A Consultant’s Experience with Green Remediation – Technical Work and General Observations

NEWMOA Workshop
Greening Cleanups: What Does It Mean and How Do You Do It?
April 21, 2009 – Portsmouth, NH
April 22, 2009 – Pomfret, CT

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GeoTrans, Inc.
A TETRA TECH COMPANY

My Background

- Earth science and engineering education
- Two years of academic research on carbon budget and role of forests as carbon sources/sinks
- Approximately 10 years of experience with soil and groundwater remediation for EPA and private clients
- Solar (PV) study, design, and installations in New Jersey
- Evaluations of solar (PV), solar thermal, CHP, geothermal heat pumps, and other green technologies for private developments
- LEED™ Accredited Professional
- Green remediation evaluations for EPA and RP's

GeoTrans Background

- Nation-wide consulting firm founded in 1979
- Long-term work in the northeast as well as on some of the most complex environmental sites across the United States including the Savannah River Site, Love Canal, the Nevada Test Site, and the Rocky Mountain Arsenal
- Extensive work for EPA in conducting third-party evaluations of Fund-lead sites
- Extensive work for EPA in developing guidance documents including…
  - *Elements for Effective Management of Operating Pump and Treat Systems*
  - *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Sites*
- Wholly-owned subsidiary of Tetra Tech (NASDAQ: TTEK)
  - ENR Ranked #6 in 2008 for overall Environmental Services
  - ENR ranked #1 in 2008 for Water
  - ENR ranked #1 in 2008 for Environmental Science.

The Rise of Green Remediation

- We've seen several factors that have motivated various parties toward green remediation
  - Conscientiousness about being good stewards of the environment
  - Federal and State mandates related to sustainability
  - Green remediation as a factor in negotiation with regulatory agency
  - Evolution from broader corporate or organization sustainability mission
  - Marketing
- Evident in all sectors
  - DoD developing its own sustainability evaluation tool
  - Private firms (RPs and their consultants) developing their own sustainability evaluation tools
  - Requests for third-party green remediation evaluations by all sectors

GeoTrans Case Studies

- Baird and McGuire
- An undisclosed real site (evaluation in process)
- Innovative remedy #1 revisiting from a green perspective
- Innovative remedy #2 revisiting from a green perspective

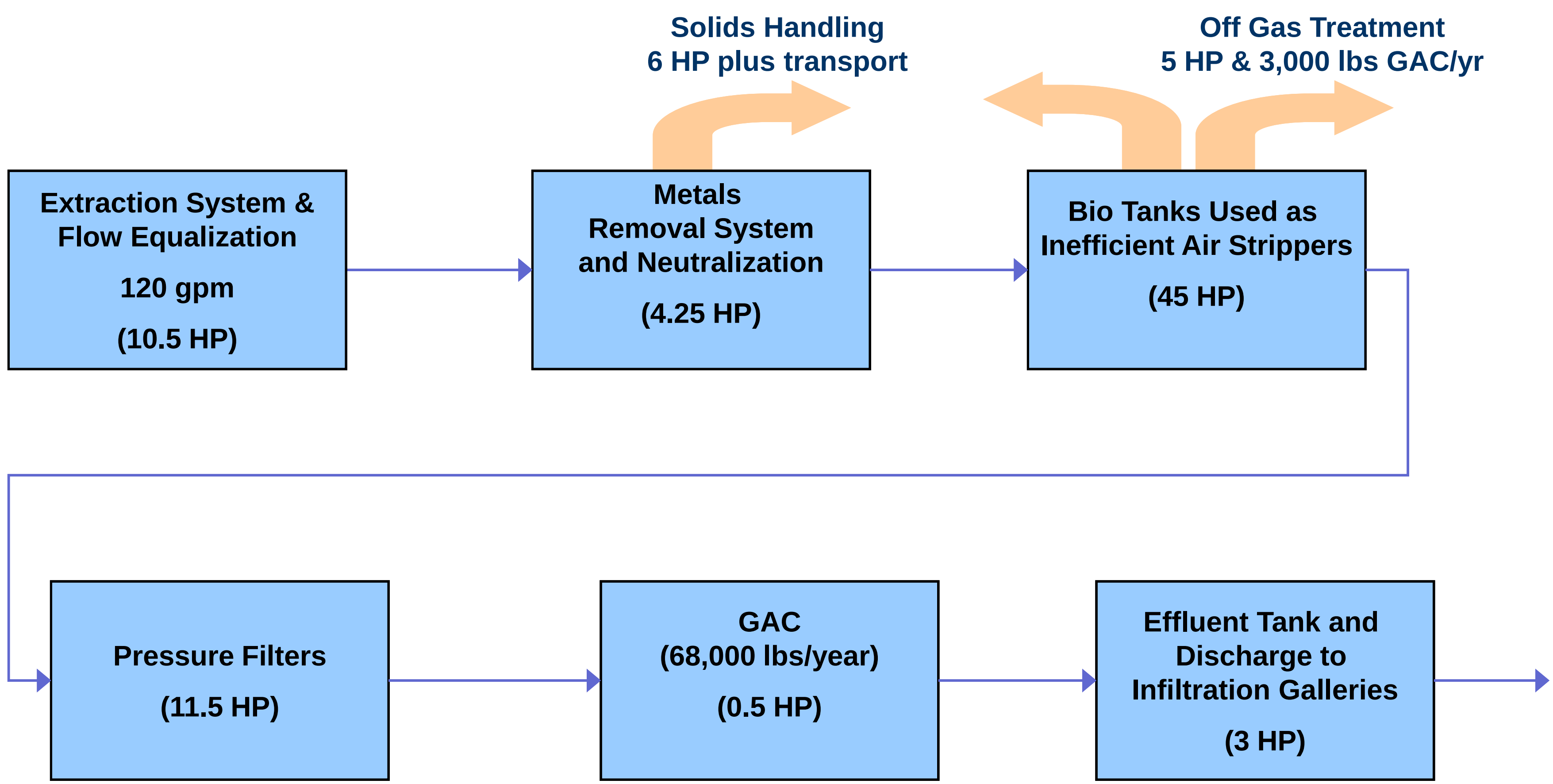
Baird and McGuire: Very Brief Background

- P&T system treating organics and arsenic
  - Organics on the decline, but naphthalene still above standards and relatively extensive, diffuse plume
  - Arsenic the continuing issue that will require long-term P&T
- RSE conducted in 2001, implementing recommendations and other work has led to a decrease in annual O&M costs from $3.5 million to $1 million
- Adequate plume capture and protectiveness have been demonstrated
- Recent focus by State on carbon footprint of remedy and continued inefficiency of GAC units…
  - MADEP requests assistance in looking at alternatives to GAC units
  - MADEP requests specific evaluation of concept to use CHP for heat-enhanced air stripping

Baird and McGuire
MA Focus on Energy and GHG Emissions

- Conservation charge: utility audits and rebates
- Renewable energy charge: funding through the MTC
- <u>ISO forward capacity market</u>
- Green Communities Act:
  - RGGI: cap and trade allowances for generators larger than 25 MW
  - Utilities required to purchase "negawatt" power
  - Resources to communities for efficiency and renewable energy
  - <u>RPS expanded to include APS for CHP</u>
- Global Warming Solutions Act: 10% to 25% below 1990 by 2020, etc.
  - Registration of emitters above 5,000 short tons/yr
  - Mass DEP voluntary reporting with the Climate Registry includes <u>Baird & McGuire emissions</u> (general reporting protocol)
- MEPA Policy: Governor's zero emissions building initiative, zero net energy buildings by 2030, Clean Energy BioFuels Act

Treatment Process Flow



Average motor horsepower indicated in parentheses

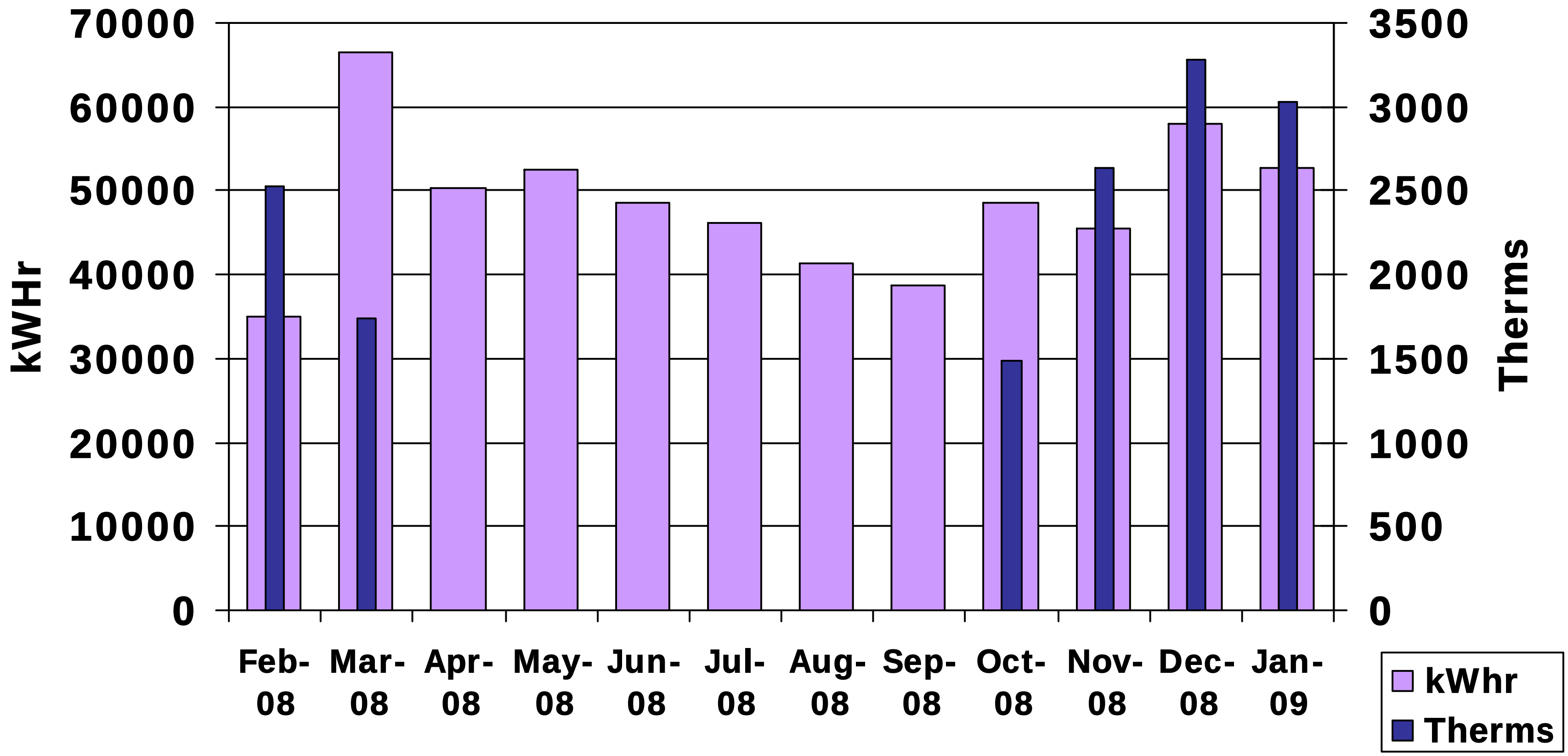
Biotanks

- Size: 172,458 gal (each)
- Detention time: 28 hours at 100 gpm (each)
- Blower size: 20 hp (each)

Granular Activated Carbon

- GAC size 10,000 lbs requires 8,000 to 8,500 lbs per change-out
  - Pressure drop from 2 psi to 15 psi

Monthly Energy Usage



Concept of CHP at Baird & McGuire

- Quantify carbon footprint for current (baseline) system and various alternatives
- Quantify life-cycle costs/savings associated with baseline system and alternatives
- Compare results and consider other pros and cons
- Select the best overall approach that balances carbon footprint, cost, reliability, and ease of operation

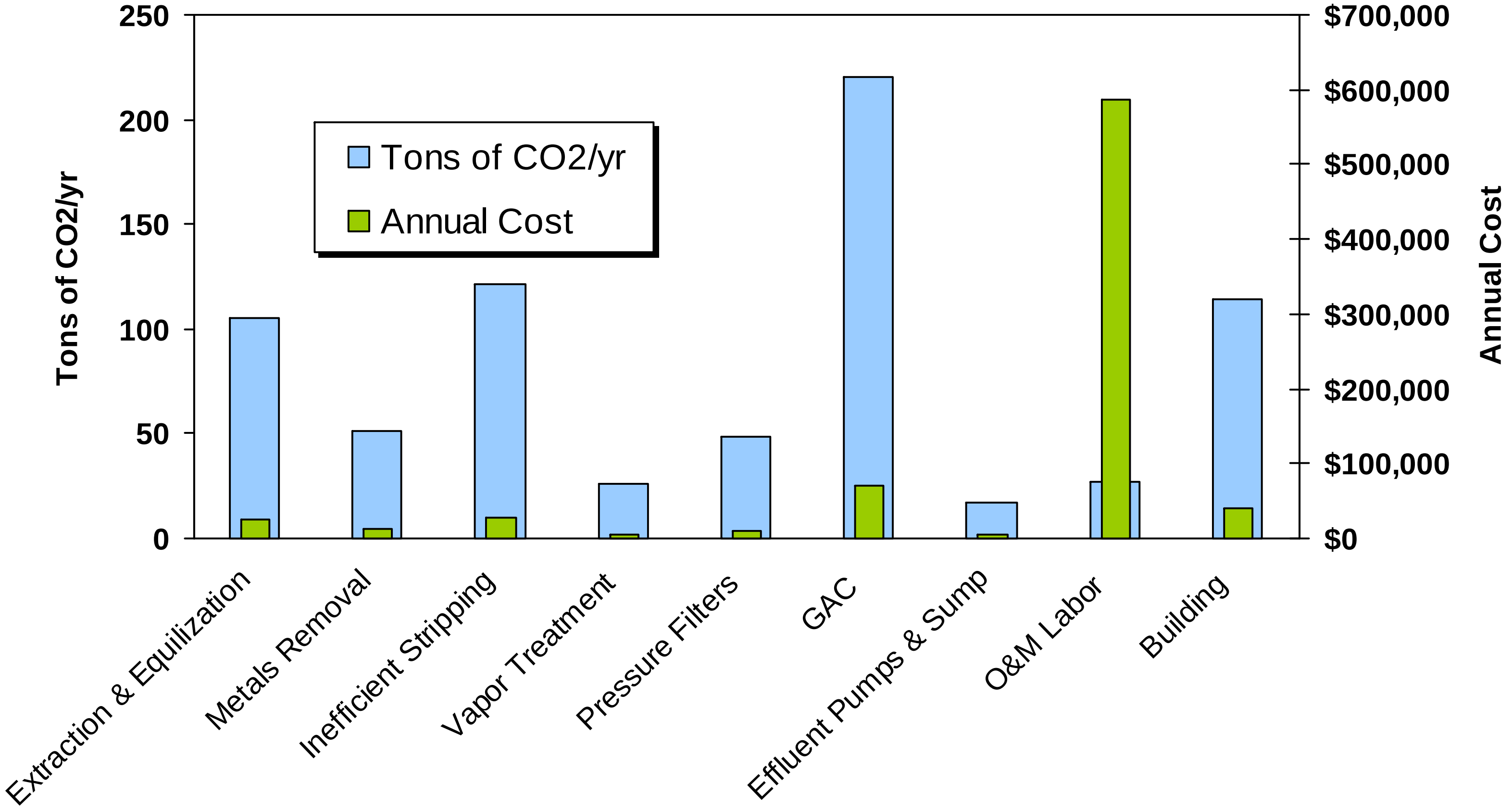
Parameters for the Study

- Carbon parameters
  - » Electricity: 1.48 lbs of CO_2 per kWh (eGRID 2005 for MA)
  - » Natural gas: 12.2 lbs of CO_2 per therm (www.nrel.gov/lci)
  - » GAC: 6.45 lbs of CO_2 per pound of GAC (discussion point)
  - » Travel: 40 lbs of CO_2 per site visit (based on approximately 2 gallons of gas per visit)
- Cost parameters
  - » Electricity: $0.17/kWh (bills)
  - » Natural gas: $1.50/therm (bills)
  - » GAC: $1.04/lb (contract estimate)
  - » Service tech visit: $450 per visit

Breakdown of Current Carbon Footprint and O&M Cost

Total O&M Cost: $784,000 per year

Total Carbon Footprint: 787 tons of CO_2 per year



O&M costs and carbon footprint (for remainder of presentation) are for O&M of treatment plant and do not include other site activities including groundwater sampling

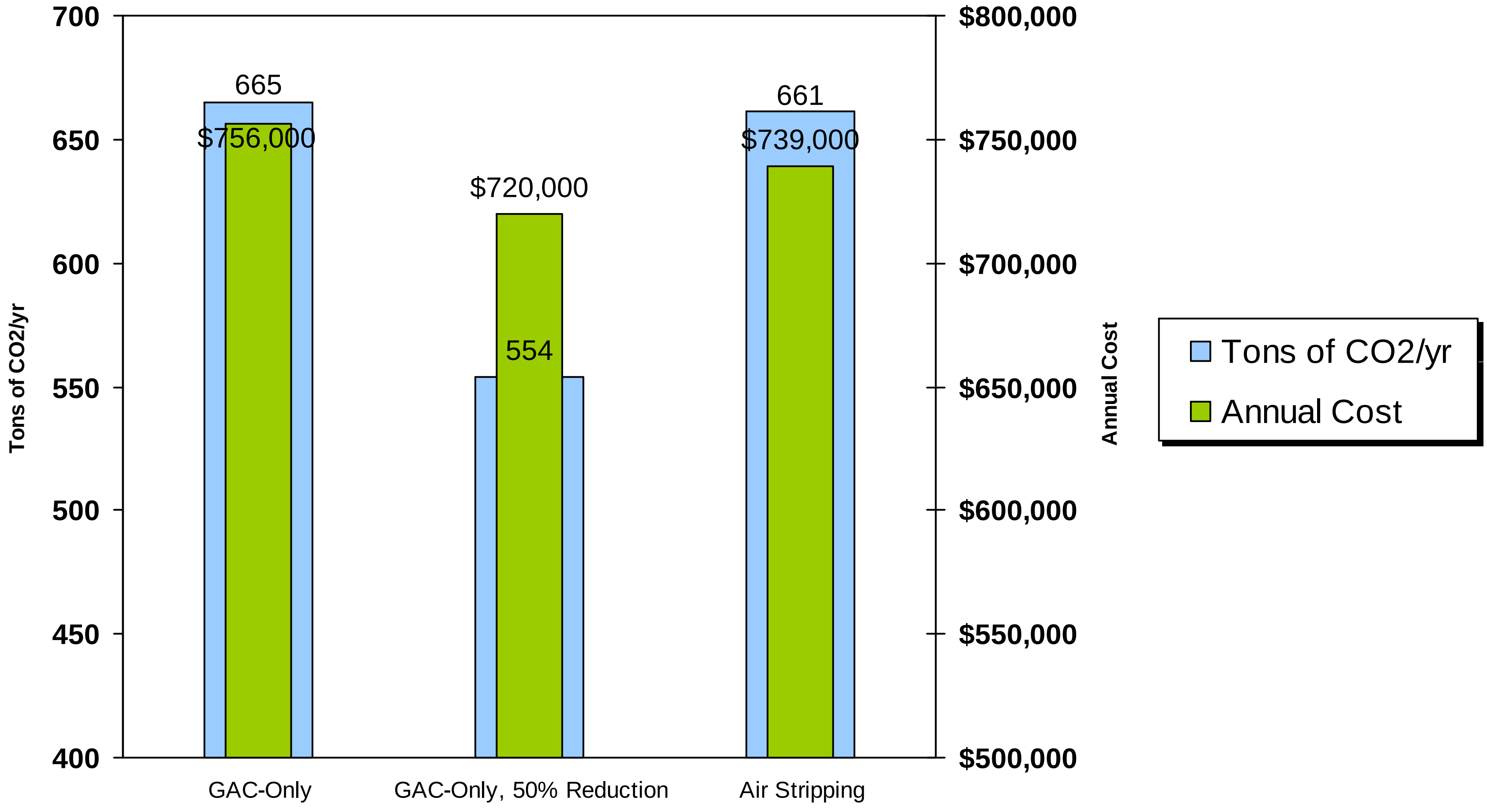
Preliminary Analysis

- The GAC has a high carbon footprint and a high cost (largely due to frequent change-outs)
- O&M labor costs are high, but the carbon footprint is relatively low
- Previous evaluations suggest capture is adequate but not much room for reducing extraction rates. VFD's on all extraction pumps, so assumption is that there is little room for reducing energy usage for extraction
- Inefficient air stripping has a substantial footprint
- Building footprint is also significant (18,700 therms of NG for heating, 75,000 kWh per year for ventilation, lighting, etc.)

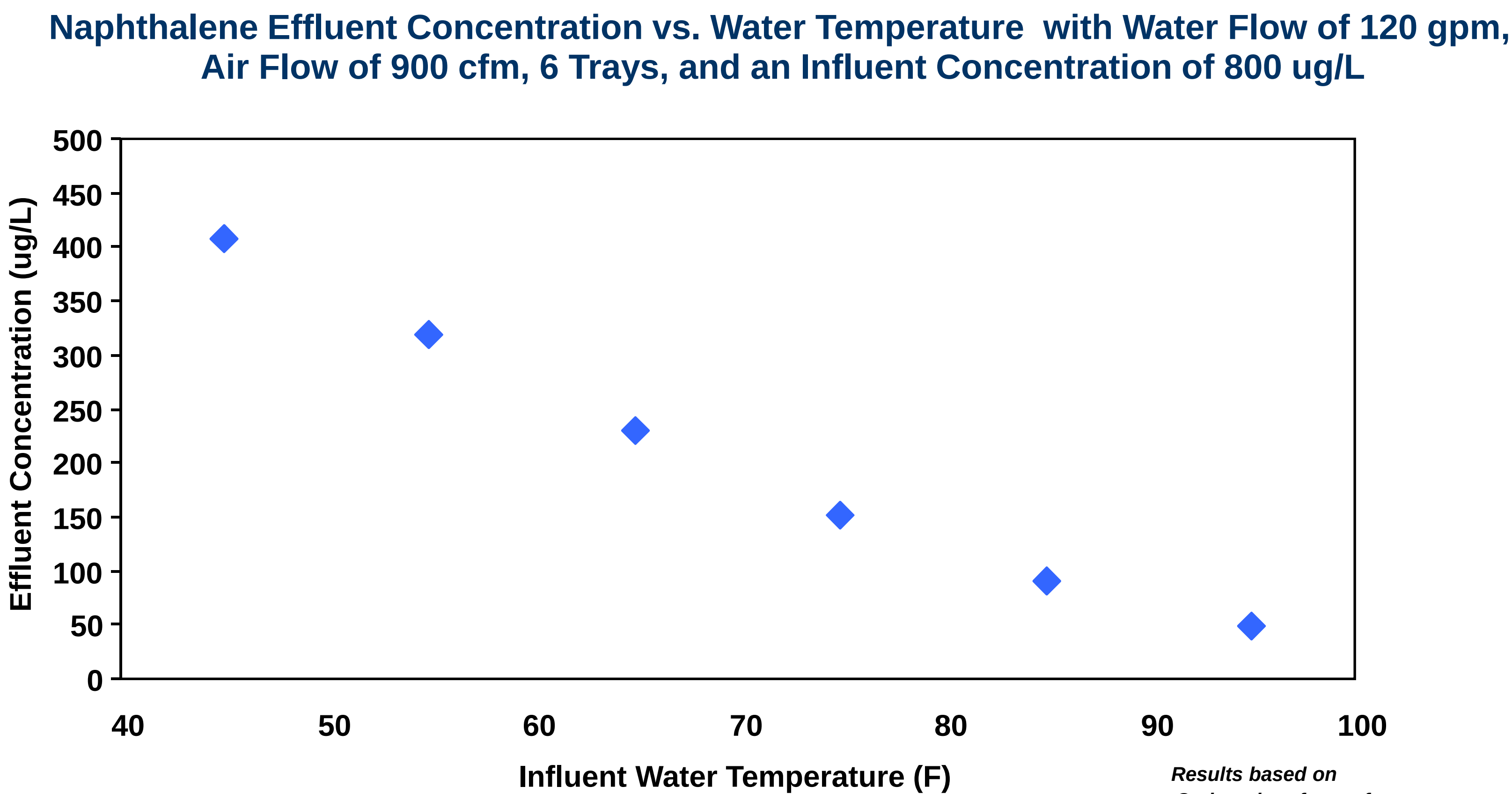
Options

- Eliminate stripping and go to GAC-only for treatment of organics, attempt to decrease GAC change-out frequency
- Eliminate GAC and go with stripping only
- Enhance stripping with waste heat from a combined heat and power unit
- Consider alternatives for building heating/cooling

Breakdown for Various Options

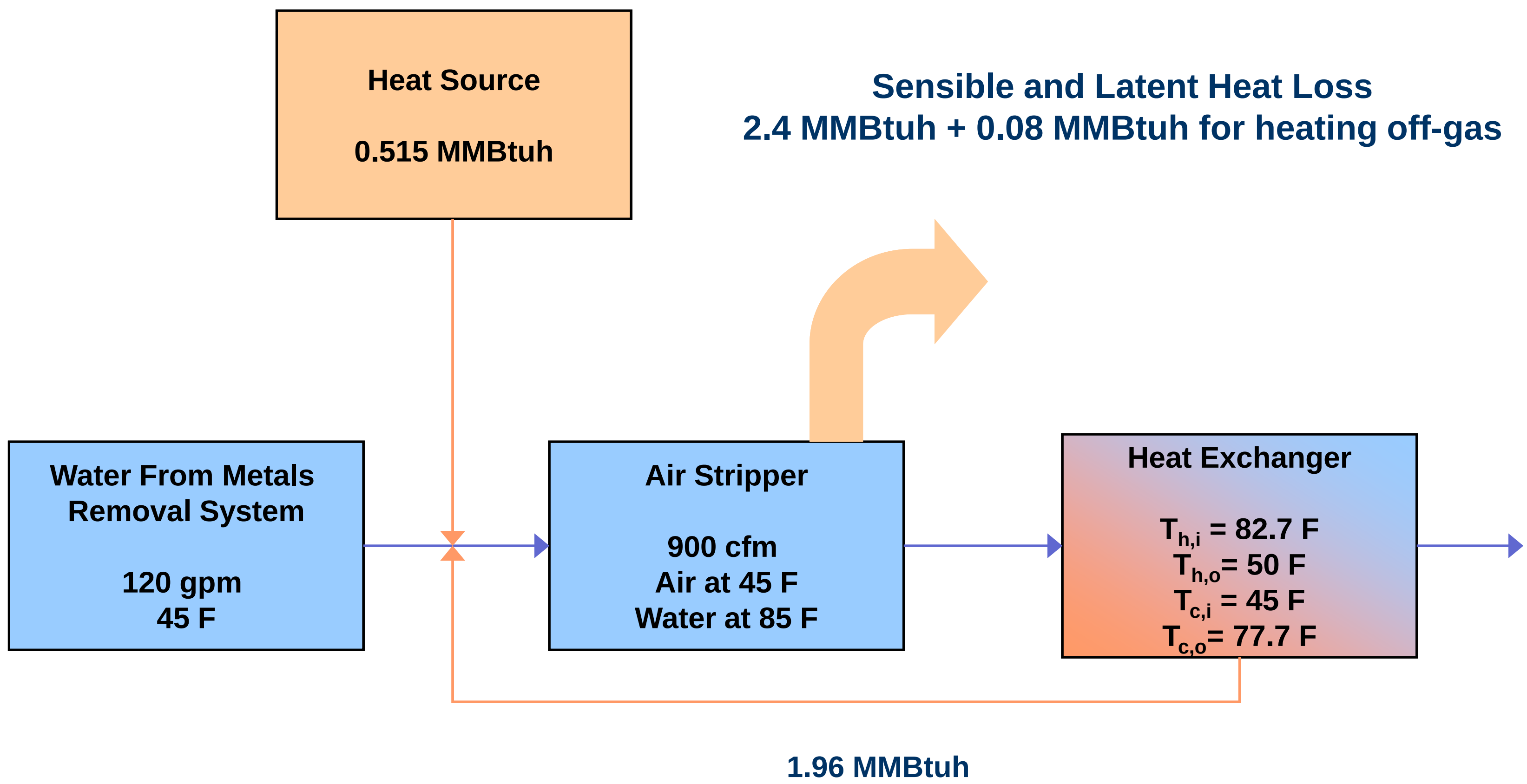


Stripping Effectiveness and Water Temperature



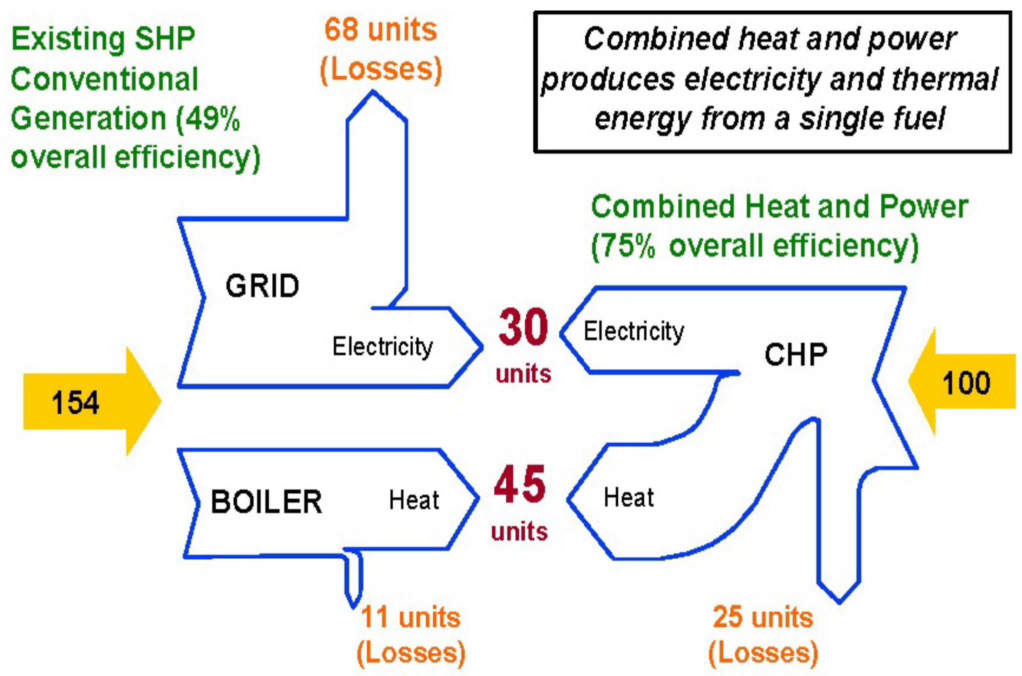
Results based on Carbonair software for STAT 180 unit

Heat-Enhanced Air Stripping

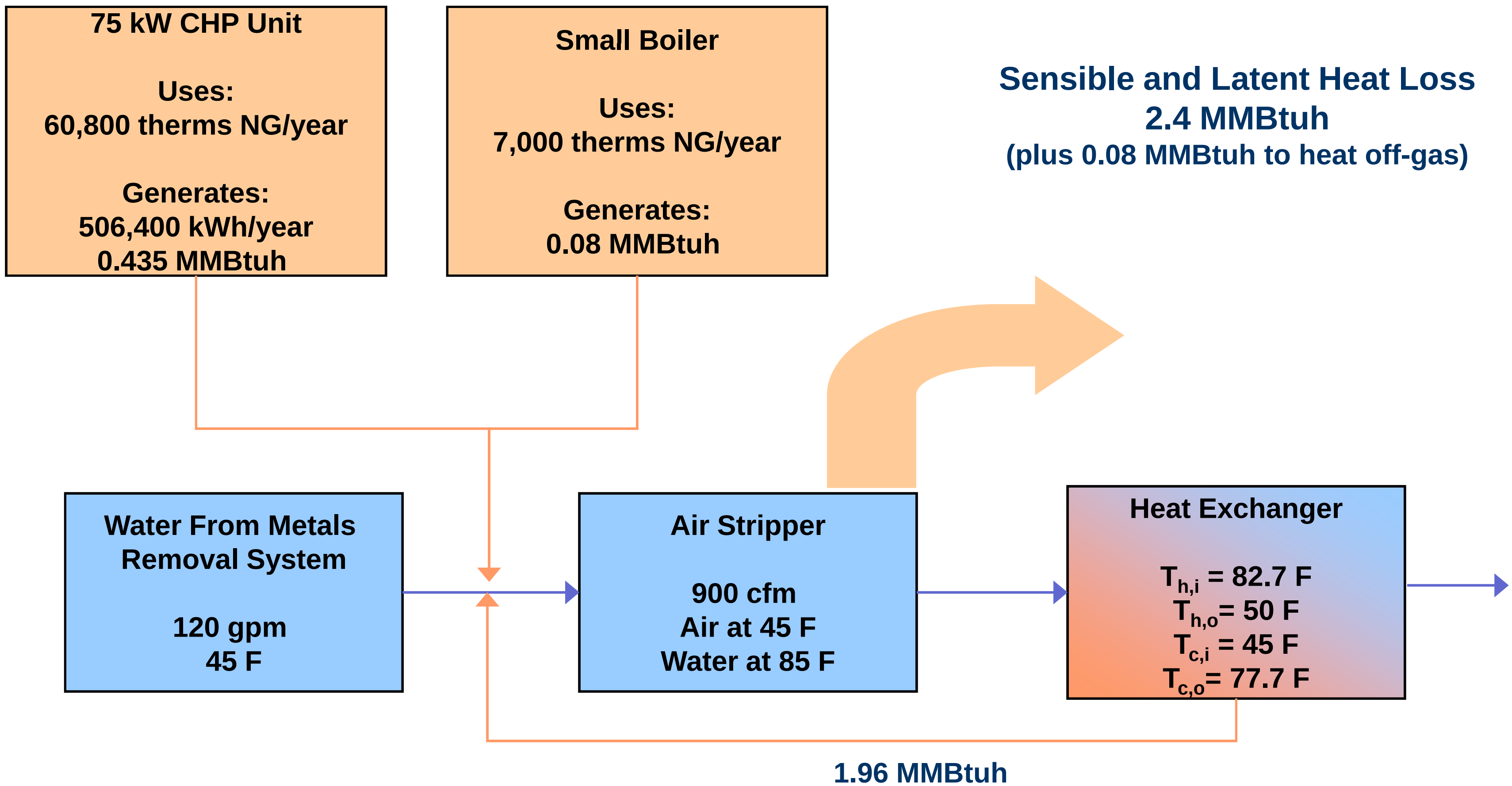


Combined Heat and Power

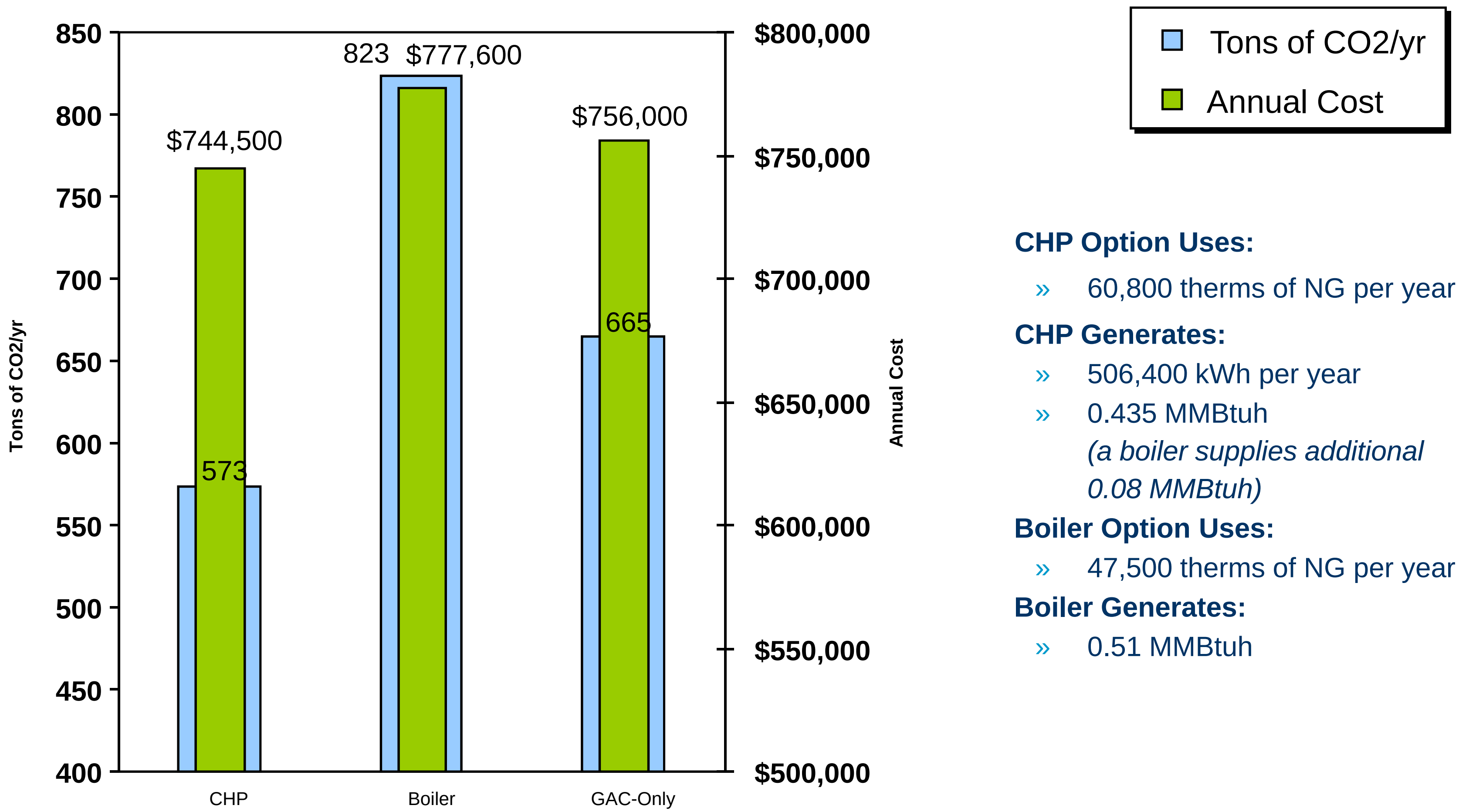
- Generate electricity on-site with a natural gas powered generator
- Rather than discharge heat to the atmosphere, use it for beneficial use
- Results in increased overall efficiency
- Only makes sense if electrical demand and heating demand are present and appropriate



CHP Heat-Enhanced Air Stripping



CHP Option vs. Boiler Option



CHP Option Uses:

- » 60,800 therms of NG per year

CHP Generates:

- » 506,400 kWh per year
- » 0.435 MMBtuh *(a boiler supplies additional 0.08 MMBtuh)*

Boiler Option Uses:

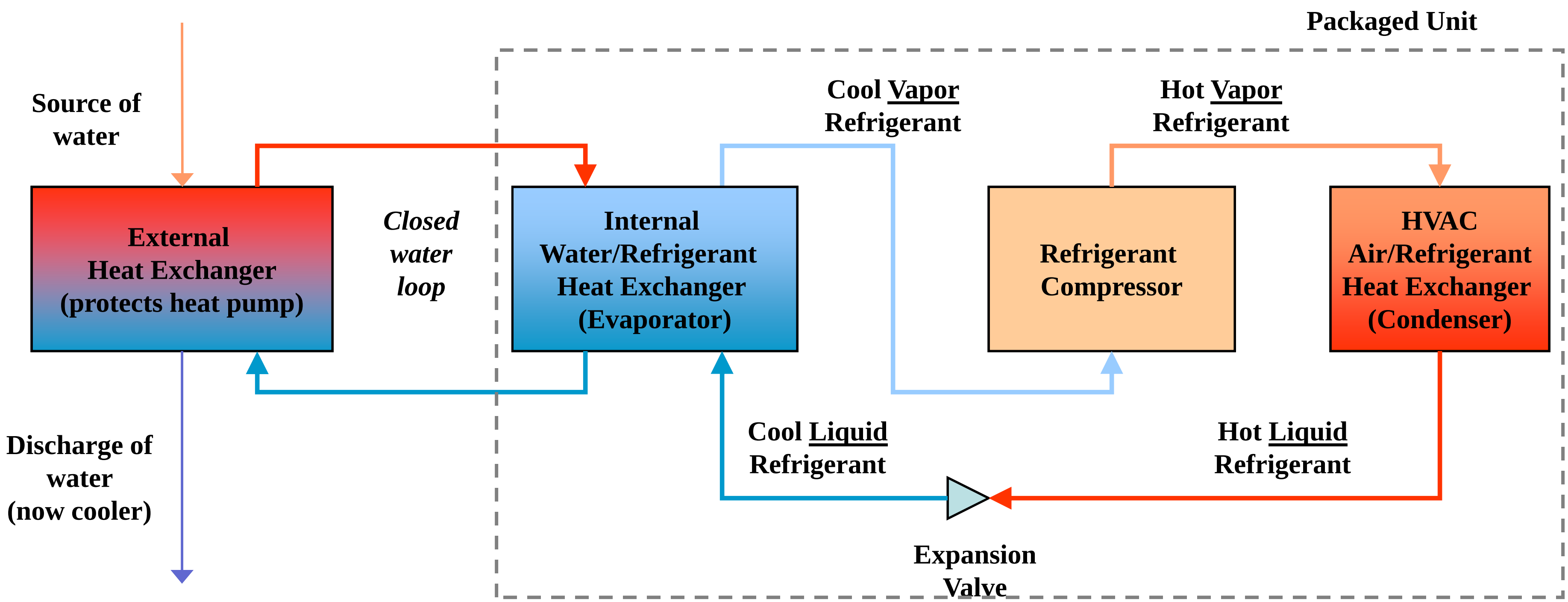
- » 47,500 therms of NG per year

Boiler Generates:

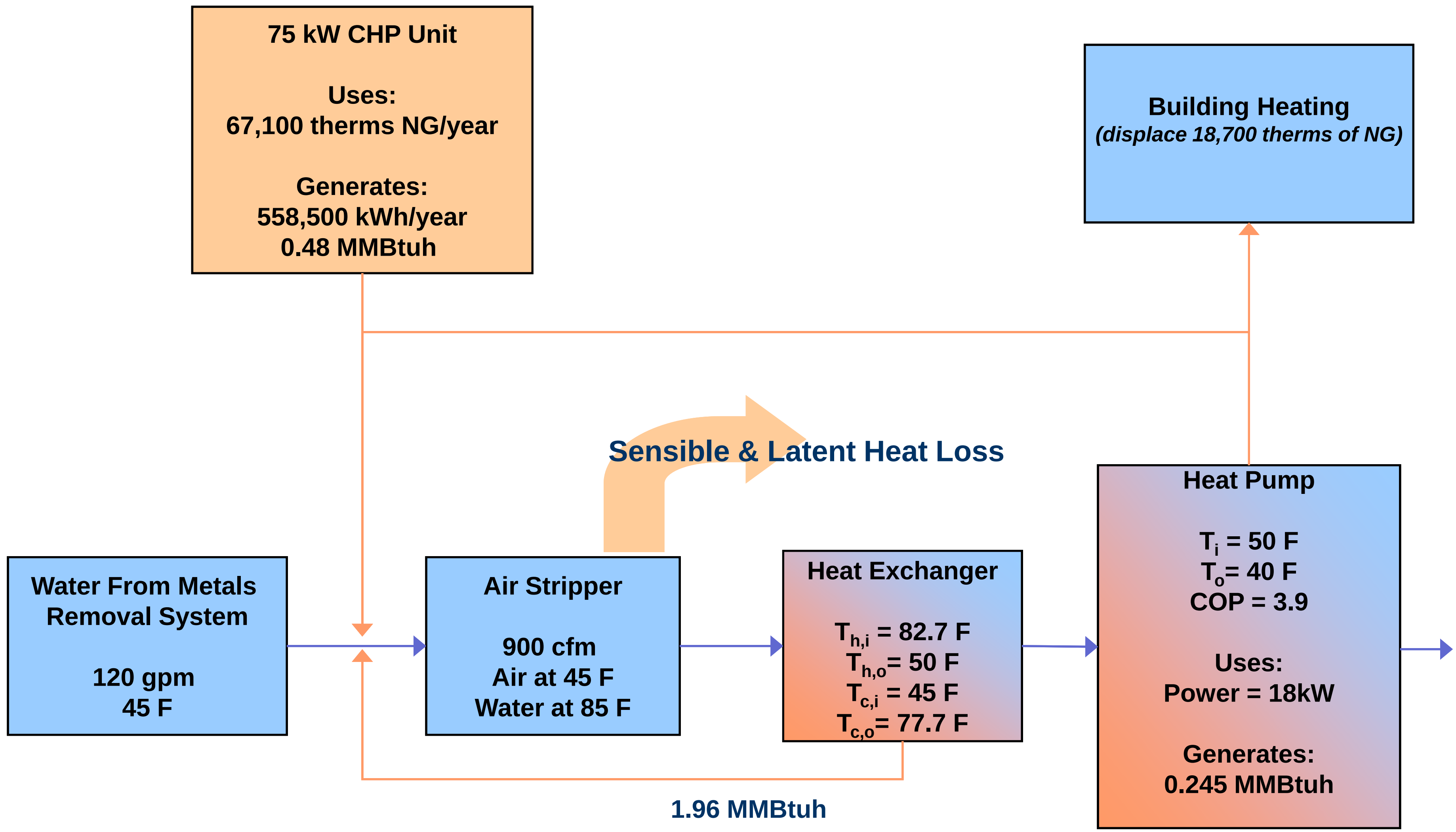
- » 0.51 MMBtuh

Water Source Heat Pumps (Heating Mode Shown)

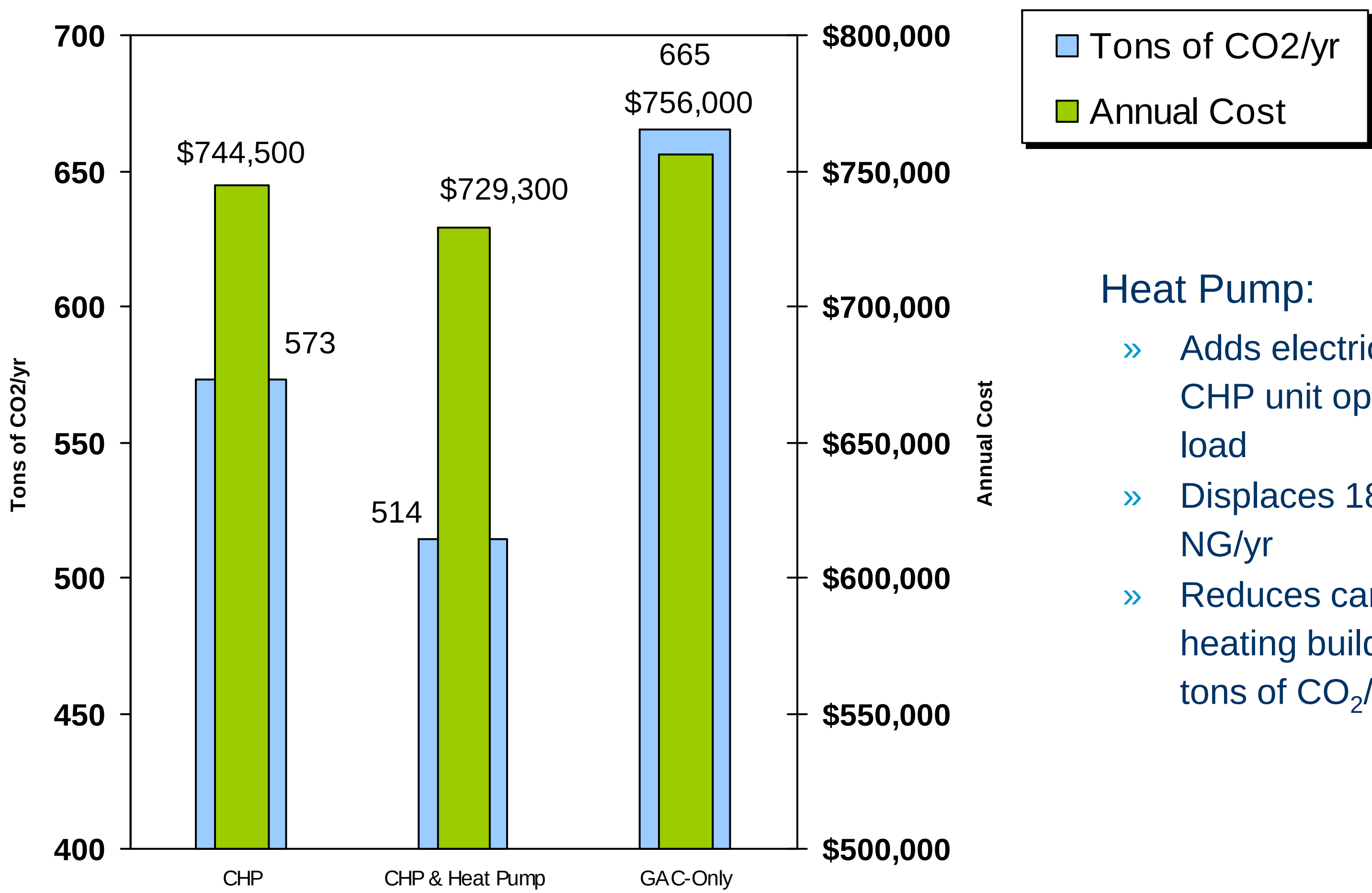
- Similar concept to air conditioner or refrigerator but
  - Heats instead of cools air
  - Uses water not air as the heat source
- Heat from water vaporizes refrigerant
- Heat from condensing refrigerant is transferred to building via HVAC system
- Heat is transferred via vaporization/condensation of refrigerant



CHP & Heat Pump



CHP Option
With and Without Heat Pump



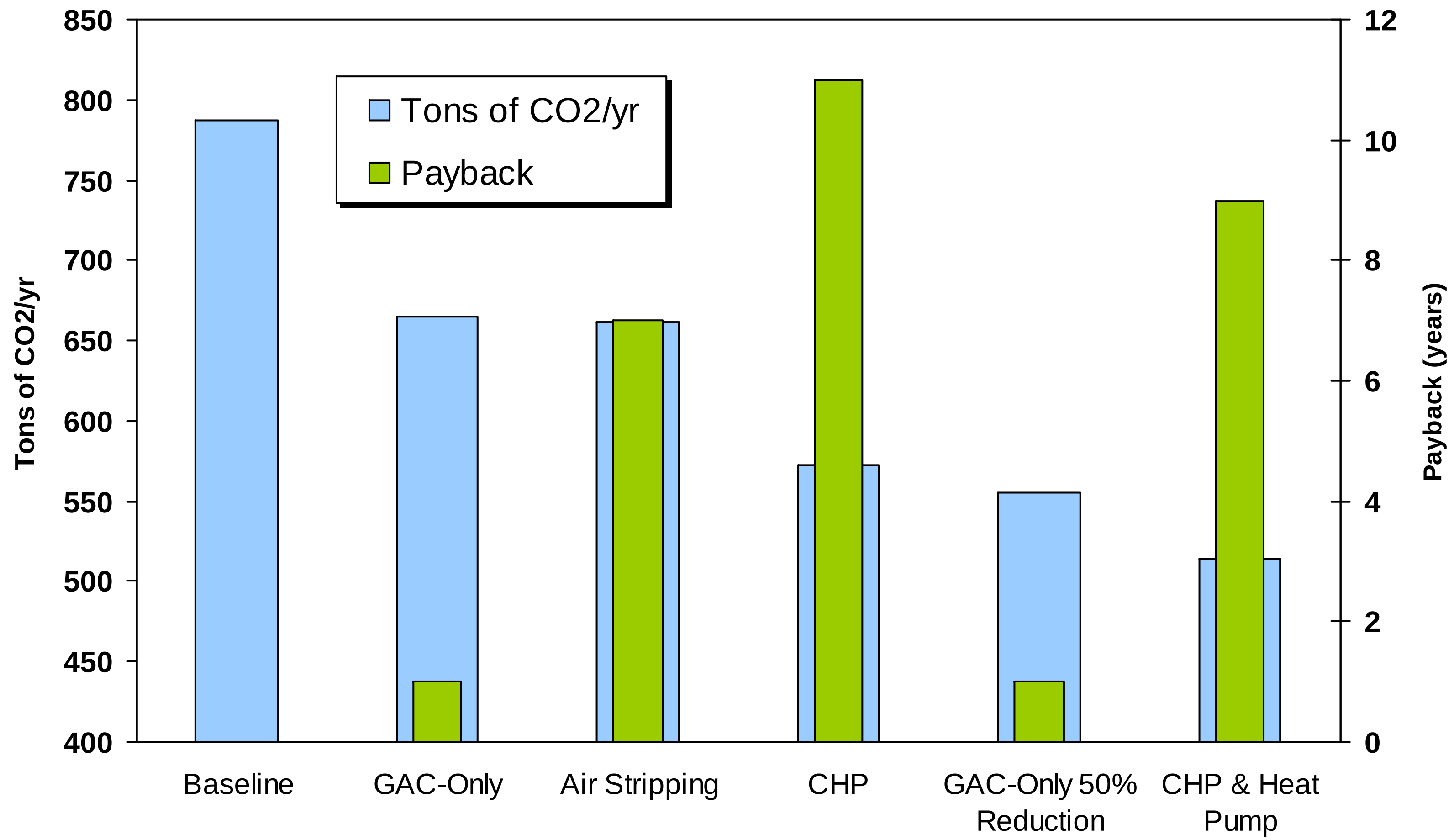
Heat Pump:

» Adds electrical load so that CHP unit operates at full load
» Displaces 18,700 therms of NG/yr
» Reduces carbon footprint for heating building by about 30 tons of CO_2/yr

% Reductions for Carbon Footprint and Cost

Option	% Reduction	
	Carbon Footprint	Annual O&M Cost
GAC-only	16%	4%
Air Stripping	16%	6%
CHP	27%	5%
GAC-only (50% reduction)	29%	9%
CHP & Heat pump	35%	7%

Payback of Various Options



Conclusions Regarding Site

- Investigate GAC performance
  - Clarifier sizing
  - Metals removal chemistry
  - Filter effectiveness
  - Backwashing effectiveness
- Depending on GAC results pilot air stripping with and without heating
- Depending on pilot results consider CHP option but concern regarding potential future reduced standards for naphthalene

Conclusions Regarding Footprint Analysis

- Labor is high cost but has a relatively low footprint
- Electricity and energy is relatively low cost but has a high footprint
- Materials can have a high footprint
- Footprint for travel, electricity, and natural gas are relatively straightforward to calculate for various options
- Footprint for materials (e.g., GAC) can be substantial but are uncertain without manufacturer input… accurate carbon footprinting for groundwater remediation requires reliable carbon footprints for materials (GAC, chemicals, etc.)
- GAC footprint is not well understood
  - 6.45 lbs of CO_2 per pound of GAC from Goldblum, et al.
  - May be substantially more than 10 lbs of CO_2 per pound of GAC for virgin, coal-based carbon but could be substantially lower for regenerated carbon
  - Emphasis on using renewable resource for GAC feedstock

Conclusions Regarding Technological Applications

- CHP (combined with heat exchangers) is a carbon and energy efficient method of heating process water
  - May be beneficial to some biological treatment systems
  - Enhances stripping efficiency
  - In-situ remedies (?)
- Optimize traditional treatment components when comparing to new or more complex treatment approaches
- CHP-enhanced stripping may be even more appropriate for contaminants such as MTBE that are difficult to remove via stripping and GAC
- Appropriately consider disadvantages associated with heating water before implementing a treatment approach that requires heating
  - Increased potential for fouling
  - System has to “come up to temperature” before effective treatment can begin
- Heat pumps for building heating and cooling may be appropriate at many P&T sites

Undisclosed Site:
Very Brief Background

- P&T system in northeast treating arsenic at former landfill site
- Flow rate 50 gpm
- Arsenic in influent at about 2.5 mg/L
- Iron in influent at about 65 mg/L
- Manganese in influent at about 2.5 mg/L
- Discharge to a POTW
- Evaluation focused on treatment plant

Where are We in the Process?

- Quantifying various environmental footprints
  - Carbon footprint associated with
    - Electricity and chemical usage
    - Waste disposal and water discharge
    - Operator labor
    - Passive LFG emissions
  - Impacts to ambient air quality (NOx, SOx, chemical vapors, etc.)
  - Impacts to local water resource (e.g., use of treated water)
  - Footprint of impacts to land and ecosystems
  - Footprint from chemical manufacturing and waste disposal
    - Landfill space and POTW capacity
    - Natural resources for chemical manufacturing

Where are We in the Process?

- Considering options for renewable energy
- Considering options for managing passive LFG emissions
- Considering reasonable modifications to treatment process assuming current flow parameters
- Considering more extensive modifications to treatment process in case increased flow is required
- Considering alternative discharge options for treated water
- Considering potential for heat pump to provide building heat (instead of current electric heaters)

Innovative Technology #1: Very Brief Background

- RP Landfill site in the northeast
- Presumptive remedy, improve cap and P&T for indefinite amount of time to capture plume
- Selected/operating remedy
  - Identify cell with source area
  - Extract water to capture plume
  - Inject extracted water (and air) into cell to create a bioreactor to consume source
  - Discharge remaining extracted water to the POTW

Green Remediation Perspective

- More intensive short-term O&M will likely avoid long-term operation
  - Reduced carbon footprint
  - Reduced traffic amongst ecosystem that has developed around closed landfill
- Reuse of some of the extracted water and reduced flow to POTW
- Potential lessons learned include
  - Potentially viable source remediation strategy for other landfill sites
  - Addition of water to some landfills (anaerobic reactor) can enhance LFG production to extend life of LFG-to-energy projects

Innovative Technology #2: Very Brief Background

- RP manufacturing site in the mid-west with TCE plume (1,100 feet wide and a mile long)
- Presumptive remedy, plume containment with P&T for 10 years until source is remediated
- Selected/operating remedy is bioaugmentation using water from the formation for mixing and injection

Green Remediation Perspective

- Electricity to extract and treat water with air stripping is replaced by electricity to inject nutrients and energy involved in manufacturing nutrients… estimated >50% reduction in carbon footprint
- Reduce daily or frequent traffic to and around the site… on site presence is limited to 4 weeks per year rather than about 3 visits per week
- Facilitate reuse of the property by avoiding above-ground structures and extensive piping
- Avoid disruption to land surface to pipe extracted water from extraction wells back to probable location of treatment plant

Lessons Learned to Date (P&T Focused)

- Design treatment buildings with energy efficiency in mind
- High footprint items are not necessarily high cost items
- Electricity usage and treatment chemicals/materials are the biggest contributors to the carbon footprint
- Electricity and chemical/material usage is directly tied to flow rate…
  - Lowering flow rates helps lower footprint
  - Invest in optimizing extraction (generally, provide adequate capture with the minimum required flow rate)… conduct a capture zone analysis
  - Thoroughly consider passive and in-situ remedies for all or some of the plume before resorting to P&T
  - Consider source removal to avoid long-term P&T… be sure that active remediation won't be needed after source removal activities… from a carbon footprint perspective, it doesn't pay to have to do both

GeoTrans' Upcoming Activities

- Completion in mid-May of green remediation evaluation at the undisclosed site mentioned earlier
- Green remediation evaluation of RP brownfields site in New Jersey
- Green remediation evaluation in association with RSE at the Alaric Superfund Site (EPA Region 4)
- Green remediation evaluation in association with RSE at the 10th Street Superfund Site (EPA Region 7)
- Potential green remediation webinar for RP during annual internal remediation conference

GeoTrans' Perspective…
Biggest Issues Facing Green Remediation

- Need for a consistent approach and consistent parameters for organizations to quantify environmental footprints
- Keep green remediation voluntary or start to enforce it?
- Encouraging green remediation if the environmental benefit is there but the payback is not as attractive as other potential investments of capital
- Consideration of the net environmental impact/benefit in selecting and implementing remedies