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Parameterization of Project Footprints – Estimating Your Impact

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Agenda

- Review current challenges with using sustainability tools
- Present potential solution – Table of Green and Sustainable Remediation (GSR) Reference Projects in terms of "Functional Units"
  - How was the Functional Units Table created?
  - How should the Functional Units Table be used?
- Final Thoughts

Common Sustainability Tools

Best Management Practices (BMPs)

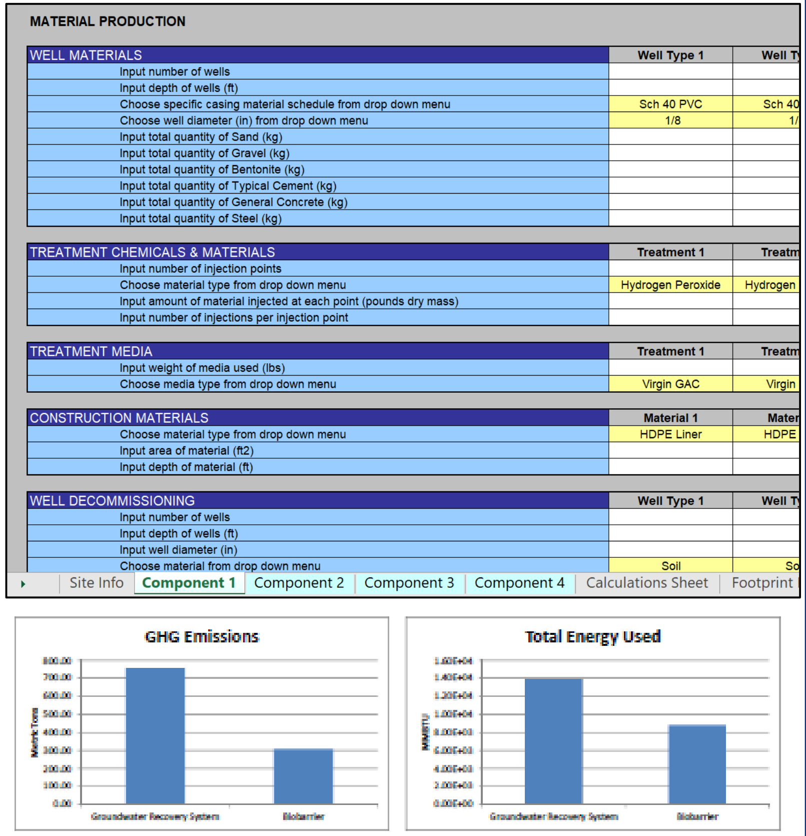
E2893 – 16

TABLE X3.1 Greener Cleanup BMP Table

Category	Best Management Practice	Core Element Addressed (at Site Level): Energy	Air	Water	Materials and Waste	Land and Ecosystems	Remediation Technology: Soil Vapor Extraction	Air Sparging	Pump and Treat	In-situ Chemical Oxidation	Bioremediation/MNA	In-situ Thermal Treatment	Phytotechnology	Subsurface Containment & Treatment Barriers	Excavation and Surface Restoration	Ex-situ Bio/Chemical Oxidation	Landfill Covers and Caps	Vapor Intrusion Mitigation
Buildings	Capture roof runoff for on-site use, as appropriate based on the water quality			X			X	X	X			X				X		
Buildings	Choose water efficient plumbing fixtures (for example, low flow fixtures, tankless water heaters)			X			X	X	X									
Buildings	Install a green roof on buildings to minimize stormwater management and improve energy efficiency	X		X		X	X	X	X									
Buildings	Install energy recovery ventilators in buildings to allow incoming fresh air while capturing energy from outgoing conditioned air	X	X				X	X	X							X		
Buildings	Install roofing with a high solar reflection index	X					X	X	X									
Buildings	Optimize use of natural light through location and orientation of windows	X					X	X	X									
Buildings	Orient new buildings (for example, south facing or with prevailing wind directions) to optimize energy efficient heating and cooling	X					X	X	X									
Buildings	Reuse existing structures for treatment system, storage, sample management, etc	X			X	X	X	X	X									
Buildings	Use energy efficient equipment such as Energy Star verified boilers or heat pumps in buildings or housings	X					X	X	X									
Buildings	Use energy efficient HVAC systems (for example, programmable heating and cooling systems) and/or establish separate heating/cooling zones	X					X	X	X									
Buildings	Use energy efficient lighting systems by incorporating elements such as LED lights or motion sensors				X		X	X	X									
Buildings	Use graywater collection systems at on-site buildings for water during cleanup activities, to minimize freshwater use			X			X	X	X	X	X	X	X	X	X	X	X	
Buildings	Use green insulation materials (for example, spray-on cellulose) when insulating buildings	X			X		X	X	X									
Materials	For ISTT using ERH, co-locate electrodes and recovery wells in the same borehole, particularly in the saturated zone, to minimize the total number of wells and land disturbance	X	X	X	X	X						X						
Materials	For ISTT, when insulating the surface of the TTZ to reduce energy losses, use greener insulation alternatives such as LECA beads (rather than polyurethane foam)	X			X							X						

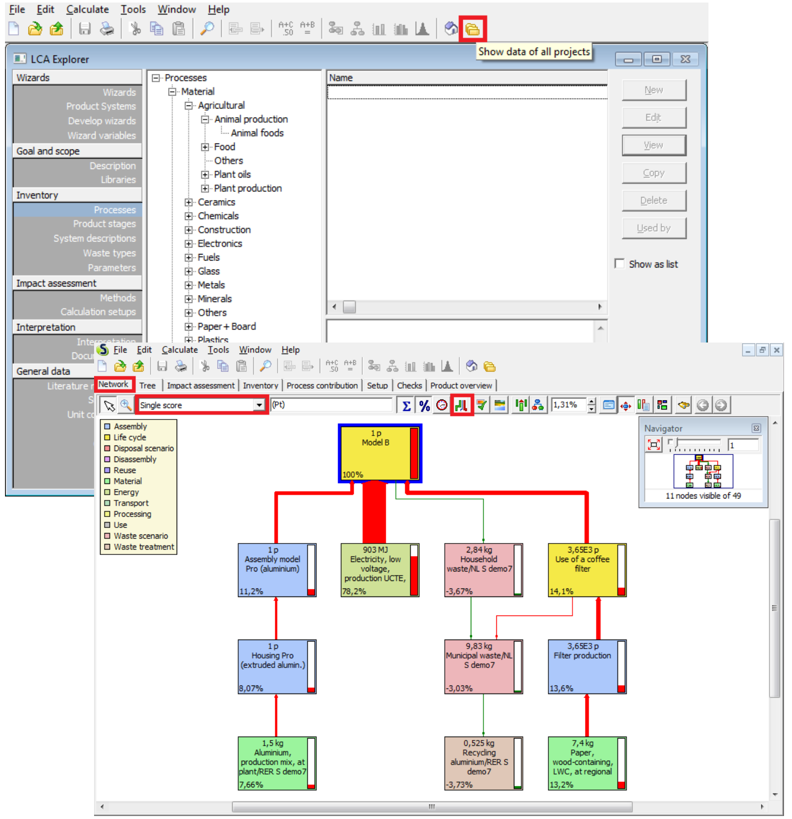
Excerpt from the ASTM Standard Guide for Greener Cleanups

Footprinting



From Sitewise

Life Cycle Assessment (LCA)



From Simapro

Background | Creating the Table | Using the Table | Final Thoughts

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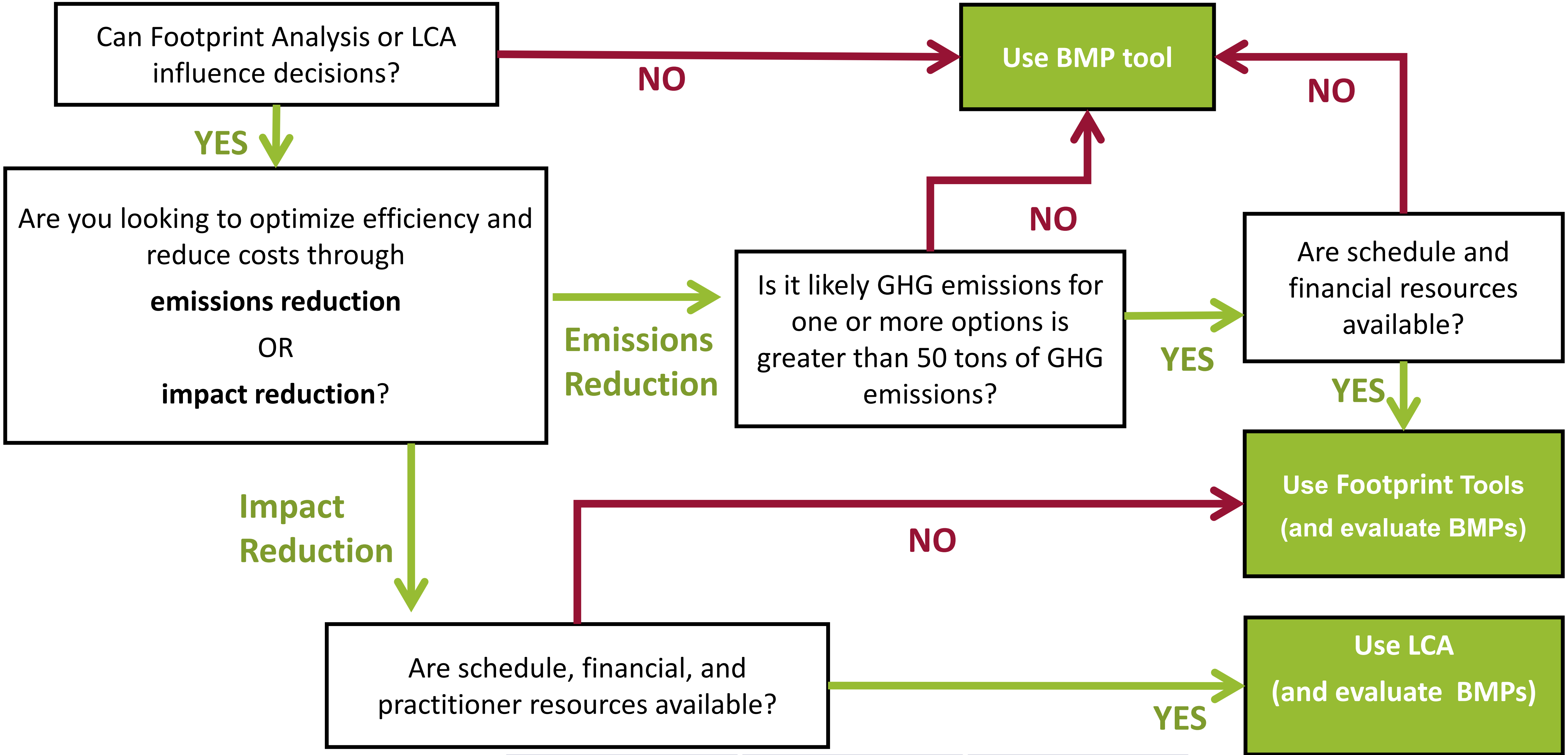
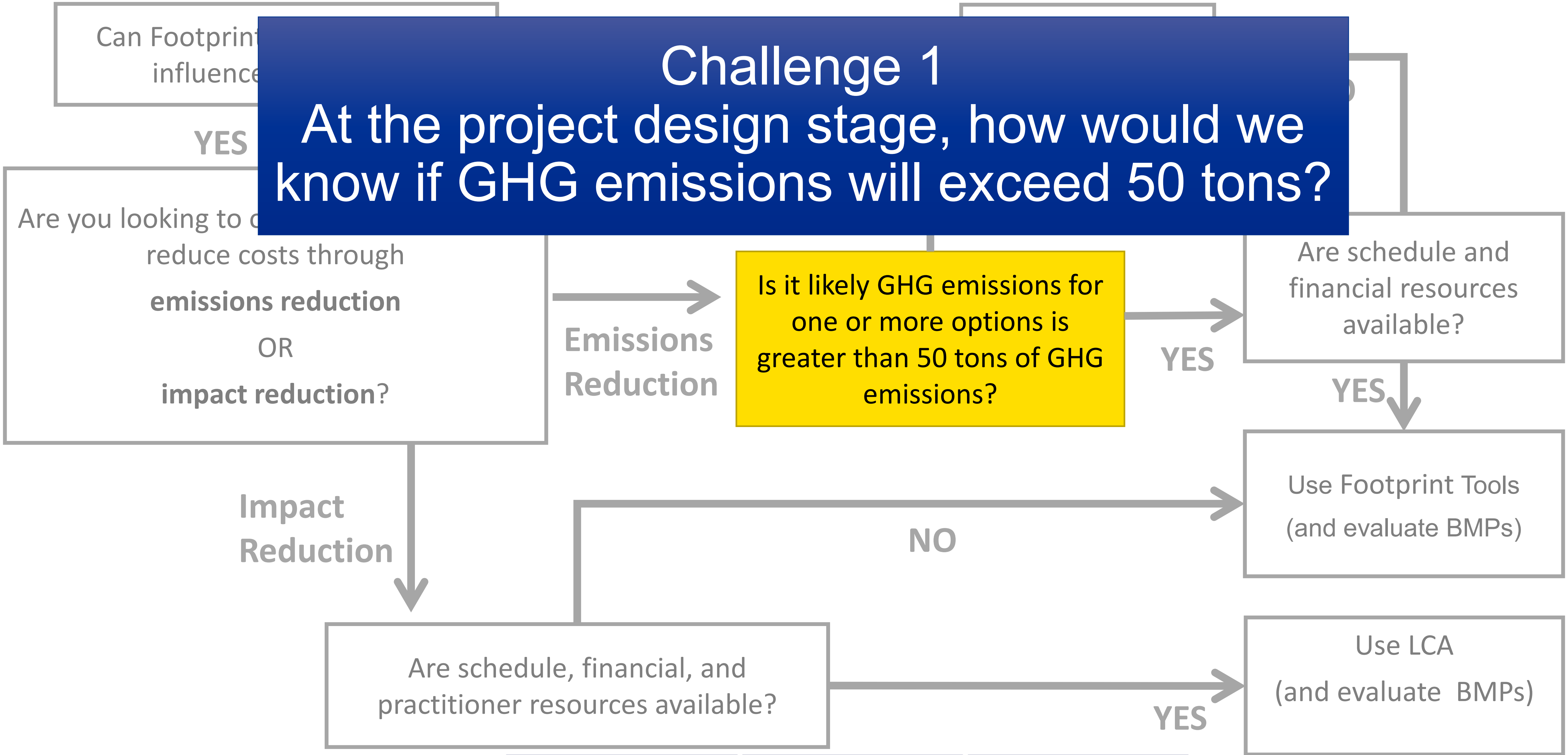
How do we choose the best tool?



How do we choose the best tool?

Challenge 1
At the project design stage, how would we know if GHG emissions will exceed 50 tons?



How do we know if our Sitewise Results make sense?

Project Details

- Operation of an existing Soil Vapor Extraction (SVE) system for 12 months (1,186 MWHr) including 10,000 lbs of regenerated GAC per month.
- Operation a … trips. Additionally … quarterly for one year …

Challenge 2
Once a footprint analysis is complete how do we know if our results make sense and are "reasonable"?

Footprint Results (from Sitewise V3.1)

	NOx (Metric Tons)	SOx (Metric Tons)	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
Results (Using Sitewise V3.1)	4.57E+05	2.59E-01	3.61E+00	4.42E+00	5.47E+00

How can we address these challenges?

Proposed Solution

1. Evaluate reference footprint assessments
2. Estimate GSR impacts in terms of a defined functional unit
3. Use results to estimate a project footprint

Challenge 1

At the project design stage, how would we know if GHG emissions will exceed 50 tons?

Challenge 2

Once a footprint analysis is complete how do we know if our results make sense and are “reasonable”?

Evaluate Reference Footprint Assessments

- Identified 19 **reference projects** completed with Sitewise Version 3.0 and 3.1
  - Included 10 key technologies/categories

1. Soil vapor extraction
2. In situ bioremediation
3. In situ chemical oxidation
4. Air sparging/bio sparging
5. In situ chemical reduction
6. Low permeability cover
7. Well installation
8. Excavation and disposal
9. Long-term monitoring
10. Transportation

  - Evaluated five core outputs

Evaluated five core outputs

1. Nitrous Oxide (NOx)
2. Sulfur Oxide (SOx)
3. Greenhouse Gas (GHG)
4. Particulate Matter (PM)
5. Energy Use

Functional units include:

- Per MWHr of operation
- Per 1,000 feet of cubic media
- Per ton of substrate
- Per ton of oxidant
- Per ton of amendment
- Per 100 feet of well installed
- Per well sampled
- Per acre covered
- Per 20 bank cubic yards
- Per ton mile

Estimate GSR impacts in terms of a defined functional unit
Example 1: Well Installation

Reference Project

Description

Install 10-2 inch diameter wells installed via sonic drilling to 50 ft bgs with 5 foot screens (total 500 feet of well)

Sitewise Results

NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
2.51E-02	1.85E-02	3.80E+01	3.43E-03	8.51E+03

Calculated Functional Unit

Description

Divided reference results by 5 to generate well installation impacts **per 100 feet**

Functional Unit Results:

Impact per 100 feet of well installed

NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
5.02E-03	3.70E-03	7.59E+00	6.86E-04	1.70E+03

Estimate GSR impacts in terms of a defined functional unit
Example 2: In Situ Bioremediation

Reference Project

Description

99 permanent injection wells (5,205 feet drilled), 2 events, 231,765 lb EVO per event. (~621,000 cubic feet of media)

Sitewise Reference Results

NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
2.47E-01	4.43E-01	5.64E+02	1.02E-01	8.89E+04

Calculated Functional Unit

Description

Divided reference results by 621 to generate well installation impacts **per 1,000 feet of media**

Functional Unit Results:

Impact per ton of substrate

NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
3.98E-04	7.14E-04	9.08E-01	1.65E-04	1.43E+02

Estimate GSR impacts in terms of a defined functional unit
Result: Functional Unit Table

Soil Vapor Extraction (SVE)

In Situ Bioremediation (ISB) (Enhanc Reductive Dechlorination [ERD])

In Situ Chemical Oxidation (ISC

Air Sparging (AS)/Bio Sparging

per ton of oxidant	4.28E-02	2.48E-02	1.89E-02	1.40E-02	1.50E+01	1.67E+01	6.69E-03	4.90E-03	3.98E+03	3.14E+03	16 wells installed (780 feet drilled), 1	99 injection wells installed (5,205 feet	

lls to 4 feet bgs (SCH 40 virgin GAC, and 30 hp ...ting for 5 years (980 ...gawatt-hours)

years (490 megawatt-hours)

njection wells (5,205 feet ...ents, 231,765 lb EVO per ...tion and operation only. ...) lb total reagent)

...nts, 27,720 lb of 100% ...nganate per injection ...peroxide). Construction ...only. (55,440 lb total)

injection wells, 3,000 feet of HDPE

...a 1,020-foot horizontal HDPE injection well, 100-hp compressor ...for 1 year (520 megawatt- ...ction and operation only.

Reference Project Narrative

Reference Project 1

One horizontal well (600 feet of 4-inch HDPE), 15-hp blower operating for 5 years (490 megawatt-hours)

	Functional Unit	NO_X (metric tons)	SO_X (metric tons)	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
Soil Vapor Extraction (SVE)	per MWHr of operation	9.81E-04	4.50E-03	9.44E-01	1.99E-03	1.17E+01
	per 1,000 cubic feet of media	1.43E-02	6.56E-02	1.38E+01	2.90E-02	1.70E+02

Reference Project Narrative

Reference Project 2

Install 48 SVE wells to 4 feet bgs (SCH 40 PVC), 6,000 lbs virgin GAC, and 30 hp blower operating for 5 years (980 megawatt-hours)

	Functional Unit	NO_X (metric tons)	SO_X (metric tons)	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
Soil Vapor Extraction (SVE)	per MWHr of operation	5.56E-04	1.09E-03	8.07E-01	1.27E-03	5.43E+01
	per 1,000 cubic feet of media	5.35E-03	1.05E-02	7.77E+00	1.23E-02	5.22E+02

Use table to estimate project footprint

Step 1: Identify which categories from the table are applicable

Review Project

Description

- Operation of an existing Soil Vapor Extraction (SVE) system for 12 months (1,186 MWHr) including 10,000 lbs of regenerated GAC per month.
- Operation and maintenance of the system is estimated to include 260 30-mile trips. Additionally, groundwater from 15 existing wells will be sampled via low-flow quarterly for one year, for a total of 60 wells sampled.

Soil Vapor Extraction	Low Permeability Cover
In Situ Bioremediation	Well Installation
In Situ Chemical Oxidation	Excavation and Disposal
Air Sparging/ Bio Sparging	Long-Term Monitoring
In Situ Chemical Reduction	Transportation

Use table to estimate project footprint

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Use table to estimate project footprint

Step 2: Identify which reference project best matches the review project

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- Operation of an existing **SVE** system for 12 months (**1,186 MWHr**) including **10,000 lbs of regenerated GAC** per month.
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Long-Term Monitoring (LTM)

Reference Project 1: Install six monitor wells to 60 feet bgs. Sample 15 wells per event (personnel travel 500 miles), no IDW due to passive sampling, 10 events. (150 wells sampled)

Reference Project 2: Install two monitor wells to 60 ft bgs. Sample 14 wells per event (personnel travel 80 miles), 140 gallons water generated per event, 34 events (476 wells sampled)

Use table to estimate project footprint

Review Project

Description

- Operation of an existing **SVE** system for 12 months (**1,186 MWHr**) including **10,000 lbs of regenerated GAC** per month.
- Operation and maintenance of the system is estimated to include 260 30-mile trips. Additionally, groundwater from **15 existing wells** will be sampled via low-flow quarterly for one year, for a total of **60 wells sampled**.

Step 2: Identify which reference project best matches the review project

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Use table to estimate project footprint

Step 3: Multiply the selected reference project values by the functional unit quantity

Table 1. GSR Reference Project Results, in terms of Functional Unit

	Functional Unit	NO_x (metric tons)		SO_x (metric tons)		GHG (metric tons)		PM (metric tons)		Energy (MMBtu)		Reference Project Narrative	
		Ref 1	**Ref 2**	Ref 1	**Ref 2**	Ref 1	**Ref 2**	Ref 1	**Ref 2**	Ref 1	**Ref 2**	Reference Project 1	**Reference Project 2**
Soil Vapor Extraction (SVE)	**per MWHr of operation**	9.81E-04	**5.56E-04**	4.50E-03	**1.09E-03**	9.44E-01	**8.07E-01**	1.99E-03	**1.27E-03**	1.17E+01	**5.43E+01**	One horizontal well (600 feet of 4-inch HDPE), 15-hp blower operating for 5 years (490 megawatt-hours)	**Install 48 SVE wells to 4 feet bgs (SCH 40 PVC), 6,000 lbs virgin GAC, and 30 hp blower operating for 5 years (980 megawatt-hours)**
	per 1,000 cubic feet of media	1.43E-02	5.35E-03	6.56E-02	1.05E-02	1.38E+01	7.77E+00	2.90E-02	1.23E-02	1.70E+02	5.22E+02		
Long-term Monitoring (LTM)	**per well sampled**	**1.30E-04**	3.40E-05	**2.40E-05**	4.30E-06	**6.90E-02**	5.98E-02	**3.10E-05**	1.10E-05	**9.00E-01**	8.10E-01	**Install six monitor wells to 60 feet bgs. Sample 15 wells per event (personnel travel 500 miles), no IDW due to passive sampling, 10 events. (150 wells**	Install two monitor wells to 60 ft bgs. Sample 14 wells per event (personnel travel 80 miles), 140 gallons non-hazardous water generated per event (transported 200 miles away), 34 events. (476 wells sampled)

Category	Functional Unit	Review Project Quantity	NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
SVE	MWHr of Operation	1186	(1186 X 5.56E-4) = **6.59E-01**	(1186 X 1.09E-3) = **1.29E+00**	(1186 X 8.07E-1) = **9.57E+02**	(1186 X 1.27E-3) = **1.51E+00**	(1186 X 5.43E+1) = **6.43E+04**
LTM	Number of wells sampled	60	(60 X 1.30E-4) = **7.80E-03**	(60 X 2.40E-5) = **1.44E-03**	(60 X 6.90E-2) = **4.14E+00**	(60 X 3.10E-5) = **1.86E-03**	(60 X 9.00E-1) = **5.40E+01**
		Total	**6.67E-01**	**1.30E+00**	**9.61E+02**	**1.51E+00**	**6.44E+04**

Challenge 1:
At the project design stage, how would we know if GHG emissions will exceed 50 tons?

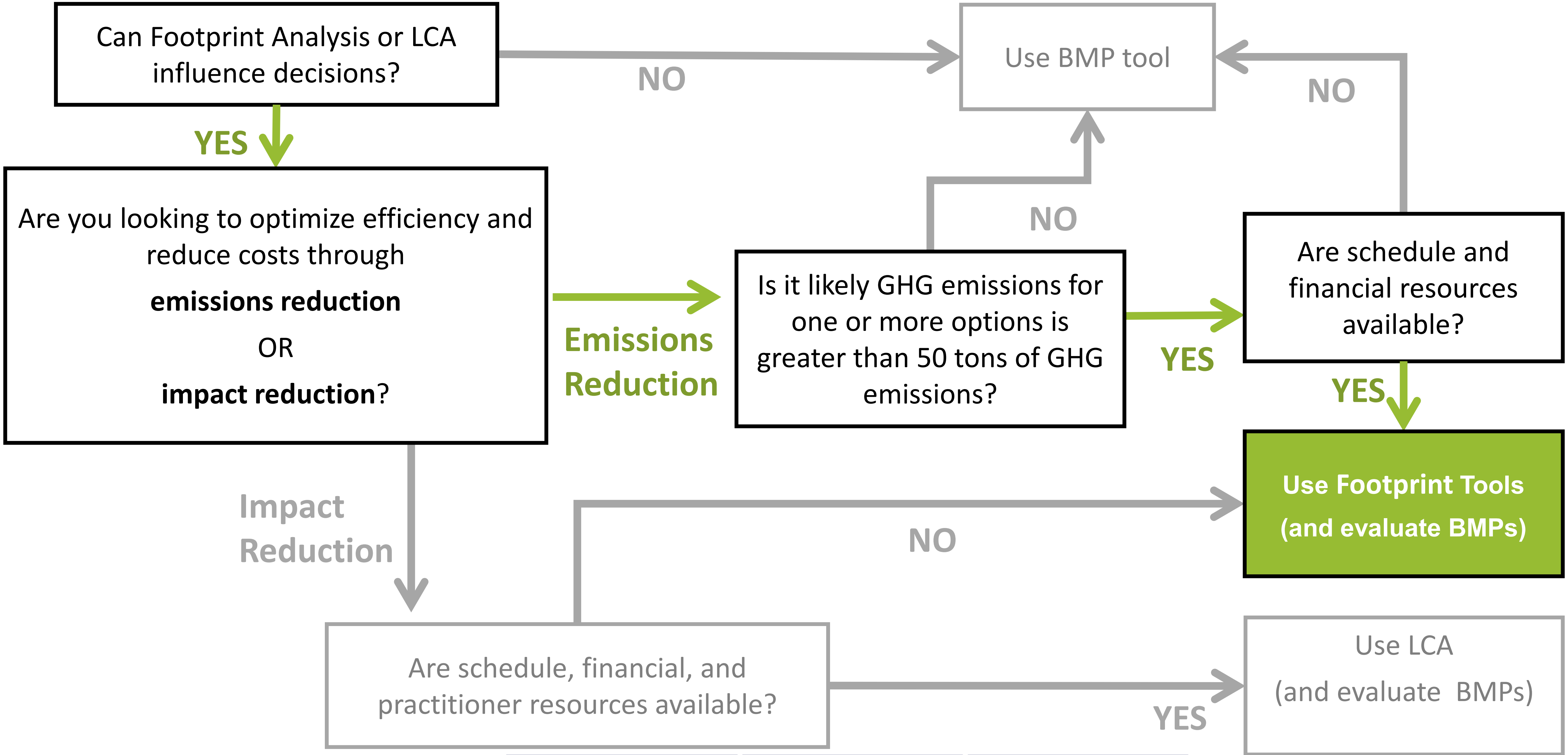
Is it likely GHG emissions for one or more options is greater than 50 tons of GHG emissions?

Category	Functional Unit	Review Project Quantity	NOx (Metric Tons)	SOx (Metric Tons	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
SVE	MWHr of Operation	1186	6.59E-01	1.29E+00	9.57E+02	1.51E+00	6.43E+04
LTM	Number of wells sampled	60	7.80E-03	1.44E-03	4.14E+00	1.86E-03	5.40E+01
		Total	6.67E-01	1.30E+00	9.61E+02	1.51E+00	6.44E+04

Key Point

- 20 minute exercise (Steps 1 to 3) can help determine whether the project is best suited for best management practices, footprint analysis, or life cycle assessment

How do we choose the best tool?



Using the Table

Step 4: Compare actual Sitewise Results to the Calculated Estimate

	NOx (Metric Tons)	SOx (Metric Tons)	GHG (metric tons)	PM (metric tons)	Energy (MMBtu)
Estimated Results (using the table)	6.67E-01	1.30E+00	9.61E+02	1.51E+00	6.44E+04
Actual Results (Using Sitewise V3.1)	4.57E+00	2.59E+00	3.61E+03	4.42E+00	5.47E+04

- Similar values are likely "reasonable"
- NOx and GHG values differ by more than a factor of three and require further consideration

Key Point

- 20 minute exercise (Step 4) can help us feel good that our calculated Sitewise results make sense and are "reasonable"

Disclaimer

- Use of this tool is NOT meant to be a substitute for a footprint analysis
- This method is just one way to address these challenges
- There are numerous category specific common oversights, pitfalls, and additional considerations in applying Sitewise

Challenges Addressed

At the project design stage, how would we know if GHG emissions will exceed 50 tons?

Once a footprint analysis is complete how do we know if our results make sense and are “reasonable”?

Key Takeaways

- Teams are aware of common sustainability tools but don’t know how to choose them
- A novice sustainability practicioner may not understand if footprint results are “reasonable”
- It is the job of sustainability champions to not only advocate for the use and consideration of these tools, but to develop the quality control tools to allow beginners to use them

Thank you!

Betsy Collins, P.E.

June 10, 2019