Waste Minimization: Is It Cost Effective During Decommissioning and Decontamination?

SESHA/DTSC Joint Pollution Prevention Mini-Conference
November 5, 2003

Department of Toxic Substances Control

Presented by:
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DECON Environmental Services, Inc.

Questions Often Asked

1) *"Is there really a need to minimize waste during decommissioning?"*
2) *"How do I define the decommissioning process?"*
3) *What specific process steps do I need to address to get financial savings using waste minimization?*
4) *How clean does clean need to be?*
5) *"What is an example of applying waste minimization and how much was actually saved?*
6) *"Are all the waste streams we examine always cost effective to minimize?"*

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Quick Answers

1) Yes, there is a need – environmental, cost of ownership, good business
2) Look at the definition of the site facility, systems and sub-systems
3) In four major process flow steps – many tasks and decisions to make in order to identify and capture savings
4) In simple terms…define the assets final disposition and verification sampling protocol needed
5) Fab closure example to follow
6) No, in some cases the total cost does not warrant applying waste minimization efforts

Disposition Options

- **Facility**
  1. Convert & upgrade
  2. Decommission & mothball
  3. Sell “as is”
  4. Upgrade & clean for another use
  5. Decommission & demolish for sale and redevelopment
- **Tool/Equipment**
  1. Sale and transfer for reuse (“as-is”, refurbish, or upgrade)
  2. Storage for future use
  3. Scrap or salvage
  4. Donation
  5. Disposal

Fab Closure Example - Background

- 40,000 sq. ft. semiconductor fab
- 15 years old
- Environmental closure cost ~ $1 Million
- Closure conducted in California under strict regulatory oversight

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Fab Closure Cost Table

Key to Acronyms and Definitions

- **FRP** – Fiber Reinforced Polymer – various composition of fiberglass
- **S/S** – Stainless Steel
- **GALV** – Galvanized or Carbon steel
- **Plastic** – PVC, Polypropylene, ABS, Polyethylene
- **L** – Landfill disposal
- **NH** – Non-hazardous waste by Federal, State, and Local Jurisdictions
- **H** – Hazardous waste (RCRA, Non-RCRA, State-mandated, Client-mandated)
- **R** – Recycled
- **OF** – Offsite Facility not owned by company
- **ON** – Onsite or internal reuse at the same or another company owned facility
- **Auxiliary Tool Process Equipment** – vacuum pumps, abatement equipment, control equipment, etc

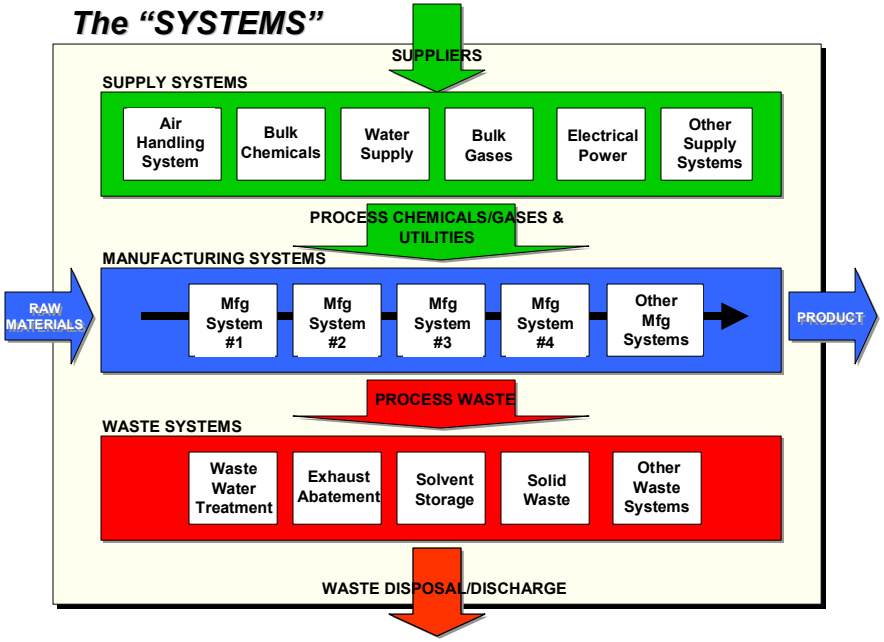
Fab Closure Cost Table

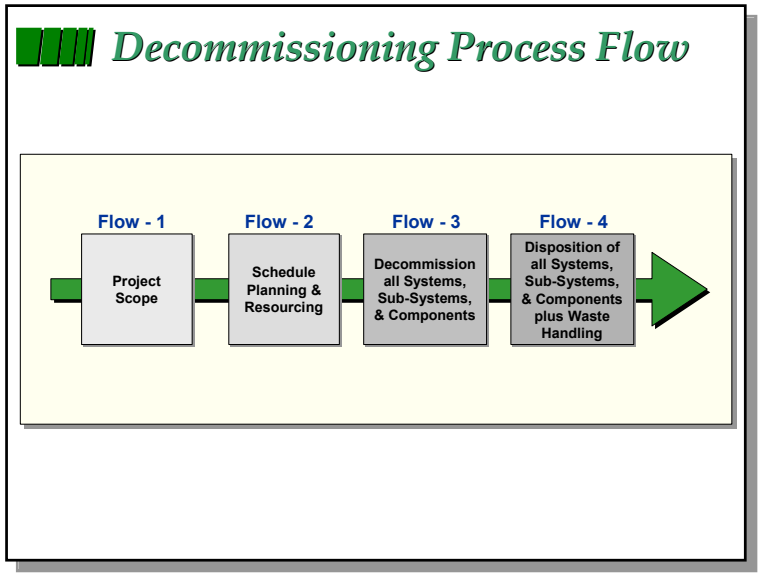
- **Cost Without Waste Minimization includes:**
  - Disposition as hazardous waste in a landfill or treatment facility
- **Cost With Waste Minimization includes:**
  - Recover waste to valuable asset applying effective cleaning techniques and defensible verification sampling & analysis protocol to show waste does not contain residual chemicals at unacceptable levels (as defined by Federal, State, Local regulations, DOT, and/or client-mandated requirements)
  - Reducing the volume of waste by onsite compression, treatment, and/or filtration methods

Type of Waste	Construction Material	Disposition Options	Cost Without Waste Minimization ($)	Cost With Waste Minimization ($)
Acid Exhaust Duct	FRP	L-H, L-NH	25,000	4,000
Acid Exhaust Duct	S/S	R-OF	25,000	2,500
Solvent Exhaust Duct	S/S or GALV	L-H, R-OF	10,000	15,500
Acid Supply & Waste Piping	Plastic	L-NH, R-OF	5,000	500
Acid Supply & Waste Piping (HF)	S/S	L-NH, R-OF	6,000	1,200
Solvent Supply & Waste Piping	GALV	L-NH, R-OF	5,000	1,500
Gas Piping	S/S	R-OF	5,000	500
Gas Cabinets	GALV	R-ON	12,000	1,500
Tool Exhaust Pipe	S/S	R-OF	10,000	1,500
Tool Process Pipe	Plastic	L-H	10,000	2,000
Auxiliary Tool Process Equipment	S/S, GALV, Plastic	L-NH, R-ON, R-OF	35,000	5,000
Acid Waste Neutralization Tanks	Plastic	L-NH	4,000	1,200
HF Waste Treatment Tanks	Plastic	L-NH	5,200	2,500
Wastewater Corrosive Chemical Supply Tanks	Plastic, GALV	L-NH, R-OF	5,800	1,500
Solvent Waste Tanks	GALV, S/S	R-OF	4,300	1,000
Solvent Supply Tanks	S/S	R-OF	4,700	500
VOC Abatement System	GALV, S/S	R-ON	4,700	0
Acid Fume Scrubbers (6)	FRP	R-OF	7,300	0
Acid Fume Scrubber Packing	Plastic	L-H	4,000	7,000
Table 1 - Fab Closure Example for Waste Minimization		Total Waste Min. Cost	$188,000	$49,400
		Total Savings	$138,600	

Decommissioning Process

- Site definitions and systems
- Decommissioning Process Flow





Some Definitions – Many Versions

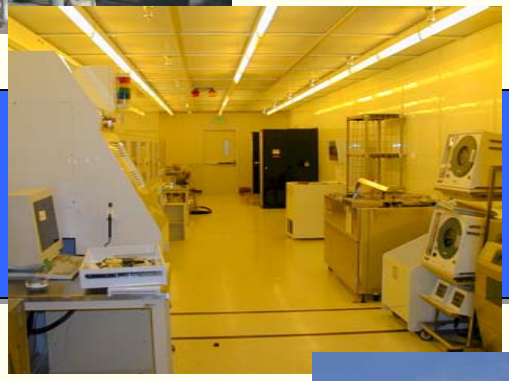
- **Decommissioning:** *The process of safely bringing down and disassociating a system, sub-system, or component*
- **System:** *An assemblage or combination of things or parts forming a complex or unitary whole to accomplish a specific process*
- **Sub-system:** *A secondary or subservient system; part of a system*
- **Component:** *An individual element in something larger (e.g. a sub-system or system)*
- **Item:** *A system, sub-system, or component*
- **End-State:** *The final appearance of the facility including the extent of decontamination required*
- **Disposition:** *What the end-state will be for systems, sub-systems, and components (e.g. move to another facility, store, salvage, waste, etc.)*

The “Site”

The "Components of the Site Facility"

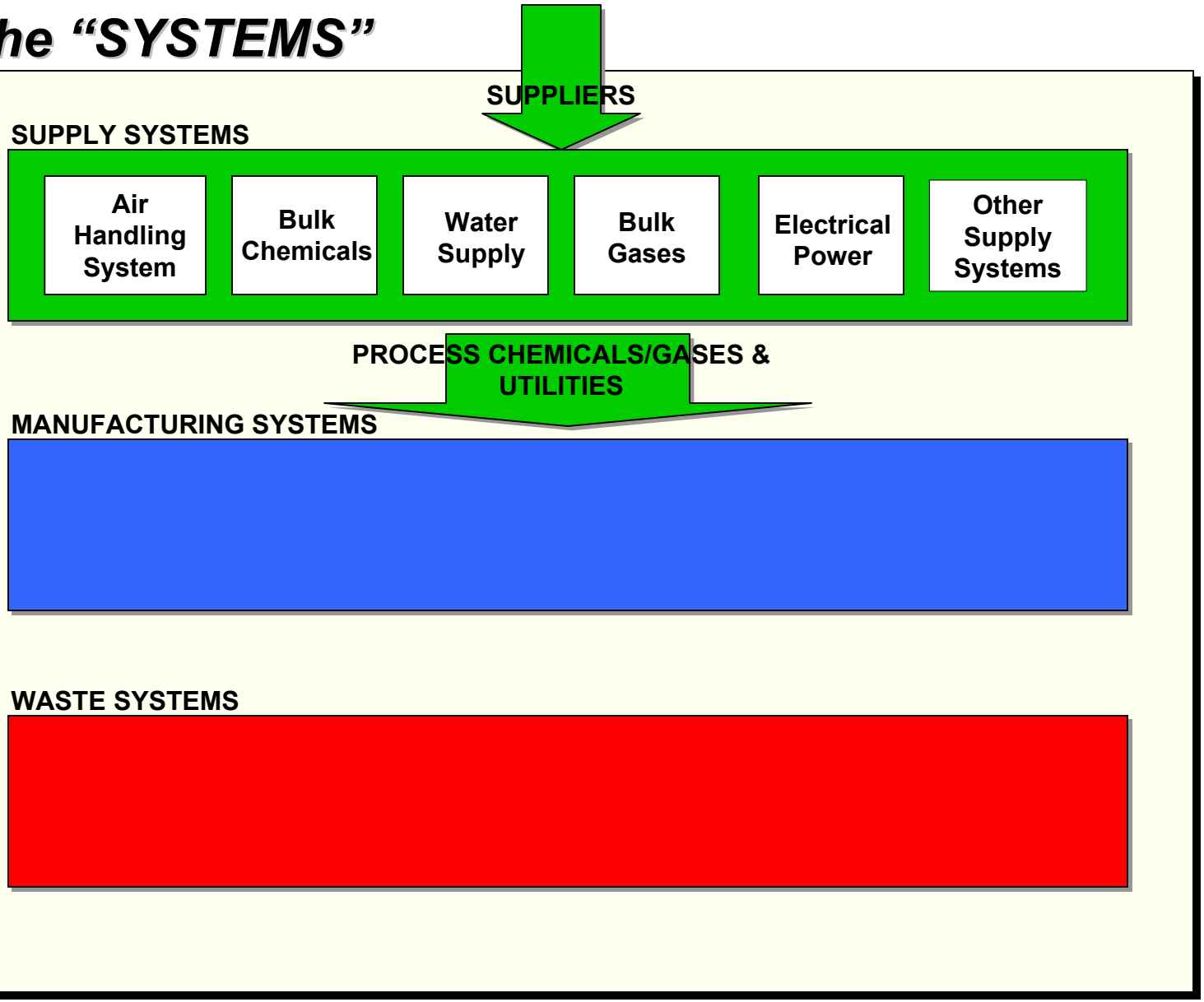
SUPPLY FACILITIES

MANUFACTURING FACILITIES

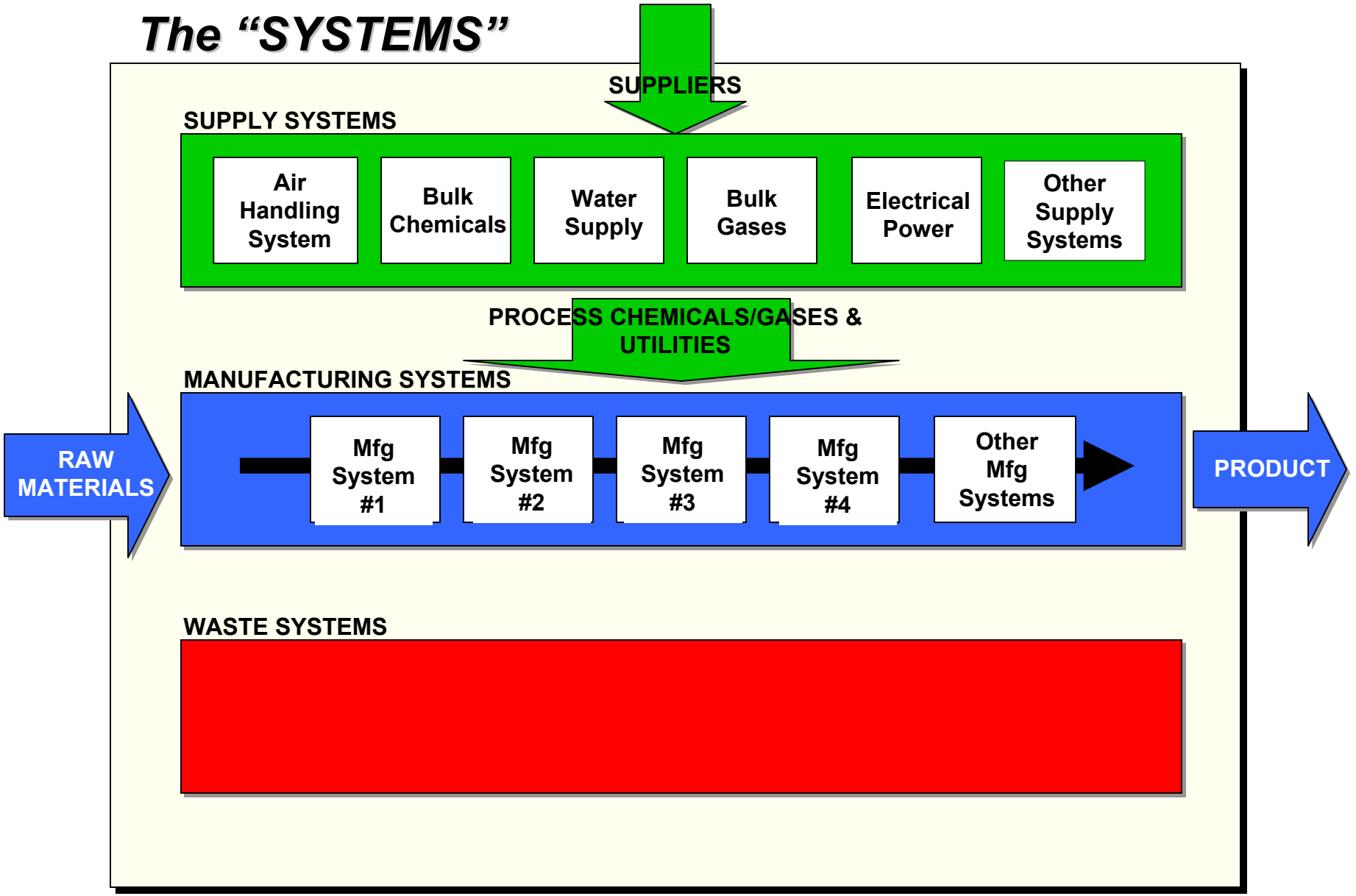


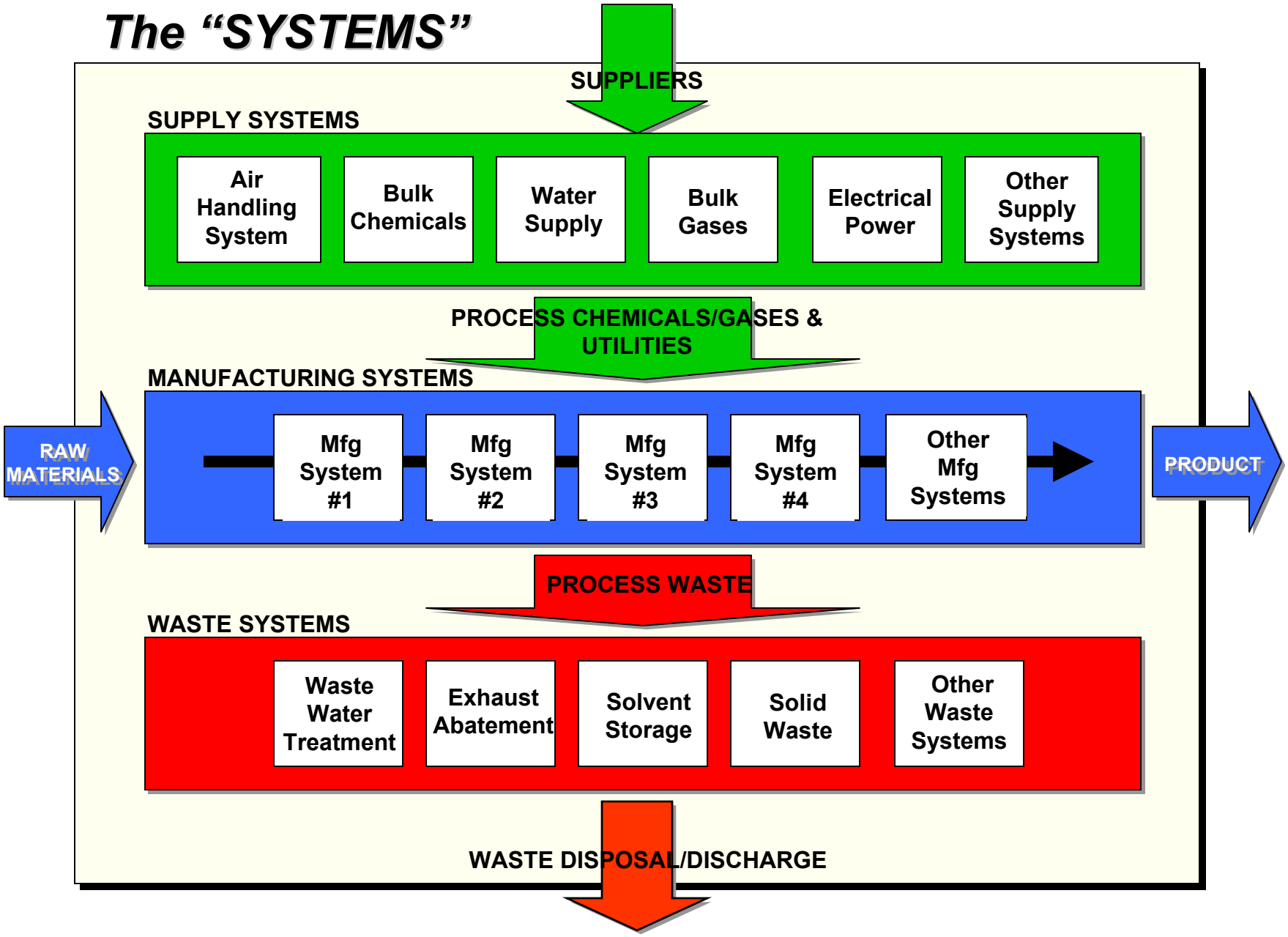
WASTE FACILITIES

The "SYSTEMS"

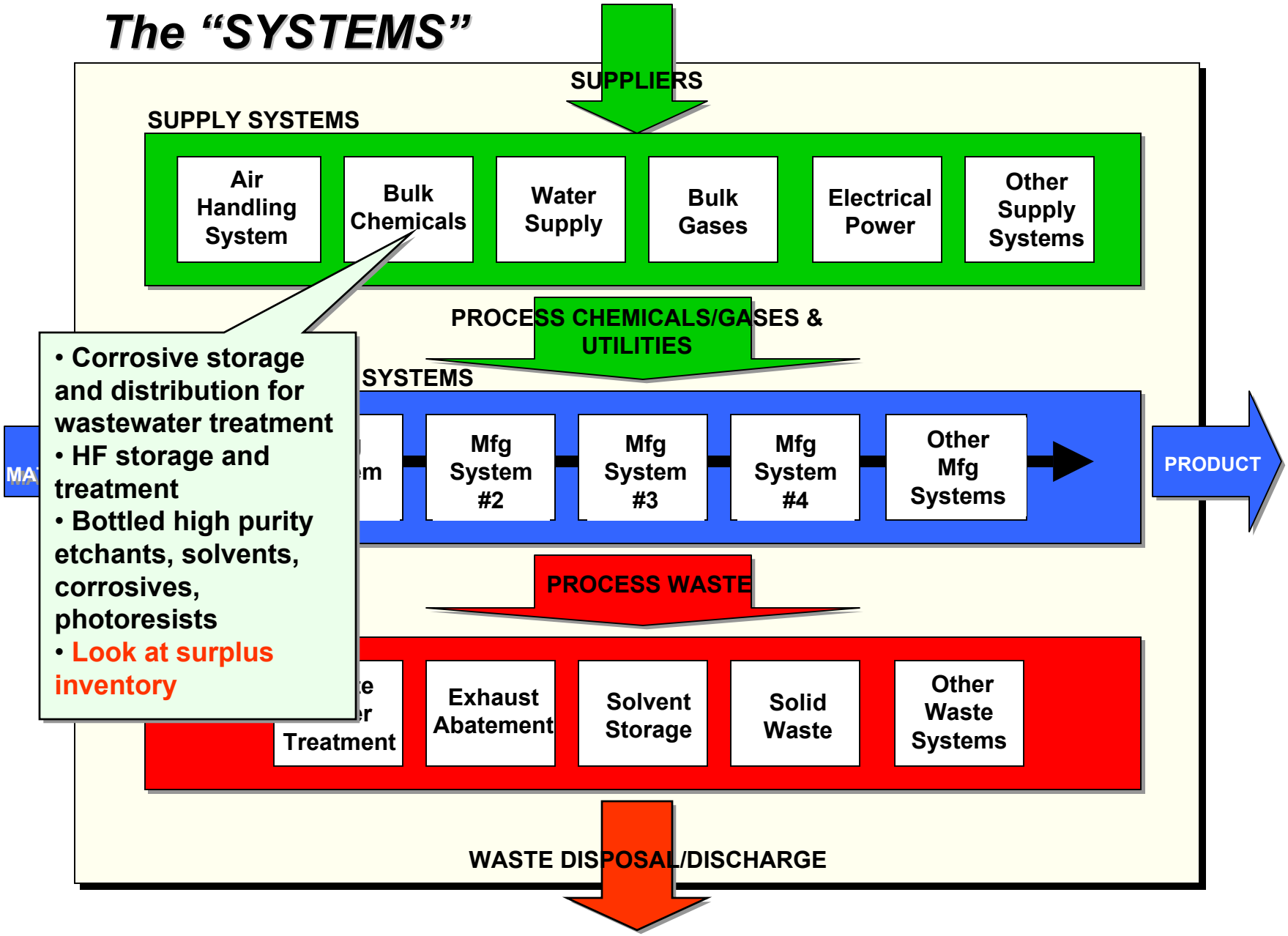

SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Chemicals
Water Supply
Bulk Gases
Electrical Power
Other Supply Systems
PROCESS CHEMICALS/GASES & UTILITIES
MANUFACTURING SYSTEMS
WASTE SYSTEMS

The "SYSTEMS"

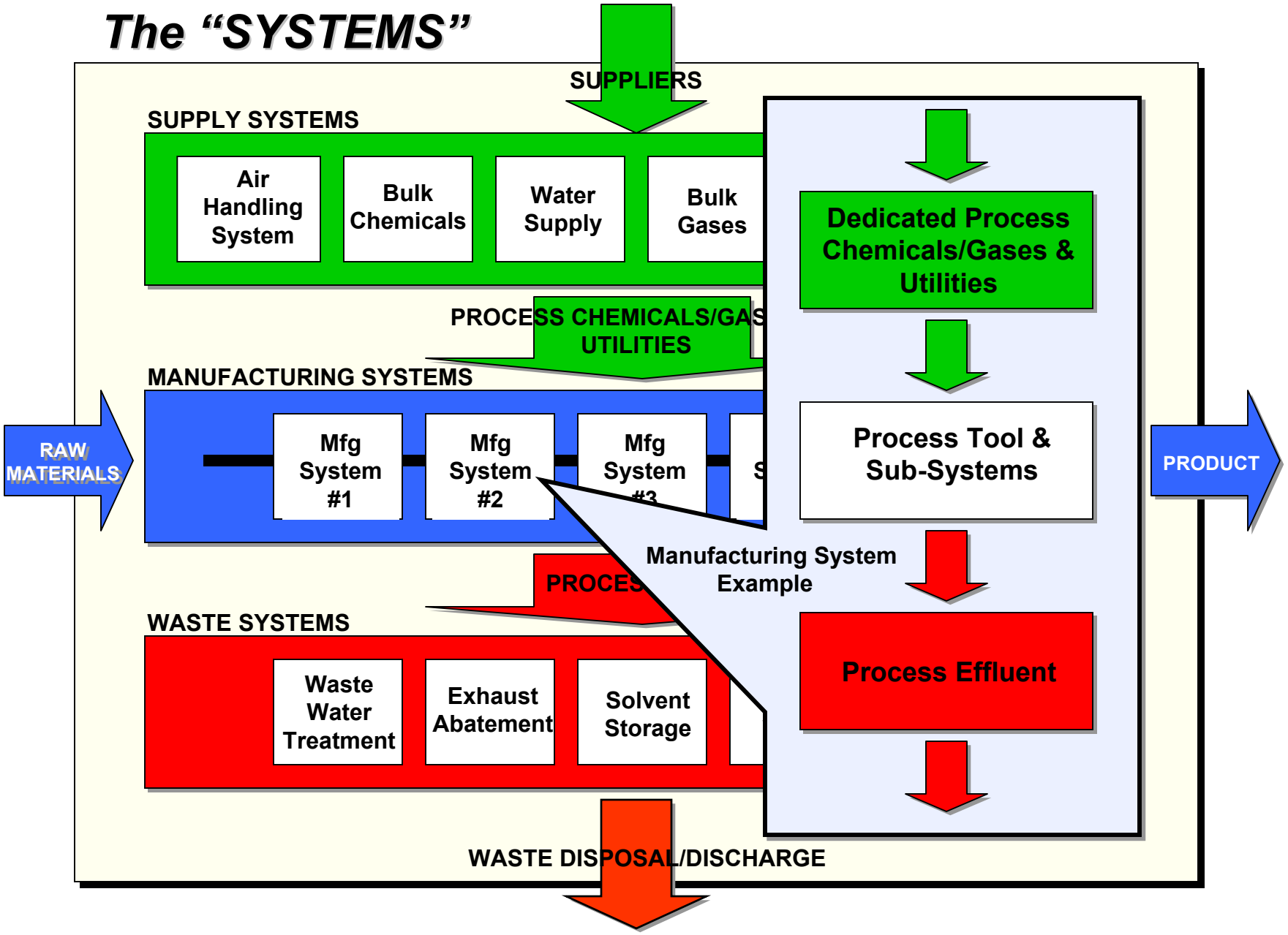

SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Chemicals
Water Supply
Bulk Gases
Electrical Power
Other Supply Systems
PROCESS CHEMICALS/GASES & UTILITIES
MANUFACTURING SYSTEMS
RAW MATERIALS
Mfg System #1
Mfg System #2
Mfg System #3
Mfg System #4
Other Mfg Systems
PRODUCT
WASTE SYSTEMS


The "SYSTEMS"
SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Chemicals
Water Supply
Bulk Gases
Electrical Power
Other Supply Systems
PROCESS CHEMICALS/GASES & UTILITIES
MANUFACTURING SYSTEMS
RAW MATERIALS
Mfg System #1
Mfg System #2
Mfg System #3
Mfg System #4
Other Mfg Systems
PRODUCT
PROCESS WASTE
WASTE SYSTEMS
Waste Water Treatment
Exhaust Abatement
Solvent Storage
Solid Waste
Other Waste Systems
WASTE DISPOSAL/DISCHARGE

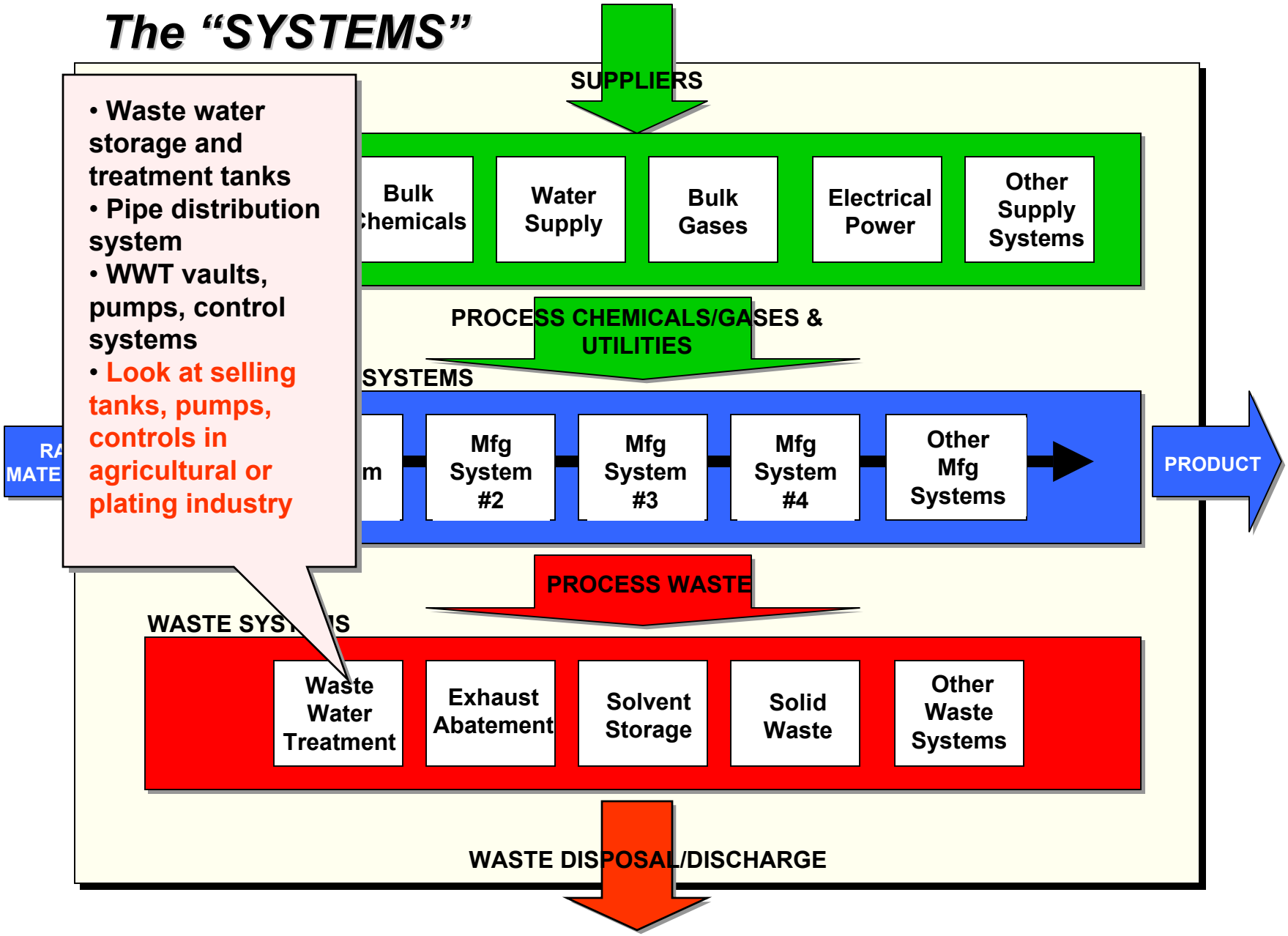
The "SYSTEMS"



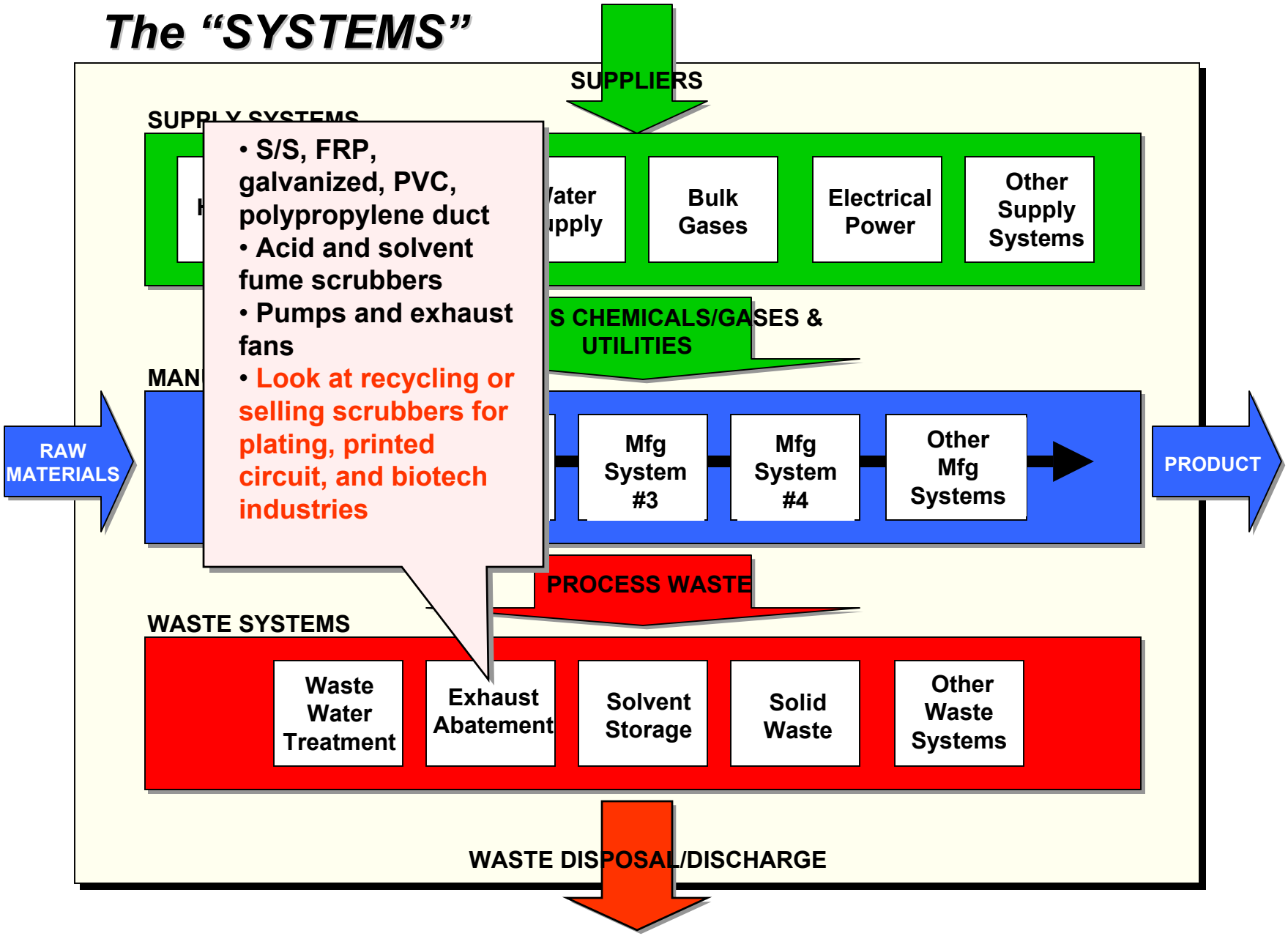
- Corrosive storage and distribution for wastewater treatment
- HF storage and treatment
- Bottled high purity etchants, solvents, corrosives, photoresists
- Look at surplus inventory

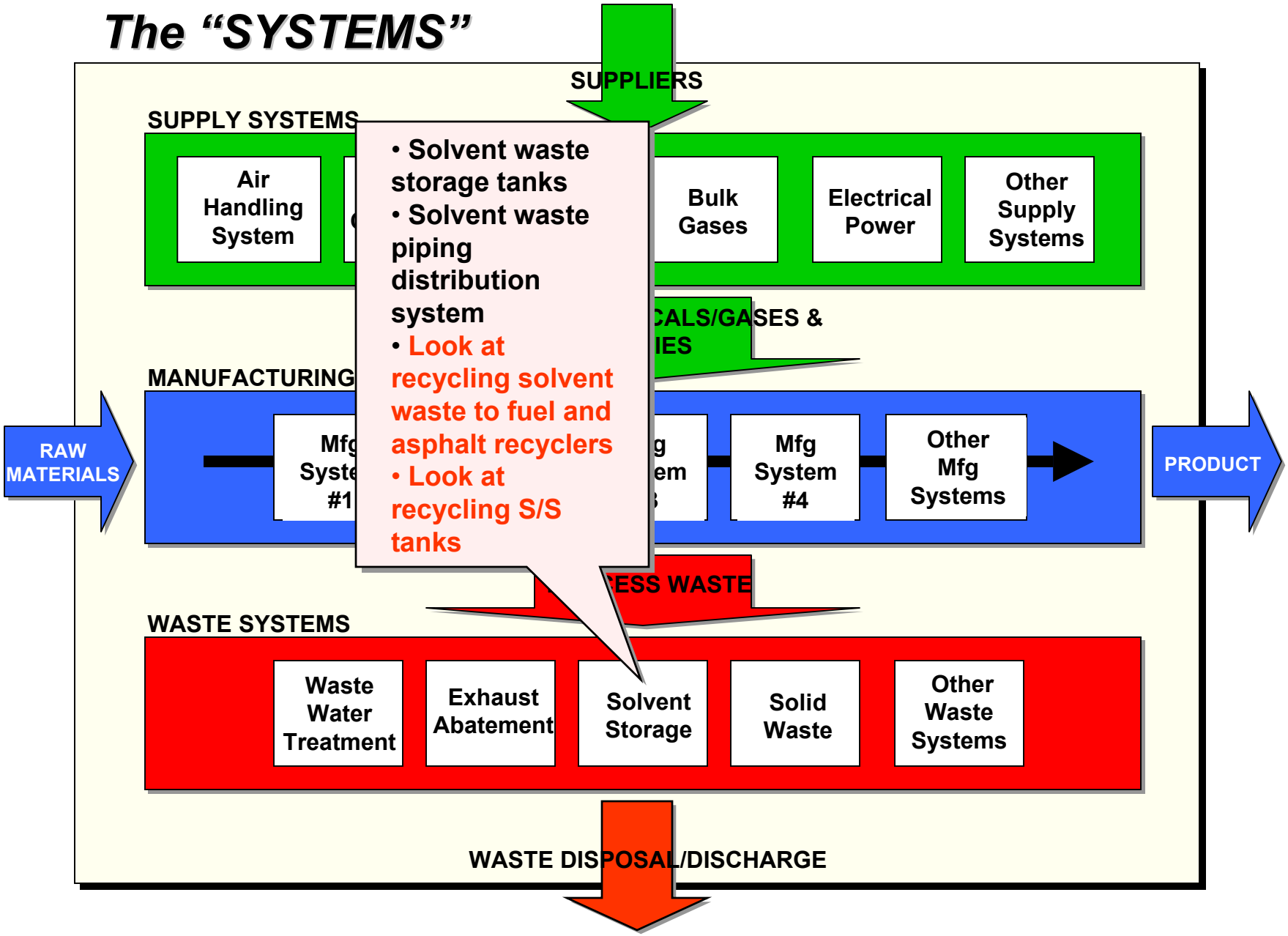

The "SYSTEMS"
SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Chemicals
Water Supply
Bulk Gases
Dedicated Process Chemicals/Gases & Utilities
PROCESS CHEMICALS/GAS
UTILITIES
MANUFACTURING SYSTEMS
RAW MATERIALS
Mfg System #1
Mfg System #2
Mfg System #3
Process Tool & Sub-Systems
PRODUCT
Manufacturing System Example
PROCES
WASTE SYSTEMS
Waste Water Treatment
Exhaust Abatement
Solvent Storage
Process Effluent
WASTE DISPOSAL/DISCHARGE

The "SYSTEMS"

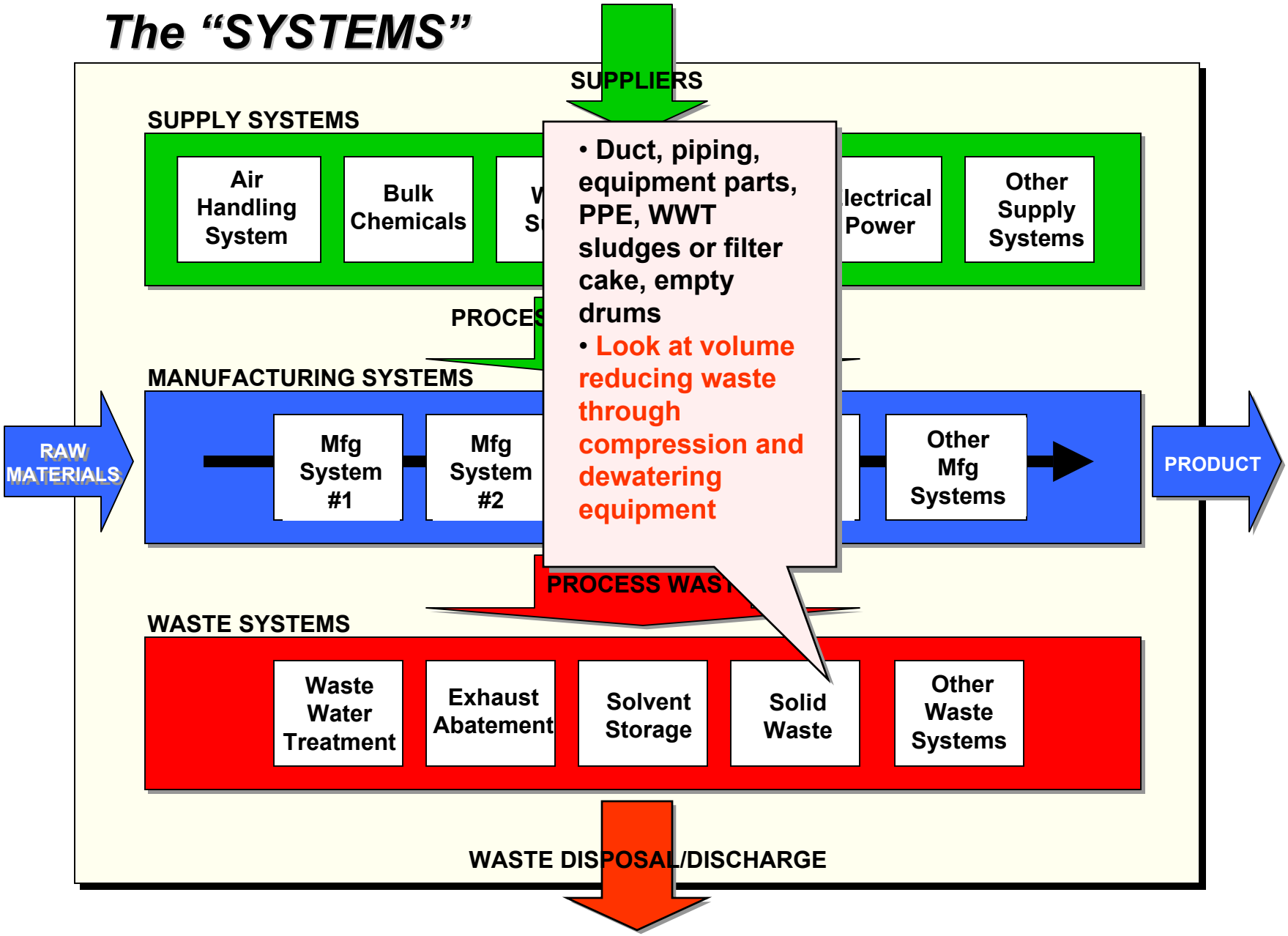


- Waste water storage and treatment tanks
- Pipe distribution system
- WWT vaults, pumps, control systems
- Look at selling tanks, pumps, controls in agricultural or plating industry


The "SYSTEMS"
SUPPLIERS
SUPPLY SYSTEMS
Water Supply
Bulk Gases
Electrical Power
Other Supply Systems
• S/S, FRP, galvanized, PVC, polypropylene duct
• Acid and solvent fume scrubbers
• Pumps and exhaust fans
• Look at recycling or selling scrubbers for plating, printed circuit, and biotech industries
S CHEMICALS/GASES & UTILITIES
MAN
RAW MATERIALS
Mfg System #3
Mfg System #4
Other Mfg Systems
PRODUCT
PROCESS WASTE
WASTE SYSTEMS
Waste Water Treatment
Exhaust Abatement
Solvent Storage
Solid Waste
Other Waste Systems
WASTE DISPOSAL/DISCHARGE


The "SYSTEMS"
SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Gases
Electrical Power
Other Supply Systems
• Solvent waste storage tanks
• Solvent waste piping distribution system
• Look at recycling solvent waste to fuel and asphalt recyclers
• Look at recycling S/S tanks
MANUFACTURING
RAW MATERIALS
Mfg System #4
Other Mfg Systems
PRODUCT
WASTE SYSTEMS
Waste Water Treatment
Exhaust Abatement
Solvent Storage
Solid Waste
Other Waste Systems
WASTE DISPOSAL/DISCHARGE

The "SYSTEMS"


SUPPLIERS
SUPPLY SYSTEMS
Air Handling System
Bulk Chemicals
lectrical Power
Other Supply Systems
• Duct, piping, equipment parts, PPE, WWT sludges or filter cake, empty drums
• Look at volume reducing waste through compression and dewatering equipment
MANUFACTURING SYSTEMS
RAW MATERIALS
Mfg System #1
Mfg System #2
Other Mfg Systems
PRODUCT
WASTE SYSTEMS
Waste Water Treatment
Exhaust Abatement
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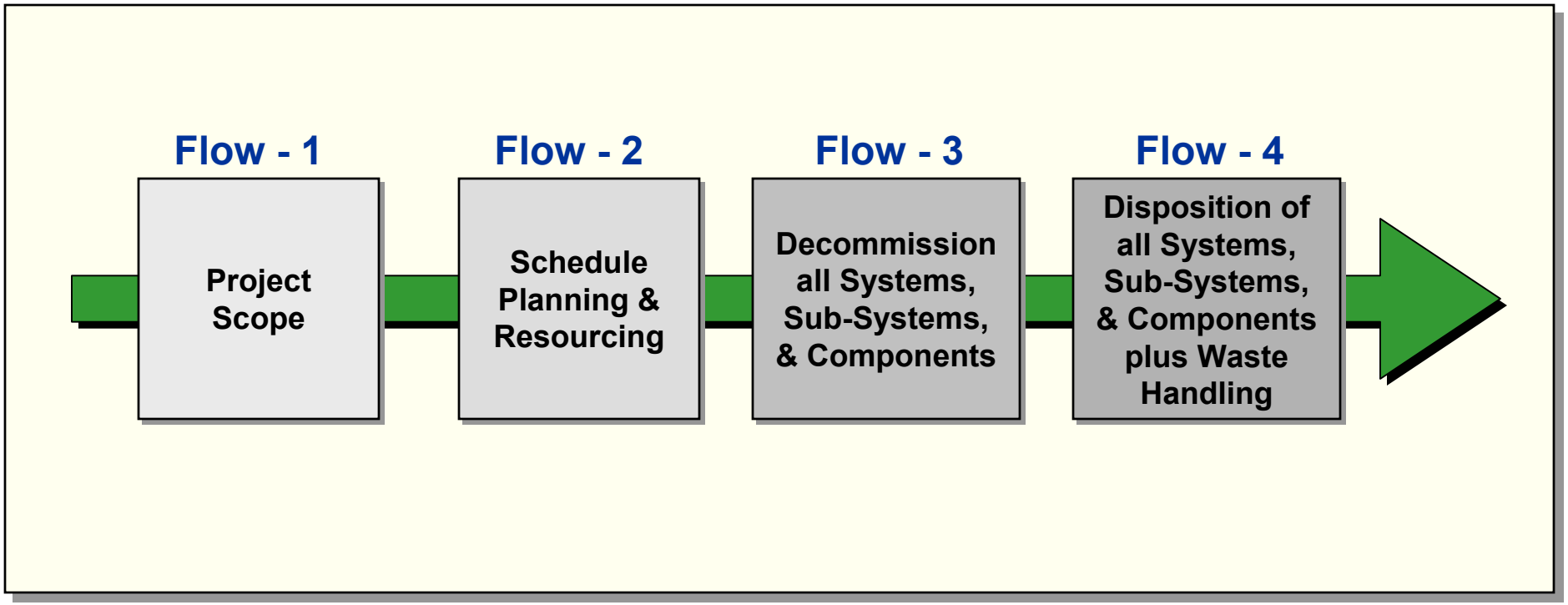
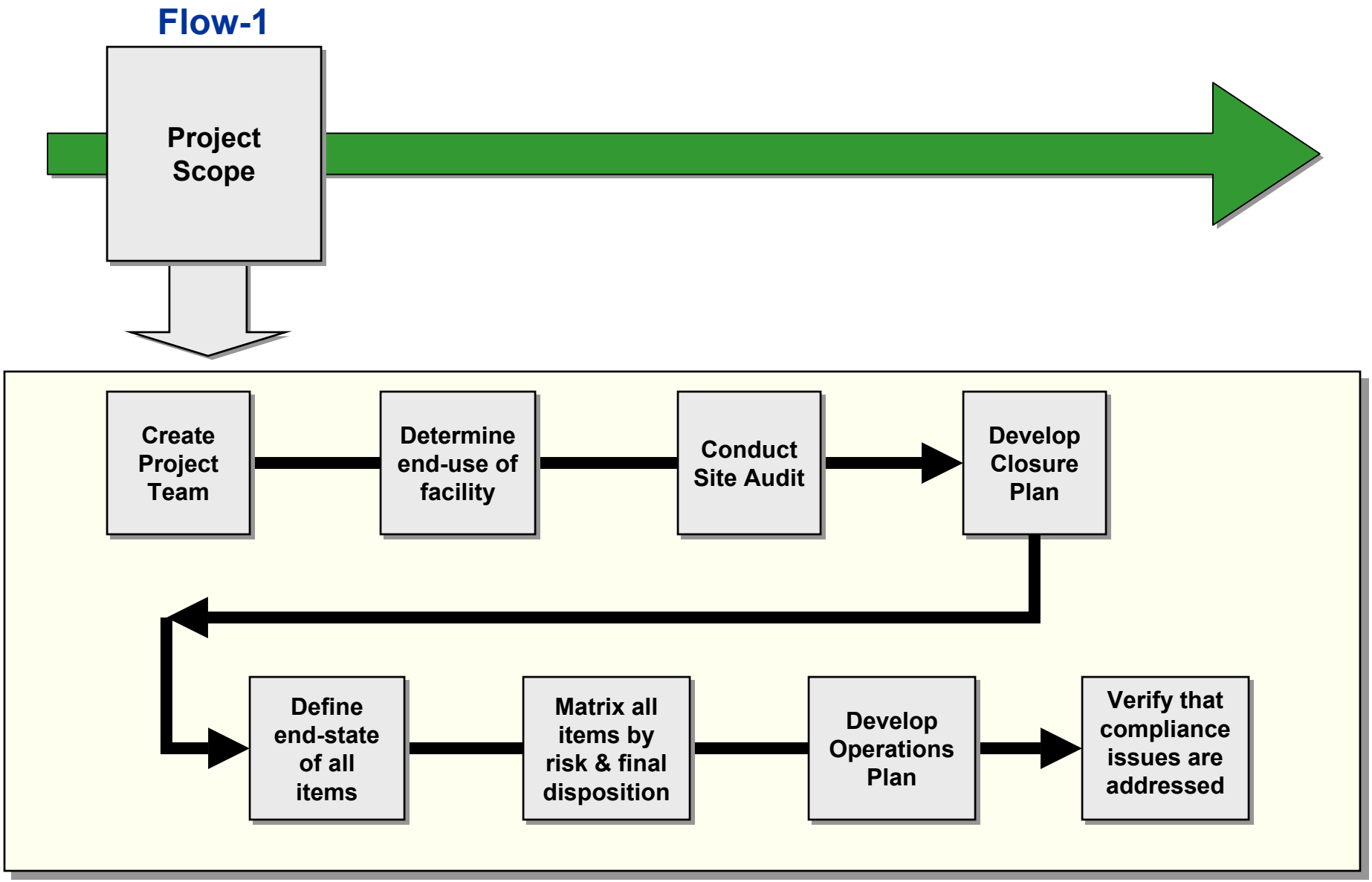
Other Waste Systems
WASTE DISPOSAL/DISCHARGE

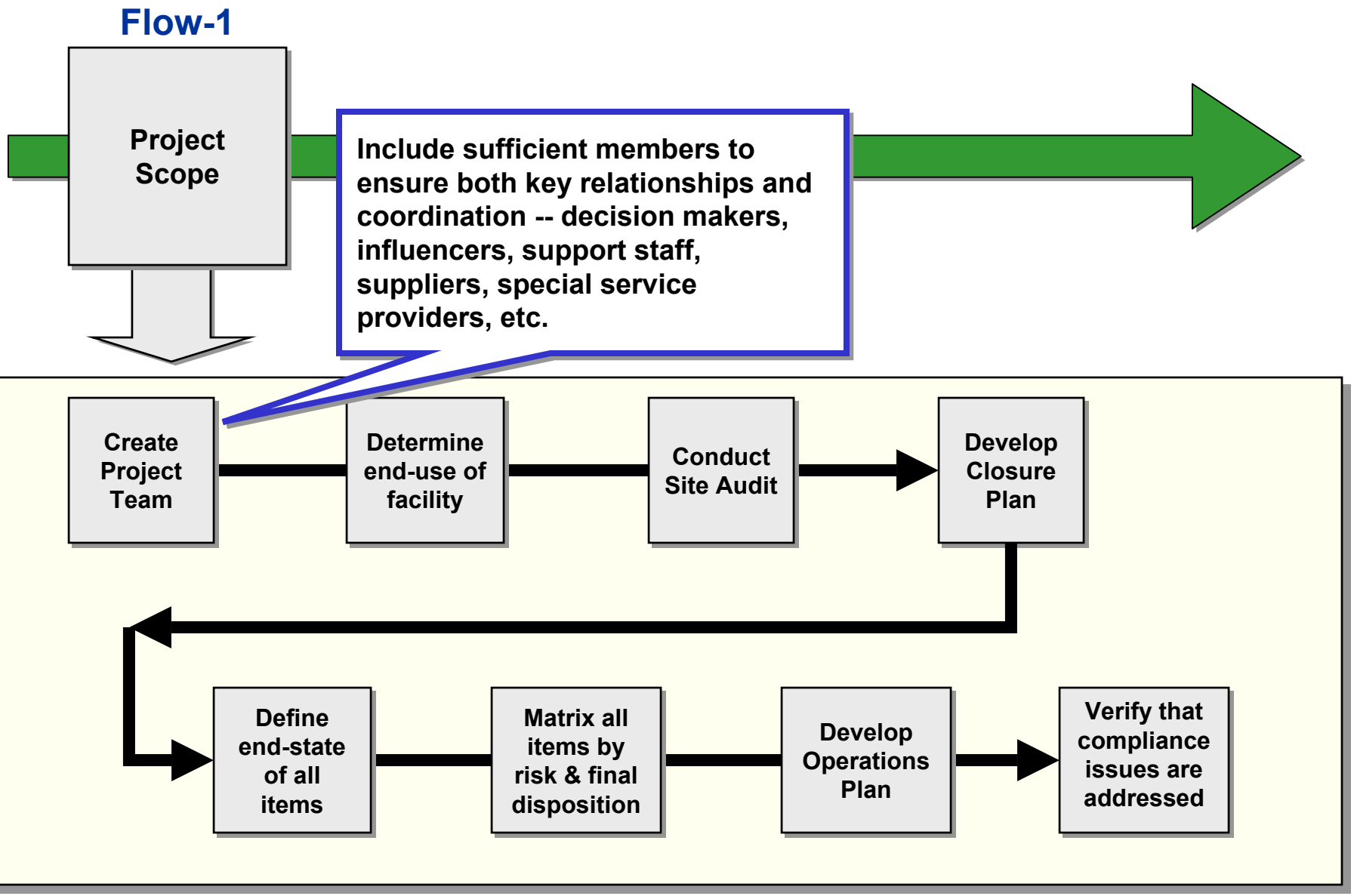
Decommissioning Process Flow



Decommissioning Process Flow - 1



Decommissioning Process Flow - 1



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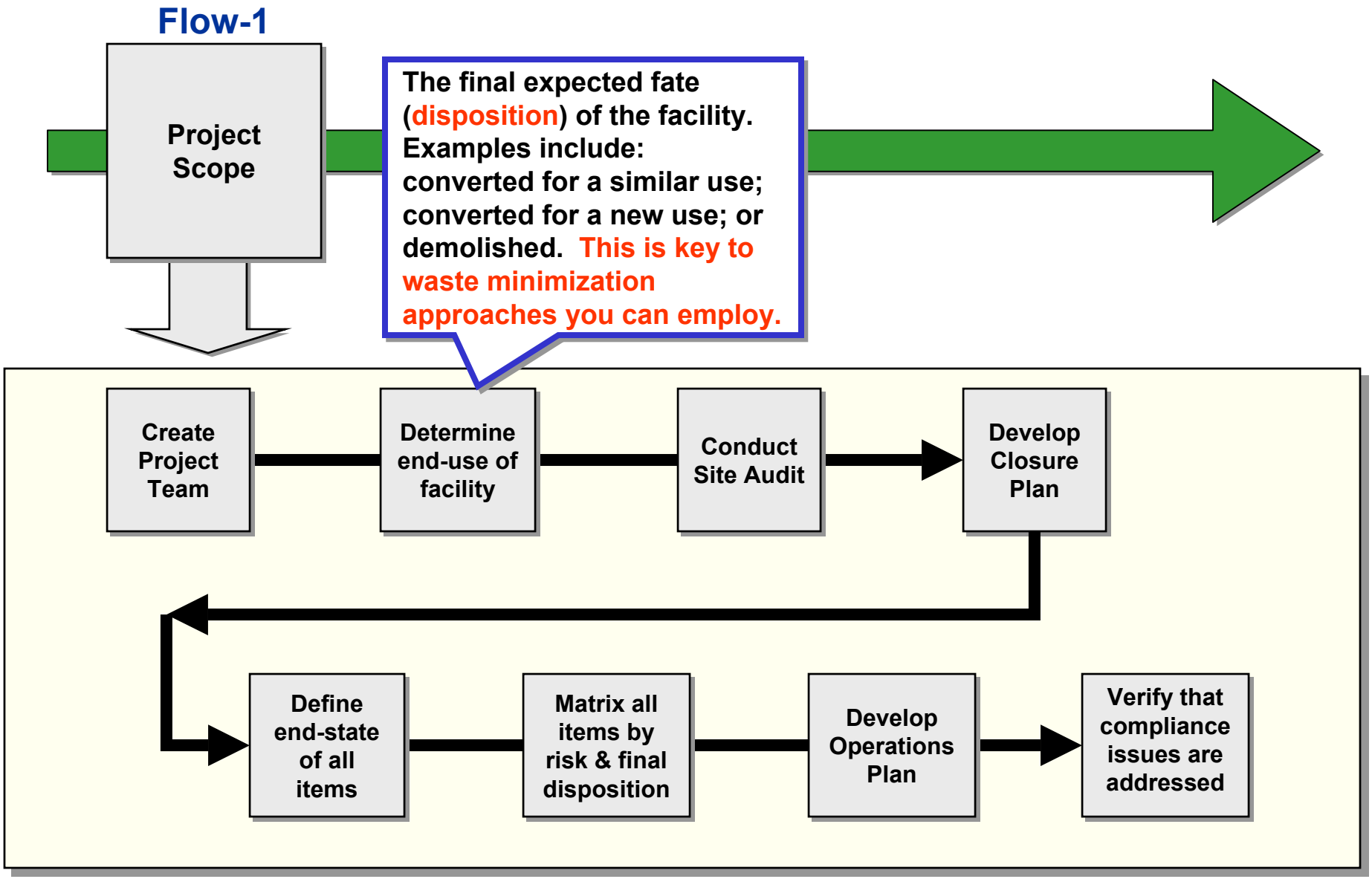
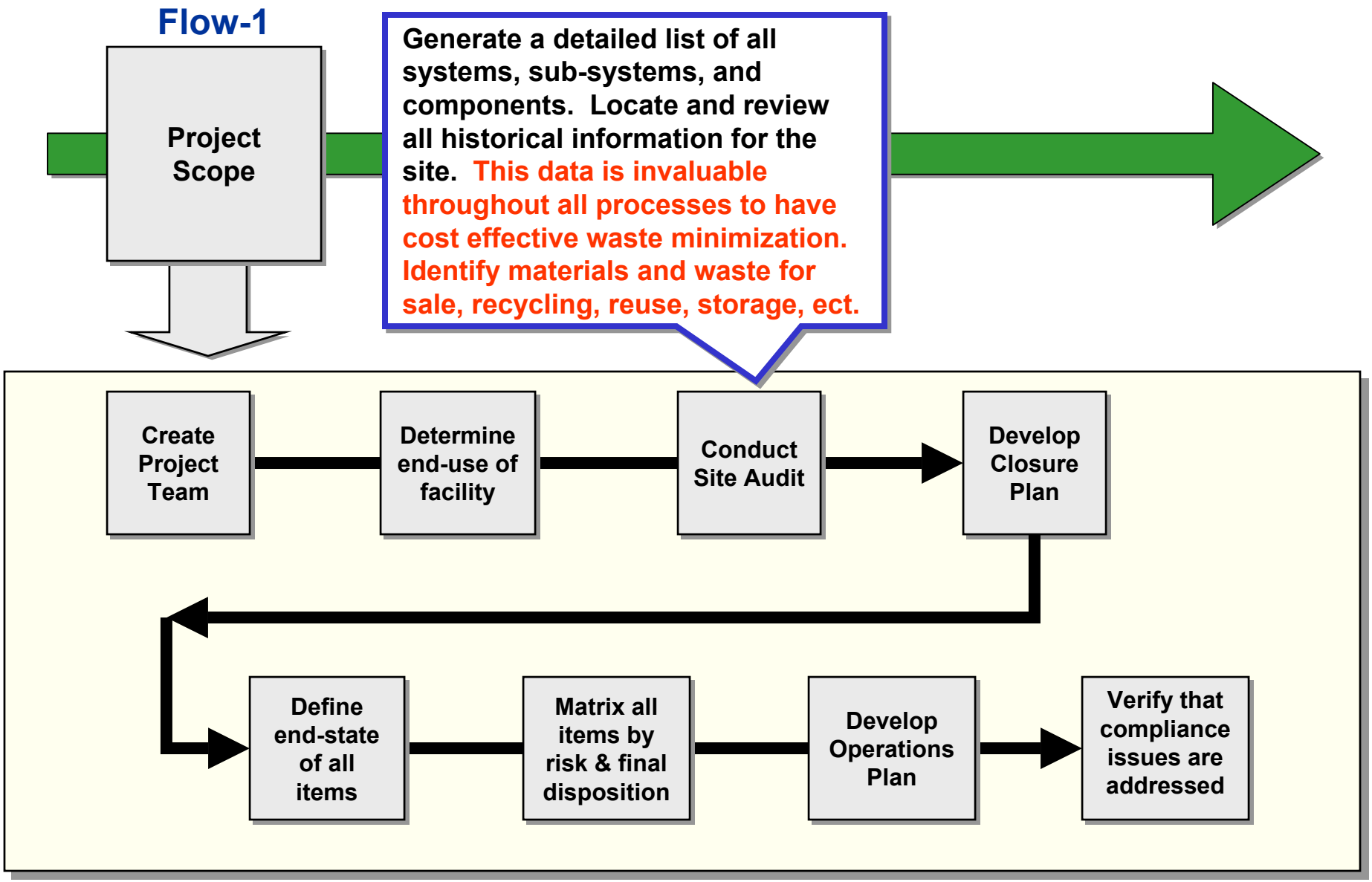


Decommissioning Process Flow - 1



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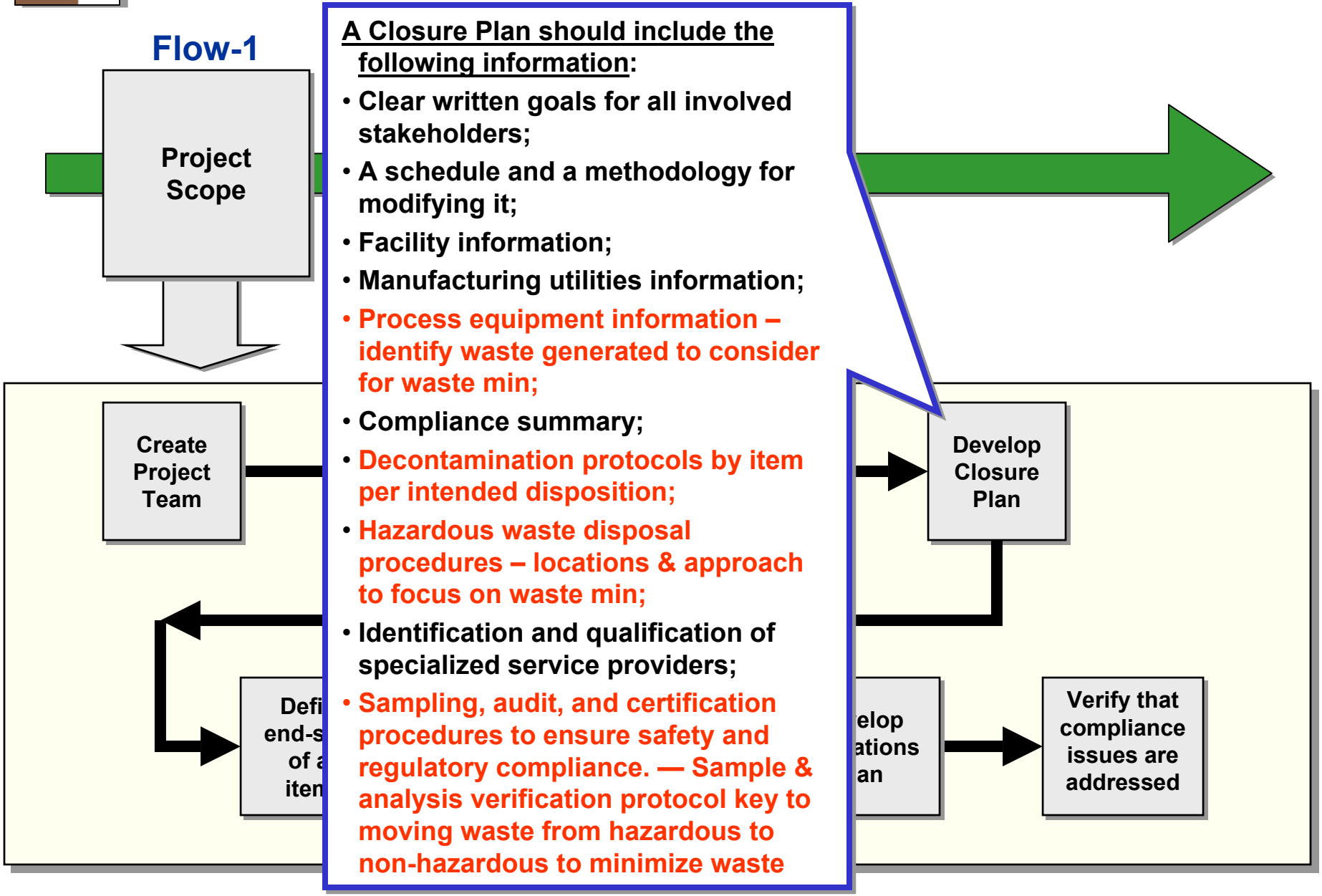
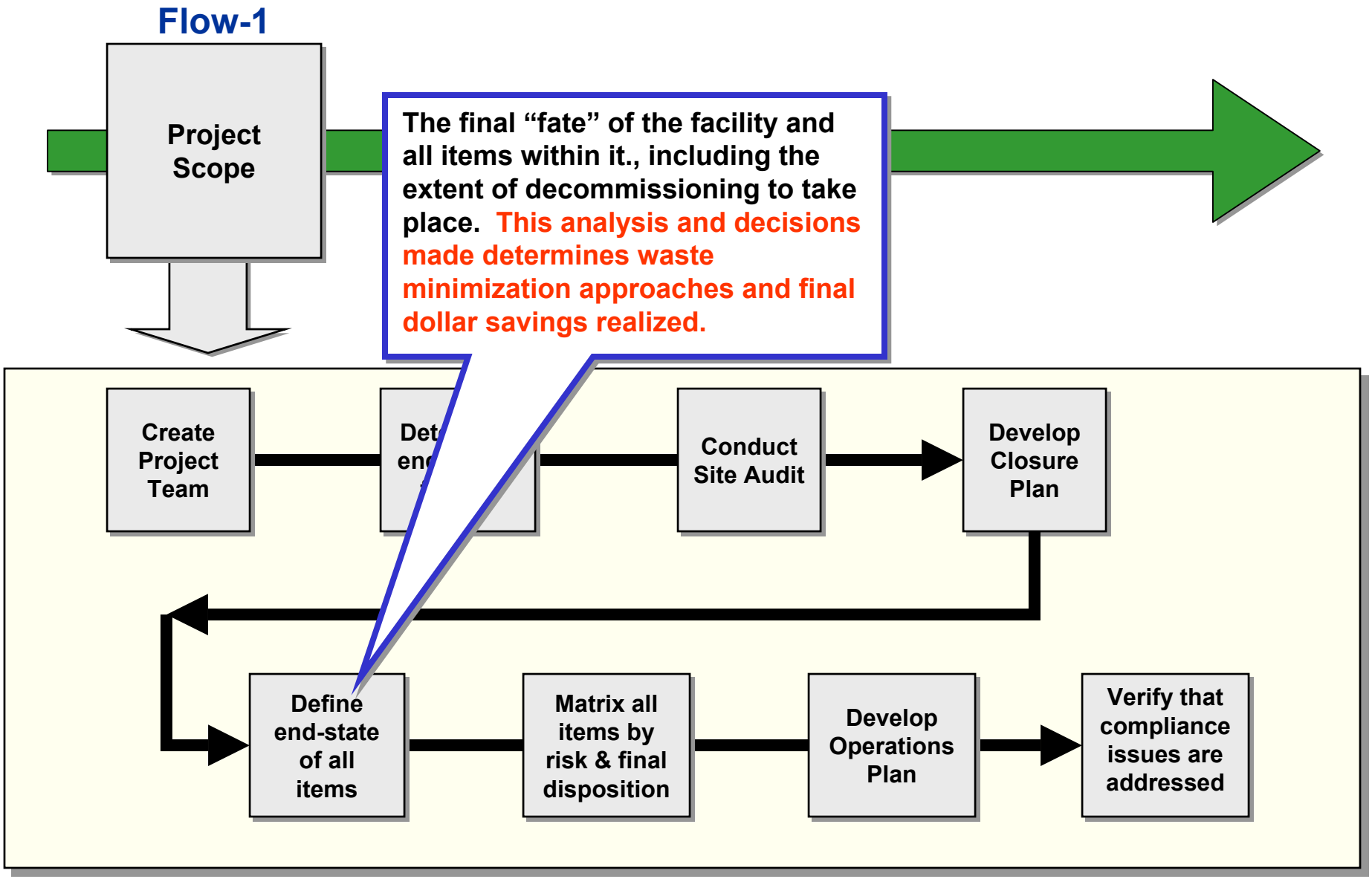


A Closure Plan should include the following information:

- Clear written goals for all involved stakeholders;
- A schedule and a methodology for modifying it;
- Facility information;
- Manufacturing utilities information;
- Process equipment information – identify waste generated to consider for waste min;
- Compliance summary;
- Decontamination protocols by item per intended disposition;
- Hazardous waste disposal procedures – locations & approach to focus on waste min;
- Identification and qualification of specialized service providers;
- Sampling, audit, and certification procedures to ensure safety and regulatory compliance. — Sample & analysis verification protocol key to moving waste from hazardous to non-hazardous to minimize waste

Decommissioning Process Flow - 1



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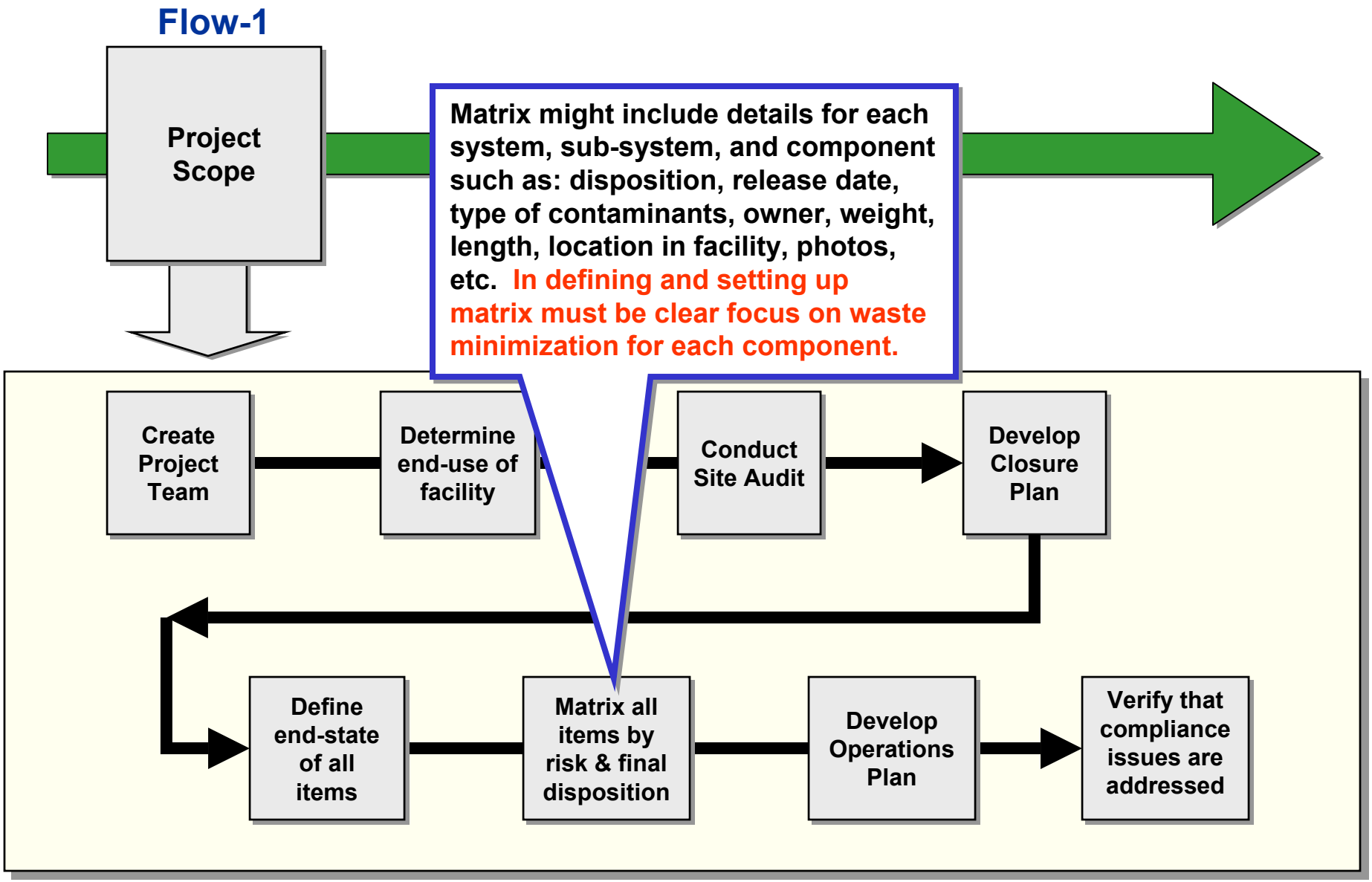

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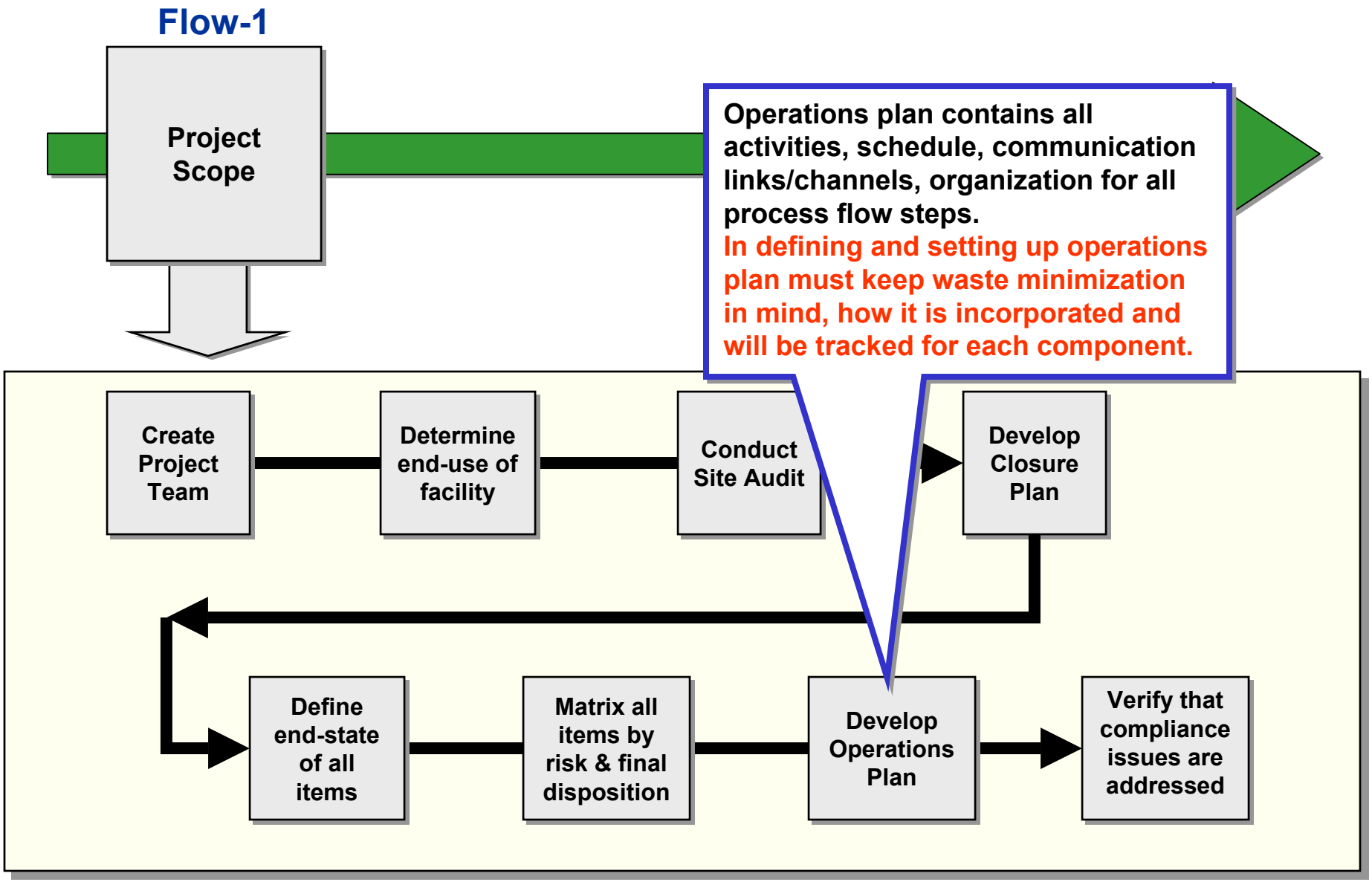
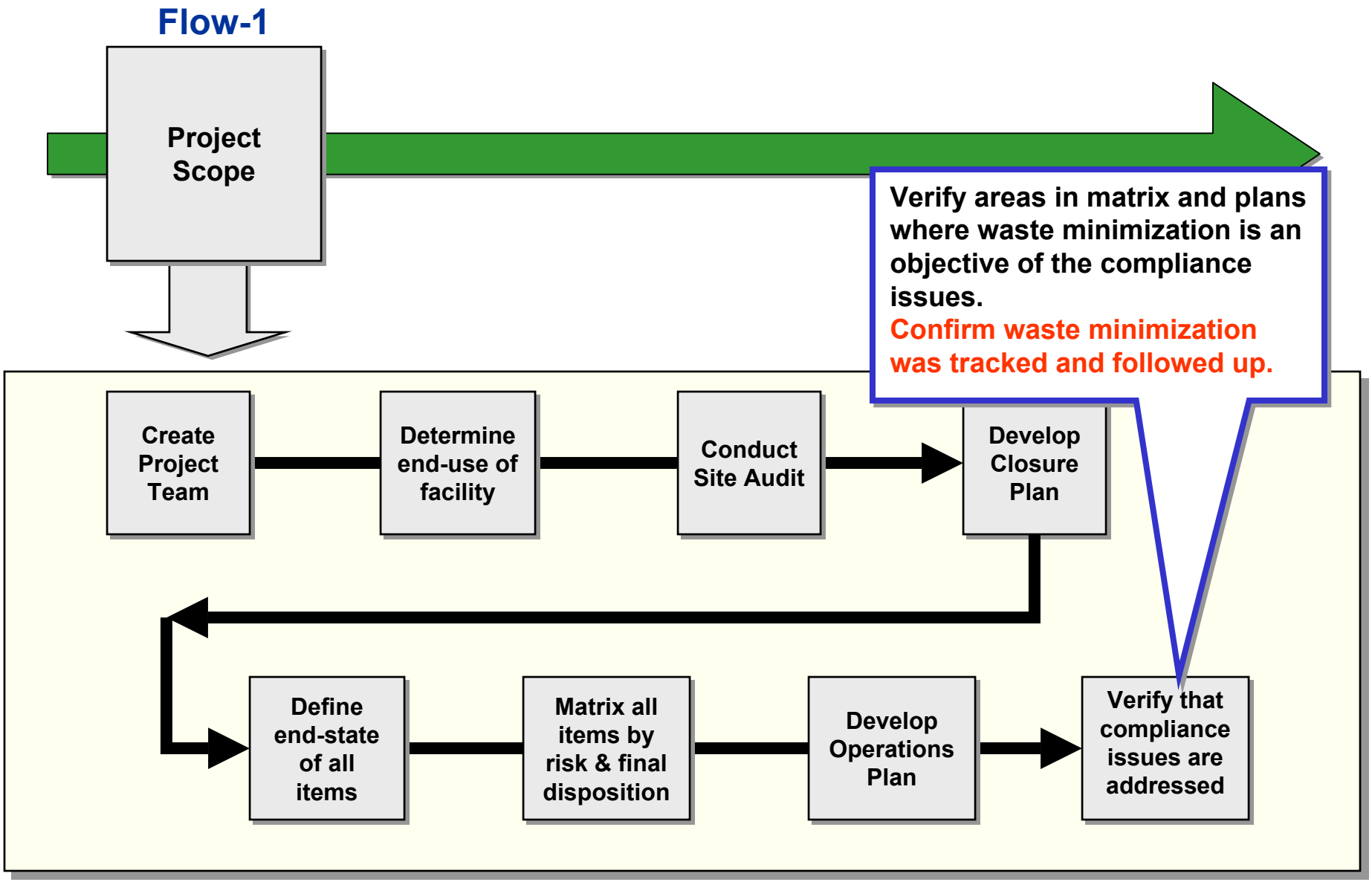
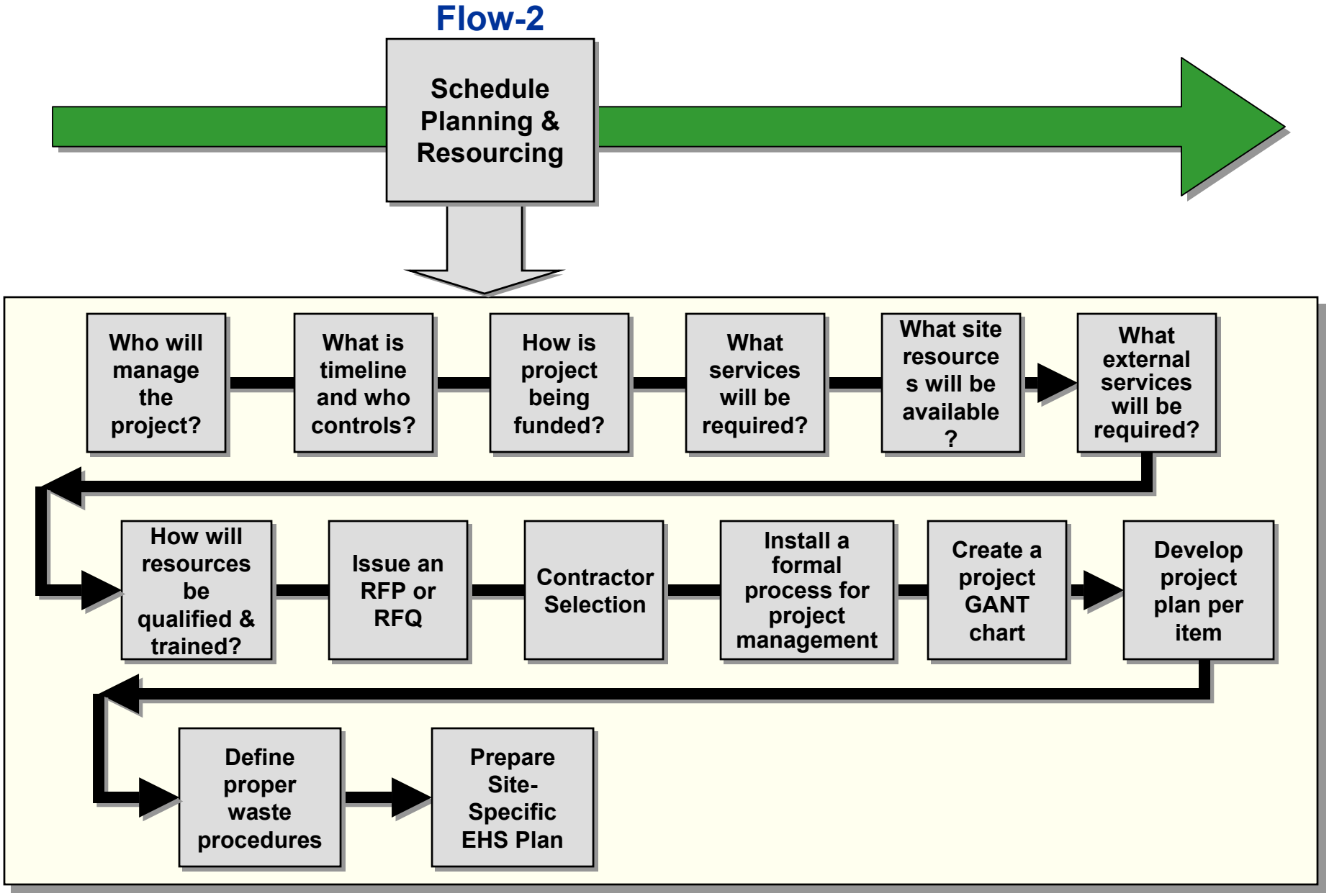


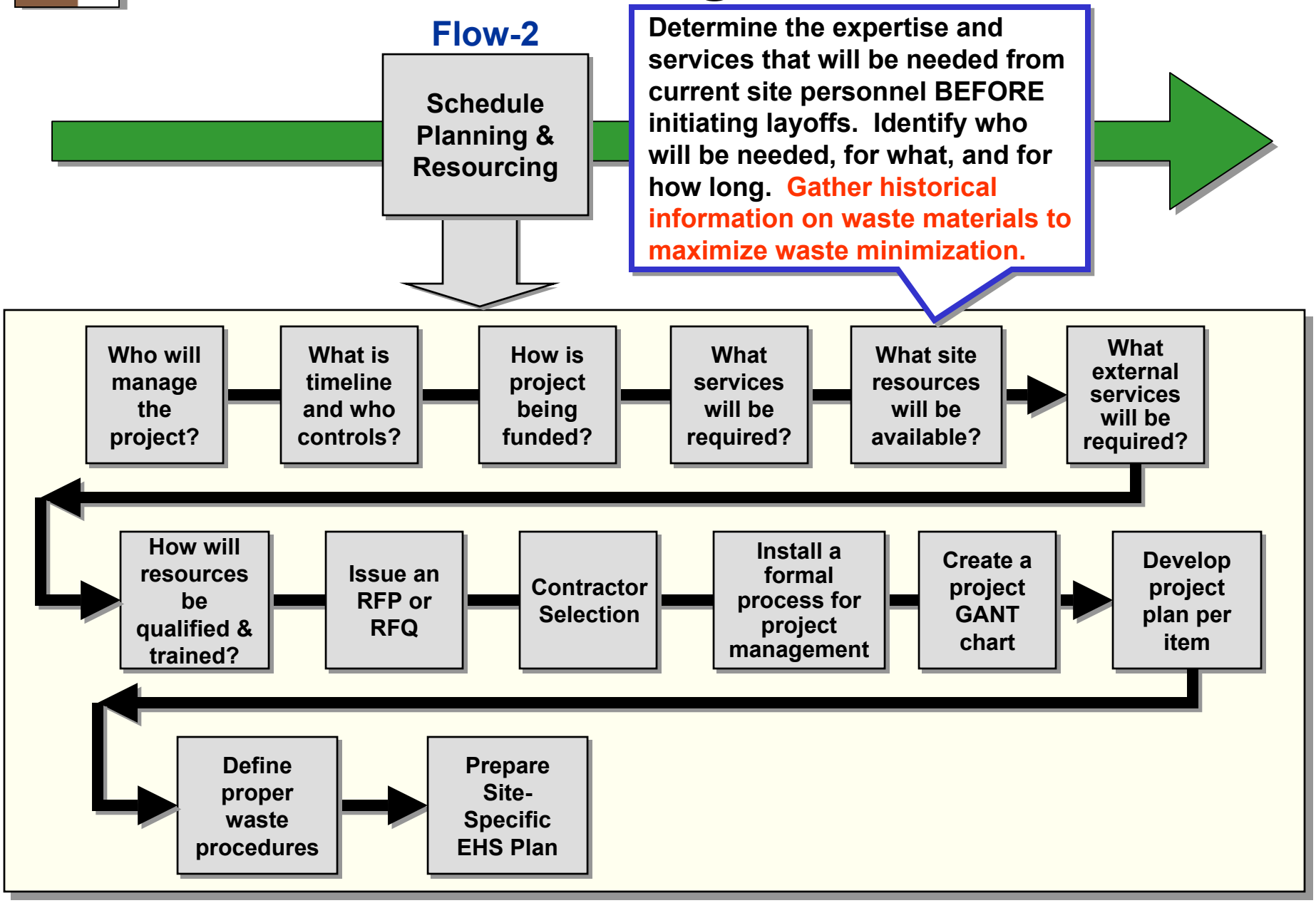
Decommissioning Process Flow - 1



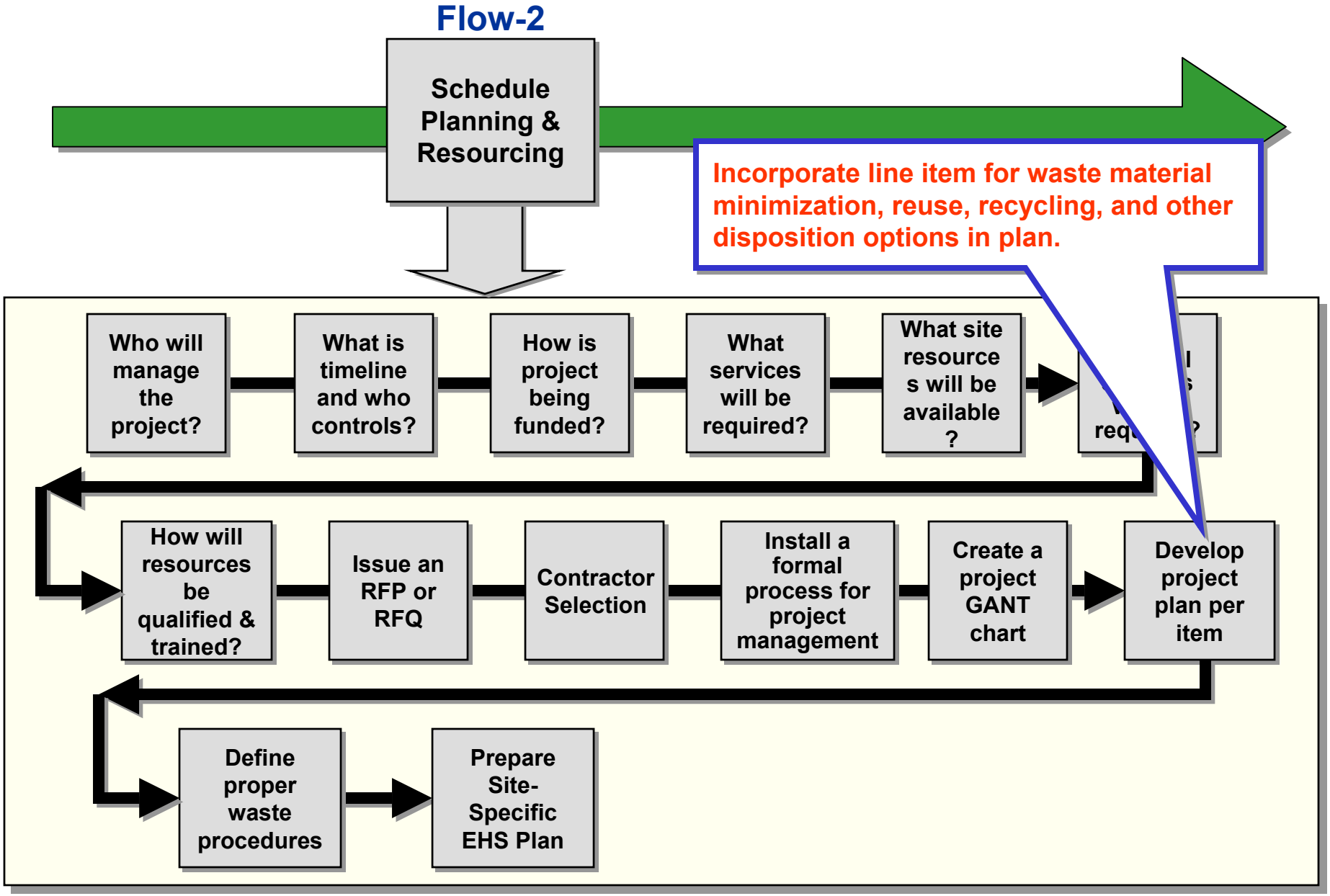
Decommissioning Process Flow - 2



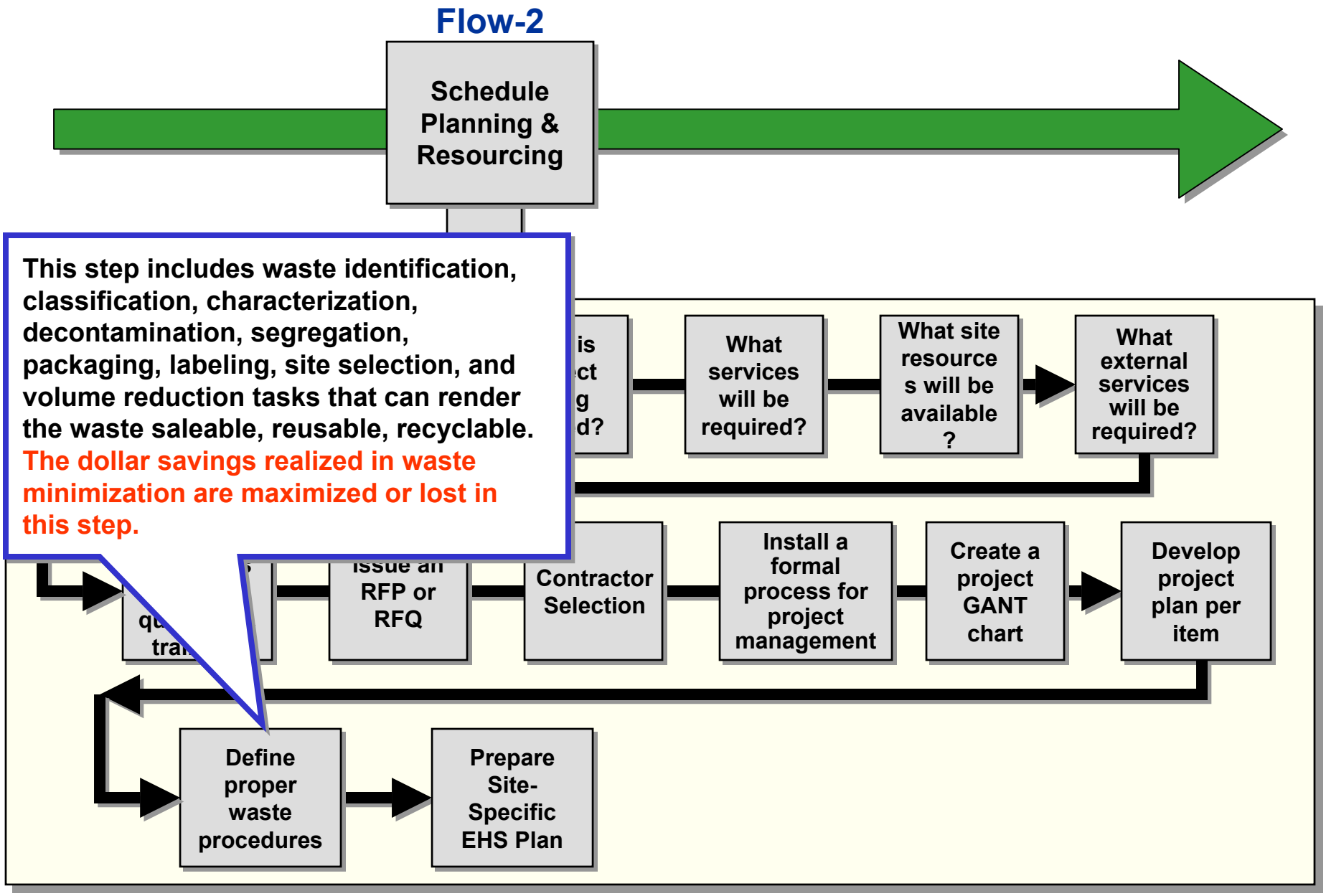
Decommissioning Process Flow - 2



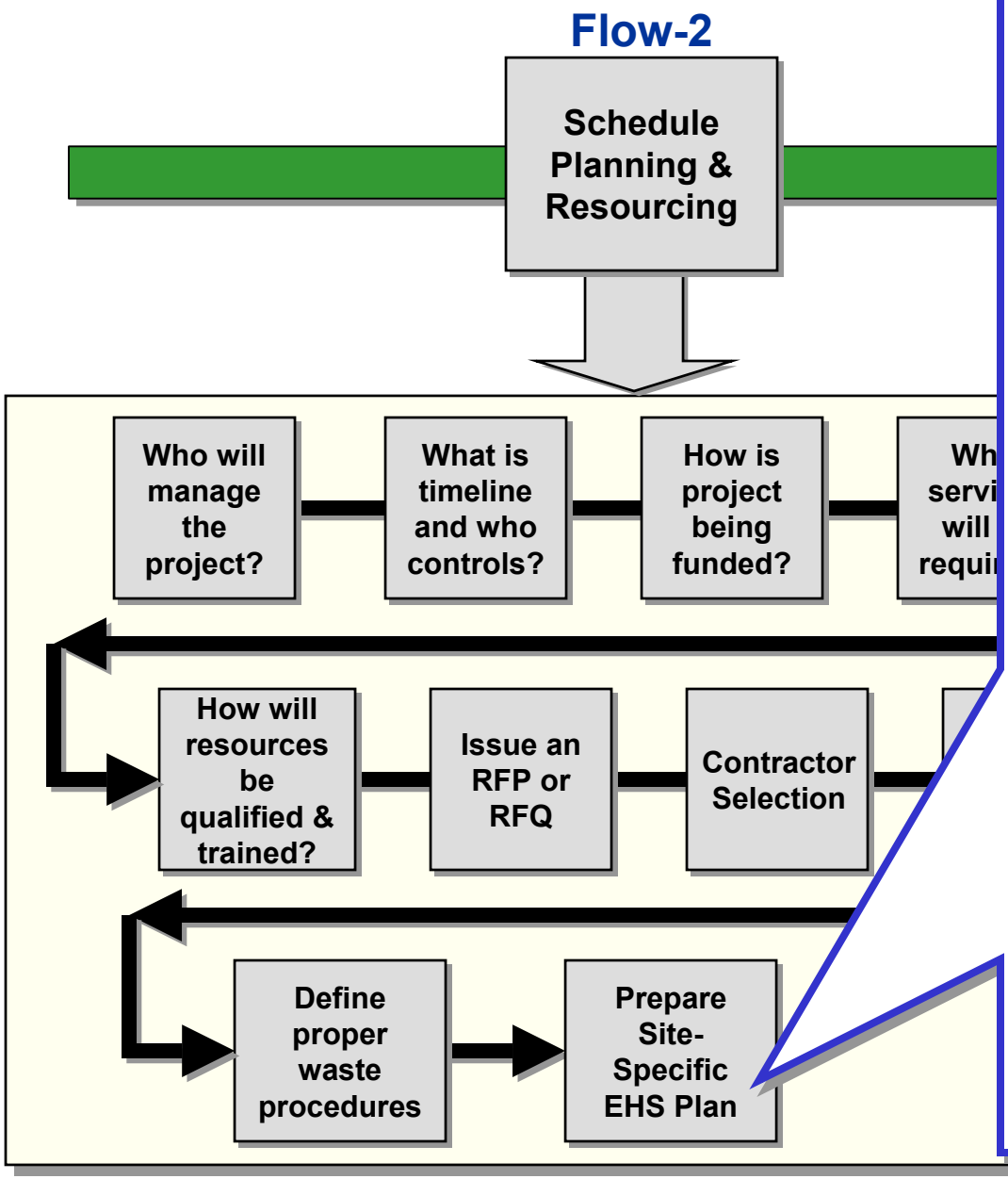
Decommissioning Process Flow - 2



Decommissioning Process Flow - 2



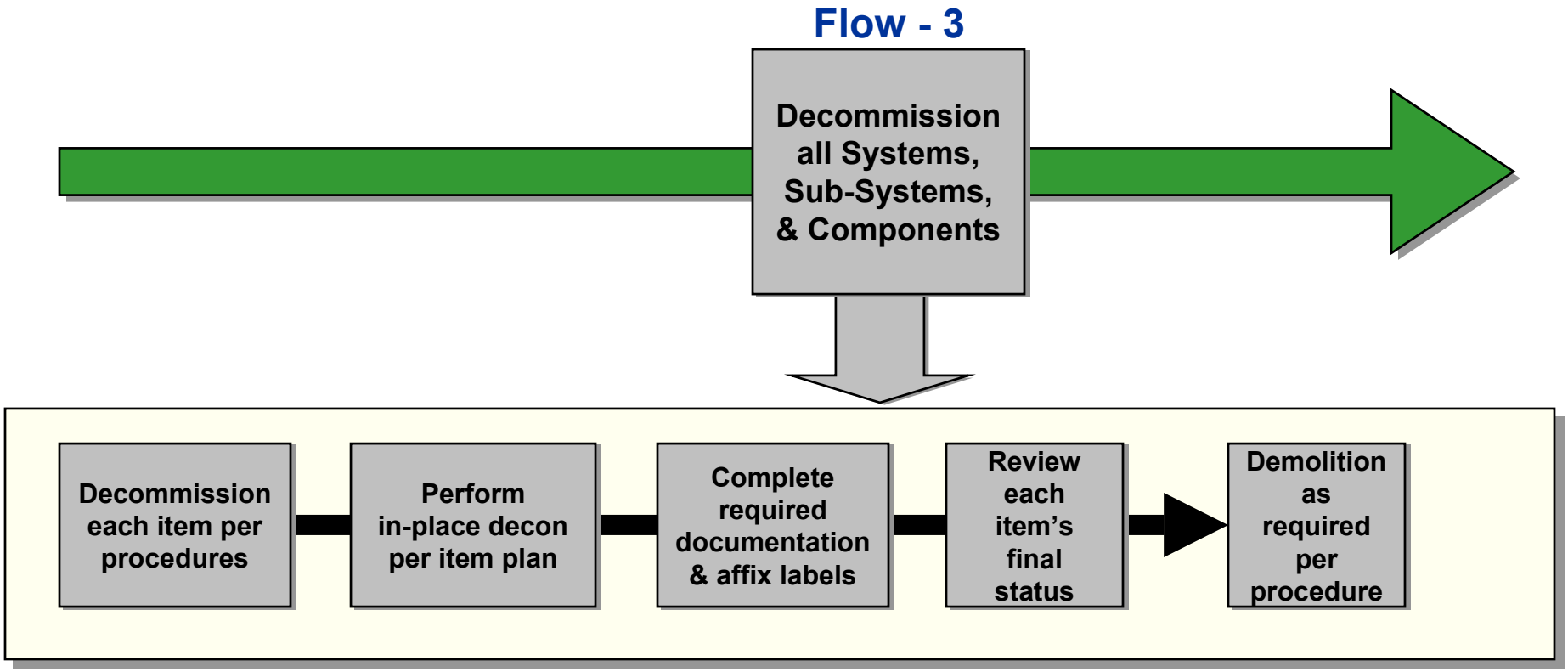
Decommissioning Process Flow - 2



Selected contractor develops a project-specific EHS plan which meets all applicable EHS regulatory requirements including the elements listed below:

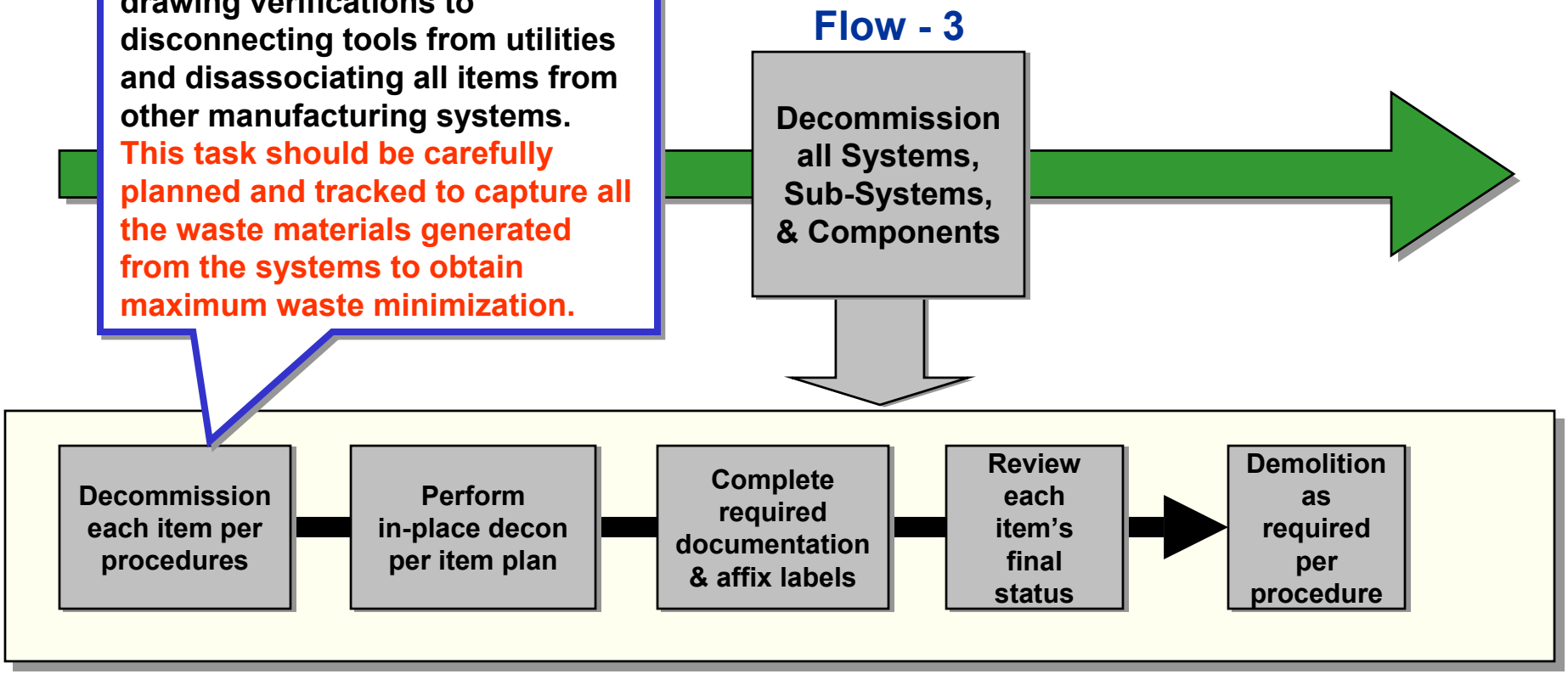
- Hazard specific EHS training;
- Task specific demolition, decontamination procedures focused on waste minimization;
- Job hazard analysis (JHA) for all construction related tasks;
- Leading indicator programs; Setup indicators to initiate segregating materials & waste for recycling, reuse, volume reduction, disposal
- A housekeeping plan; Prevents unnecessary waste being disposed of rather than minimized
- A disciplinary action plan;
- Incident reporting and investigation;
- A return-to-work program;
- A new employee training program (buddy program); and
- A project readiness plan.

Decommissioning Process Flow - 3



Decommissioning Process Flow - 3

Decommissioning spans from pre-disconnect activities and drawing verifications to disconnecting tools from utilities and disassociating all items from other manufacturing systems. This task should be carefully planned and tracked to capture all the waste materials generated from the systems to obtain maximum waste minimization.

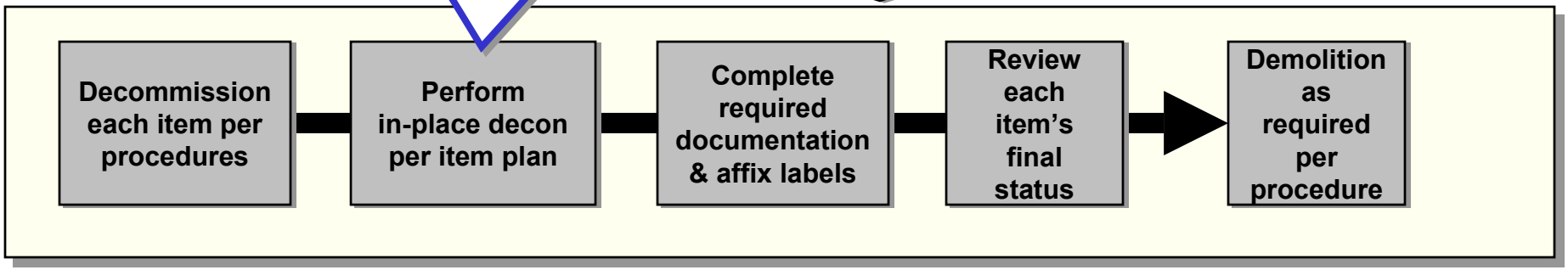


Decommissioning Process Flow - 3

Decontamination procedures and verification sampling & analysis protocol for each in-place tool, piece of equipment and facility area is paramount to performing this task;
Clean, segregate, and size reduce exhaust duct, process pipe, and equipment parts for metals, plastic to reuse and recycle is critical to effectively minimizing waste

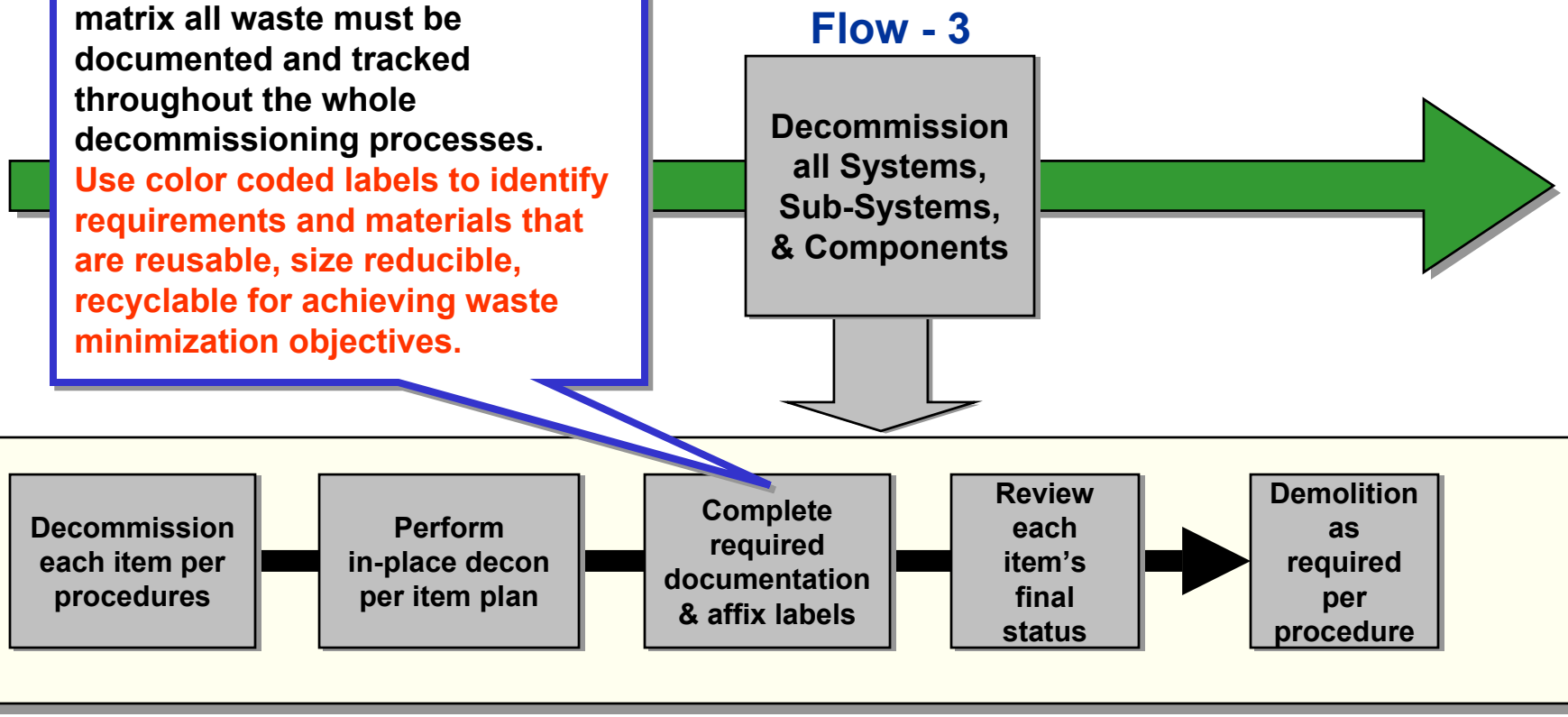
Flow - 3

Decommission all Systems, Sub-Systems, & Components

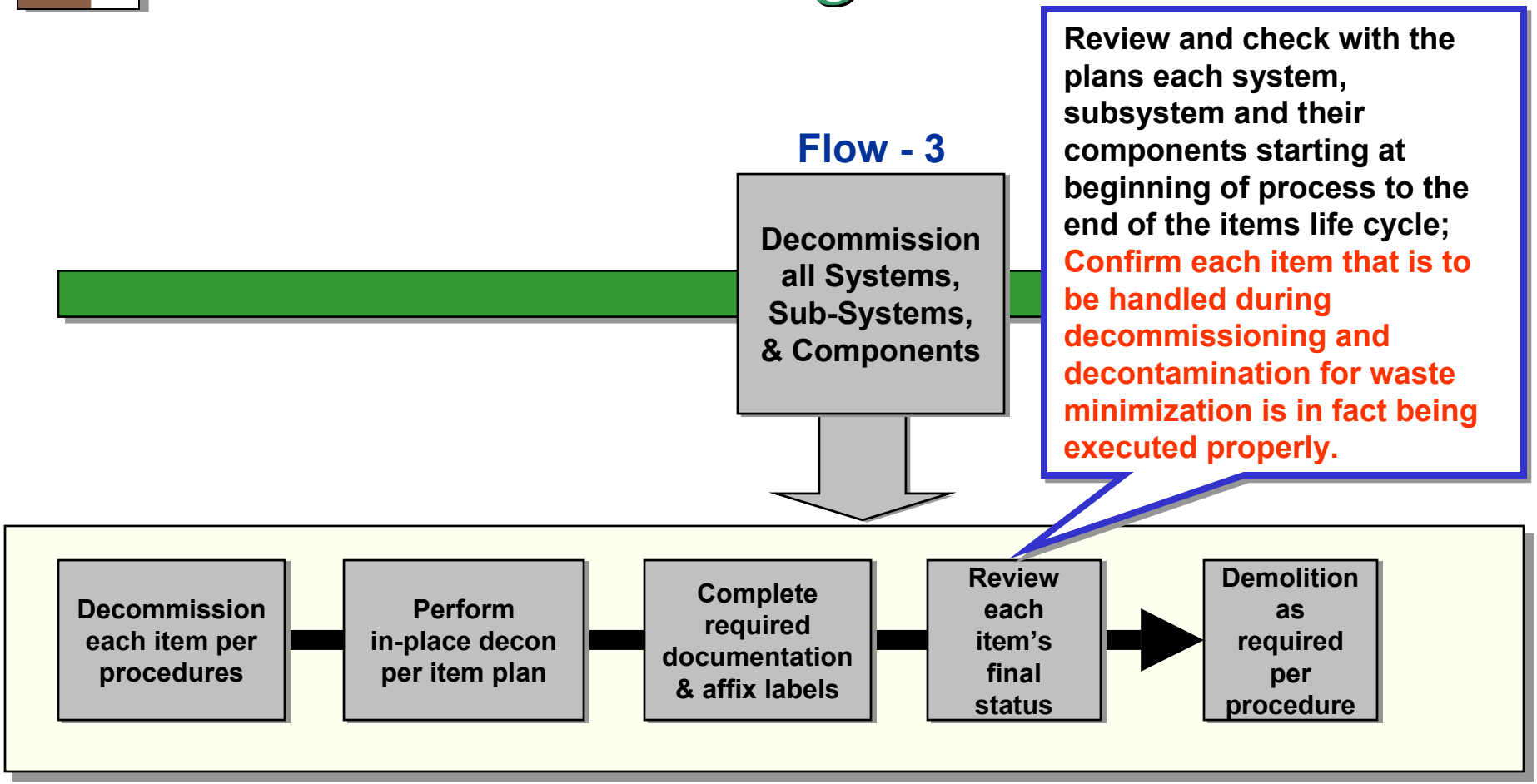


Decommissioning Process Flow - 3

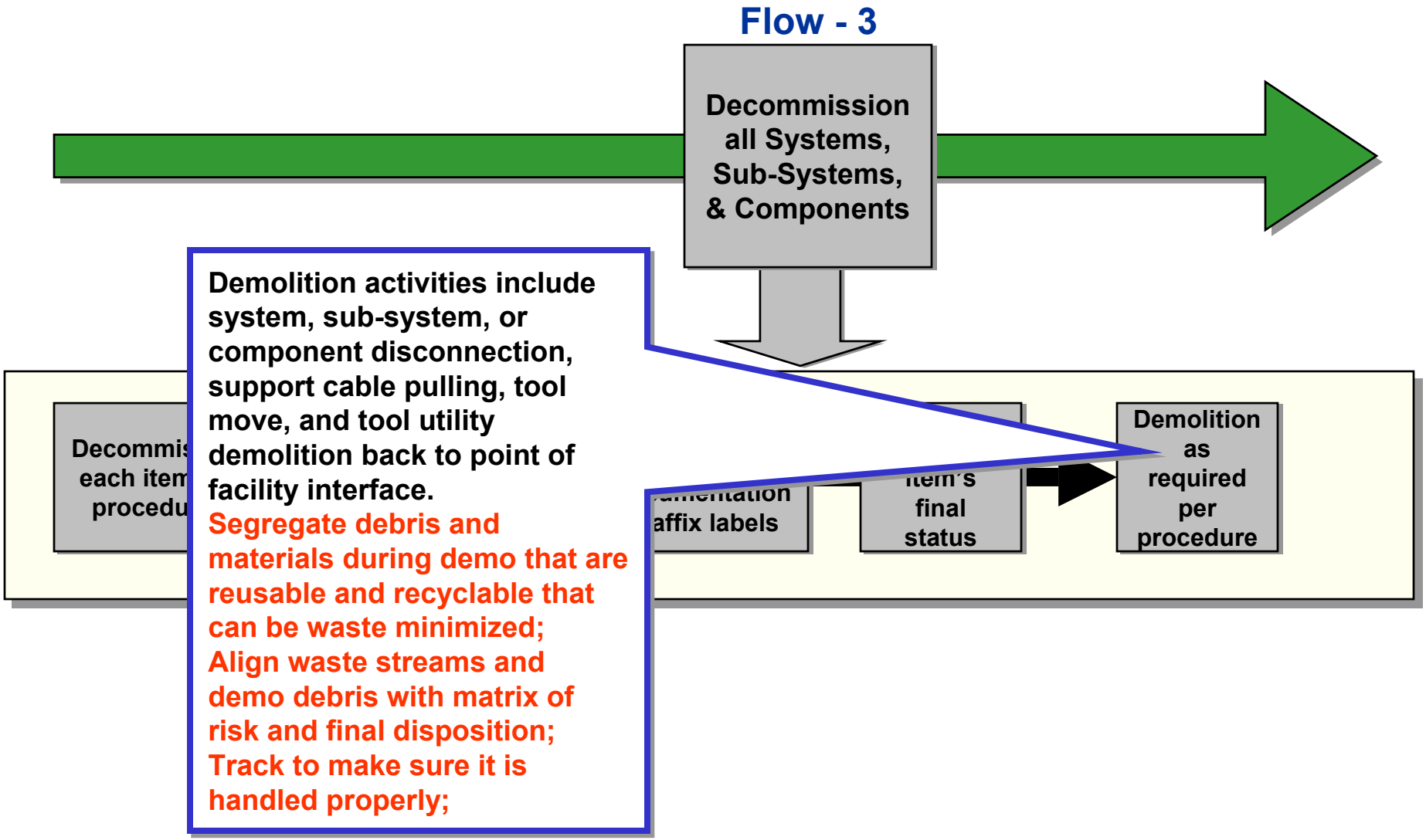
Starting with original site audit matrix all waste must be documented and tracked throughout the whole decommissioning processes.
Use color coded labels to identify requirements and materials that are reusable, size reducible, recyclable for achieving waste minimization objectives.



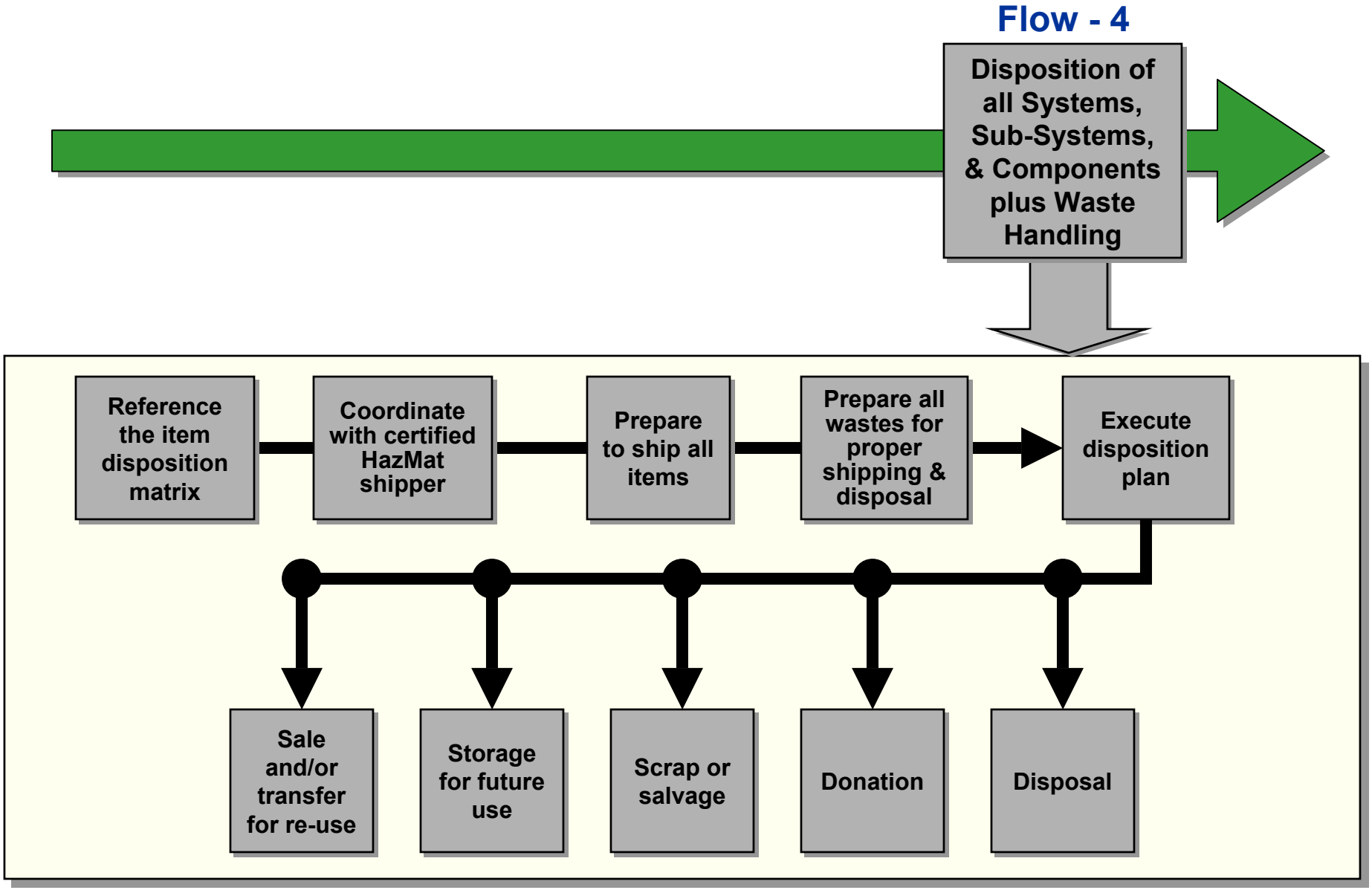
Decommissioning Process Flow - 3



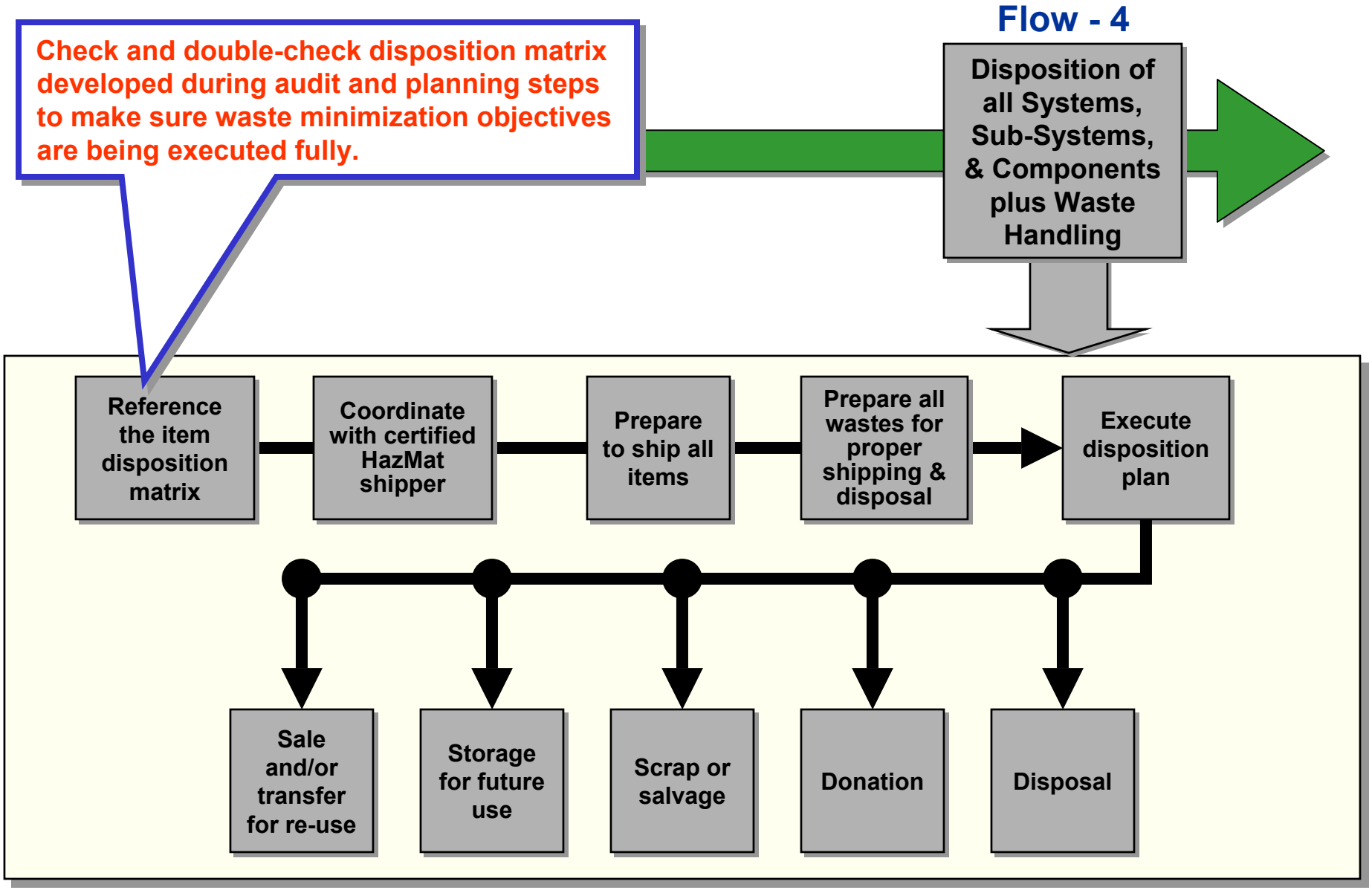
Decommissioning Process Flow - 3



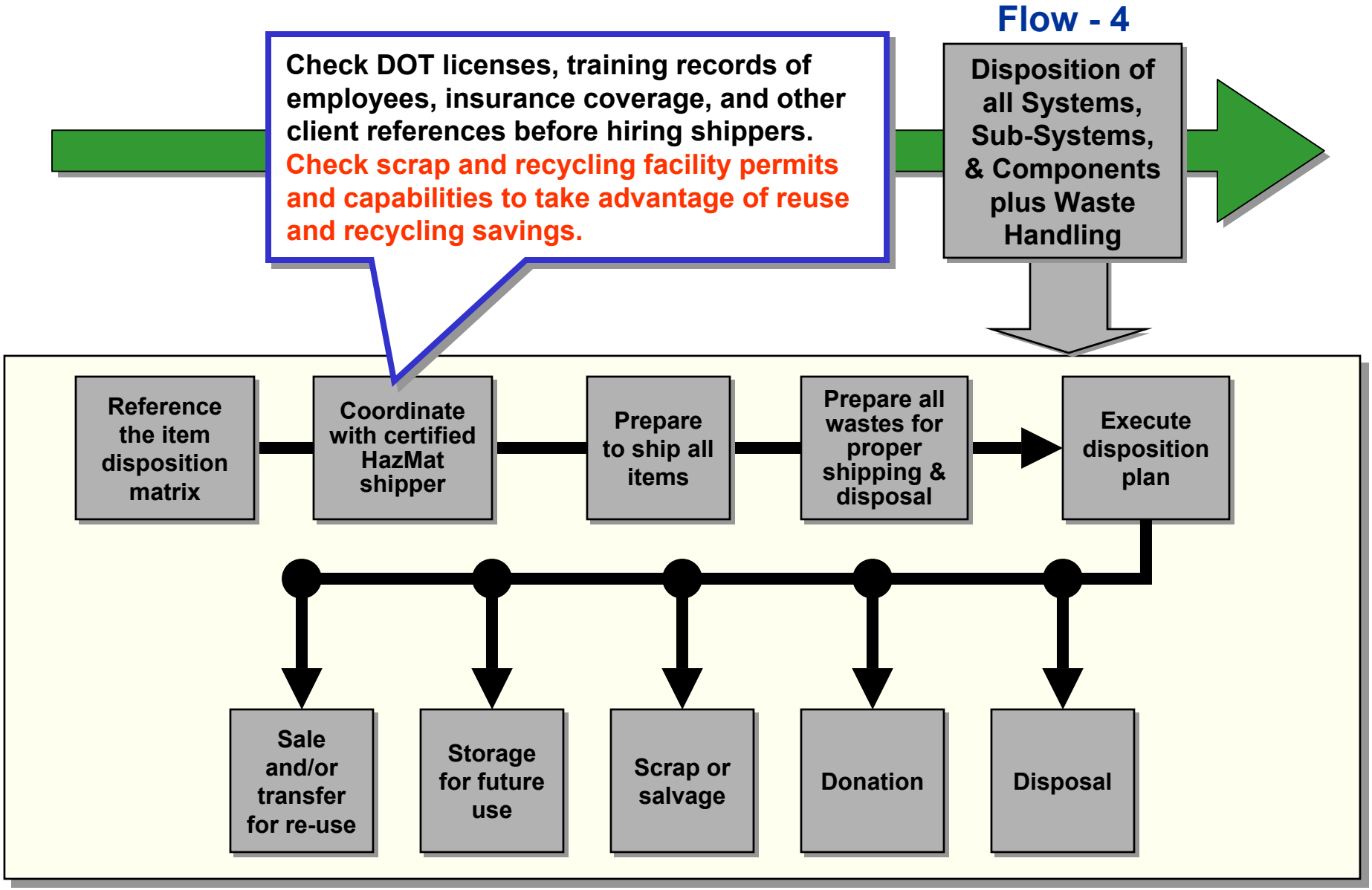
Decommissioning Process Flow - 4



Decommissioning Process Flow - 4



Decommissioning Process Flow - 4



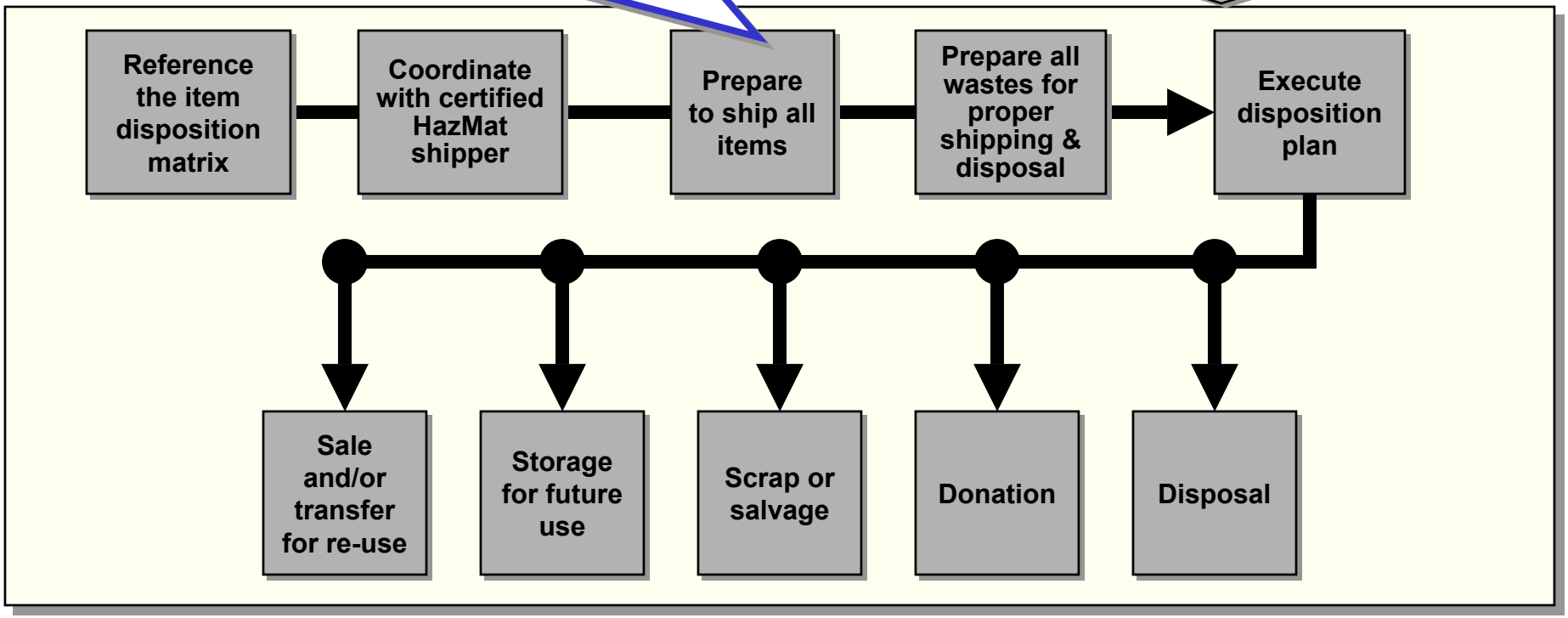
g Process Flow - 4

Origin Services:
- Package item per spec to prevent against leakage or contamination.
- Coordinate removal and rigging (may include contracting disassembly of systems).
- Export packing and crating (for immediate shipment or storage).
- All risk cargo transit insurance, if required.
- Preparation of shipping and export documentation.
- Outbound shipment by air and/or sea.

Confirm all waste & recycled or reused materials are packaged to meet DOT & Int'l requirements/laws

Flow - 4

Disposition of all Systems, Sub-Systems, & Components plus Waste Handling



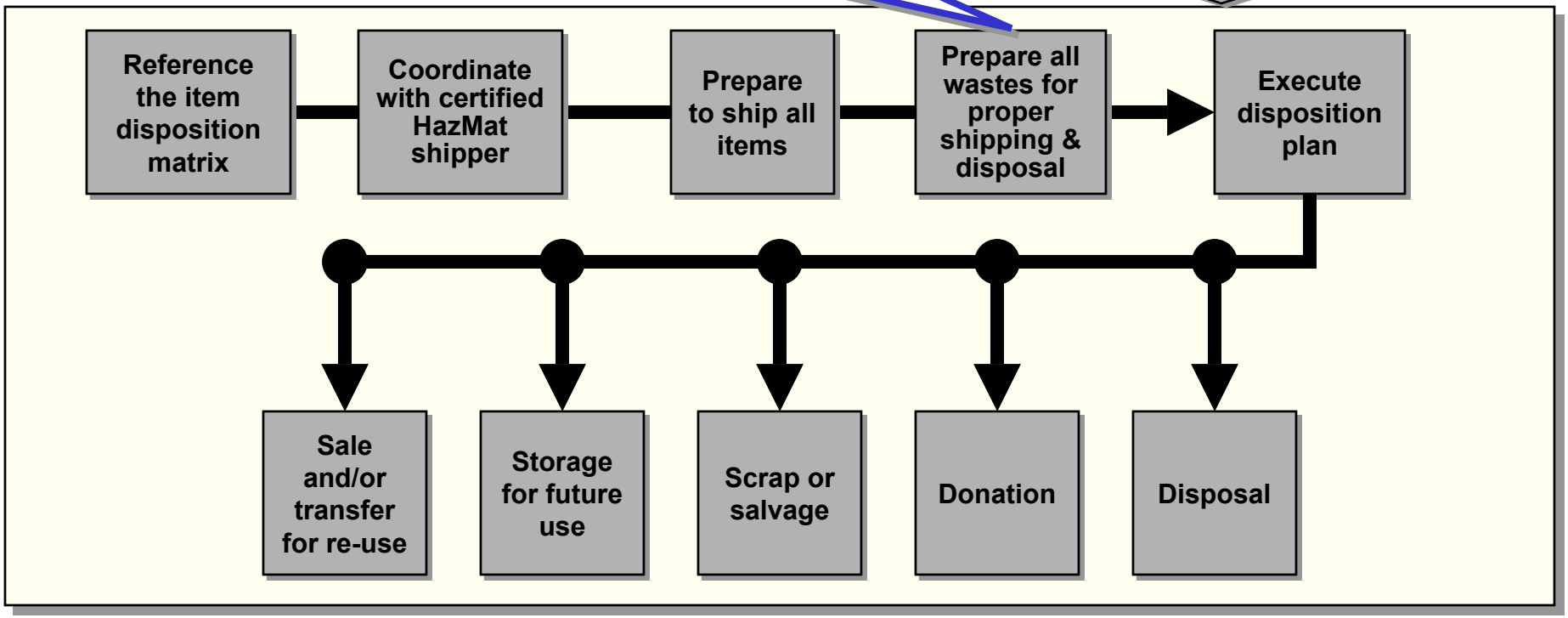
Decommissioning Process Flow - 4

- Profile waste or recyclable/scrap materials with facility
- Prepare manifests, shipping documents – generator sign paperwork
- Schedule disposal or recycling site receiving date
- Request certificate of destruction for waste incinerated

Audit final destination disposal or recycling facility.
Check scrap and recycling facility permits and capabilities to take advantage of reuse and recycling savings.

Flow - 4

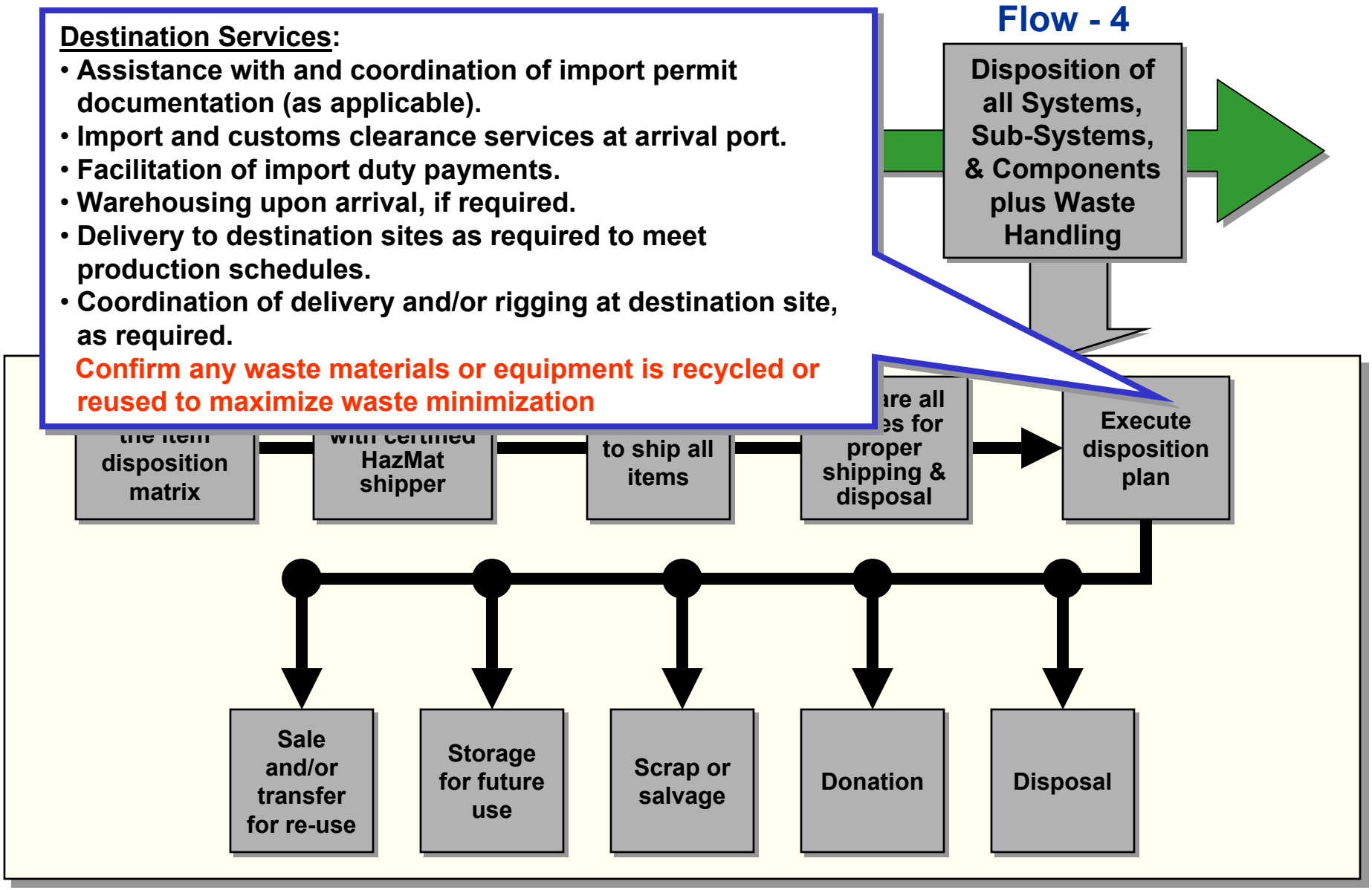
Disposition of all Systems, Sub-Systems, & Components plus Waste Handling



Decommissioning Process Flow - 4

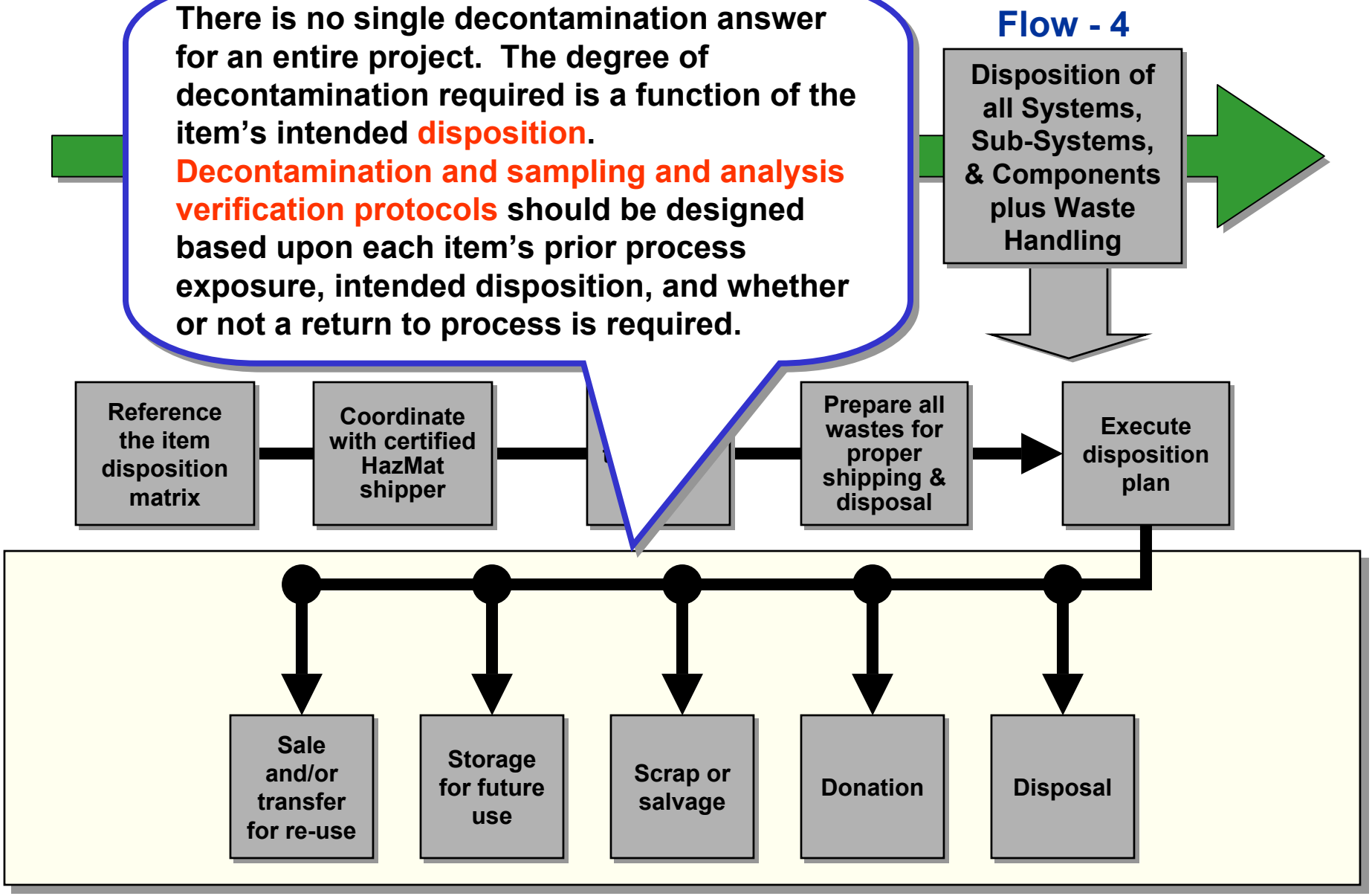
Destination Services:
- Assistance with and coordination of import permit documentation (as applicable).
- Import and customs clearance services at arrival port.
- Facilitation of import duty payments.
- Warehousing upon arrival, if required.
- Delivery to destination sites as required to meet production schedules.
- Coordination of delivery and/or rigging at destination site, as required.

Confirm any waste materials or equipment is recycled or reused to maximize waste minimization



Decommissioning Process Flow - 4

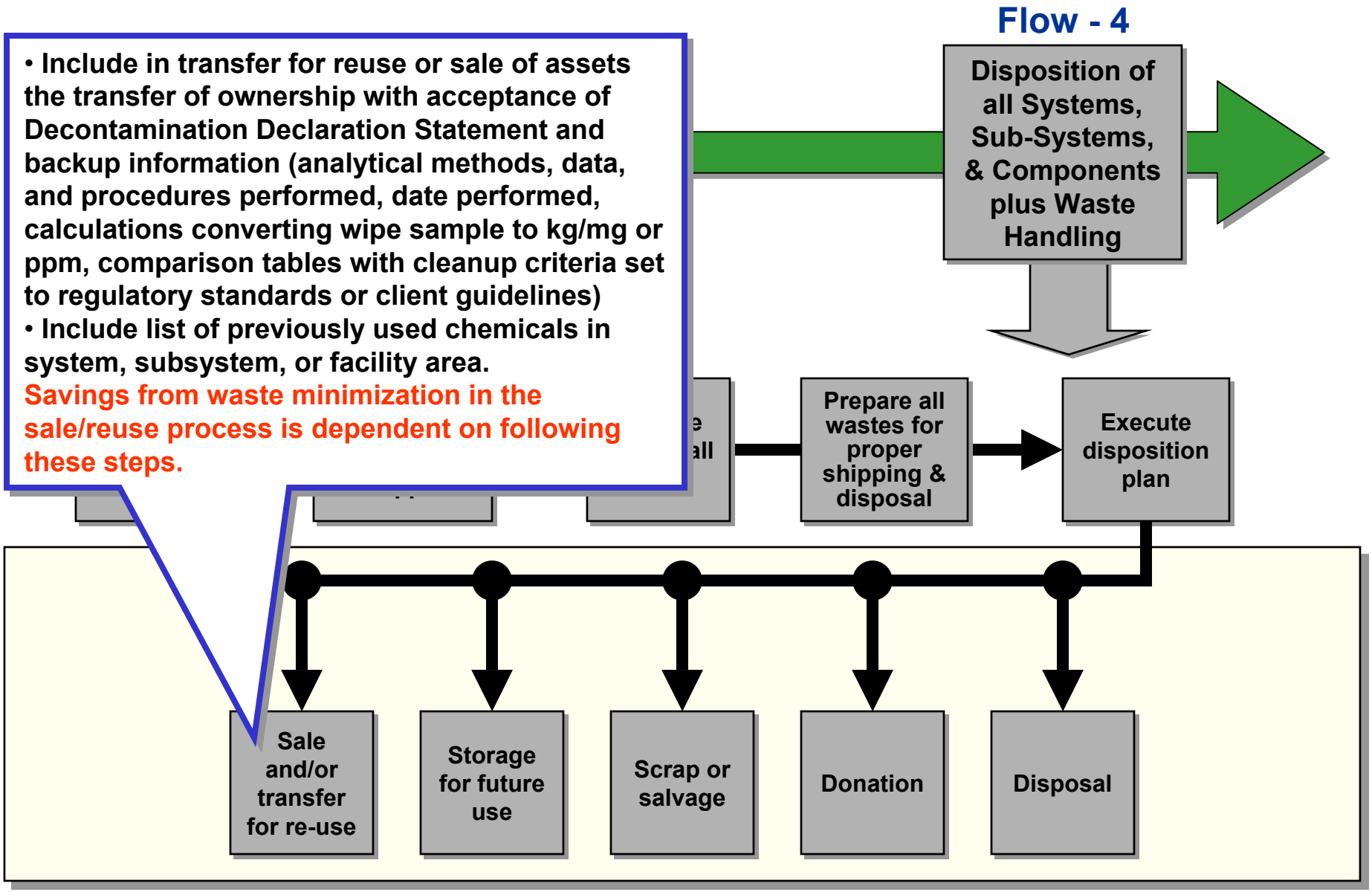
There is no single decontamination answer for an entire project. The degree of decontamination required is a function of the item's intended disposition. Decontamination and sampling and analysis verification protocols should be designed based upon each item's prior process exposure, intended disposition, and whether or not a return to process is required.



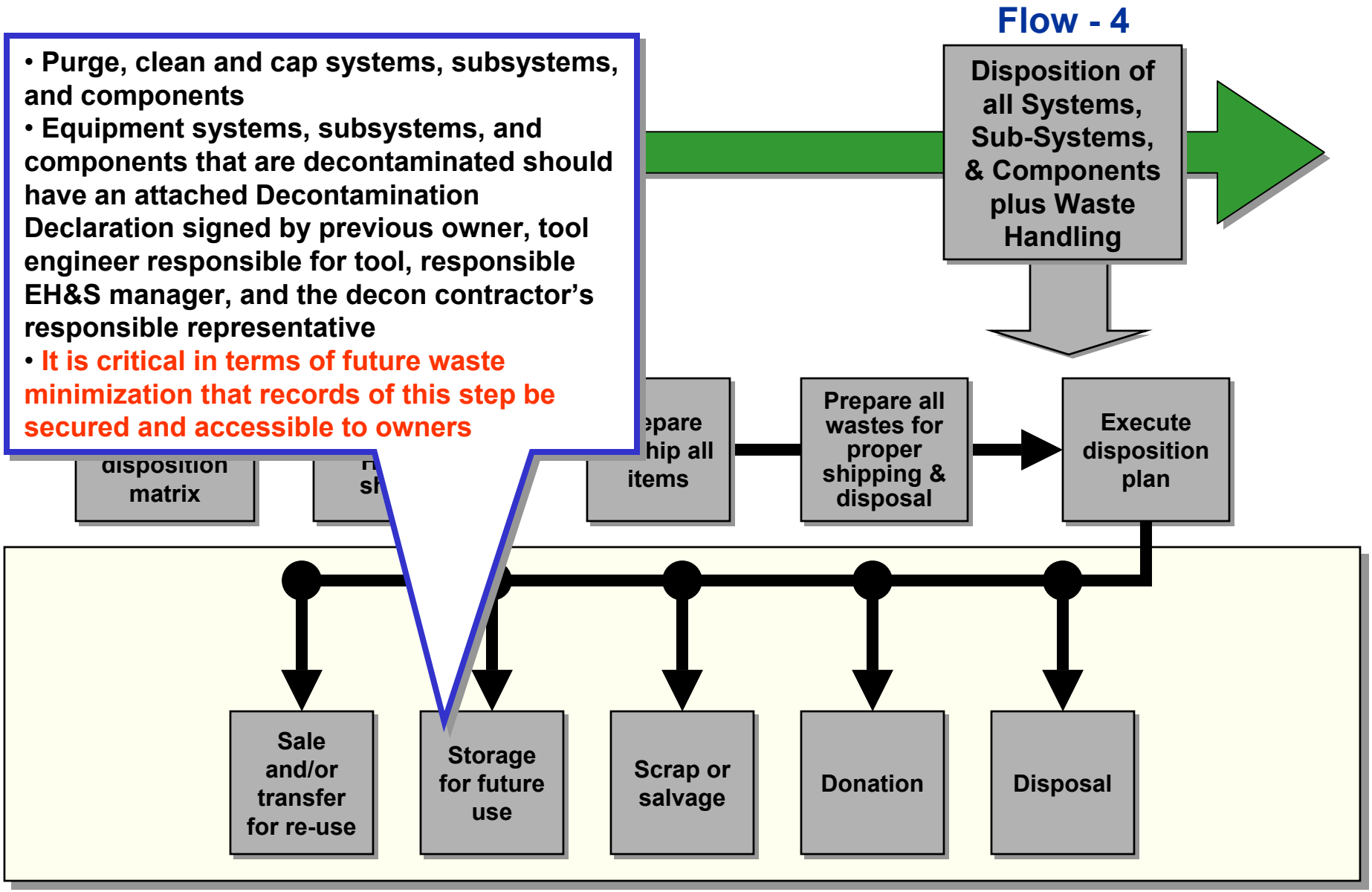
Verification Wipe Sampling Protocol

- DECON developed wipe sampling verification protocol for facility closures
- Satisfies regulators for equipment or facility closure when compared to Federal, State, Local regulatory standards (Federal WET, TCLP; CA TTLC, STLC, etc.)
- Formula used is based on determining chemical constituent concentration amount on surfaces with a discrete thickness and known density
- Final wipe sample result calculated is mg/kg or ppm
- Result compares to most regulatory standards for hazardous waste characterization
- Result provides verification that the surface has been decontaminated to the acceptable regulatory or company-standard chemical constituent concentration

Decommissioning Process Flow - 4



Decommissioning Process Flow - 4



Decommissioning Process Flow - 4

- Clean systems, subsystems, and components as required by scrap or salvage firm receiving the materials, waste, or equipment and to satisfy transport laws and requirements
- Volume reduction of scrap and waste provides significant dollar savings in the waste minimization process

Flow - 4

Disposition of all Systems, Sub-Systems, & Components plus Waste Handling

Prepare all wastes for proper shipping & disposal

Execute disposition plan

Sale and/or transfer for re-use

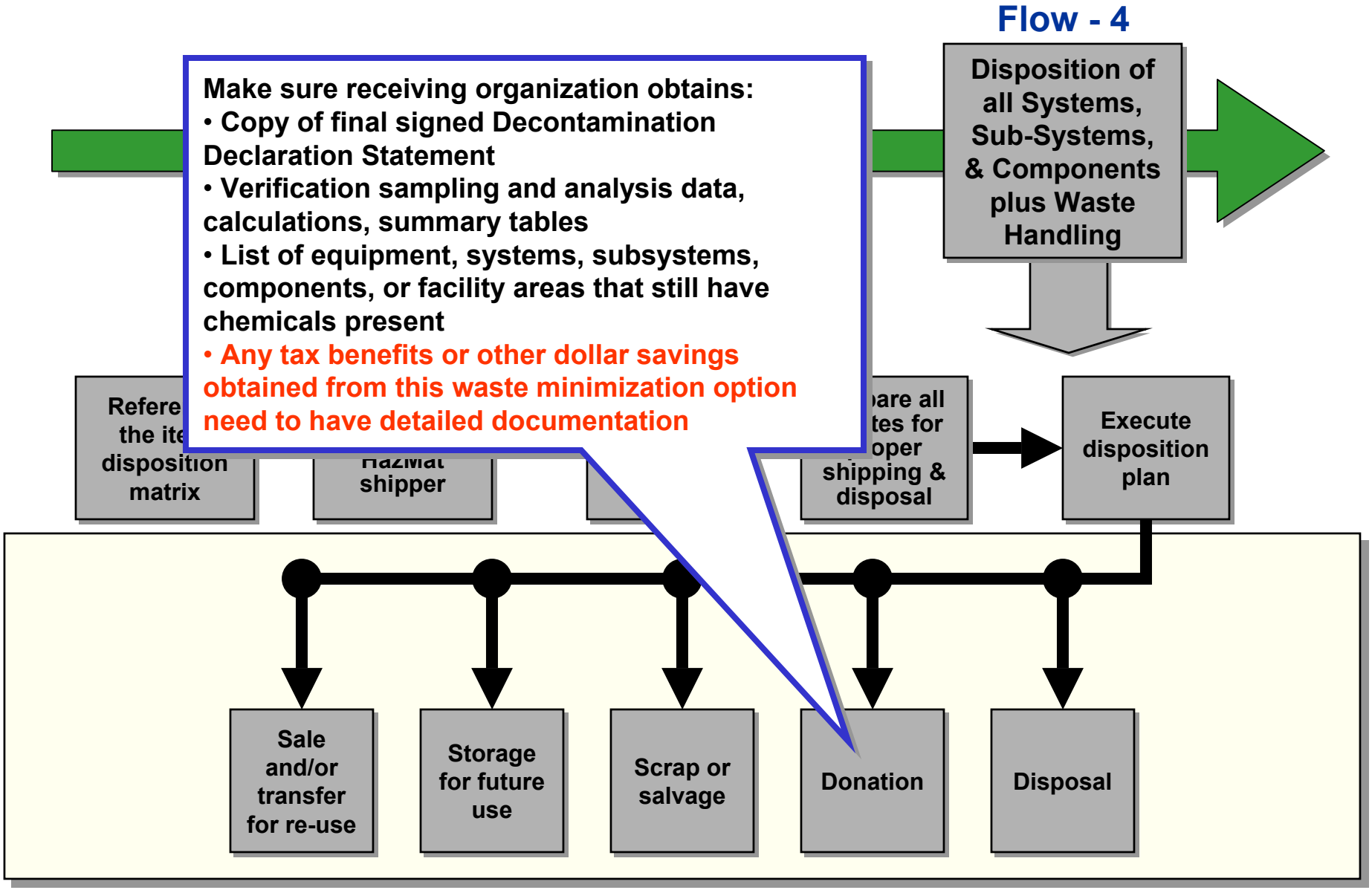
Storage for future use

Scrap or salvage

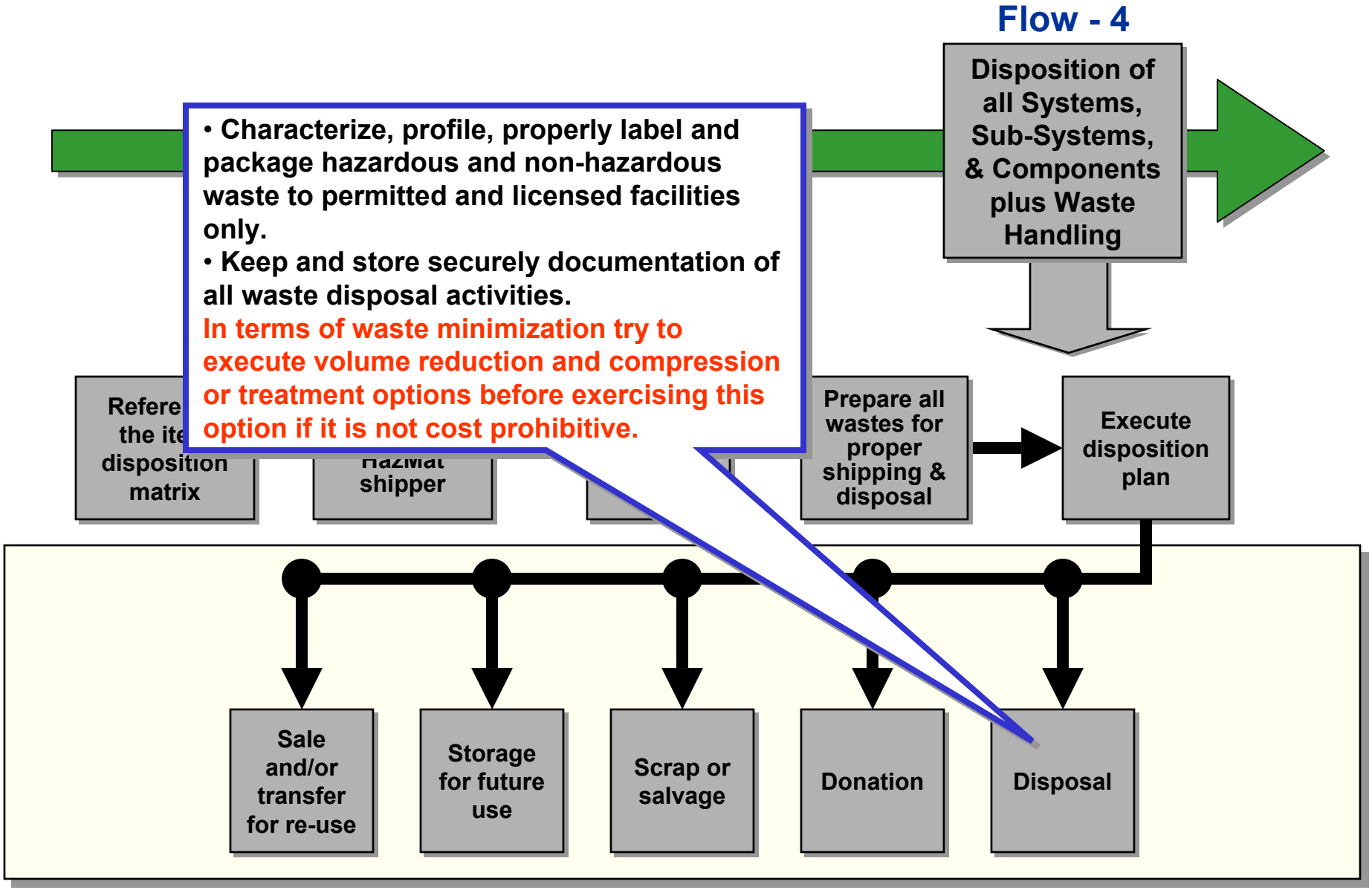
Donation

Disposal

Decommissioning Process Flow - 4



Decommissioning Process Flow - 4



Acknowledgments and References

- The industry professionals who have participated in the global series of SEMI Decommissioning Workshops
- The 40 members of the SEMI Decommissioning Task Force
- Bernard Frist, EORM and Robert Barnes, Robert B. Barnes Associates, Inc., *Analyzing Fab Closure Alternatives, ISESH 10th Annual Conference, Noordwijk 2003*

Department of Toxic Substances Control

For More Detailed Information

- Presentation slides
- ***DECON Verification Wipe Sampling Protocol for Facility Closures***
- Other DECON facility and equipment decommissioning and decontamination procedures
- Leave your business card, or

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