From **Waste** to **Reuse**: 
Chemical Waste Management and Environmental Sustainability

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Agenda – Waste to Reuse

• Intel fab processing waste management
  • Historical
  • Current
• 2020 Corporate Environmental Goals
  • Zero Hazardous Chemical Waste to Landfill
• Fab waste management progress
• Future Direction
• Supplier Opportunity
**Fab Chemical Waste Management**

In 2012, Intel materials organization assumed management of fab chemical waste from the logistics group

- Intel fab chemical waste strategy pivoted from compliance focus to focus on disposal method and cost
  - **reuse** > **recycle** > **disposal**

![2012 Waste Disposal Method]

- Total volume – 47K tons
Why does Intel care about disposal methods?

Intel CEO’s stated EHS policy

- “responsible environmental stewardship is good business”

Benchmarking

- Semiconductor manufacturers
  - 30% in-house regeneration, 95% recycle*
  - 95% recycling rate of manufacturing waste**
- Customer sustainability requirements

2020 Waste Environmental Goals

- Zero hazardous chemical waste to landfill
- 90% solid waste recycle

**Sources of Fab Processing Waste**

**Air Emissions**
- VOCs
- SO$_x$, NO$_x$
- PM10, PM2.5
- HAPs
- PFCs
- HF, HCl

**Waste Water Pollutants**
- HF
- NH4OH
- Metal ions
- Aqueous ions, TDS
- Organics, TN etc

**Chemical Waste – Intel supply chain focus**

- Lithography –
  - Solvent waste
- Dry Etch and Thin Films
  - PFC gases converted to HF in POU device
- Polish Waste
  - Polish solids and metal ions
- Metals deposition
  - Metal plating waste
- Wet etch
  - Aqueous and solvent waste
Wet Etch – Aqueous Waste

Onsite Waste Management

- NH₄OH
  - NH₄OH\(_{(aq)}\) + NaOH $\rightarrow$ NH₃\(_{(g)}\)
  - NH₃\(_{(g)}\) + H₂SO₄ $\rightarrow$ (NH₄)₂SO₄\(_{(aq)}\)
- HF
  - HF\(_{(aq)}\) + Ca(OH)₂ $\rightarrow$ CaF₂\(_{(s)}\)
- NH₄OH/HF
  - NH₄ treatment
  - HF treatment
- H₂SO₄ – offsite disposal
- AWN – neutralized acids and bases
  - TDS - total dissolved solids
Wet Etch – Specialty Base Cleaners
organic/water solutions

- Onsite Waste Management
  - Classified as hazardous Waste
  - Collect and truck, manage disposal offsite
2013 US and 2014 IR Supplier Disposal Bid
Focus on disposal (reuse > recycle > disposal)

Total volume – 54K tons
## Supplier Disposal Bid Opportunities – Wet Cleans

<table>
<thead>
<tr>
<th>Wet Clean → Waste stream</th>
<th>Pre-RFQ</th>
<th>2014 RFQ Proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄OH → onsite treatment (NH₄)_₂SO₄</td>
<td><strong>Waste Water treatment</strong></td>
<td><strong>Fertilizer manufacturing</strong></td>
</tr>
<tr>
<td>HF → onsite treatment CaF₂</td>
<td><strong>Landfill or cement kiln recycle</strong></td>
<td><strong>Cement Kiln Recycle</strong></td>
</tr>
<tr>
<td>Specialty base cleaners → collect and truck</td>
<td><strong>Incineration</strong></td>
<td>Numerous Supplier proposals</td>
</tr>
<tr>
<td>Non-wet clean chemistry: litho solvents</td>
<td><strong>Fuel Blend</strong></td>
<td><strong>Solvent purification and recovery</strong></td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td><strong>Onsite neutralization</strong></td>
<td><strong>2017 Collect and truck → landfill</strong></td>
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</tbody>
</table>

**Specialty base cleaners – >40% of total waste volume**

- Incineration
- WWT at local POTW
- Fuel blend
- Reuse opportunity → rail car cleaning
  - EPA regulated waste under RCRA
  - RCRA exemption
    - Commercial replacement
- Current - Low BTU direct fuel
- Proposed by 2020 – water recovery and org fuel or chemical reuse
2013 US and 2014 IR Supplier Disposal Bid

Focus on disposal (reuse > recycle > disposal)

Total volume – 54K tons

Preferred

Reduce
Reuse
Recycle
Fuel
WWT
Incineration
Landfill

2015 Waste Disposal Method

Total volume – 76K tons
2013 US and 2014 IR Supplier Disposal Bid

Focus on Cost

- Closer Disposal Options
- Transportation Methods

- Pie chart showing
  - Disposal 49%
  - Transportation 45%
  - Other

- Bar chart showing
  - $/ton over time for AZ, IR, OR, and TOTAL
  - Colors for:
    - Trans
    - Treatment
    - Other
  - Years 2013 to 2018
2019 and Beyond – Focus for the Future

**Trend**
- Increased volumes
- Focus on business continuity
- Increased complexity

Total Chemical Waste by Year

- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019

11 Elements

15 Elements

Up to 45 Elements
## Disposal Opportunities 2019 and Beyond – Wet Cleans

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<th>Opportunities</th>
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<td>NH$_4$OH →</td>
<td><strong>Fertilizer manufacturing</strong></td>
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<tr>
<td>CaF$_2$</td>
<td><strong>Cement kiln recycle</strong></td>
<td><strong>Cement Product (IR)</strong></td>
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<td></td>
<td></td>
<td><strong>Cement kiln recycle (US)</strong></td>
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<tr>
<td>Specialty base cleaners</td>
<td><strong>Low BTU Fuel</strong></td>
<td><strong>Water recovery</strong></td>
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<td><strong>Organic high BTU fuel</strong></td>
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<tr>
<td>Salt loading (aqueous cleans)</td>
<td></td>
<td><strong>Landfill Na$_2$SO$_4$</strong></td>
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<tr>
<td>Spent sulfuric acid</td>
<td><strong>&lt;2017 local sewer</strong></td>
<td><strong>Recovery offsite</strong></td>
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<td><strong>Stabilize and landfill</strong></td>
<td><strong>Onsite recovery for facility reuse</strong></td>
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2019 and Beyond – Focus for the Future

- Continued emphasis on *reuse/recovery* while maintaining cost pressure
- Separately investigate onsite waste treatment to *reduce* volumes
- Continued focus on 2020 Corporate Hazardous Waste Environmental Goal – *Zero Hazardous Chemical Waste to Landfill*
- *Stretch goals – 2025 Corporate Goals*
Wet Clean Supplier Call to Action

Current Wet Clean Rinse Profile

Proposed Wet Clean Rinse Profile
Thank you
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