of PFAS removed
Influent Concentrations to Water Treatment System

High influent concentrations → Consider regenerable resin
Influent Concentrations to REIX System

Pre-treatment removes some PFAS – goal is to protect the resin
Eflluent from Lead IX Vessel

Concentrations < 200 ppt after first lead RIEX vessel
Effluent from Lag Vessel

Consistent: 100% compliance with treatment objective; nearly non-detect in all sampling events
Consistent Performance

- Volume water treated
- PFAS removal
  - Pre-treatment media
  - Hydrogeological areas of greater concentration
- Seasonal variation
Regeneration Efficiency

- No obvious media degradation
- No increased regeneration frequency
- Consistent PFAS mass recovered

<table>
<thead>
<tr>
<th>Criteria</th>
<th>5-Cycle Average</th>
<th>5-Cycle Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Days</td>
<td>245</td>
<td>56</td>
</tr>
<tr>
<td>Volume Water Treated (ML)</td>
<td>128</td>
<td>26</td>
</tr>
<tr>
<td>PFAS Removed (g)</td>
<td>330</td>
<td>112</td>
</tr>
<tr>
<td>PFAS Recovered (g)</td>
<td>369</td>
<td>173</td>
</tr>
<tr>
<td>Mass Balance (removed-recovered)</td>
<td>-39</td>
<td>77</td>
</tr>
</tbody>
</table>
Optimization Efforts Continue

New media evaluation

2.7x capacity with RePureNext; >4x capacity for HBGV PFAS of interest
Investigation efforts

Microplastics

Are we putting microplastics into the environment by with technology involving large vessels of plastic media?

ASTM D8332-20
Standard Practice for Collection of Water Samples with High, Medium, or Low Suspended Solids for Identification and Quantification of Microplastic Particles and Fibers
### Investigation efforts

#### Microplastics

<table>
<thead>
<tr>
<th>Criteria</th>
<th>AU (Site #1)</th>
<th>US (Site #2 / Lab #1)</th>
<th>US (Site #2 / Lab #2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microplastic count (microplastics/L)</td>
<td>27 / 34</td>
<td>0.6 / 0</td>
<td>1.1 / 1.0</td>
</tr>
<tr>
<td>Sample collected</td>
<td>Grab</td>
<td>ASTM 8332-20</td>
<td></td>
</tr>
<tr>
<td>Analysis performed</td>
<td>Microscopy/LDIR</td>
<td>PLM/Raman</td>
<td>Microscopy/LDIR</td>
</tr>
<tr>
<td>Plastics identified</td>
<td>No polystyrenic / PMMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resin sample match</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
</tr>
</tbody>
</table>

Findings do not suggest MP contribution to the environment from two IEX treatment locations.
What We’ve Accomplished

- Higher concentrations; longer treatment times; bundled locations

- Ancillary Benefits
  - ESG metrics, reduced future lability, waste minimization

<table>
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<tr>
<th>4 years full-time operation</th>
<th>1.5B Litres treated</th>
<th>HBGVs Achieved</th>
<th>19+ kg PFAS removed</th>
<th>20+ Regen Cycles</th>
</tr>
</thead>
</table>

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What We’ve Learned

- Consistently works (PFAS removal and resin regeneration)
- Not a silver bullet
- Accurate design parameters
- Optimization continues

- Future-proof
  - Tightening regulations
  - Off-ramp for destruction
The Future of Environmental Solutions
Thank you – Questions?

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