Coal Combustion By-Products (CCBs): An Overview

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Why We Care What Happens to CCBs

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- All CCBs contain metal oxides and trace metals of high leachability
- Disposed or placed in the raw state, CCBs harm the environment
- Tens of millions of tons of CCBs are stored in fill sites in Maryland
- Hundreds of millions of tons are stored in the Chesapeake Bay watershed

In The News: TVA

Historic Disaster: TVA Plant, Tennessee

On Dec. 22, 2008, the largest coal ash spill in U.S. history was unleashed from the TVA plant in Roane County. Failure of a containment wall sent millions of gallons of sludge containing toxic materials into the Emory River.

From: NBC 10 in Knoxville
https://www.wbir.com/article/news/historic-disaster-10-years-after-the-ash-spill/51-3125fb4d-93bc-4dd8-9ce1-63a449fa6ff9
Accessed 2/12/19.

In The News: Hurricane Impacts in Carolinas

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Dam breach sends toxic coal ash flowing into a major North Carolina river

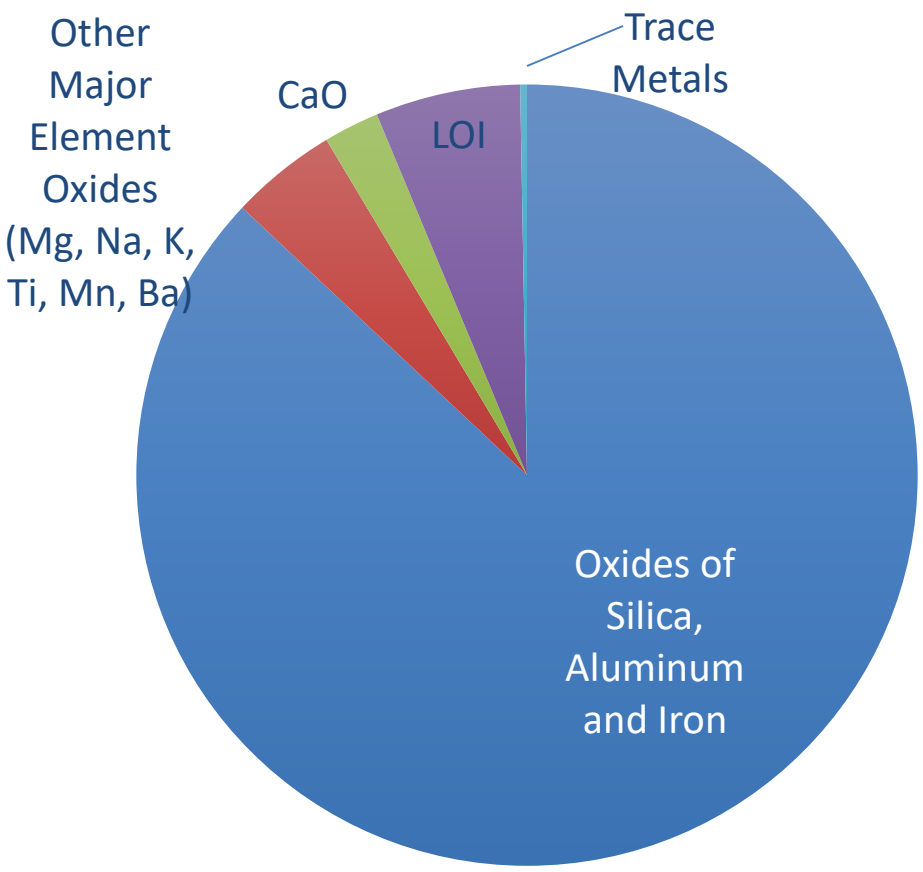
North Carolina floodwaters continued to inundate a 47-year-old basin of toxic coal ash alongside Duke Energy's L.V. Sutton power plant on Saturday, sending polluted waters pouring into a man-made lake and then into the Cape Fear River.

From: Washington Post
https://www.washingtonpost.com/energy-environment/2018/09/21/dam-breach-reported-former-nc-coal-plant-raising-fears-that-toxic-coal-ash-may-pollute-cape-fear-river/?noredirect=on&utm_term=.c9b1332e163b Accessed 2/12/19

CCBs Produced in Maryland (2017)

CCB Type	Quantity Produced in 2017 (tons)	% Used	Type of Use
Class F Fly Ash	199,336	92%	Cement, Concrete
Bottom Ash	27,091	0%	--
Class C Fly Ash	11,857	0 %	--
Boiler Slag	3,425	0 %	--
FBC Material	305,963	100 %	Surface Coal Mine Reclamation
FGD Material	373,442	93%	Wallboard, Cement, Agriculture
Total	**921,114**	**91%**	--

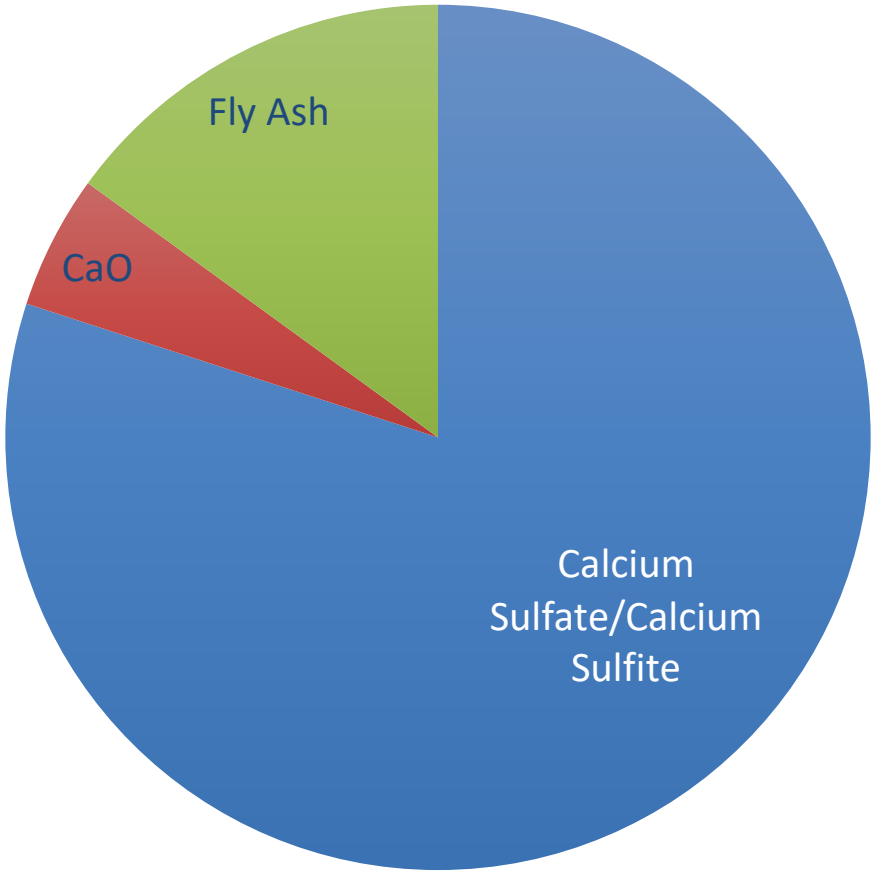
Typical Chemistry of Class F Fly Ash



Trace Metals, present at levels ranging from < 1 to 600 mg/kg:

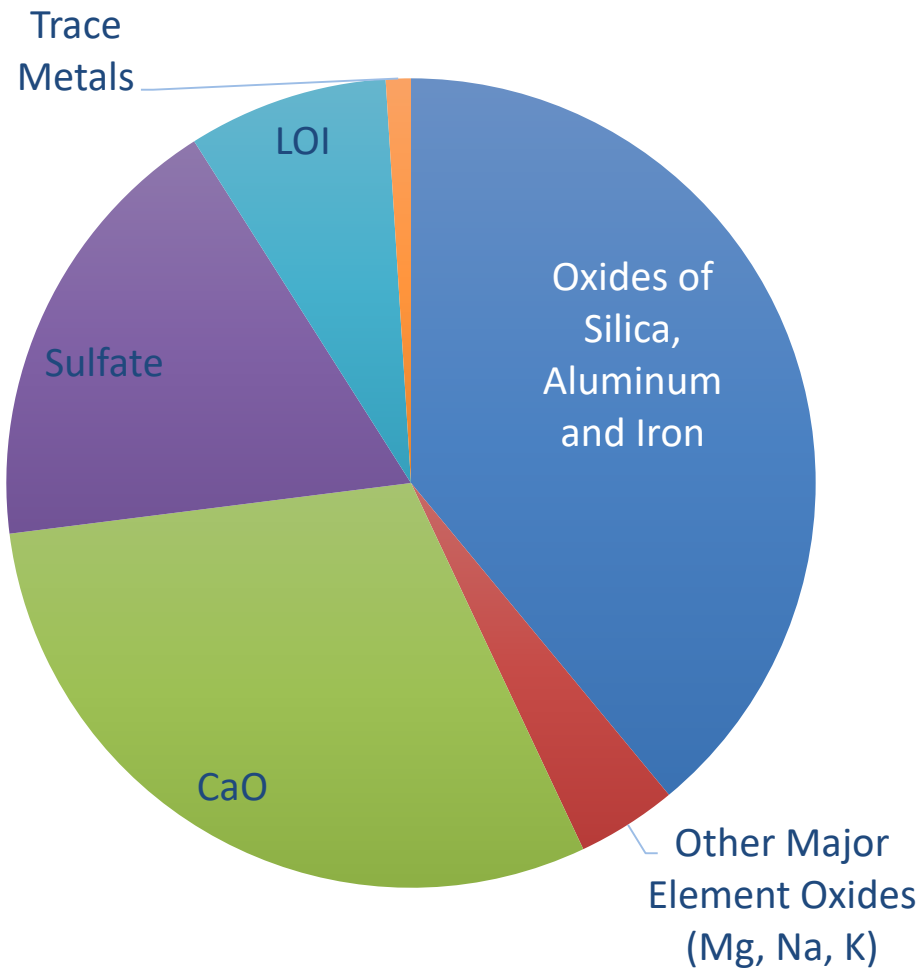
Thallium
Barium
Vanadium
Arsenic
Zinc
Chromium
Nickel
Lead
Cobalt
Copper
Molybdenum
Selenium
Mercury

Typical Chemistry of FGD Material



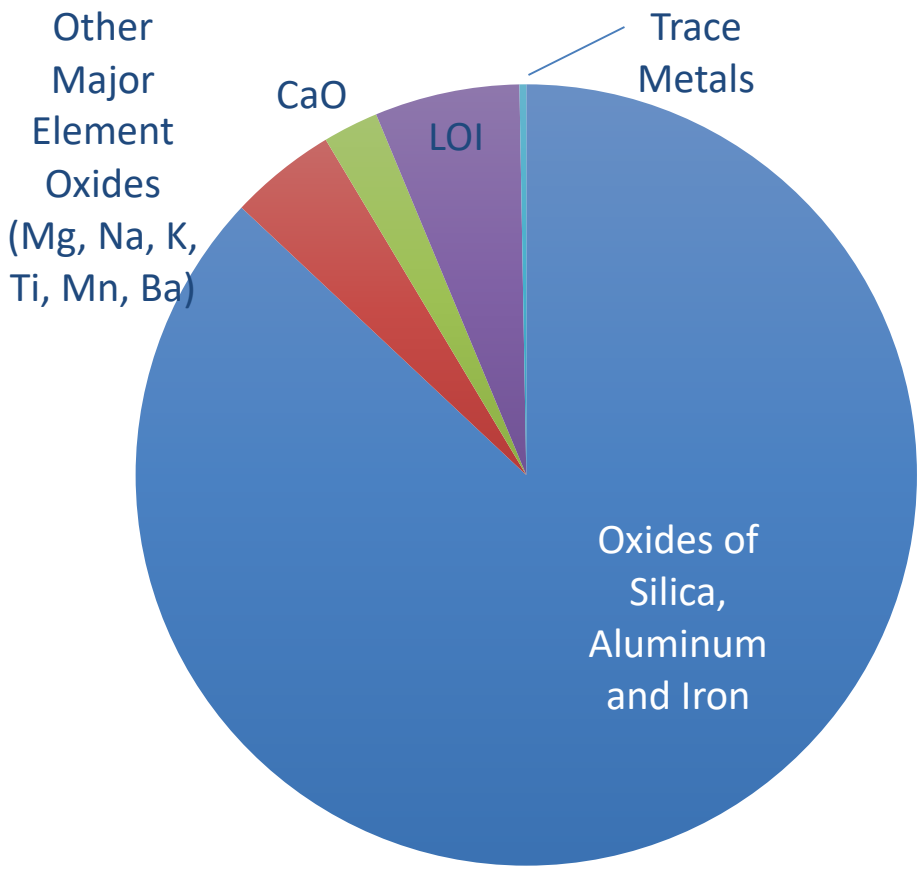
Ratios vary depending upon type of scrubber system used at the plant.

Typical Chemistry of FBC Material



Trace Metals comparable to Class F Fly Ash

Typical Chemistry of Bottom Ash

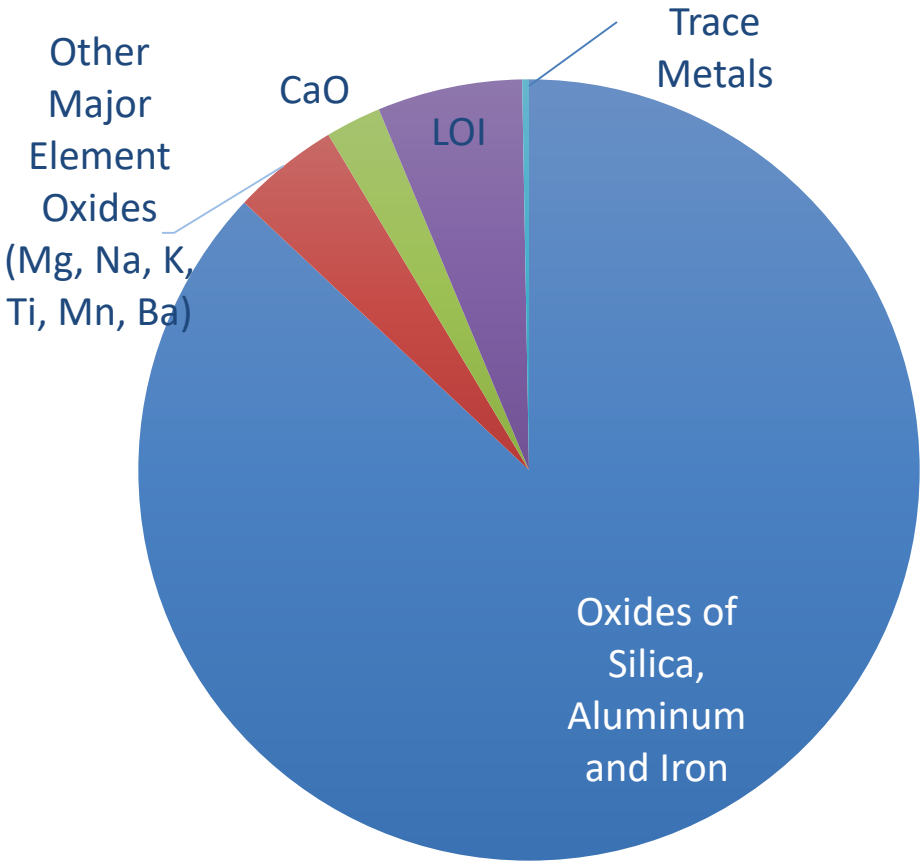


Chemistry similar to fly ash.

Primary differences between fly ash and bottom ash are generally physical:

- Particle Size (bottom ash is coarser)
- Particle Shape (bottom ash is more angular)
- Crystallinity (bottom ash is less glassy)

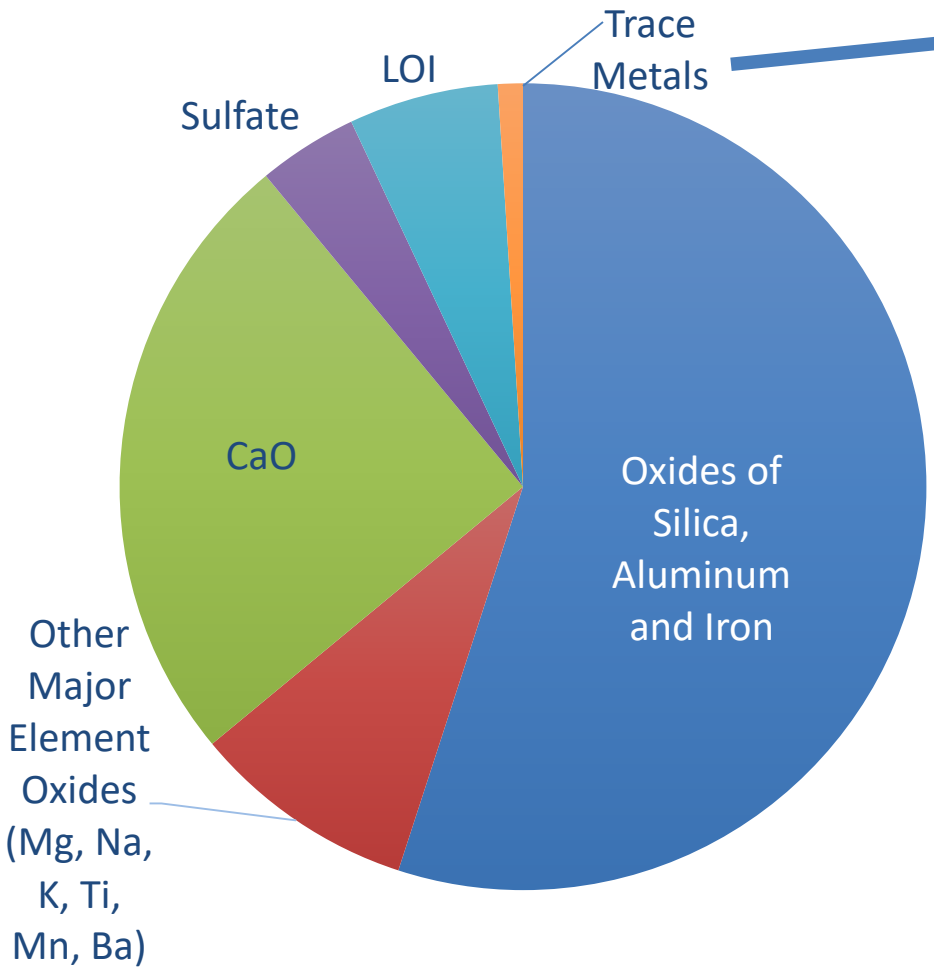
Typical Chemistry of Boiler Slag



Chemical composition and grain size are similar to bottom ash.

Unlike bottom ash, boiler slag collects in a molten state and is glassy rather than crystalline.

Typical Chemistry of Class C Fly Ash



Trace metals comparable to Class F Fly Ash

Typical Chemistry of Hemi-hydrates (Concrete)

Multiple chemical reactions are involved, including:

- $2Ca_3SiO_5 + 7H_2O \rightarrow 3CaO_2SiO24H_2O + 3Ca(OH)_2$ + Heat
- $2Ca2SiO_4 + 5H2O \rightarrow 3CaO_2SiO24H_2O + Ca(OH)_2$ + Heat

Leaching rates for CCBs that are solidified into concrete are orders of magnitude lower than for non-solidified CCBs.

2014 study by EPA concluded that leaching of trace metals from concrete made with CCBs was comparable to or lower than leaching of the same constituents from concrete made without CCBs.

Reference: http://matse1.matse.illinois.edu/concrete/prin.html, and https://www.epa.gov/sites/production/files/2014-12/documents/ccr_bu_eval.pdf

Location of CCB Production in Maryland

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Warrior Run
FBC Material – 838 T/day (100% Used)

C.P. Crane
Class C Fly Ash – 32.5 T/day (0% Used)
Boiler Slag – 9.4 T/day (0 % Used)

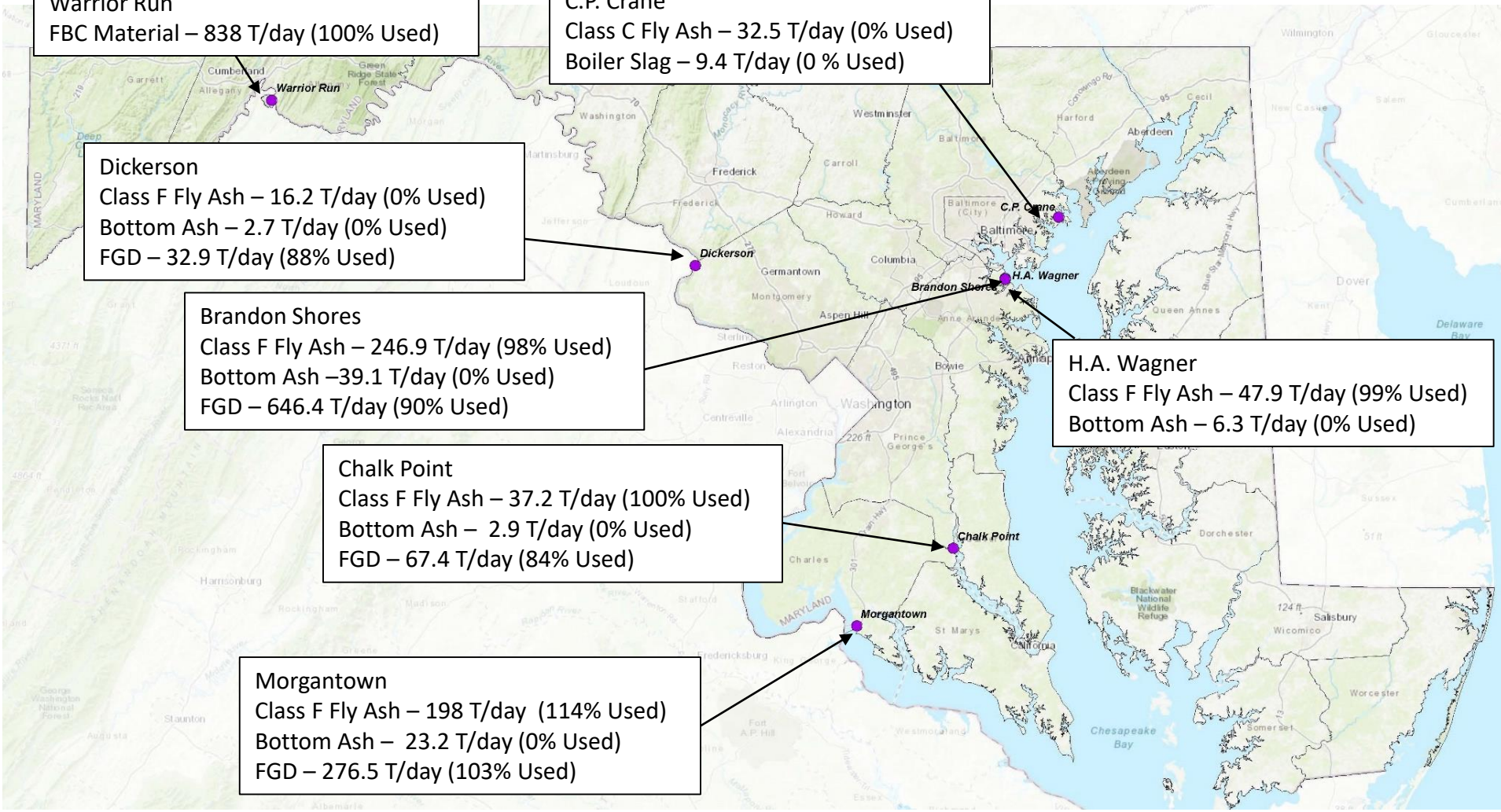
Dickerson
Class F Fly Ash – 16.2 T/day (0% Used)
Bottom Ash – 2.7 T/day (0% Used)
FGD – 32.9 T/day (88% Used)

Brandon Shores
Class F Fly Ash – 246.9 T/day (98% Used)
Bottom Ash –39.1 T/day (0% Used)
FGD – 646.4 T/day (90% Used)

H.A. Wagner
Class F Fly Ash – 47.9 T/day (99% Used)
Bottom Ash – 6.3 T/day (0% Used)

Chalk Point
Class F Fly Ash – 37.2 T/day (100% Used)
Bottom Ash – 2.9 T/day (0% Used)
FGD – 67.4 T/day (84% Used)

Morgantown
Class F Fly Ash – 198 T/day (114% Used)
Bottom Ash – 23.2 T/day (0% Used)
FGD – 276.5 T/day (103% Used)



CCB Beneficiation Plants in Maryland

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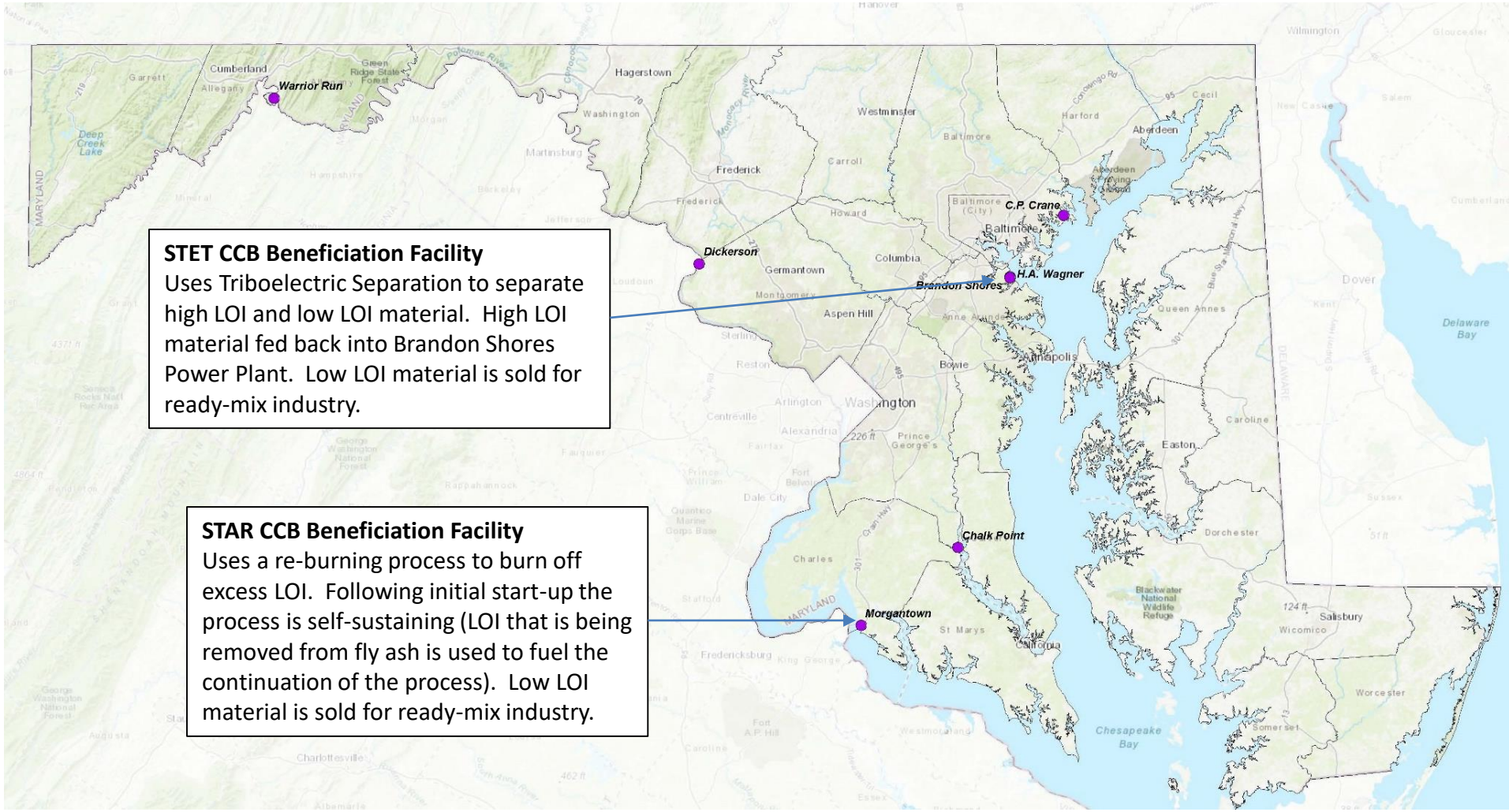
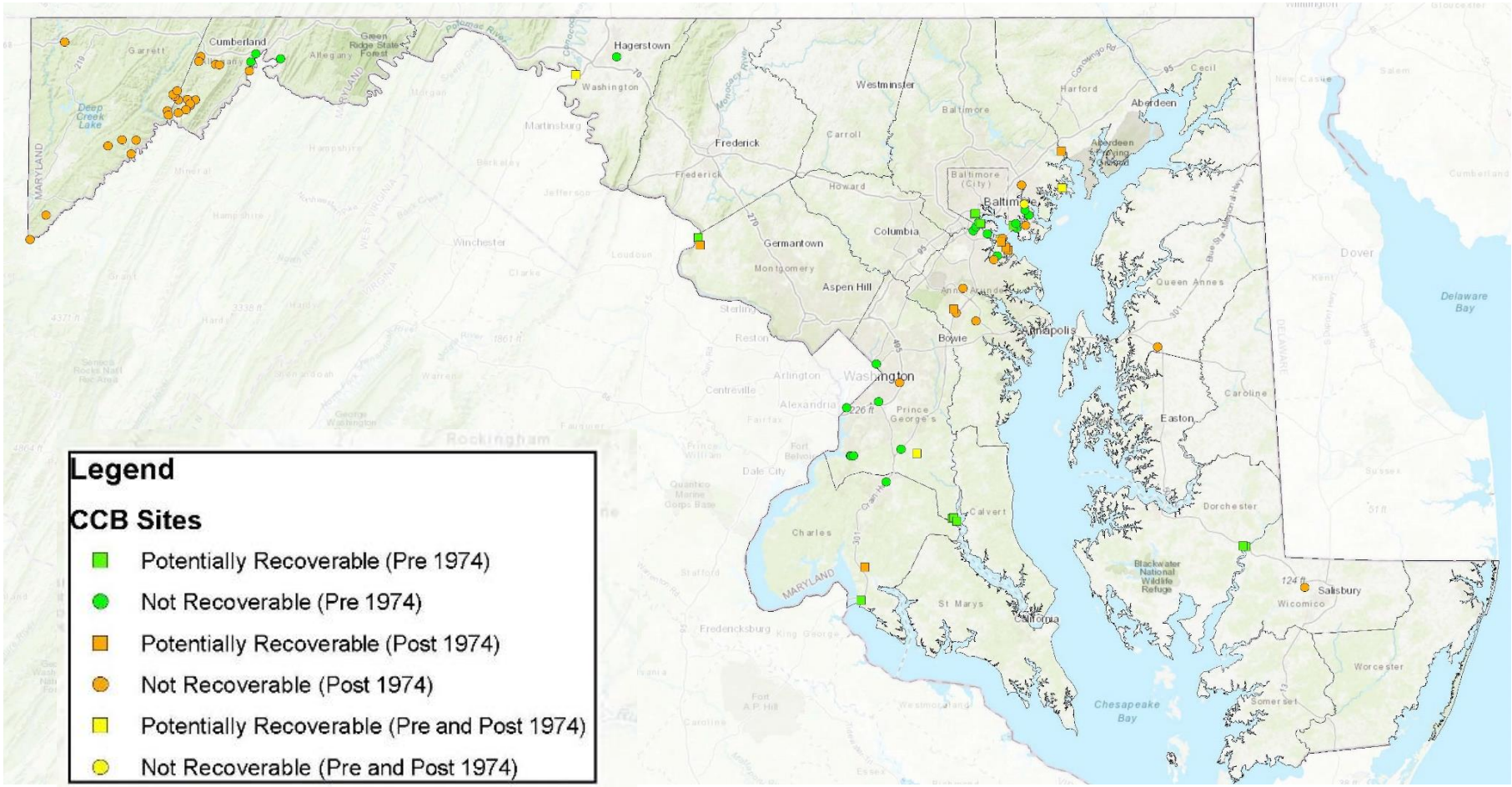


STET CCB Beneficiation Facility
Uses Triboelectric Separation to separate high LOI and low LOI material. High LOI material fed back into Brandon Shores Power Plant. Low LOI material is sold for ready-mix industry.

STAR CCB Beneficiation Facility
Uses a re-burning process to burn off excess LOI. Following initial start-up the process is self-sustaining (LOI that is being removed from fly ash is used to fuel the continuation of the process). Low LOI material is sold for ready-mix industry.

Legacy CCB Sites In Maryland

Maryland's Pozzolan Act (passed in 1974) provided that by-product materials with pozzolanic properties (such as CCBs) should be used or stored for future recovery.

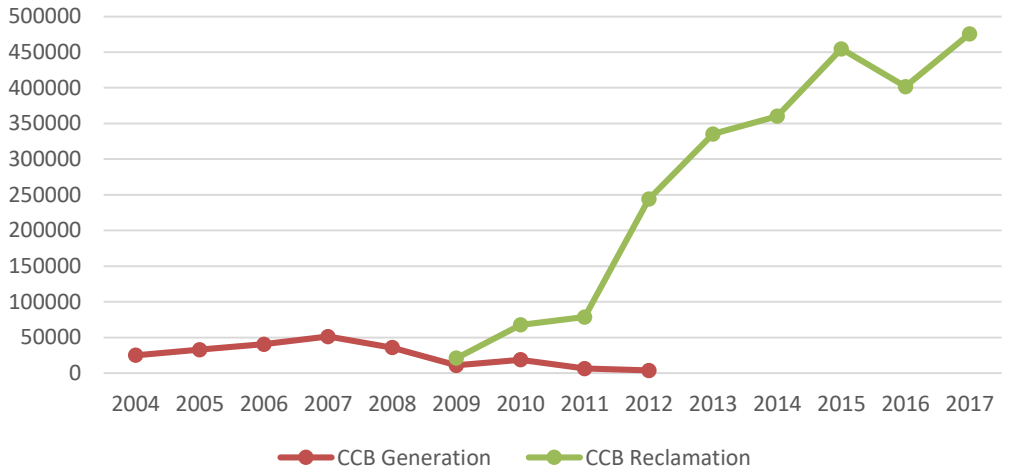


CCB Recovery at R. Paul Smith Landfill

As of the December 2017, nearly 2.5 million tons of material had been removed from this landfill.

The landfill is expected to be completely emptied in 2020.

CCB Generation and Reclamation from R. Paul Smith (tons per year)



Impact of STAR CCB Beneficiation Facility on CCB Use at Morgantown

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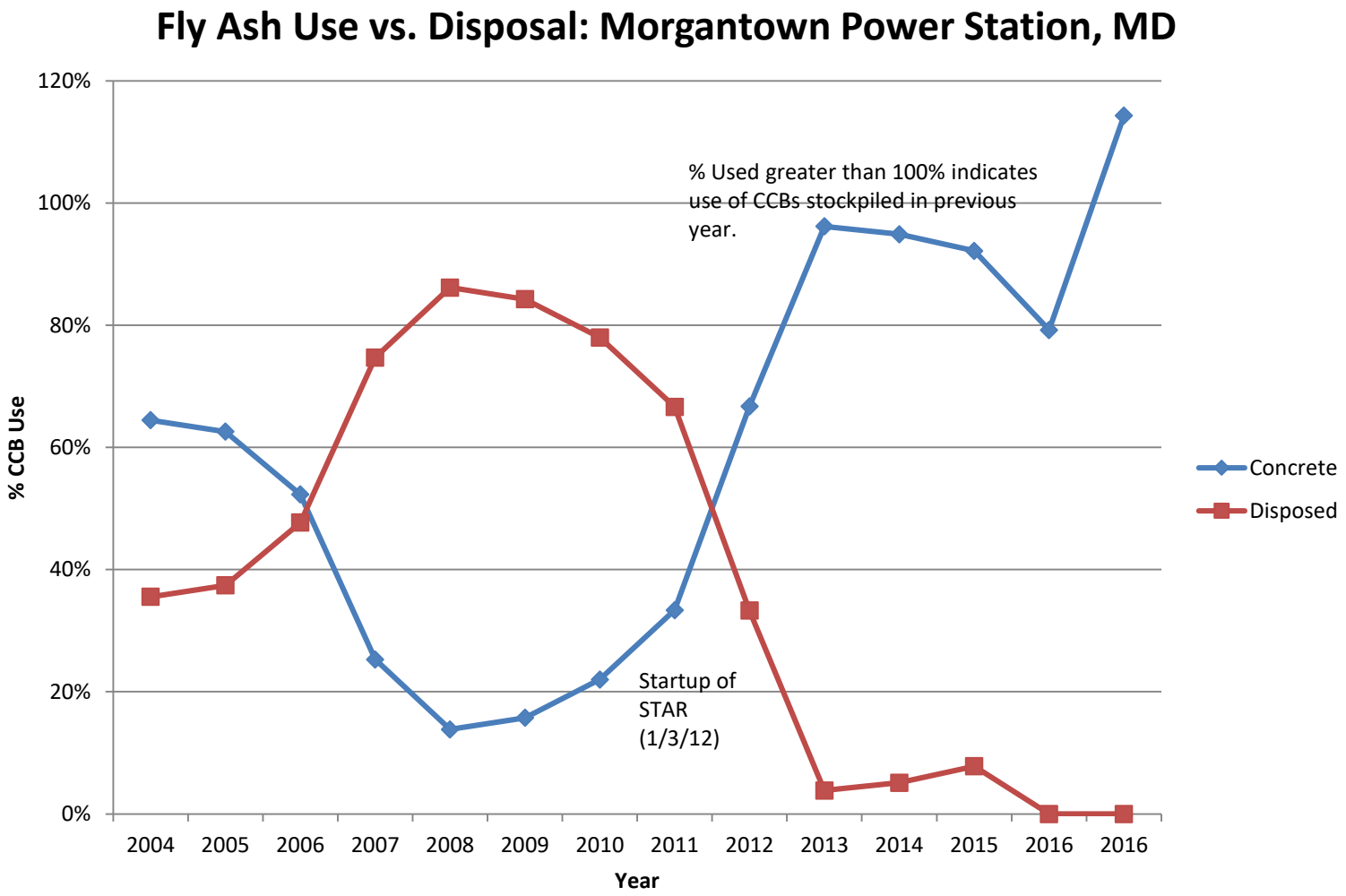
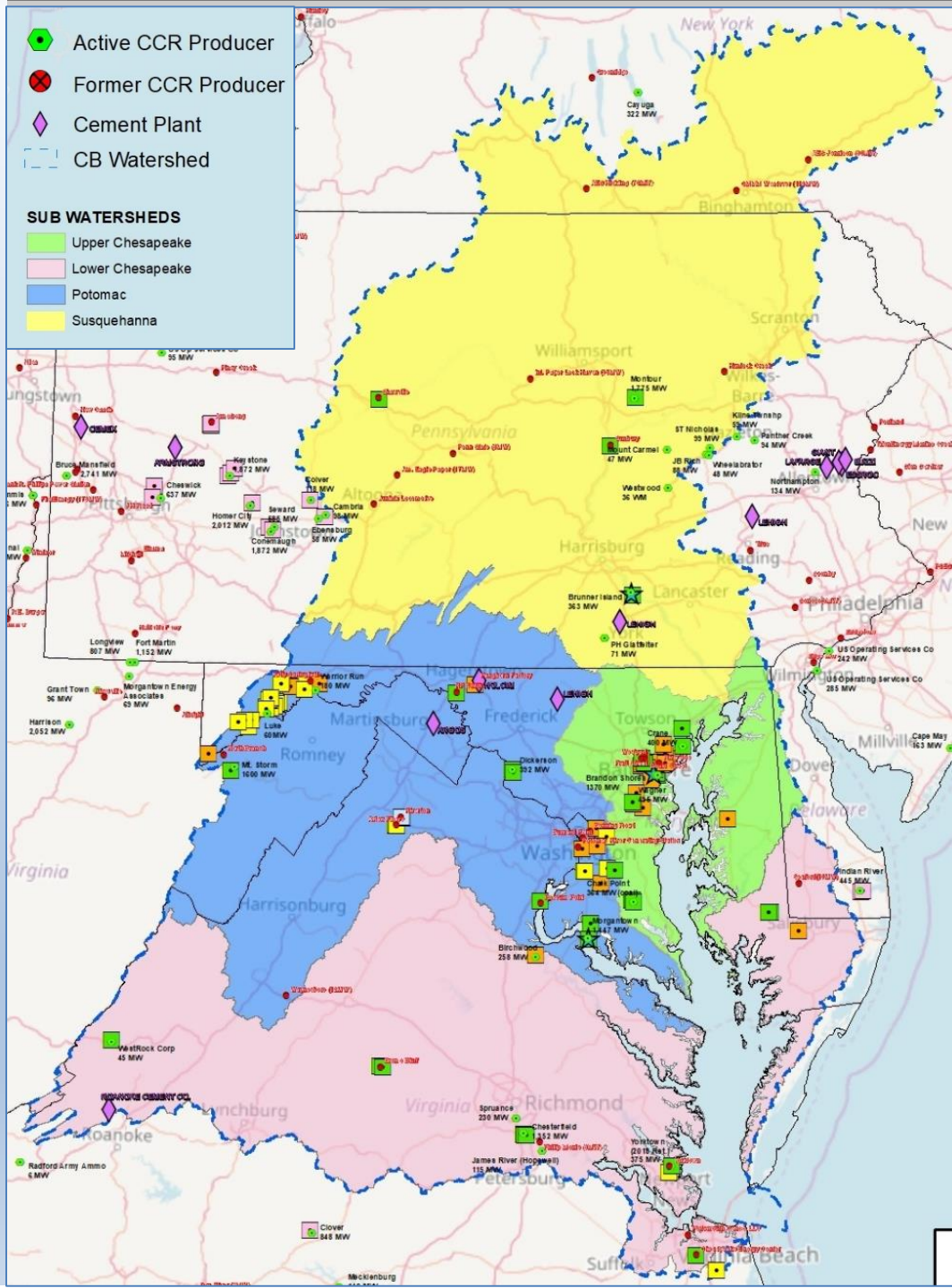


CCB Deposits in the Chesapeake Bay Watershed



CCB Deposits in the Potomac River Watershed

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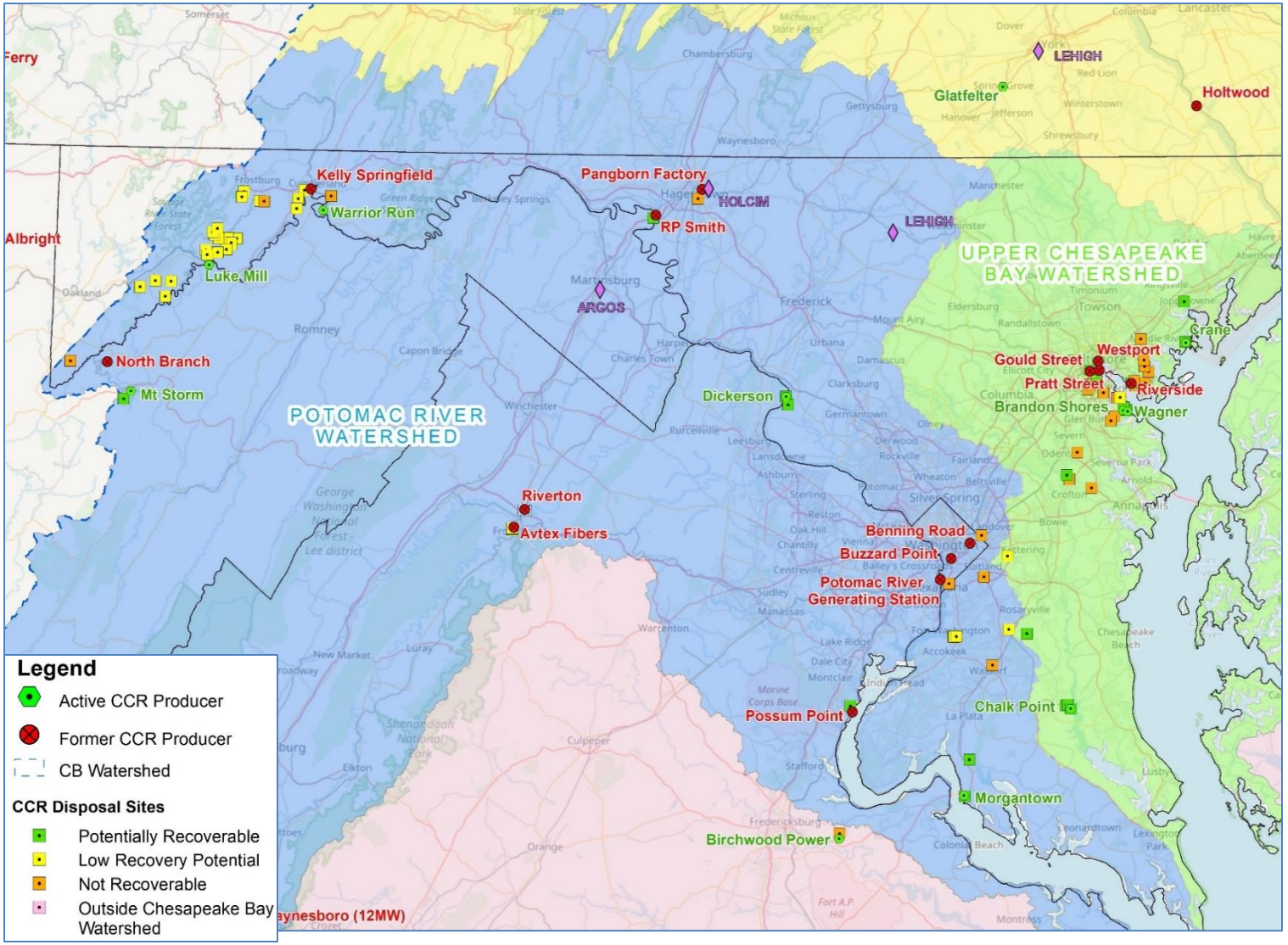

CCB Deposits in the Susquehanna River Watershed

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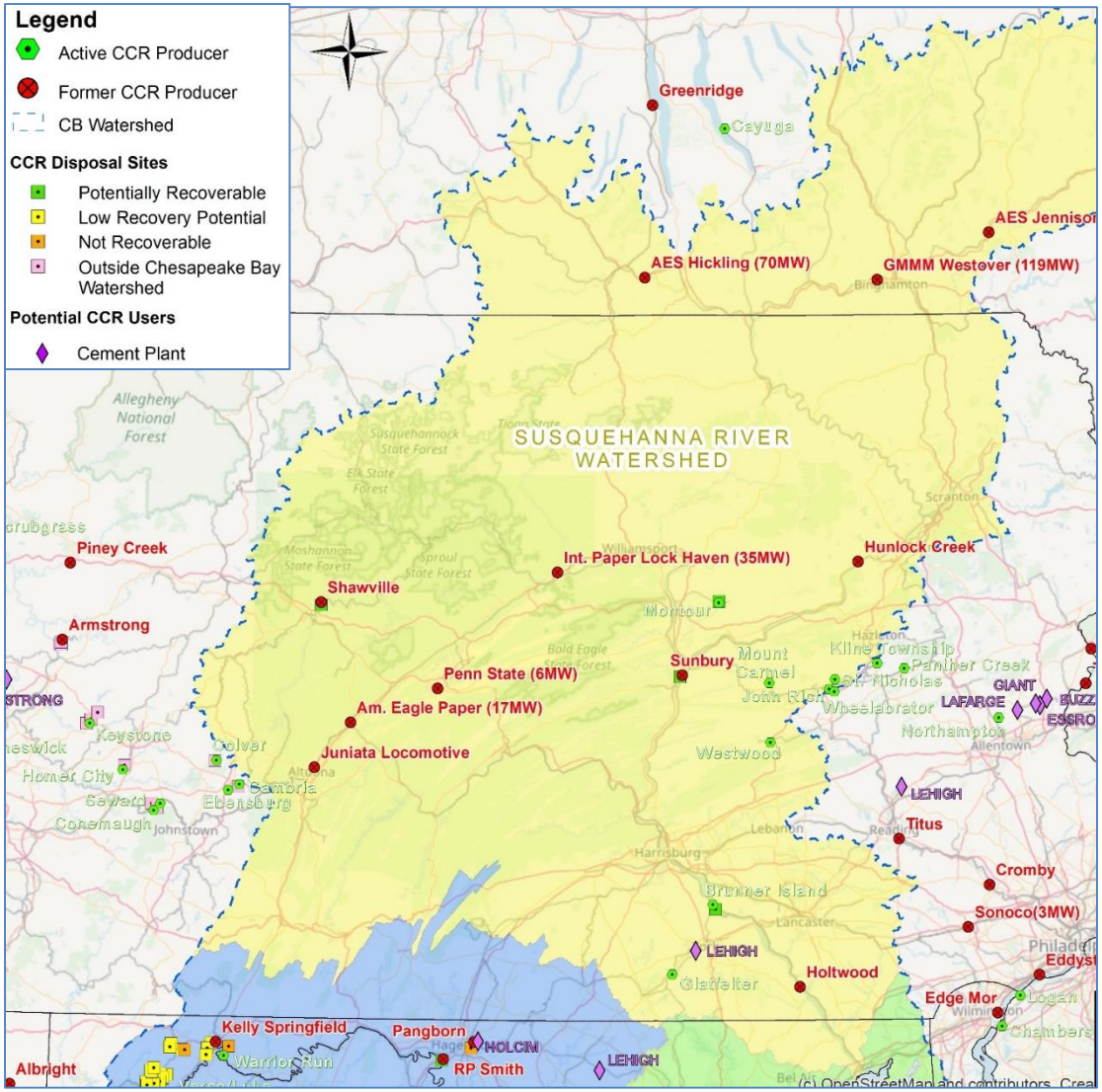

Strategy for Consumption of CCBs

- Maryland coal-fired power plants generate 1 to 1.5 million tons of CCBs annually.
- An estimated 20 to 25 million tons of CCBs are present in legacy CCB fill/storage sites across Maryland.
- Strategy: to create an infrastructure that facilitates economical recovery and transport of legacy CCBs to industry.
    - Even with such infrastructure, all material will not be removed in a short time.
- Goal: beneficially use all freshly produced CCBs, as well as, 5 million tons/year of legacy CCBs across the Chesepeake Bay Watershed over the next 3 to 5 decades.

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