



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

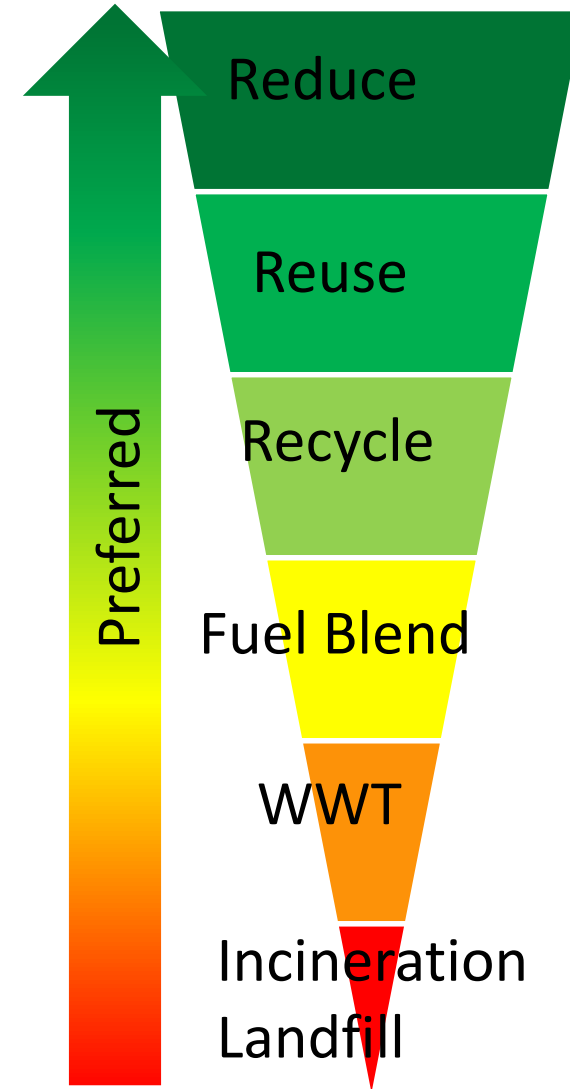
Kathleen Fiehrer, Intel Materials Engineer

April 1, 2019



# 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

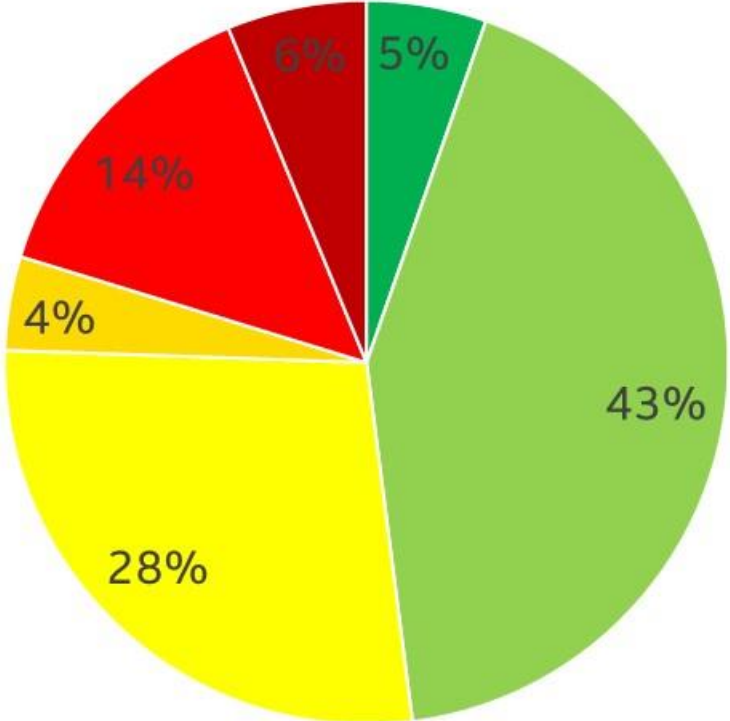


# Fab Chemical Waste Management

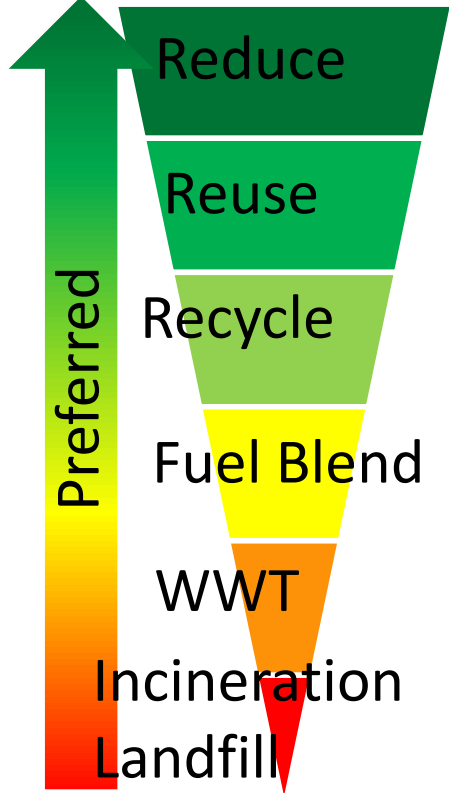
In 2012, Intel materials organization assumed management of fab chemical waste from the logistics group

- 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

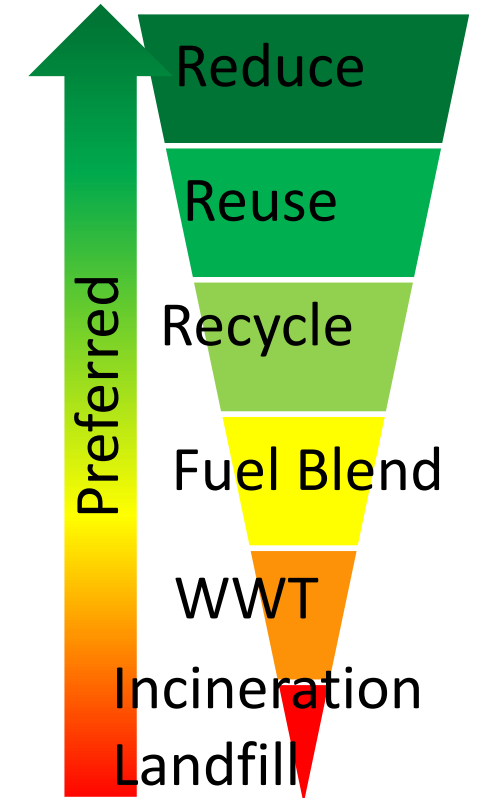
- “responsible environmental stewardship is good business”

## 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



\* <https://www.tsmc.com/csr/en/focus/greenManufacturing/wasteManagement.html> 2018

\*\* <https://www.samsung.com/us/aboutsamsung/sustainability/environment/resource-efficiency/> 2016

# Sources of Fab Processing Waste

## Air Emissions

- VOCs
- SO<sub>x</sub>, NO<sub>x</sub>
- PM10, PM2.5
- HAPs
- PFCs
- HF, HCl

## Waste Water Pollutants

- HF
- NH<sub>4</sub>OH
- Metal ions
- Aqueous ions, TDS
- Organics, TN etc

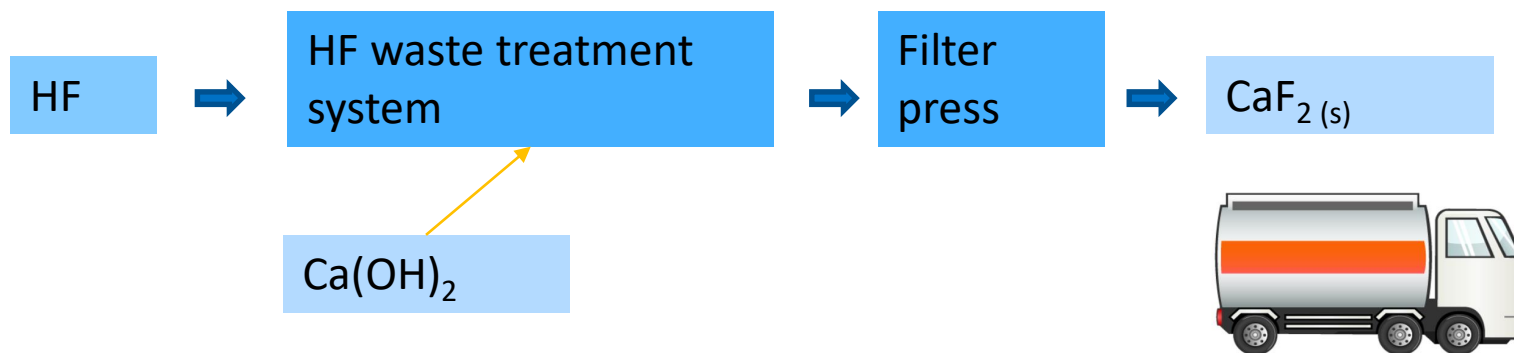
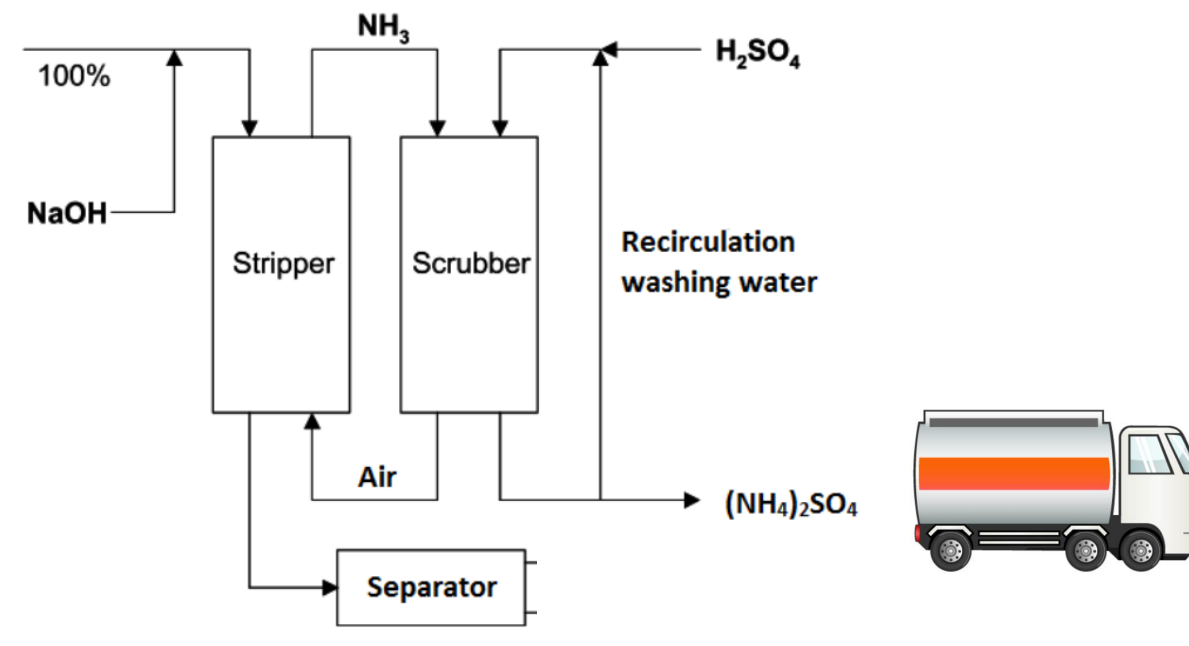
## Chemical Waste – Intel supply chain focus

- 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

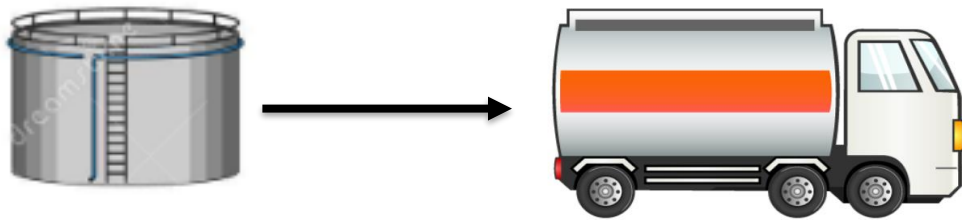
- $\text{NH}_4\text{OH}$ 
  - $\text{NH}_4\text{OH}_{(\text{aq})} + \text{NaOH} \rightarrow \text{NH}_3(\text{g})$
  - $\text{NH}_3(\text{g}) + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4(\text{aq})$
- HF
  - $\text{HF}_{(\text{aq})} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaF}_2(\text{s})$
- $\text{NH}_4\text{OH}/\text{HF}$ 
  - $\text{NH}_4$  treatment
  - HF treatment
- $\text{H}_2\text{SO}_4$  – offsite disposal
- AWN – neutralized acids and bases
  - TDS - total dissolved solids



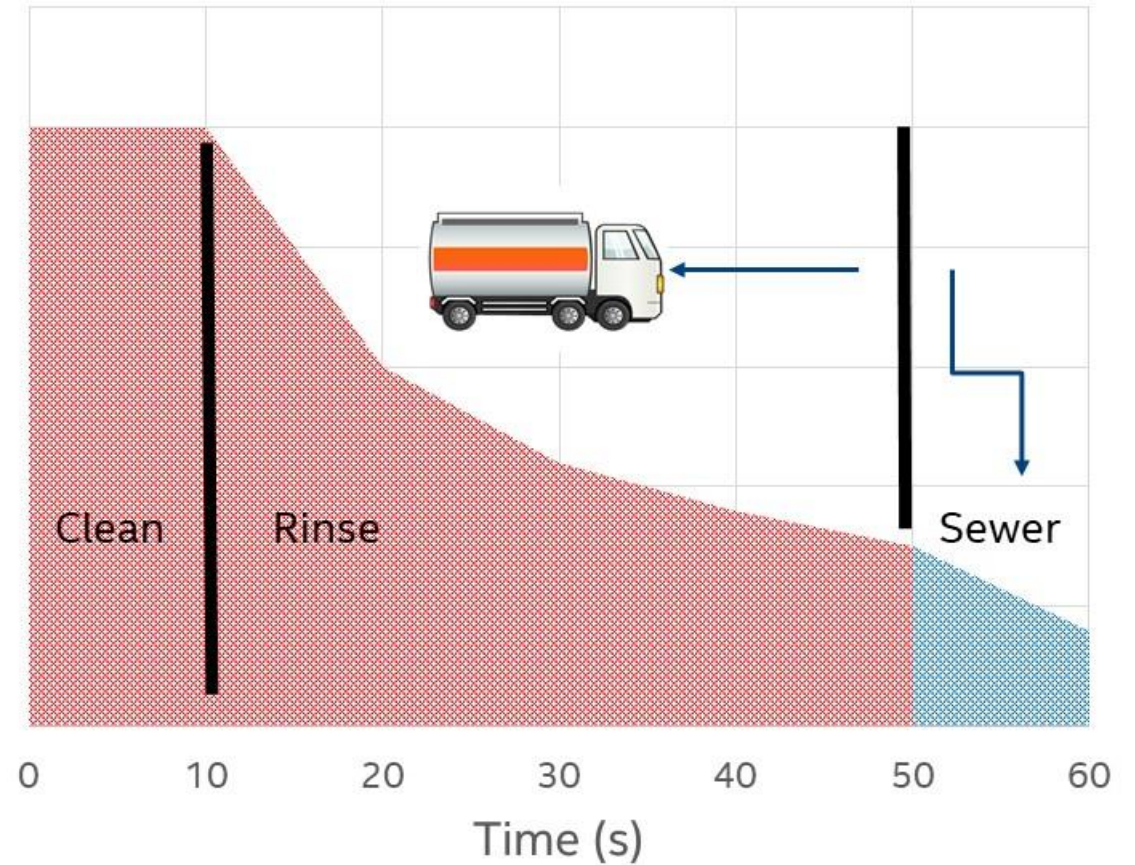
# Wet Etch – Specialty Base Cleaners

## organic/water solutions

- Onsite Waste Management
  - Classified as hazardous Waste
  - Collect and truck, manage disposal offsite



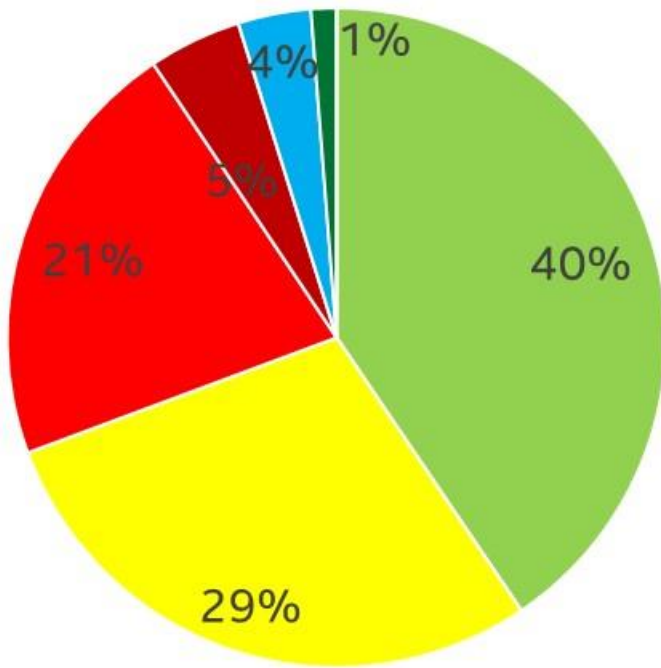
Wet Clean Chemistry & Rinse Profile



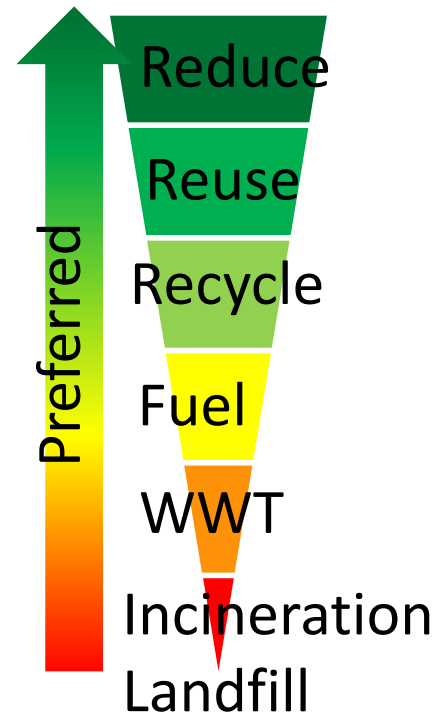
# 2013 US and 2014 IR Supplier Disposal Bid

Focus on disposal (**reuse** > **recycle** > **disposal**)

2013 Disposal Method



Total volume – 54K tons

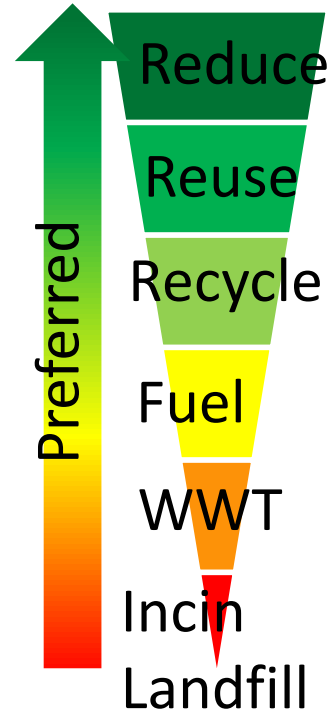


# Supplier Disposal Bid Opportunities – Wet Cleans

Wet Clean → Waste stream	Pre-RFQ	2014 RFQ Proposal
NH <sub>4</sub> OH → onsite treatment (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Waste Water treatment	Fertilizer manufacturing
HF → onsite treatment CaF <sub>2</sub>	Landfill or cement kiln recycle	Cement Kiln Recycle
Specialty base cleaners → collect and truck	Incineration	Numerous Supplier proposals
Non-wet clean chemistry: litho solvents	Fuel Blend	Solvent purification and recovery
Sulfuric acid	Onsite neutralization	2017 Collect and truck → landfill

Specialty base cleaners – >40% of total waste volume

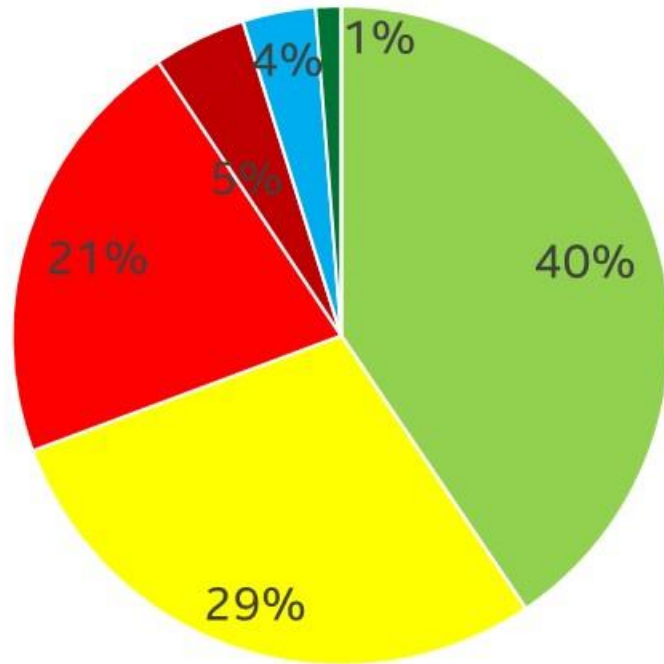
- Incineration
- WWT at local POTW
- Fuel blend
- Reuse opportunity → rail car cleaning
  - EPA regulated waste under RCRA
  - RCRA exemption
    - Commercial replacement
- Current - Low BTU direct fuel
- Proposed by 2020 – water recovery and org fuel or chemical reuse



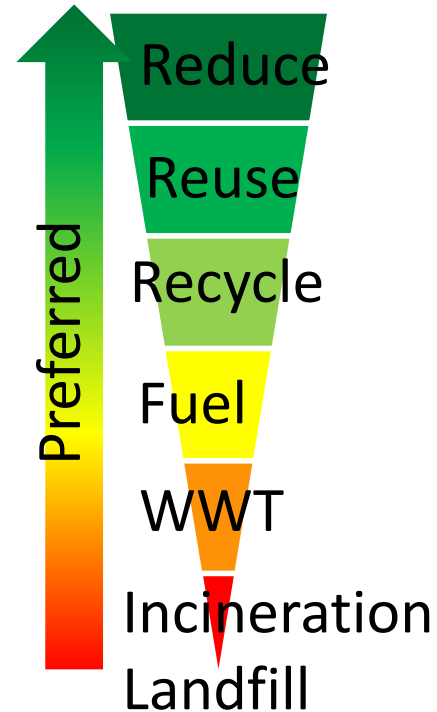
# 2013 US and 2014 IR Supplier Disposal Bid

Focus on disposal (**reuse** > **recycle** > **disposal**)

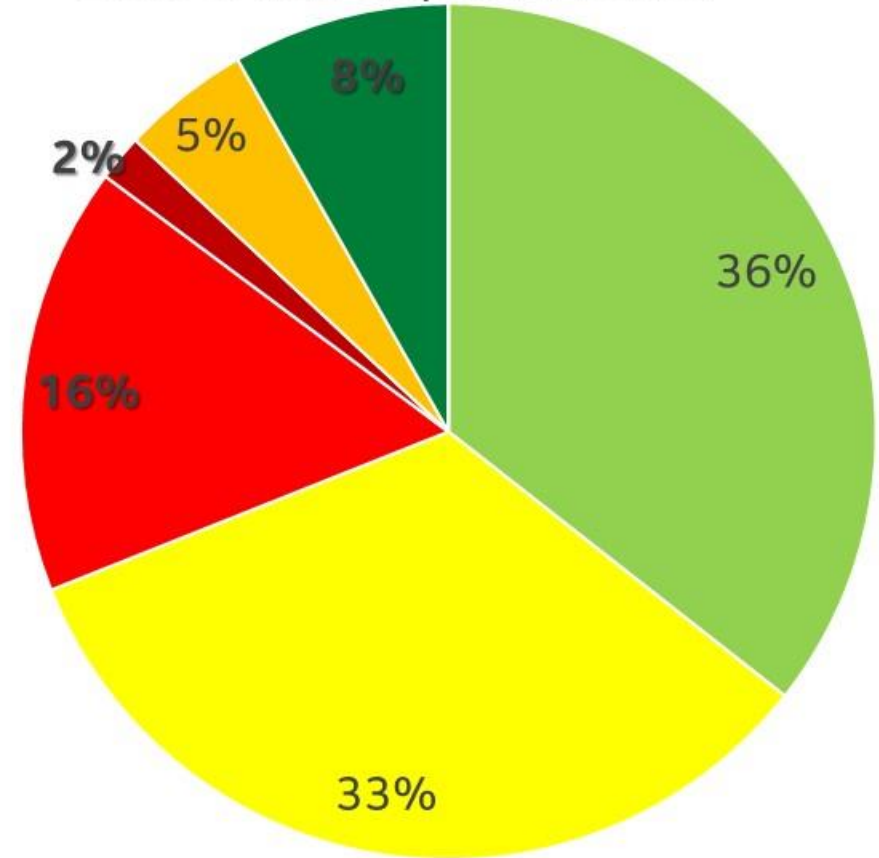
### 2013 Disposal Method



Total volume – 54K tons



### 2015 Waste Disposal Method

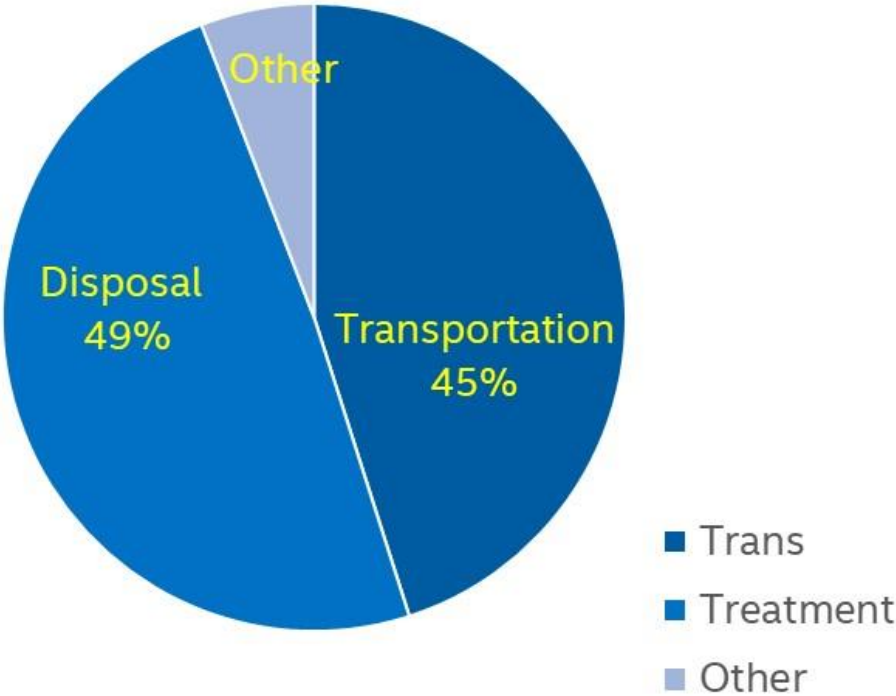


Total volume – 76K tons

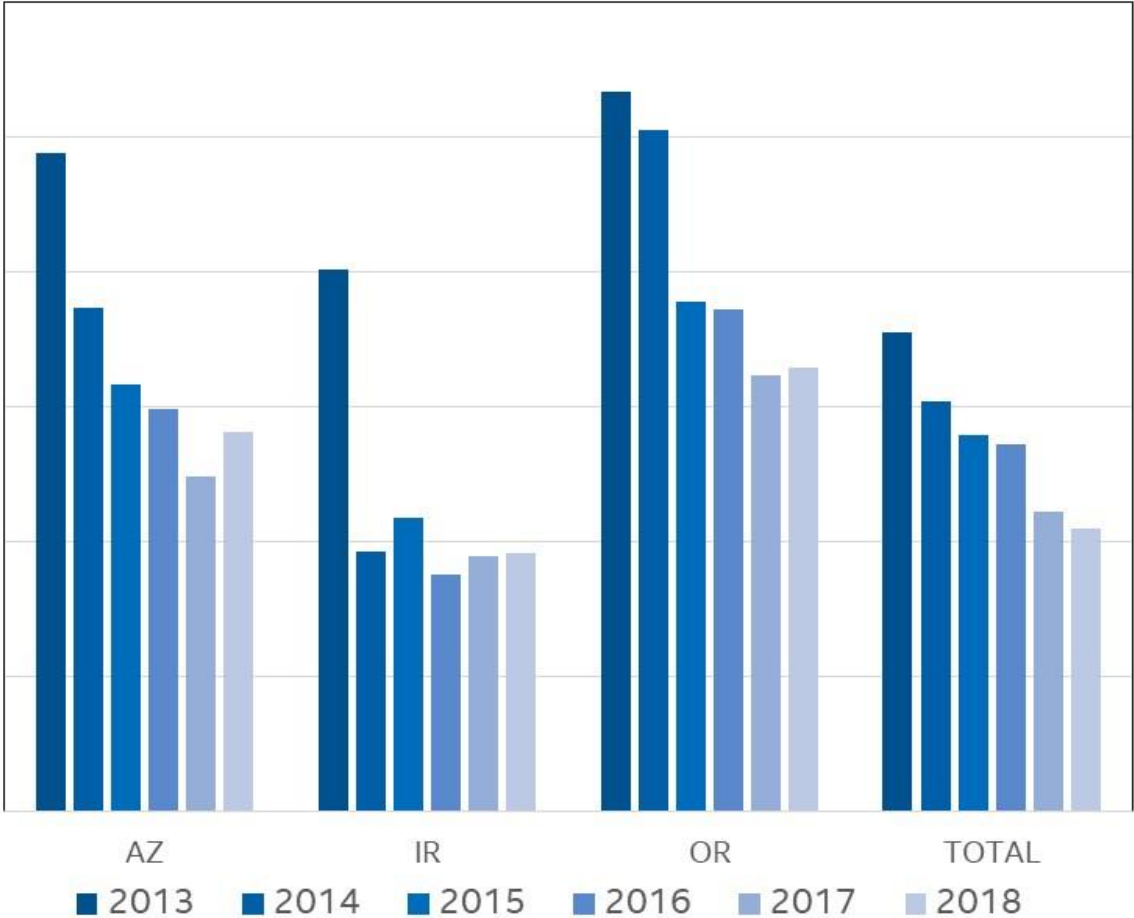
# 2013 US and 2014 IR Supplier Disposal Bid

## Focus on Cost

- Closer Disposal Options
- Transportation Methods



\$/ton over time

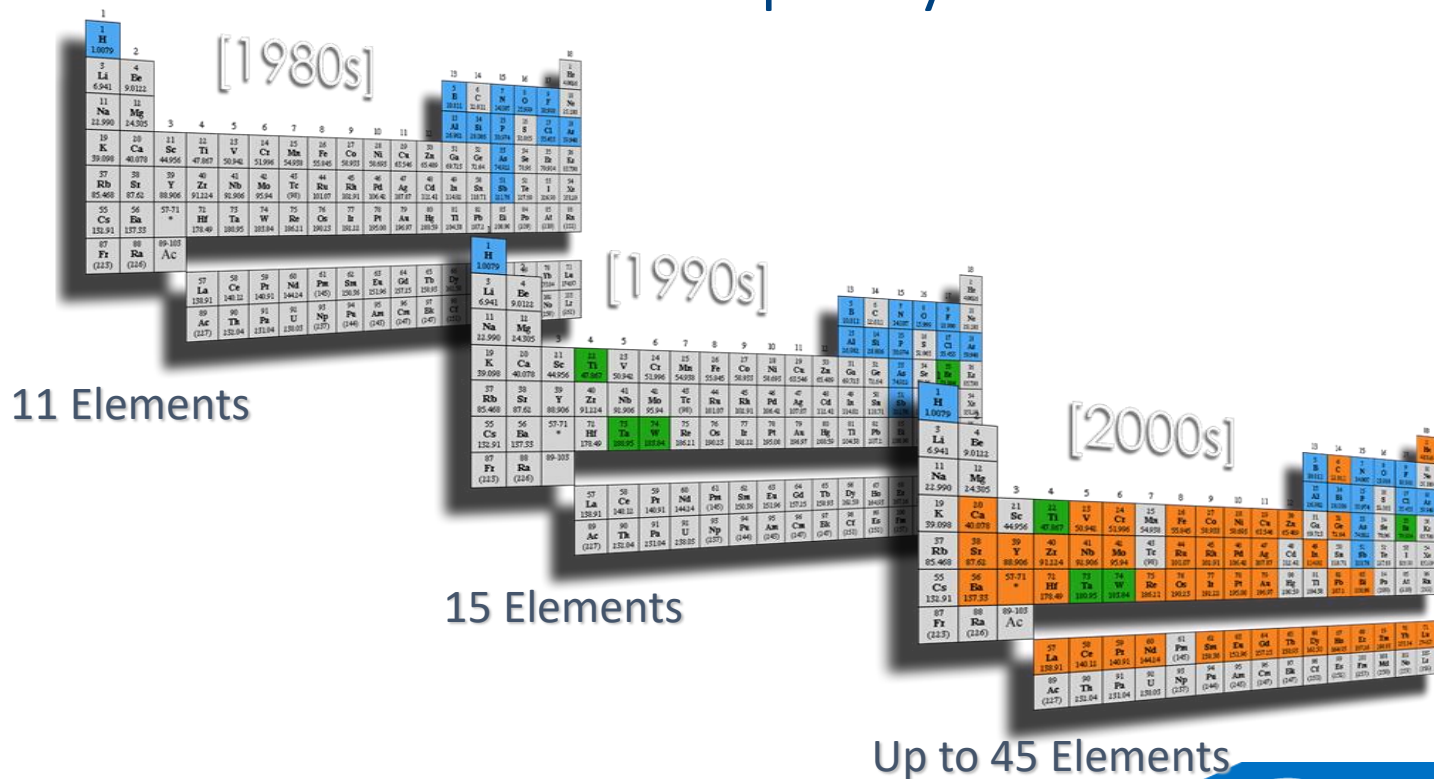
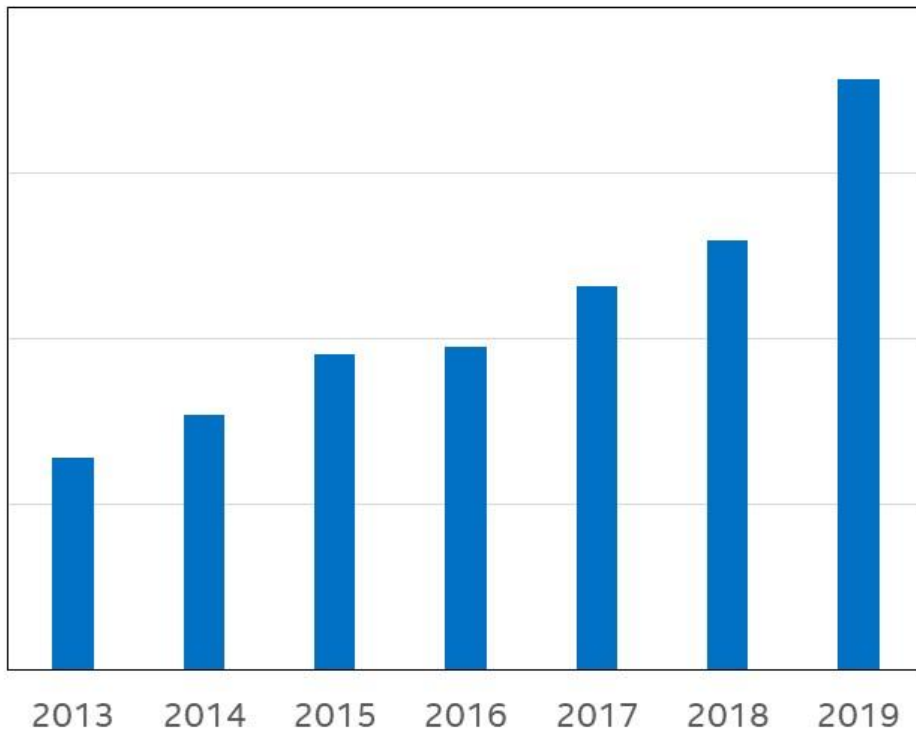


# 2019 and Beyond – Focus for the Future

## Trend

Total Chemical Waste by Year

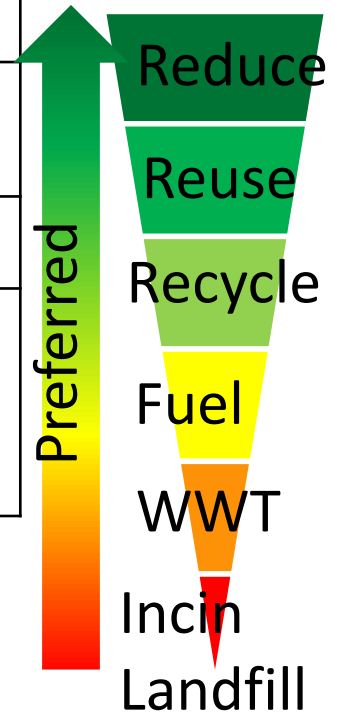
- Increased volumes
- Focus on business continuity
- Increased complexity



Up to 45 Elements

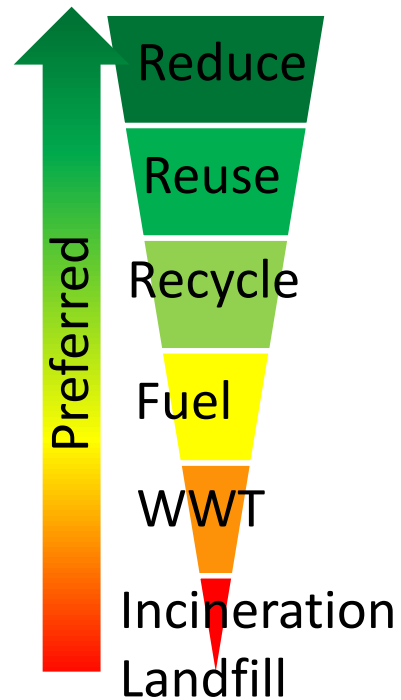
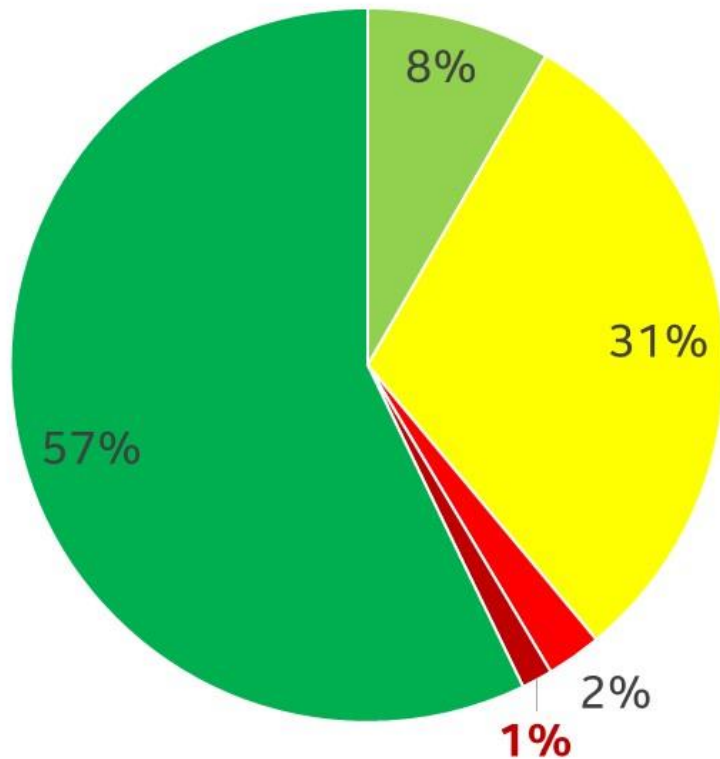
# Disposal Opportunities 2019 and Beyond– Wet Cleans

Wet Clean → Waste stream	Current	Opportunities
NH <sub>4</sub> OH →	Fertilizer manufacturing	Fertilizer manufacturing
CaF <sub>2</sub>	Cement kiln recycle	Cement Product (IR) Cement kiln recycle (US)
Specialty base cleaners	Low BTU Fuel	Water recovery Organic high BTU fuel
Salt loading (aqueous cleans)		Landfill Na <sub>2</sub> SO <sub>4</sub>
Spent sulfuric acid	<2017 local sewer  Stabilize and landfill	<ul style="list-style-type: none"> <li>Recovery offsite</li> <li>Onsite recovery for facility reuse</li> </ul>



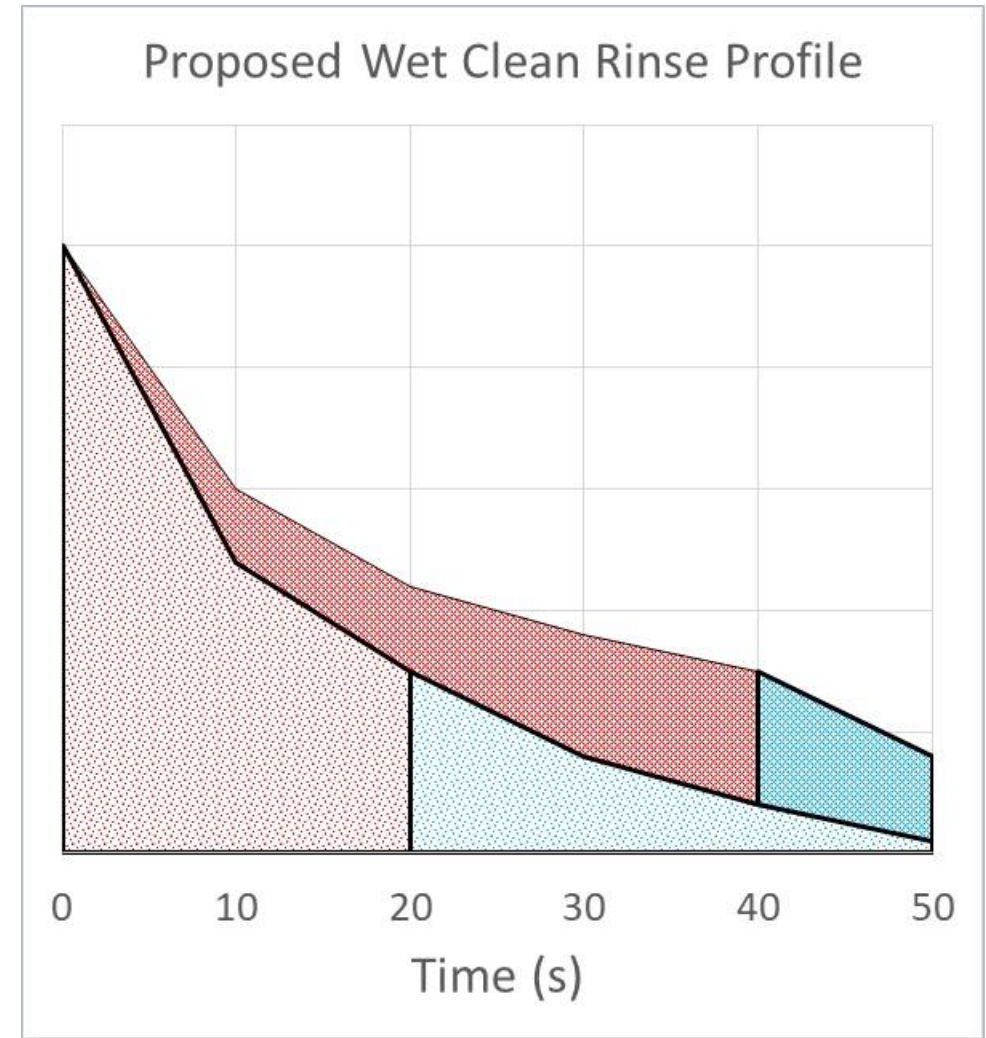
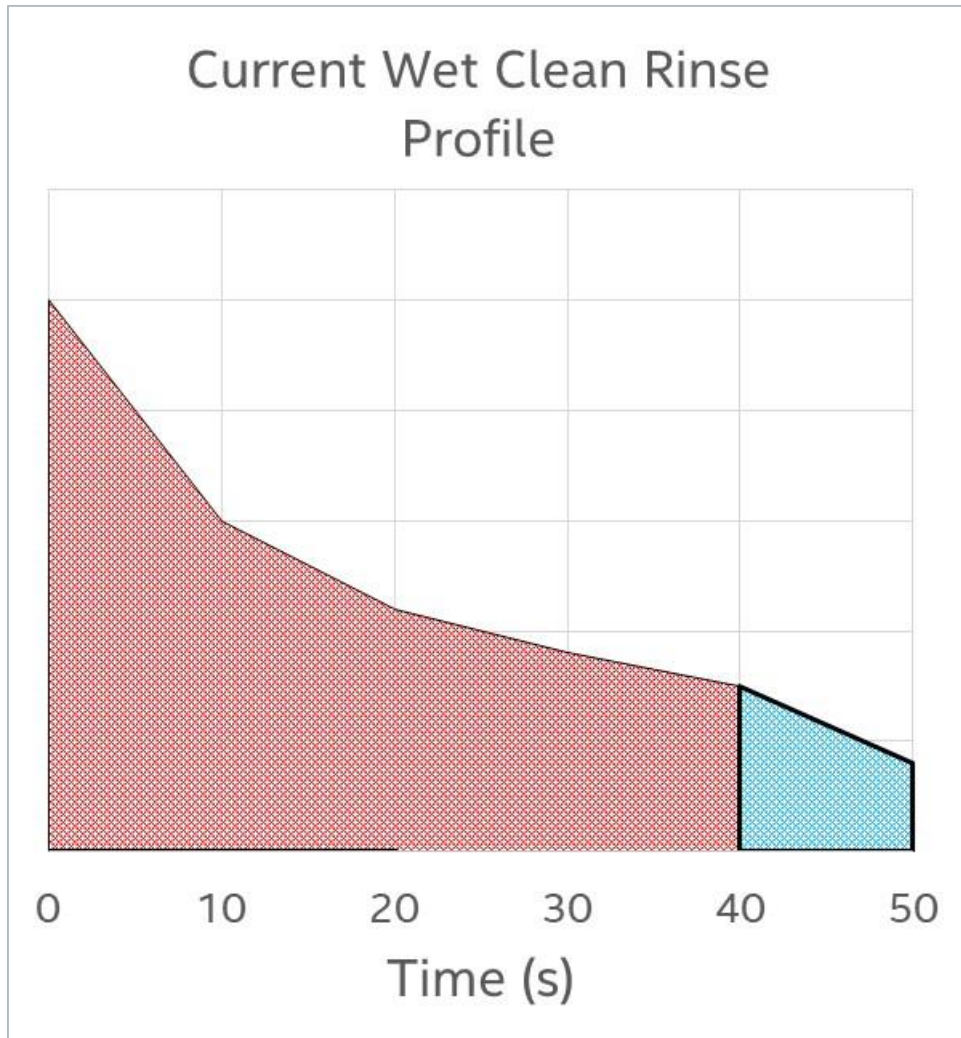
# 2019 and Beyond – Focus for the Future

Target Disposal Methods



- 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



Thank you  
Questions?

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