MARYLAND

Department of the Environment

A History of Power Plant Controls in Maryland

What Did We Learn? – Where do We go Next?

Part 2 - NOx Issues

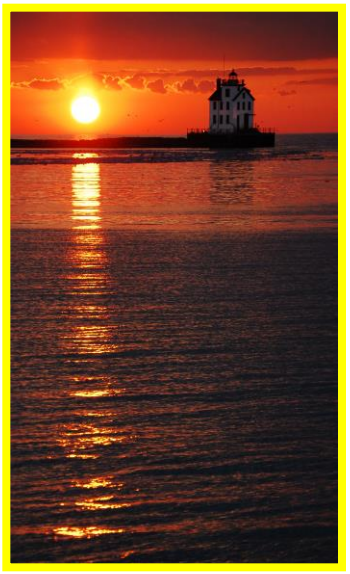
MDE

2014 NOx RACT Requirement

- In 2014, MDE is required to update NOx RACT (Reasonably Available Control Technology) requirements in the Maryland SIP (State Implementation Plan)
- RACT must be updated every time a new standard is adopted
- The current 75 ppb standard was adopted in 2008
- The updated NOx RACT SIP is due on July 20, 2014
- This rulemaking process is intended to support that SIP submittal

Issues With NOx Emissions

- The new 75 ppb ozone standard requires us to focus on peak day NOx emissions
- Healthy Air Act (HAA) annual and “ozone season” caps have not forced units to always run emissions controls when they are needed
- Linked to lower capacity factors at many units
  - Coal units are simply not being asked to run as often as they used to run
- Some units also appear to not always be running their control equipment at a high level of efficiency to insure maximize emission reductions

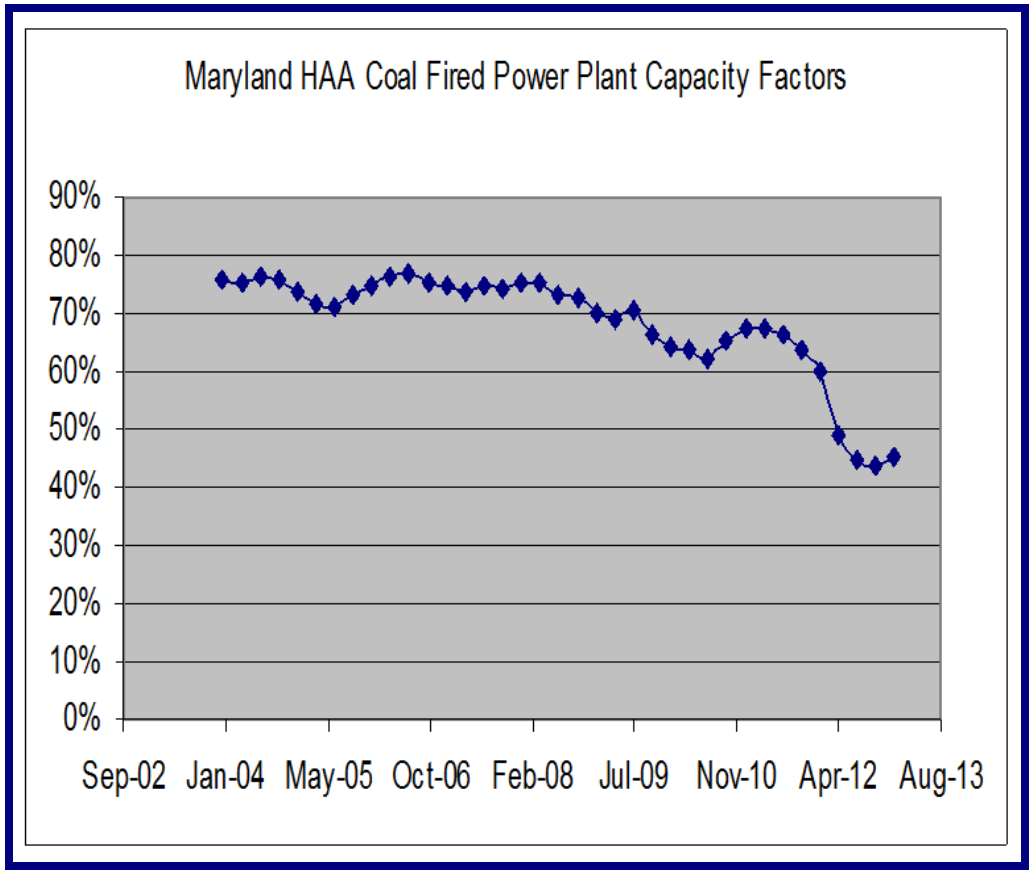


Very Old Short-Term Emission Limits

- The HAA used ozone-season and annual caps to drive very significant emission reductions of NOx
- The short-term limits for NOx in Maryland regulations date back to the 1990s
  - For the new 75 ppb ozone standards, peak day NOx emissions have become extremely important
  - Current short-term limits are clearly not appropriate for addressing peak day NOx emissions
    - All short-term limits for all units will need to be updated

Decreasing Capacity Factors

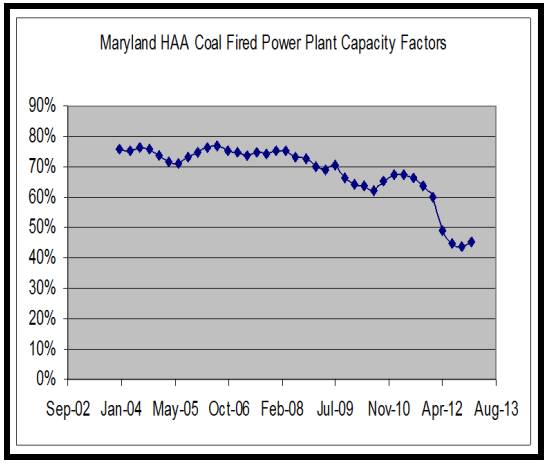
- Capacity factor HAA Coal Fired Units



Capacity Factors of Maryland Coal plants have almost been reduced by 50%

Compliance with the HAA

- All of Maryland's power generators fully comply with the Maryland HAA of 2006
- The HAA used a regulatory scheme that allowed companies to choose where to control within their "system" to most cost-effectively meet the NOx and SO2 caps set in the Act.
  - Some units controlled more – some less
- The HAA set annual caps for SO2 and annual and ozone season caps for NOx
  - Short-term limits (hourly or daily) were not part of the HAA
  - Caps were set assuming that Maryland coal plants would continue to operate at pre-2006 levels



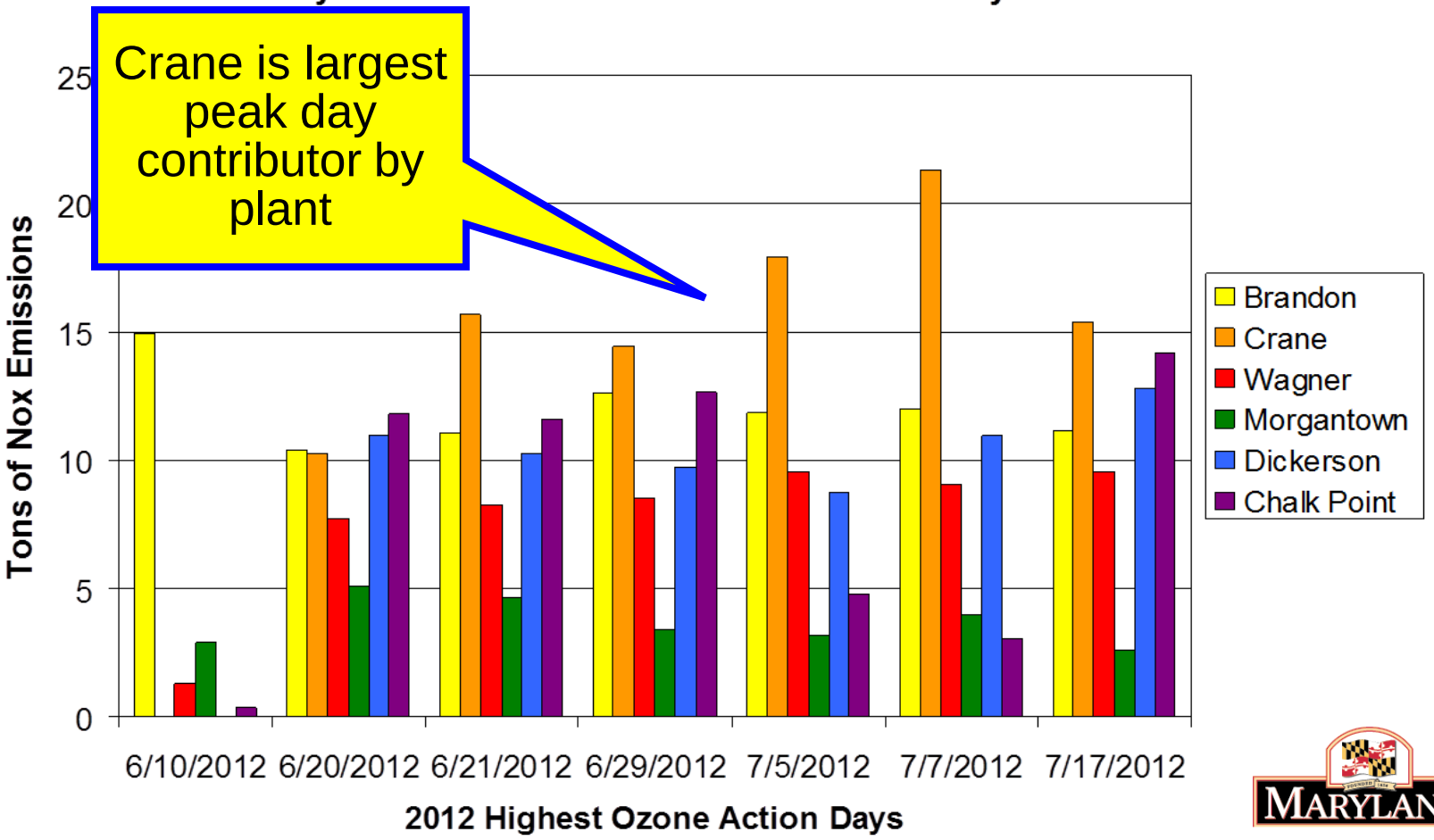
The HAA Worked Well

- The regulatory scheme in the HAA worked very well
  - Helped bring Maryland into attainment for the PM Fine standard and helped Maryland get very close to meeting the old 85 ppb ozone standard.
  - The HAA (2006) was designed for these older standards
- The new 1-hour SO2 standard and the current 75 ppb ozone standard will require an enhanced regulatory scheme that focuses on:
  - Individual units and
  - Shorter term (hourly or daily) emission limits

NOx Emissions on Peak Ozone Days

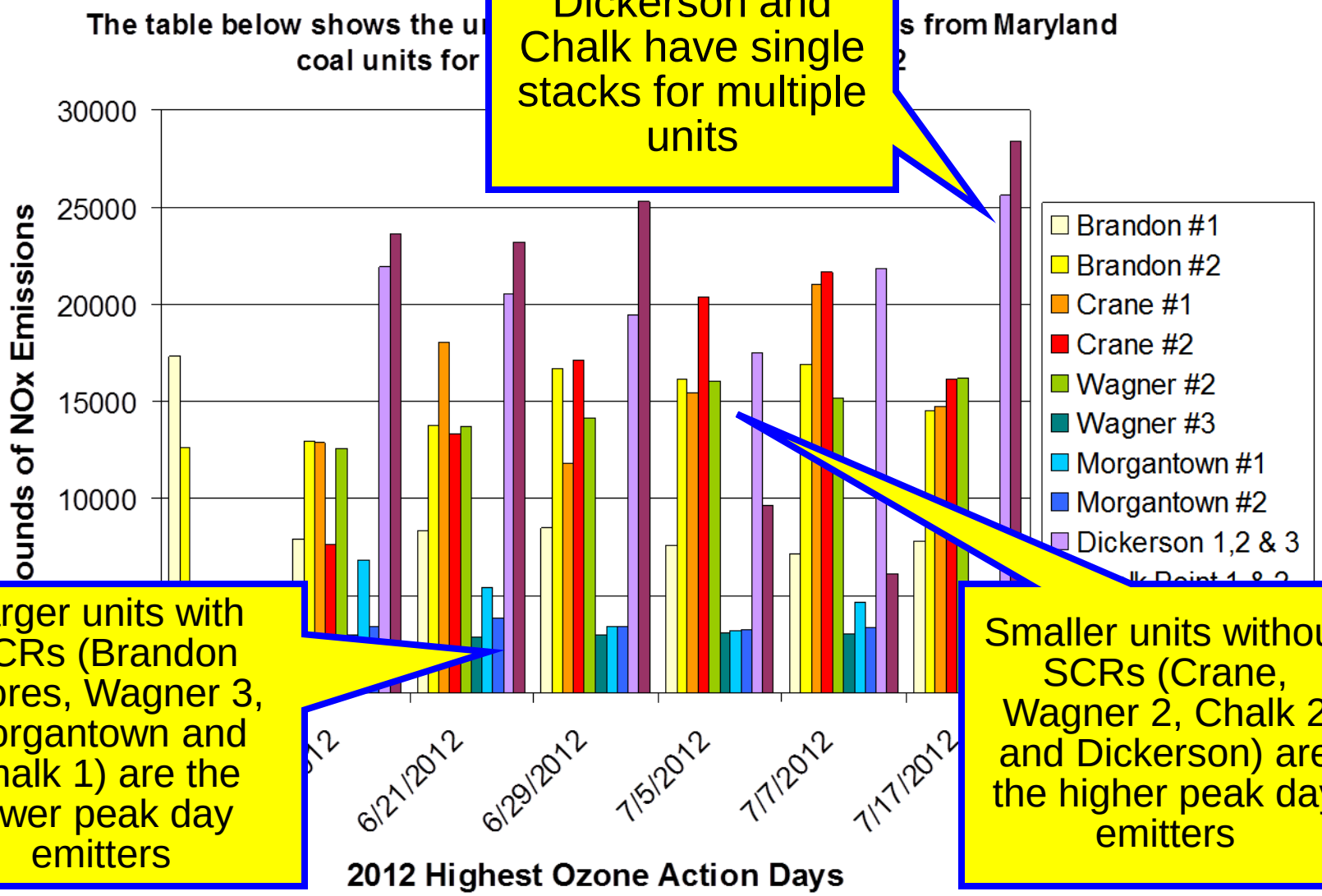
Daily NOx Emissions By Plant

The table below shows the plant-by-plant, daily NOx emissions from Maryland coal units for the 7 worst ozone days in 2012



NOx Emissions on Peak Ozone Days

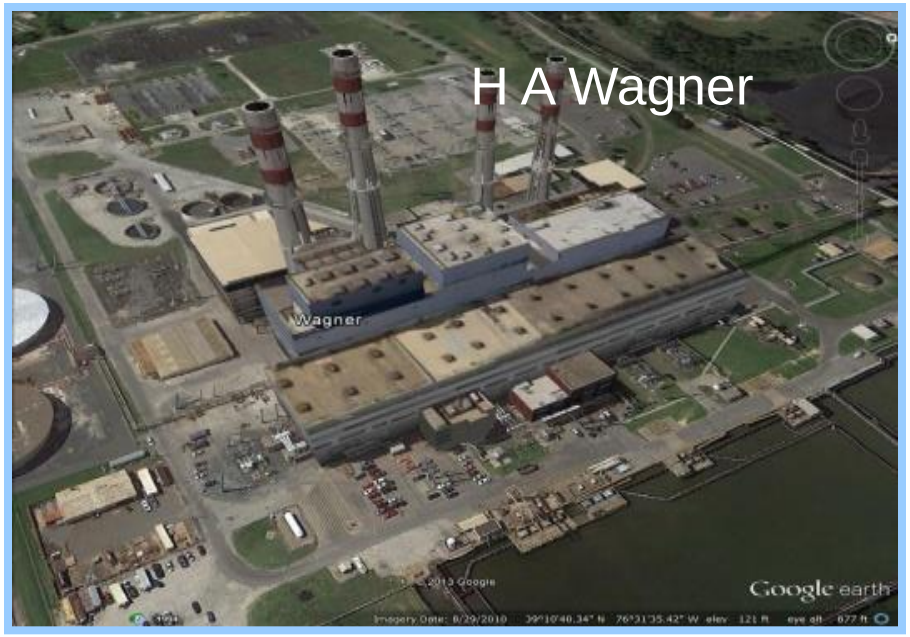
Daily NOx Emissions By Unit



Dickerson and Chalk have single stacks for multiple units

Larger units with SCRs (Brandon Shores, Wagner 3, Morgantown and Chalk 1) are the lower peak day emitters

Smaller units without SCRs (Crane, Wagner 2, Chalk 2 and Dickerson) are the higher peak day emitters



- Fort Smallwood Complex
  - Brandon Shores - Units 1 and 2
  - Wagner – Units 1, 2, 3 and 4
  - All on one contiguous property
- C.P. Crane – Units 1 and 2

Raven System Wide Compliance with MD HAA

HAA set annual and ozone season caps and allowed "system-wide" averaging
With tougher ozone standard and focus on "peak days" – units
that "under-controlled" are now being re-evaluated

	Brandon Shores Unit 1	Brandon Shores Unit 2	Crane Unit 1	Crane Unit 2	Wagner Unit 2	Wagner Unit 3	Total
2012 Annual NOx Tons	1,405	2,735	9[illegible]			503	7,440
2012-On Annual NOx Limit, Tons	2,414	2,519	68[illegible]			1,115	8,026
2012 Ozone NOx Tons	727	[illegible]	[illegible]			155	3,492
2 Oz Li	[illegible]	[illegible]	284	317	225	481	3,630

These two numbers show annual tons very close to annual limit

These two numbers show ozone season tons very close to the ozone season limit

Units with Red font use credits from units in Grey font to meet annual HAA Limit

Brandon Shores

- Built in 1984
- Boiler type - Brandon Shores 1 and 2 are both Babcock & Wilcox wall fired Units
- Installed 2 Selective Catalytic Reduction (SCR) control systems in 2002 ($100M, and a cost of around 4% plant efficiency)
- Total capacity = 1,400 MW

Unit	Capacity (MW)	NOx Controls	Old NOx RACT (lb/mmBTU) 30-Day Rolling Average	HAA Limit* (Tons)	2012 Annual (Ozone) Average NOx Emission Rate (lb/mmBTU)
Brandon 1 (Coal)	700	SCR	0.50	2,414	0.13 (0.09)
Brandon 2 (Coal)	700	SCR	0.50	2,519	0.22 (0.12)

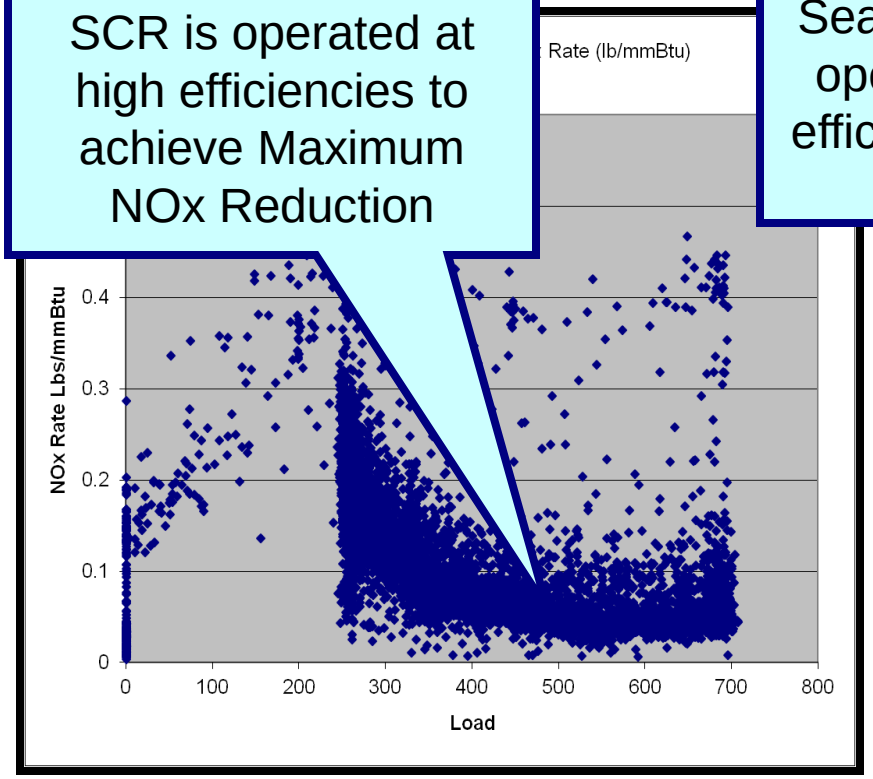
Brandon Shores Unit 1

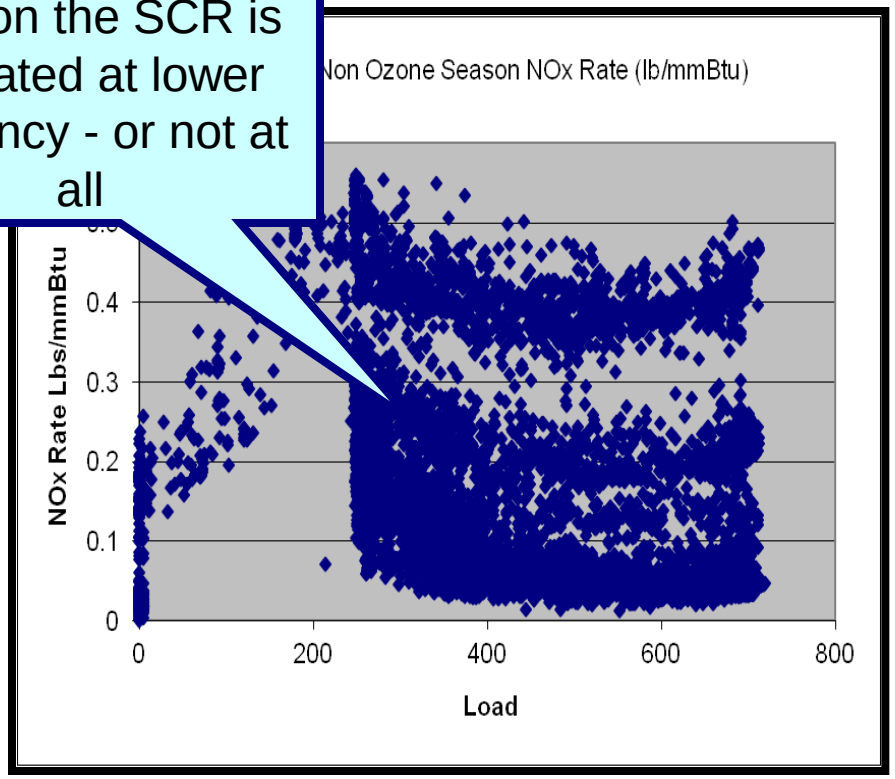
2010 to 2012 Data

Ozone Season Versus Non Ozone Season Operation

In Ozone Season the SCR is operated at high efficiencies to achieve Maximum NOx Reduction

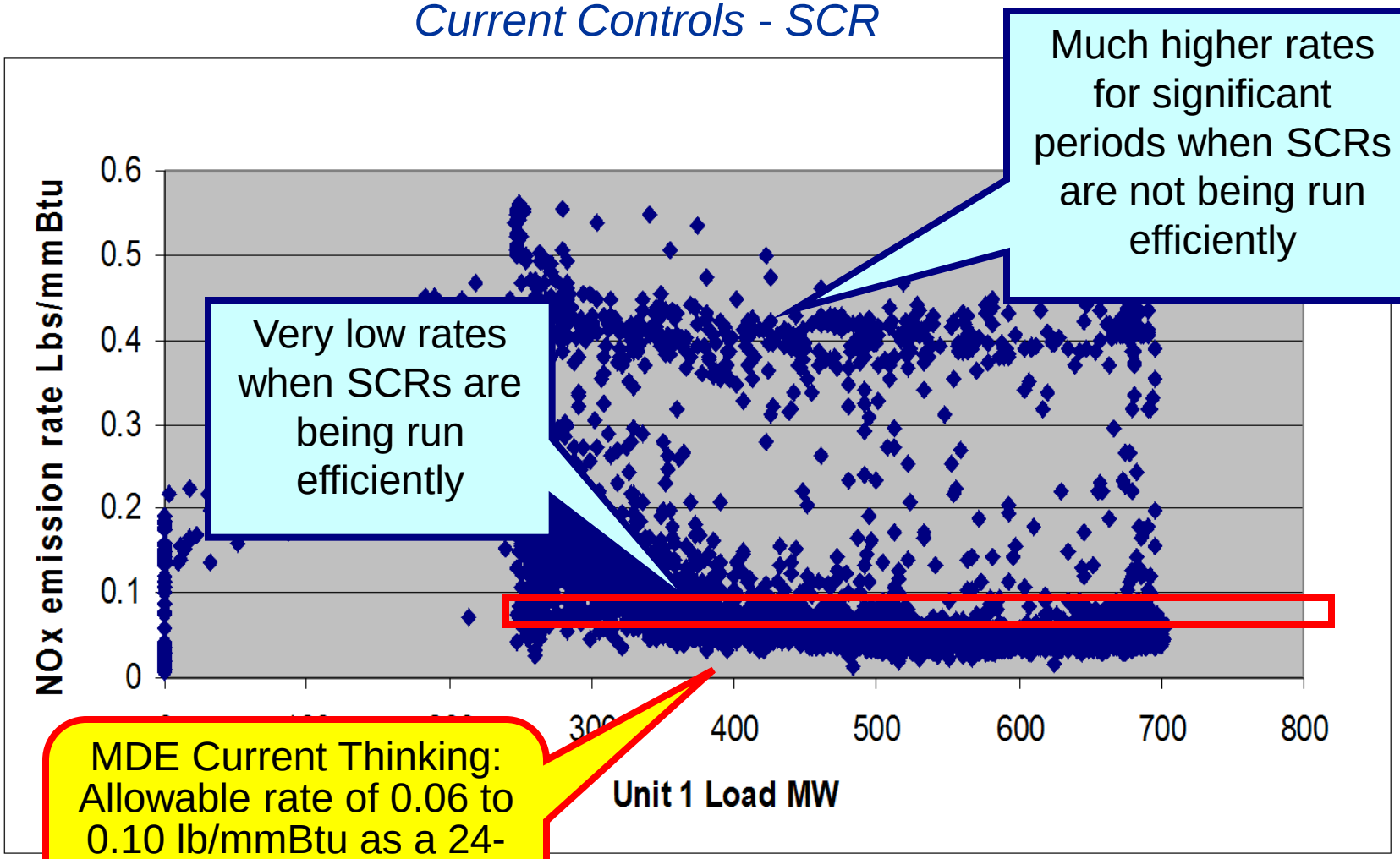
In non Ozone Season the SCR is operated at lower efficiency - or not at all





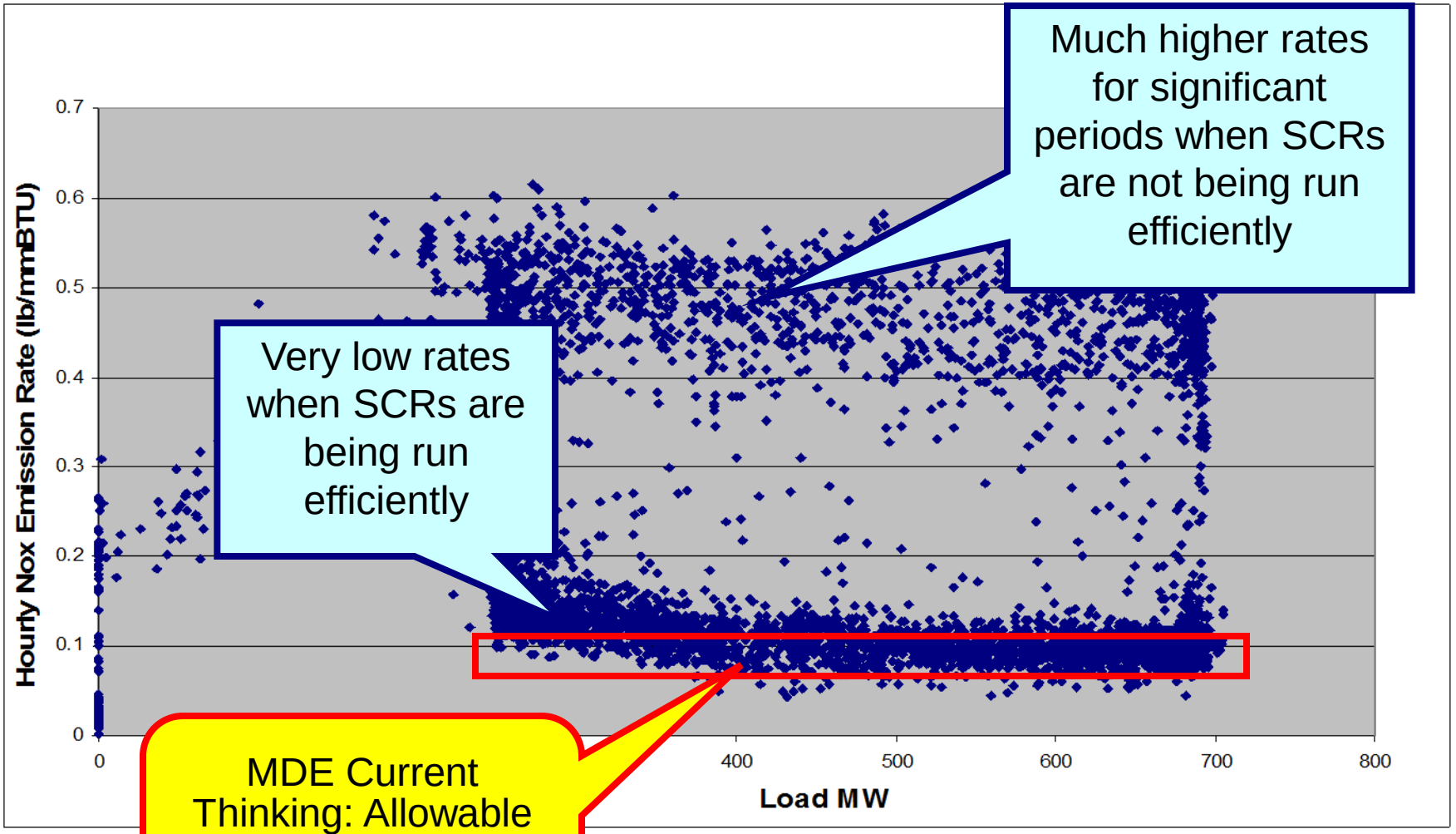
Brandon Shores Unit 1 - 2012

Current Controls - SCR



Brandon Shores Unit 2 - 2012

Current Controls - SCR



Brandon Shores 1 and 2 - Conclusions

- Continuous operation of the NOx controls would have reduced 1,650 tons of NOx emissions in 2012.
- Current thinking - 24 Hr Rolling Avg NOx Emission Limit of 0.06 to 0.10 lb/mmBtu for Unit 1
- Current thinking - 24 Hr Rolling Avg NOx Emission Limit 0.08 to 0.11 lb/mmBtu for Unit 2

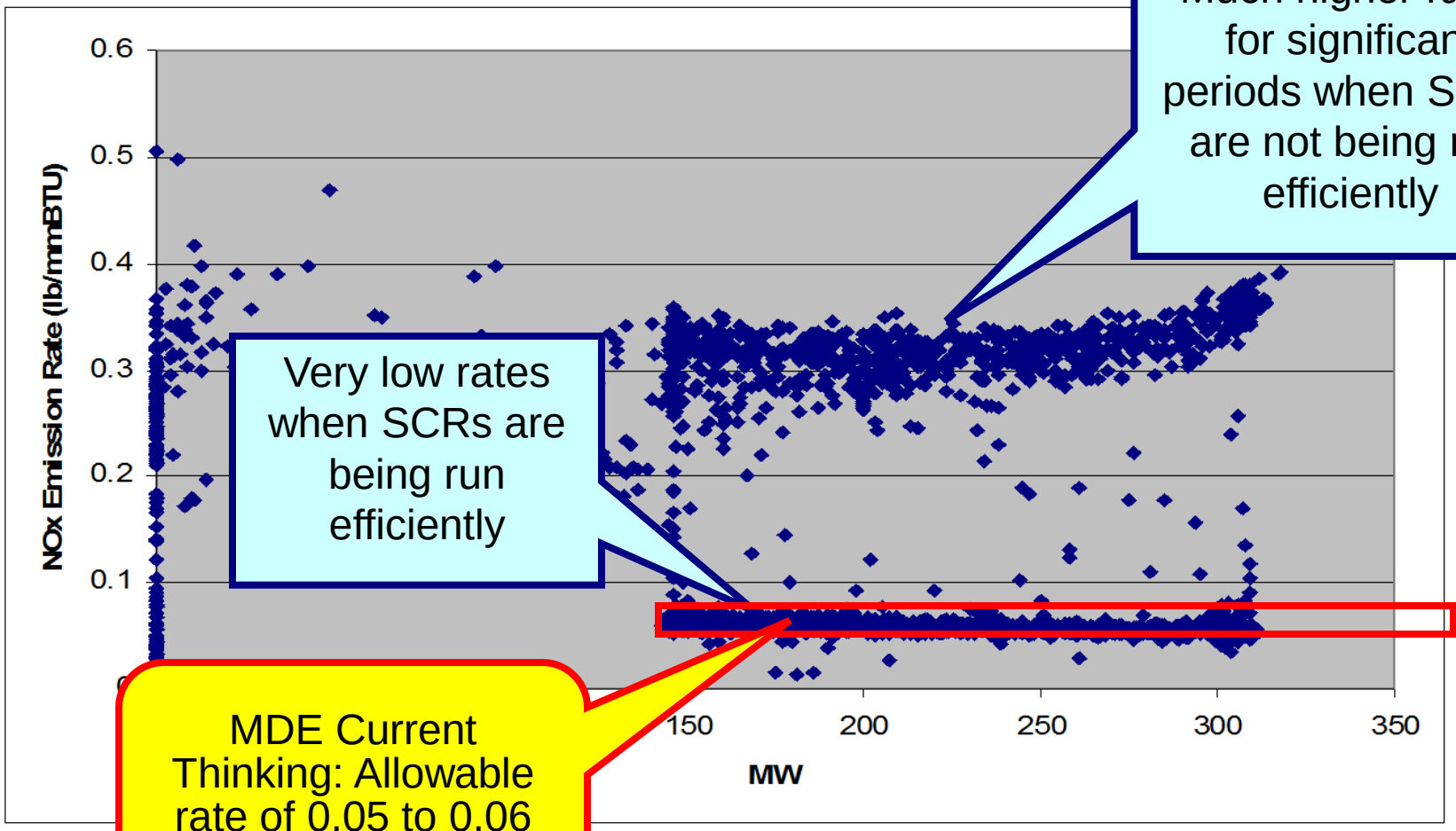
Wagner Power Station

- Built in 1959 - 1972
- Boiler types
  - Units 2 and 3 are both coal burning Babcock & Wilcox wall fired unit units
  - Units 1 and 4 are Babcock & Wilcox Gas and Oil units
- Installed a SCR & SNCR control systems in 2003 & 2008 ($55M)
- Total capacity = 1,400 MW

Unit	Capacity (MW)	NOx Controls	Old NOx RACT (lb/mmBTU) 30-Day Rolling Average	HAA Limit* (Tons)	2012 Annual (Ozone) Average NOx Emission Rate (lb/mmBTU)
Wagner 2 (Coal)	**136**	**SNCR**	**0.50**	**555**	**0.39 (0.43)**
Wagner 3 (Coal)	**359**	**SCR**	**0.50**	**1,115**	**0.13 (0.06)**

Wagner Unit 3

Current Controls - SCR

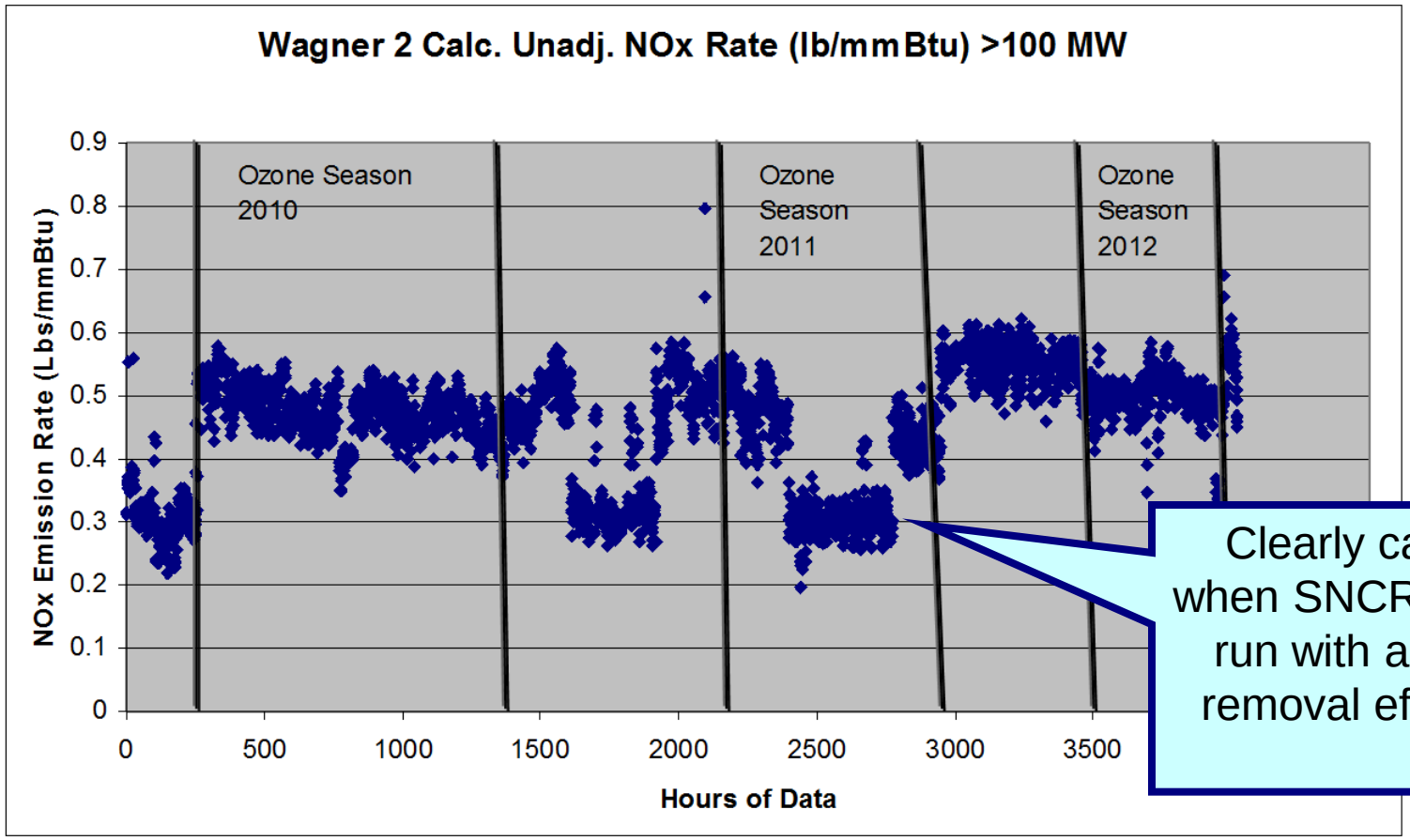


Wagner 3 - Conclusion

- Operation of SCR at Wagner 3 similar to Brandon Shore SCR's.
- Continuous operation of controls could have reduced 213 tons of NOx in 2012 at Wagner 3.
- MDE Current Thinking - 24 Hr Rolling Avg NOx Emission Limit 0.05 to 0.06 lb/mmBtu.

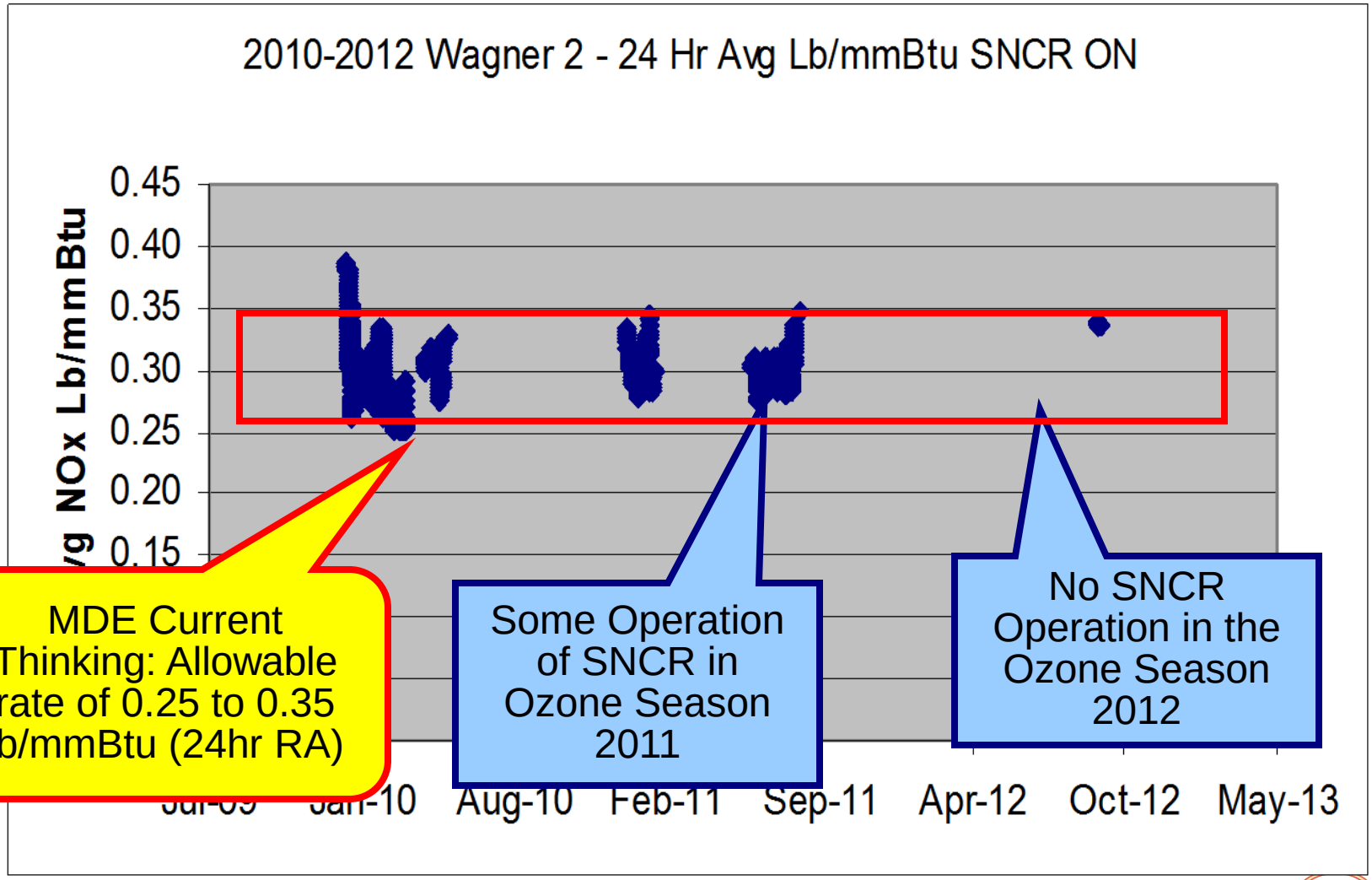
Wagner 2

Current Controls - SNCR

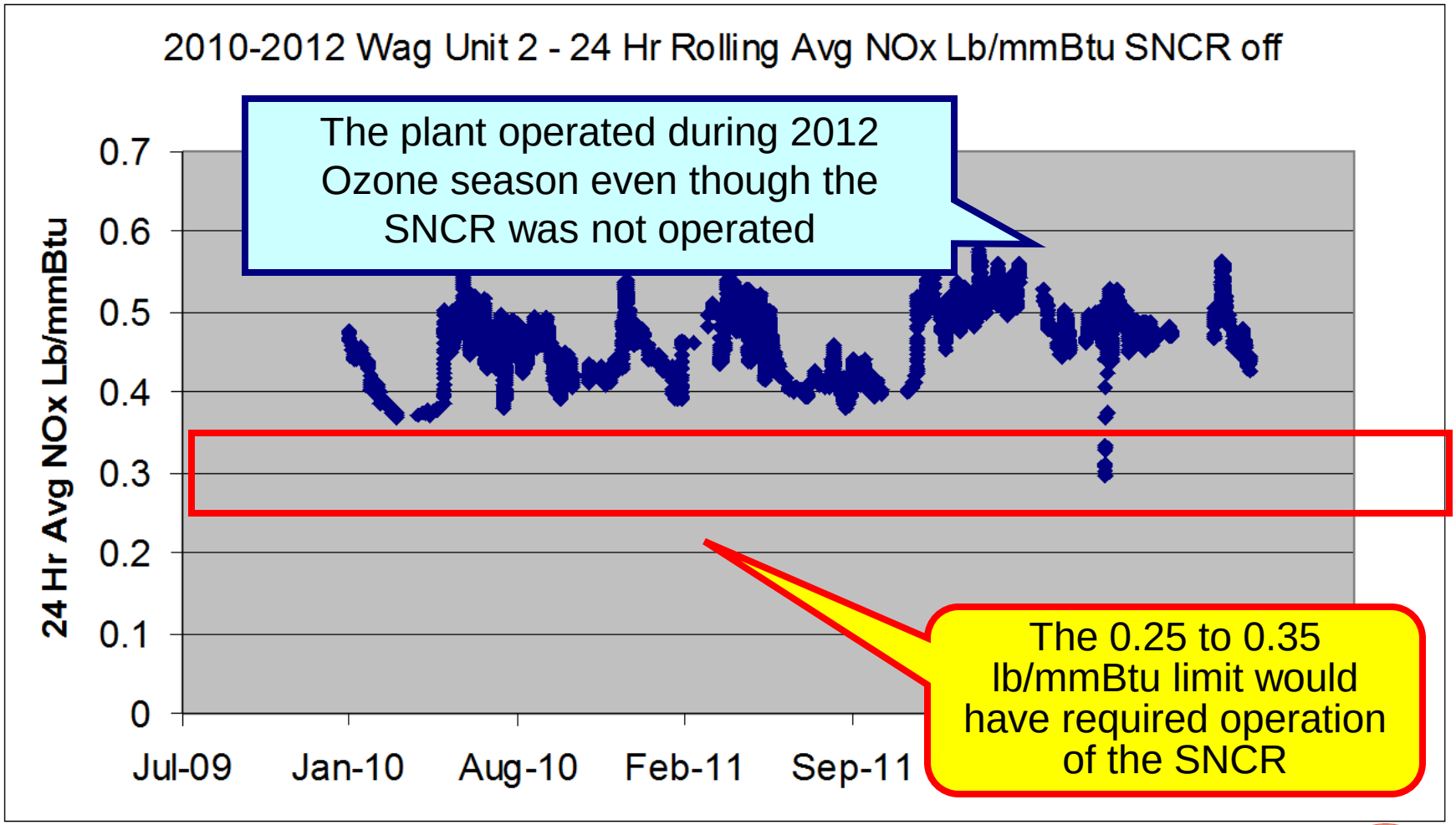


Clearly can see when SNCR is being run with a higher removal efficiency

Wagner 2 - SNCR In Operation



Wagner 2 - SNCR Off



Wagner 2 - Conclusions

- The SNCR on Unit 2 ran 28% of time it could have run.
- The SNCR did not run in the ozone season of 2012 at all.
- Continuous operation of controls could have reduced 198 tons of NOx in 2012 at Wagner 2.
- Current thinking - 24 Hr Rolling Avg NOx Emission Limit between 0.25 and 0.35 lb/mmBtu.

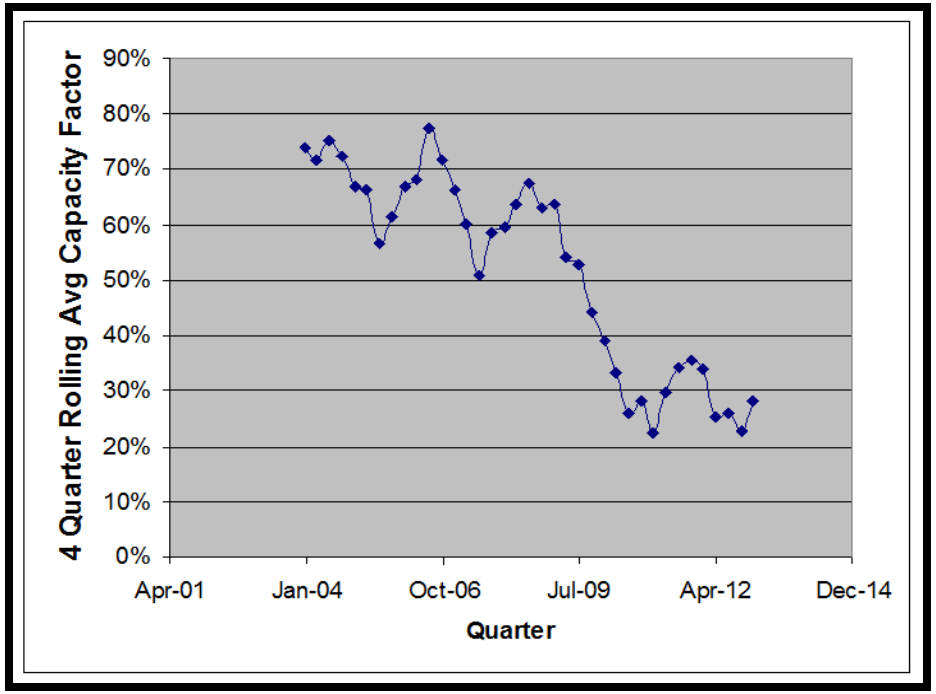
Raven Power – C.P. Crane

- Built in 1963
- Boiler types
  - Units 1 and 2 are both coal burning cyclone units - Babcock and Wilcox Boilers
- Installed SNCRs in 2009 ($12 M)
- Total capacity = 400 MW

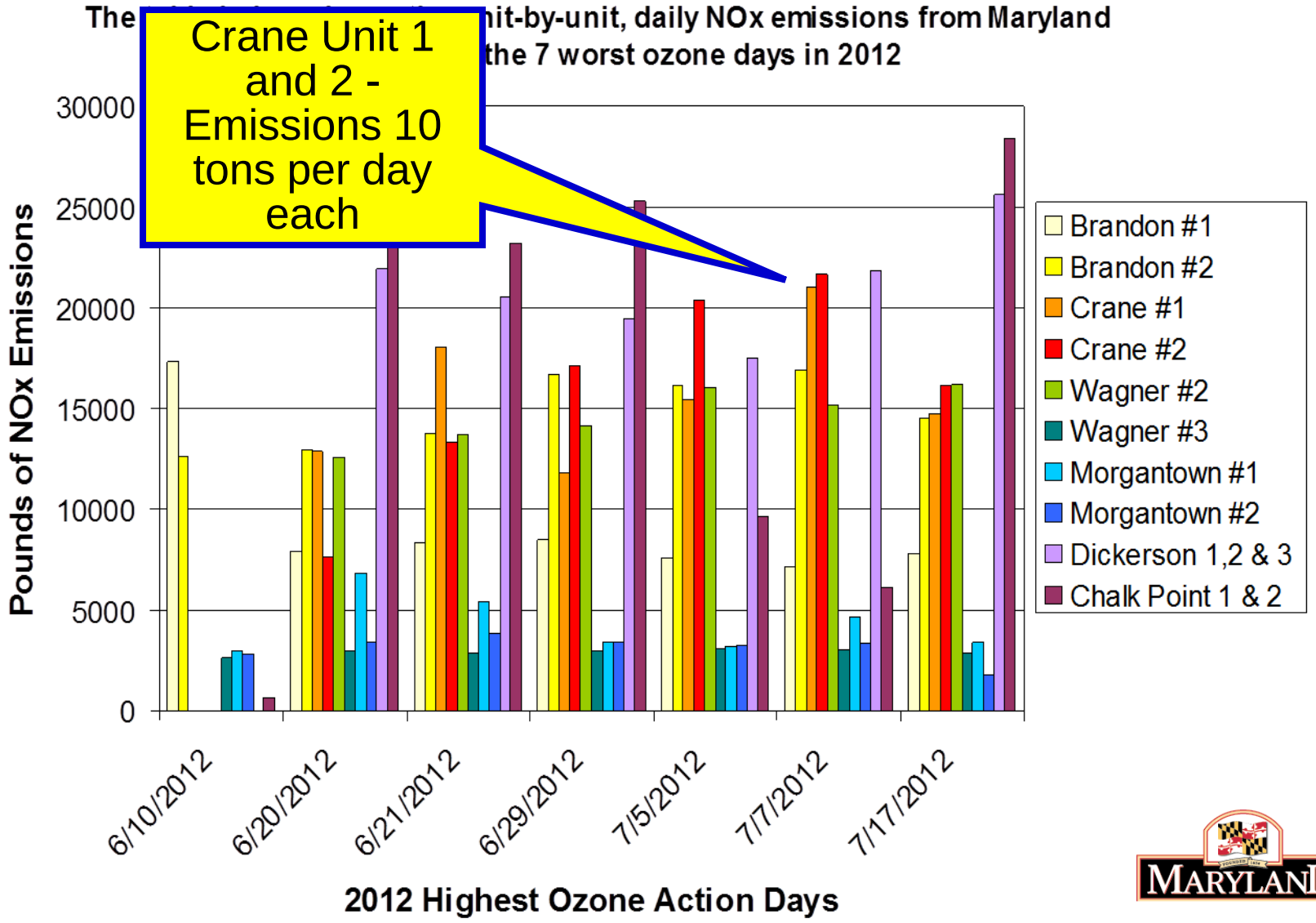
Unit	Capacity (MW)	NOx Controls	Old NOx RACT (lb/mmBTU) 30-Day Rolling Average	HAA Limit* (Tons)	2012 Annual (Ozone) Average NOx Emission Rate (lb/mmBTU)
CP Crane 1 (Coal)	**200**	**SNCR**	**0.70**	**686**	**0.400 (0.411)**
CP Crane 2 (Coal)	**200**	**SNCR**	**0.70**	**737**	**0.357 (0.410)**

Capacity Factors at Crane

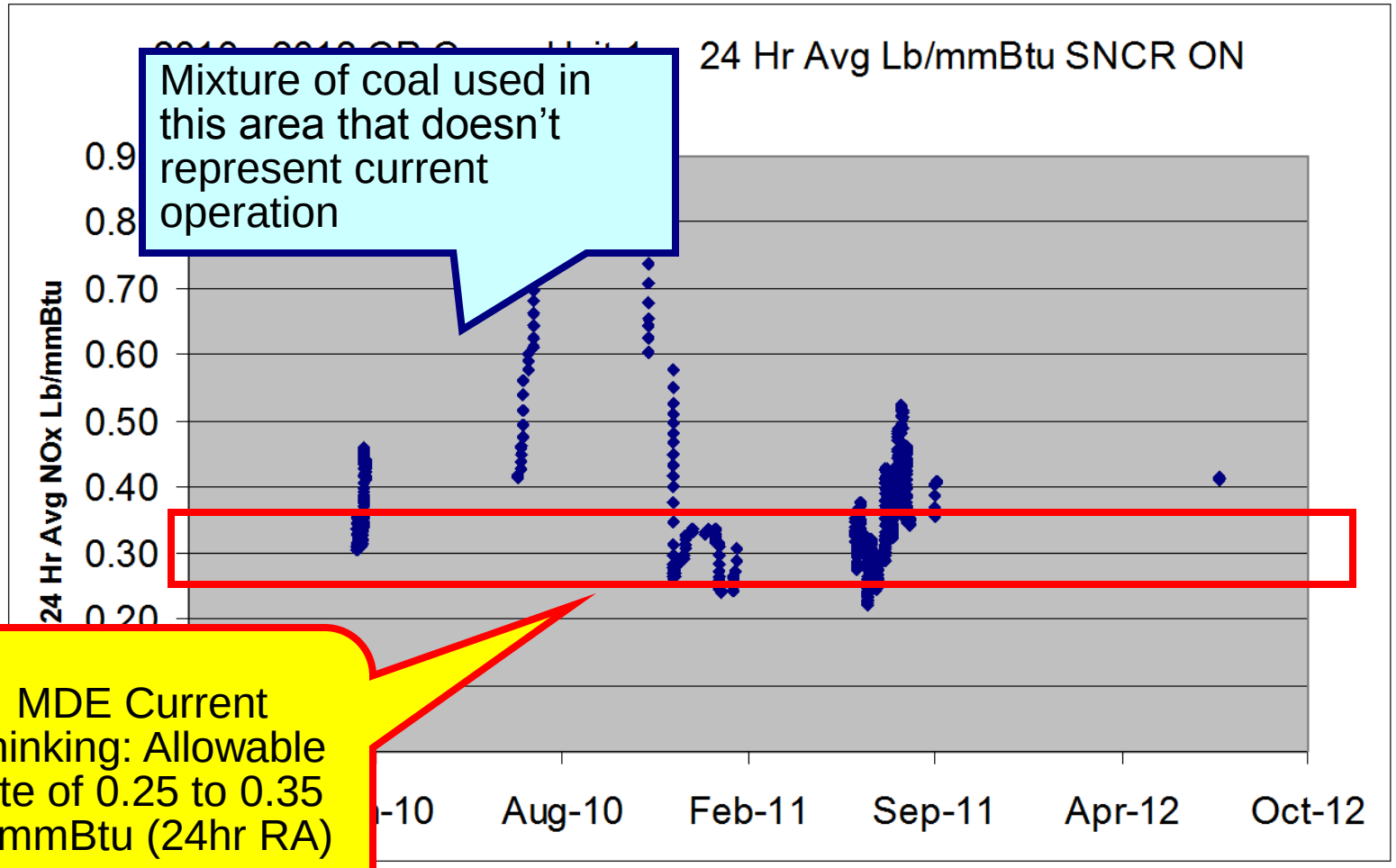
- Dramatic reductions since 2001 to 2007 timeframe
- Units are simply not being called upon to run as much as they used to be called upon



NOx Emissions on Peak Ozone Days

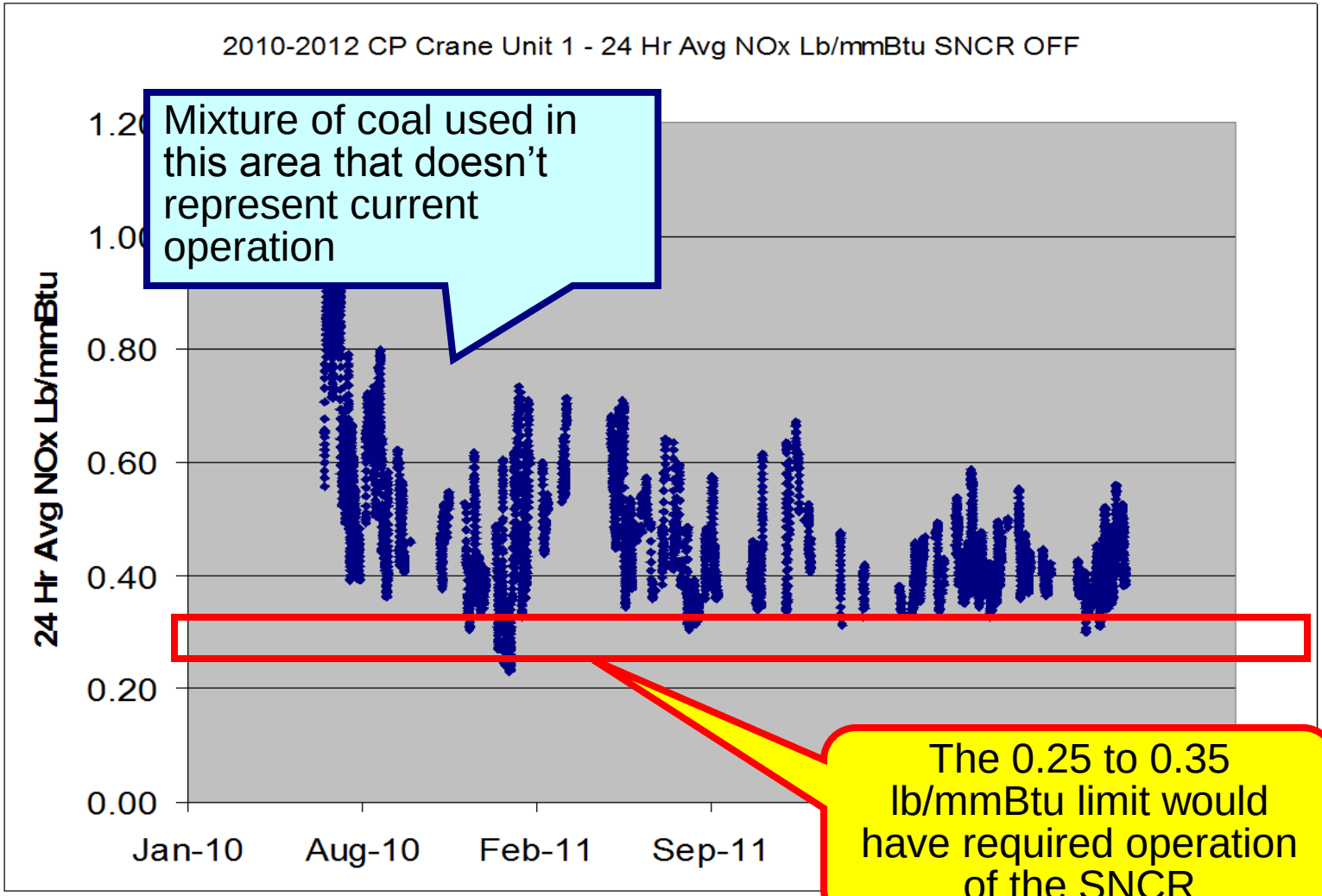


Crane Unit 1 – SNCR On



MDE Current Thinking: Allowable rate of 0.25 to 0.35 lb/mmBtu (24hr RA)

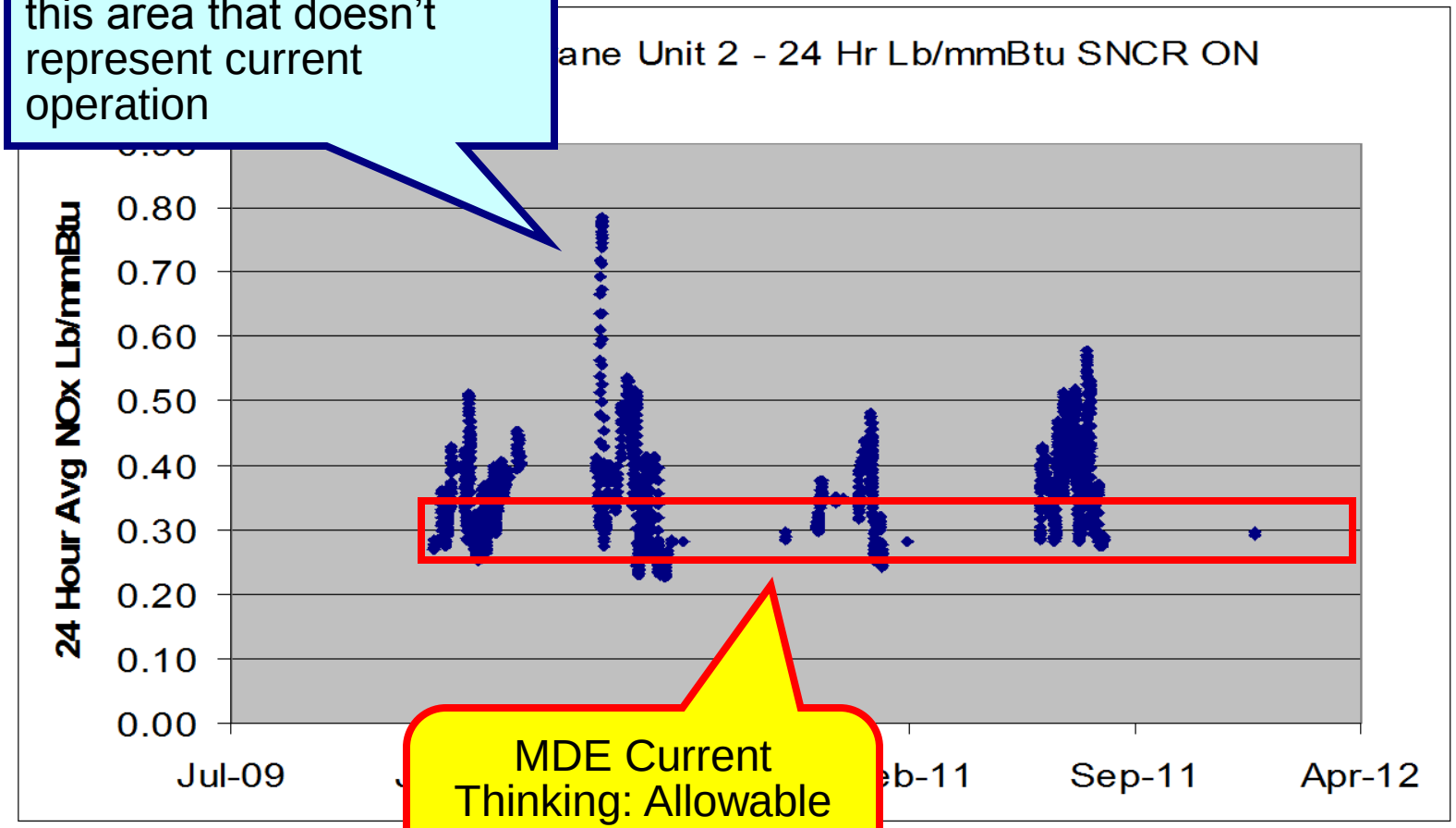
Crane Unit 1 – SNCR Off



Crane Unit 2 – SNCR On

2010-2012 – 24 Hr Avg NOx Lbs/mmBtu

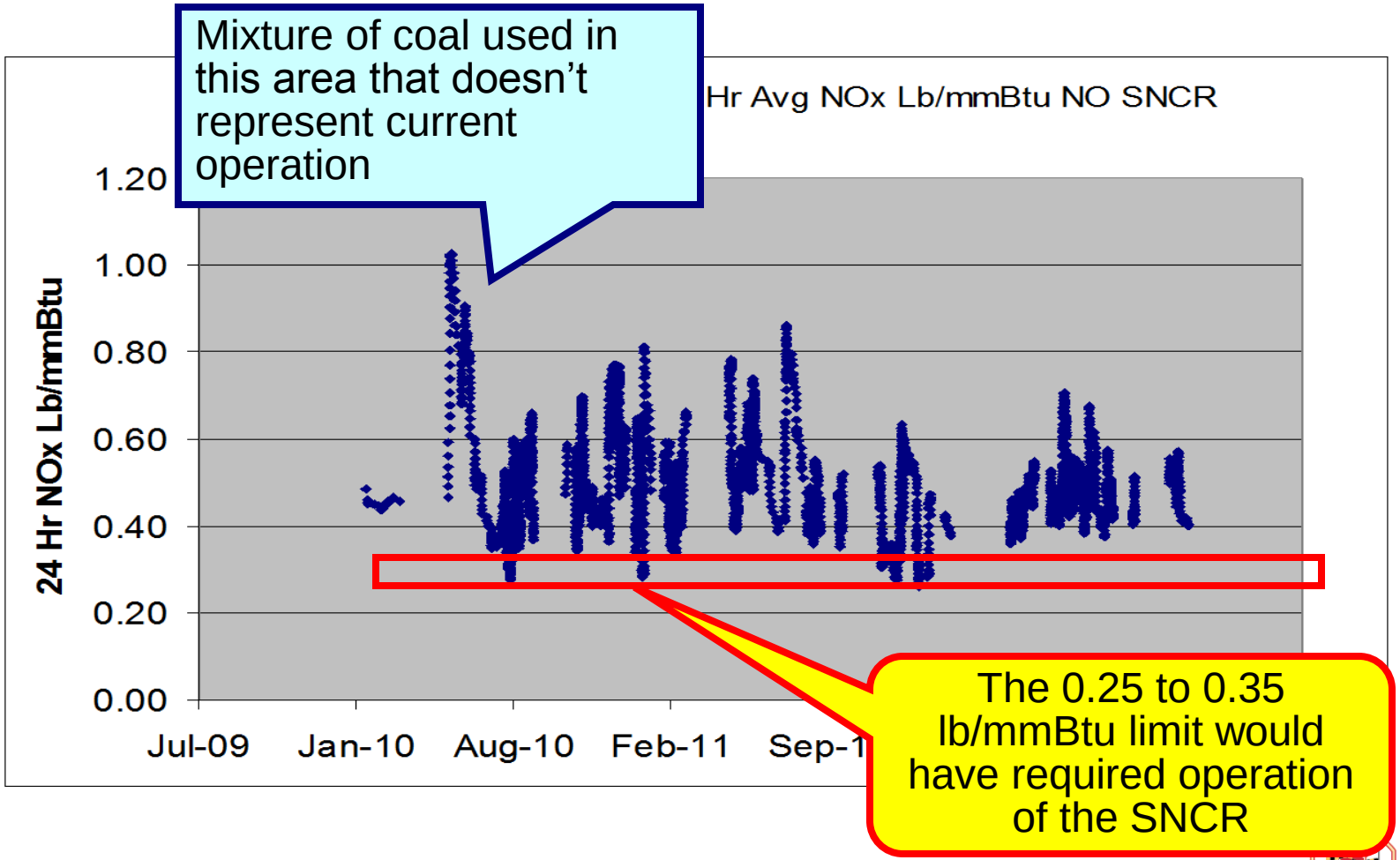
Mixture of coal used in this area that doesn't represent current operation



MDE Current Thinking: Allowable rate of 0.25 to 0.35 lb/mmBtu (24hr RA)

Crane Unit 2 – SNCR Off

2010-2012 Data -24 Hr Avg NOx Lb/mmBtu



Deeper Reductions at Crane

- MDE is researching a hybrid SCR/SNCR technology that appears to be well suited for both Crane units
- Appears to significantly reduce NOx
  - 0.08 to 0.11 lb/mmBtu
- Very cost effectively
  - $2000 to $3000 per ton
- Operational by 2015 to support Moderate area attainment needs

C.P. Crane – Conclusions

- SNCR operation
  - Unit 1 SNCR ran 14% of time it could have.
  - Unit 2 SNCR ran 33% of time it could have.
- Through 2015
  - Current thinking – Unit 1
    - Through 2015 - 24 Hr Rolling Average NOx Emission Limit of 0.25 to 0.35 lb/mmBtu.
  - Current thinking – Unit 2
    - Through 2015 - 24 Hr Rolling Average NOx Emission Limit of 0.25 to 0.35 lb/mmBtu
- By 2015
  - Current thinking - Both Units
    - 24 Hr Rolling Average NOx Emission Limit of 0.08 to 0.11 lb/mmBtu

Raven Power – Current MDE Thinking

Short-Term NOx Limits

Coal Fired Units	Old NOx RACT	MDE Current Thinking Updated NOx RACT
Brandon Unit 1 (SCR)	0.50 lb/mmBTU 30 Day Rolling Average	0.06 to 0.10 lb/mmBTU 24-hr Rolling Average
Brandon Unit 2 (SCR)	0.50 lb/mmBTU 30 Day Rolling Average	0.08 to 0.11 lb/mmBTU 24-hr Rolling Average
Wagner Unit 2 (SNCR)	0.50 lb/mmBTU 30 Day Rolling Average	0.25 to 0.35 lb/mmBTU 24-hr Rolling Average
Wagner Unit 3 (SCR)	0.50 lb/mmBTU 30 Day Rolling Average	0.05 to 0.06 lb/mmBTU 24-hr Rolling Average
Crane Unit 1 (SNCR)	0.70 summer/1.50 winter Lb/mm Btu 30 Day Rolling Average	0.25 to 0.35 lb/mmBTU 24-hr Rolling Average By 2015 – 0.08 to 0.11 lb/mmBtu 24-hr Rolling Average
Crane Unit 2 (SNCR)	0.70 summer/1.50 winter Lb/mm Btu 30 Day Rolling Average	0.25 to 0.35 lb/mmBTU 24-hr Rolling Average By 2015 – 0.08 to 0.11 lb/mmBtu 24-hr Rolling Average

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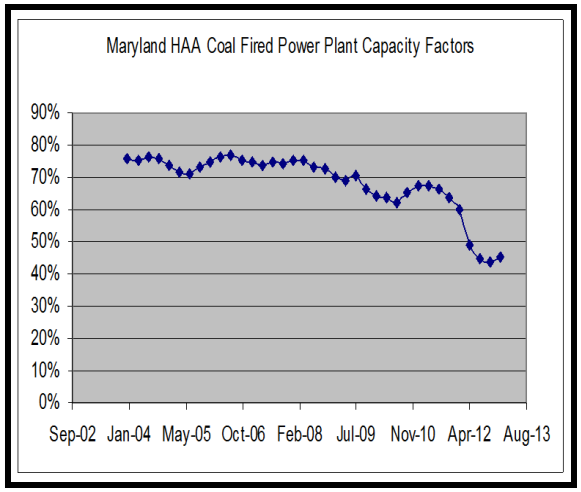
- Morgantown - Units 1 and 2
- Dickerson – Units 1, 2 and 3
- Chalk Point – Units 1 and 2

Compliance with the HAA

- All of Maryland's power generators fully comply with the Maryland Healthy Air Act (HAA)
- The HAA used a regulatory scheme that allowed companies to choose where to control within their "system" to most cost-effectively meet the NOx and SO2 caps set in the Act.
  - Some units controlled more – some less
- The HAA set annual caps for SO2 and annual and ozone season caps for NOx
  - Short-term limits (hourly or daily) were not part of the HAA
  - Caps were set assuming that Maryland coal plants would continue to operate at pre-2006 levels



The HAA Worked Well

- The regulatory scheme in the HAA worked very well
  - Helped bring Maryland into attainment for the PM Fine standard and helped Maryland get very close to meeting the old 85 ppb ozone standard.
  - The HAA (2006) was designed for these older standards

- The new 1-hour SO2 standard and the current 75 ppb ozone standard will require an enhanced regulatory scheme that focuses on:
  - Individual units and
  - Shorter term (hourly or daily) emission limits

NRG System Wide Compliance with the HAA

HAA set annual and ozone season caps and allowed "system-wide averaging
With tougher ozone standard and focus on "peak days" – units
that "under… …evaluated

	Morgantown Unit 1	Mor… U…			Dickerson Units 1 2 & 3	Total
2012 Annual NOx Tons	343	456	544	1,756	1,…40	4,581
2012-On Annual NOx	2,094	2,079	1,166	1,223	1,736	8,098
		195	98	828	761	2,034
2012-On Ozone NOx Limit, Tons	868	864	503	542	760	3,567

These two numbers show Annual tons emitted well under annual limit

Units with Red font use credits from units in Grey font to meet annual HAA Limit

These two numbers show Ozone Season tons emitted well under Ozone Season limit

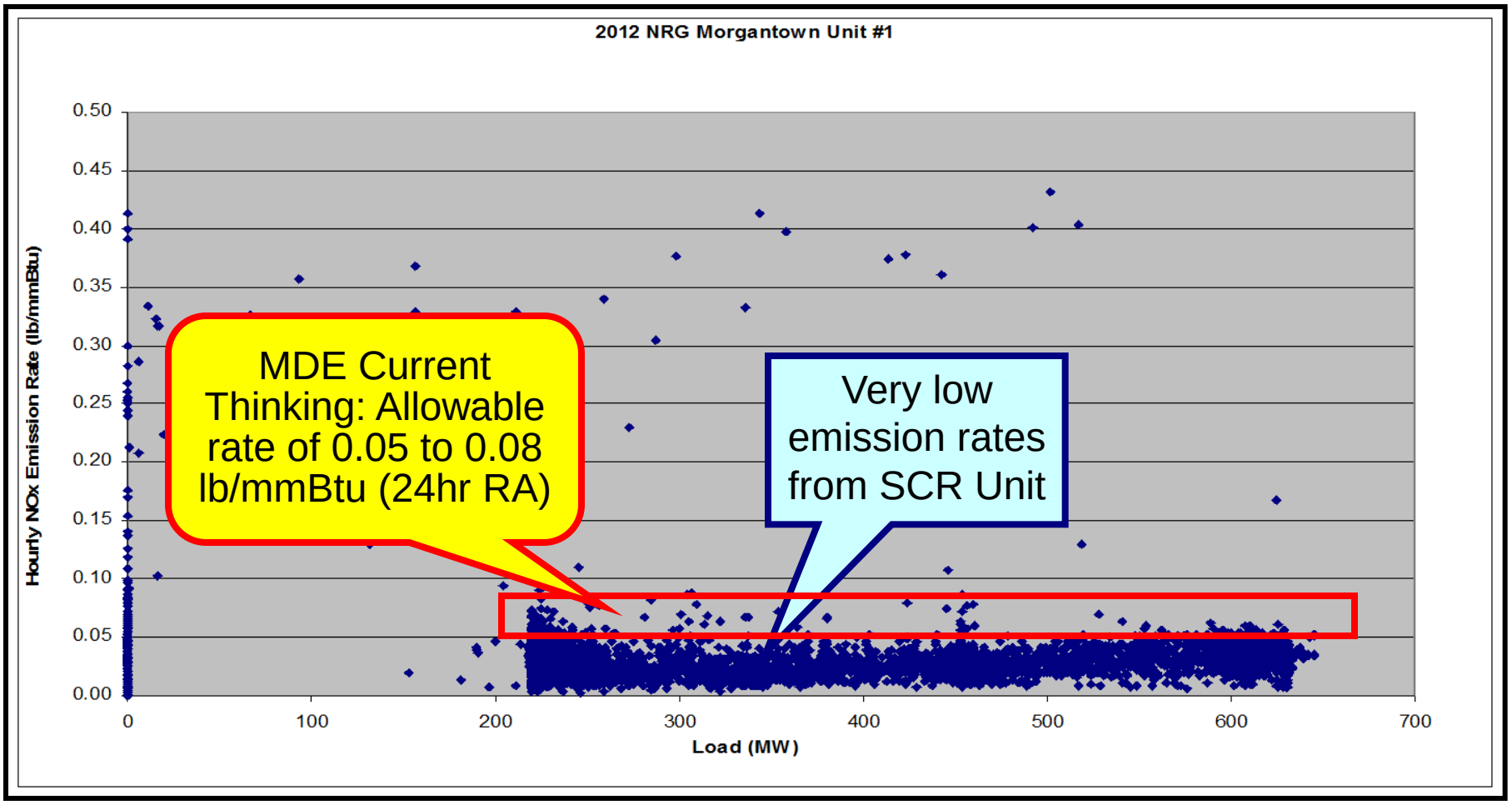
NRG – Morgantown

- Built in 1967
- Boiler types
  - Units 1 And 2 are both coal burning T-fired units - manufactured by Alstom
- Installed SCR control systems in 2007 and 2008 (about $120M)
- Total capacity = 1,280 MW

Unit	Capacity (MW)	NOx Controls	Old NOx RACT 30-Day Rolling Average (lb/mmBTU)	HAA Facility Allowance (Tons)	2012 Average NOx Emission Rate (lb/mmBTU)
Morgantown Unit #1 Tangentially Coal Fired	640	Low NOx Burners, Over Fired Air, and SCR	0.70	Annual - 2,094 Ozone - 1,053	Annual - 0.032 Ozone - 0.032
Morgantown Unit #2 Tangentially Coal Fired	640	Low NOx Burners, Over Fired Air, and SCR	0.70	Annual - 2,079 Ozone - 1,048	Annual - 0.031 Ozone - 0.030

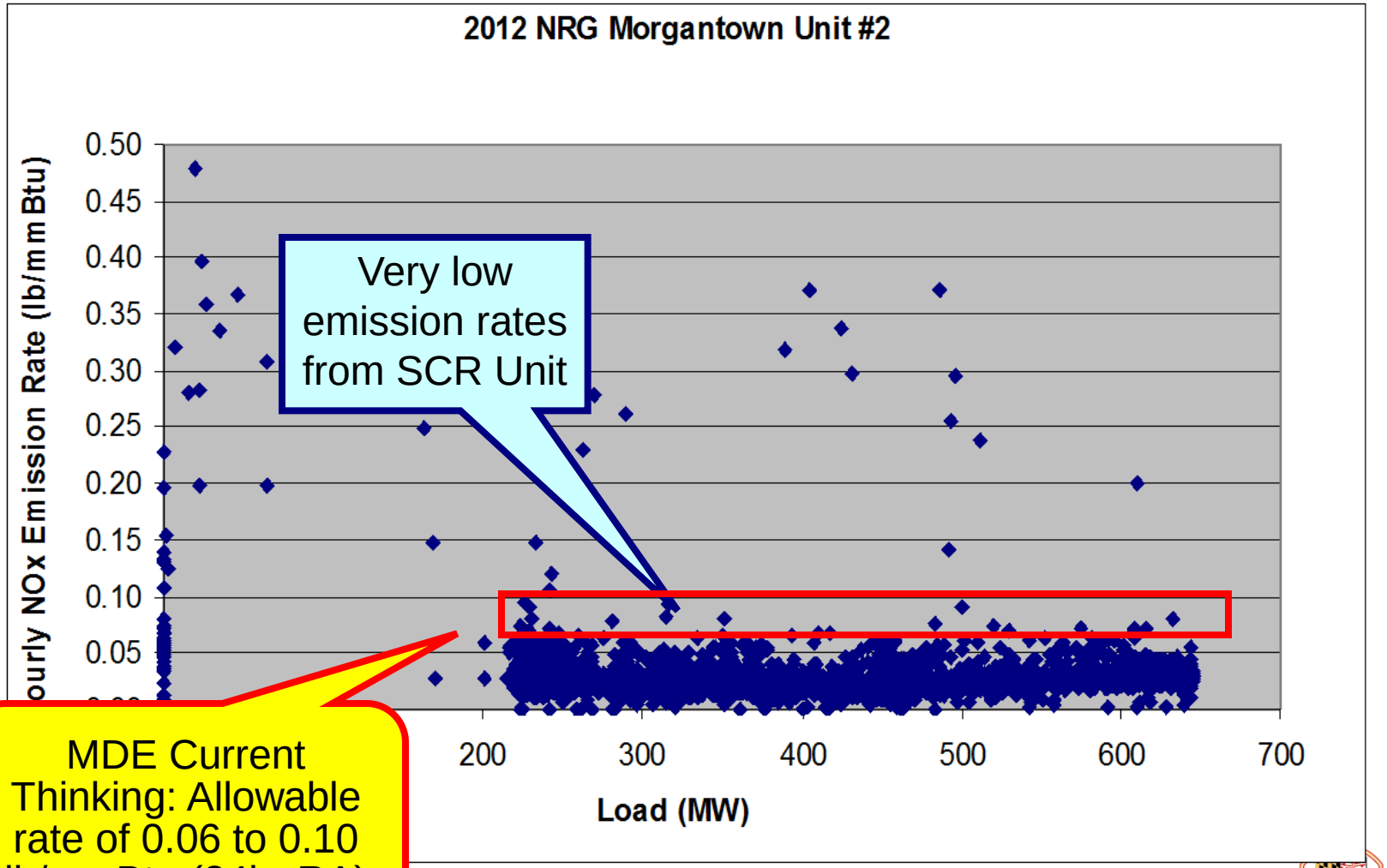
Morgantown Unit 1

Current Controls - SCR



Morgantown Unit 2

Current Controls - SCR



Morgantown - Conclusions

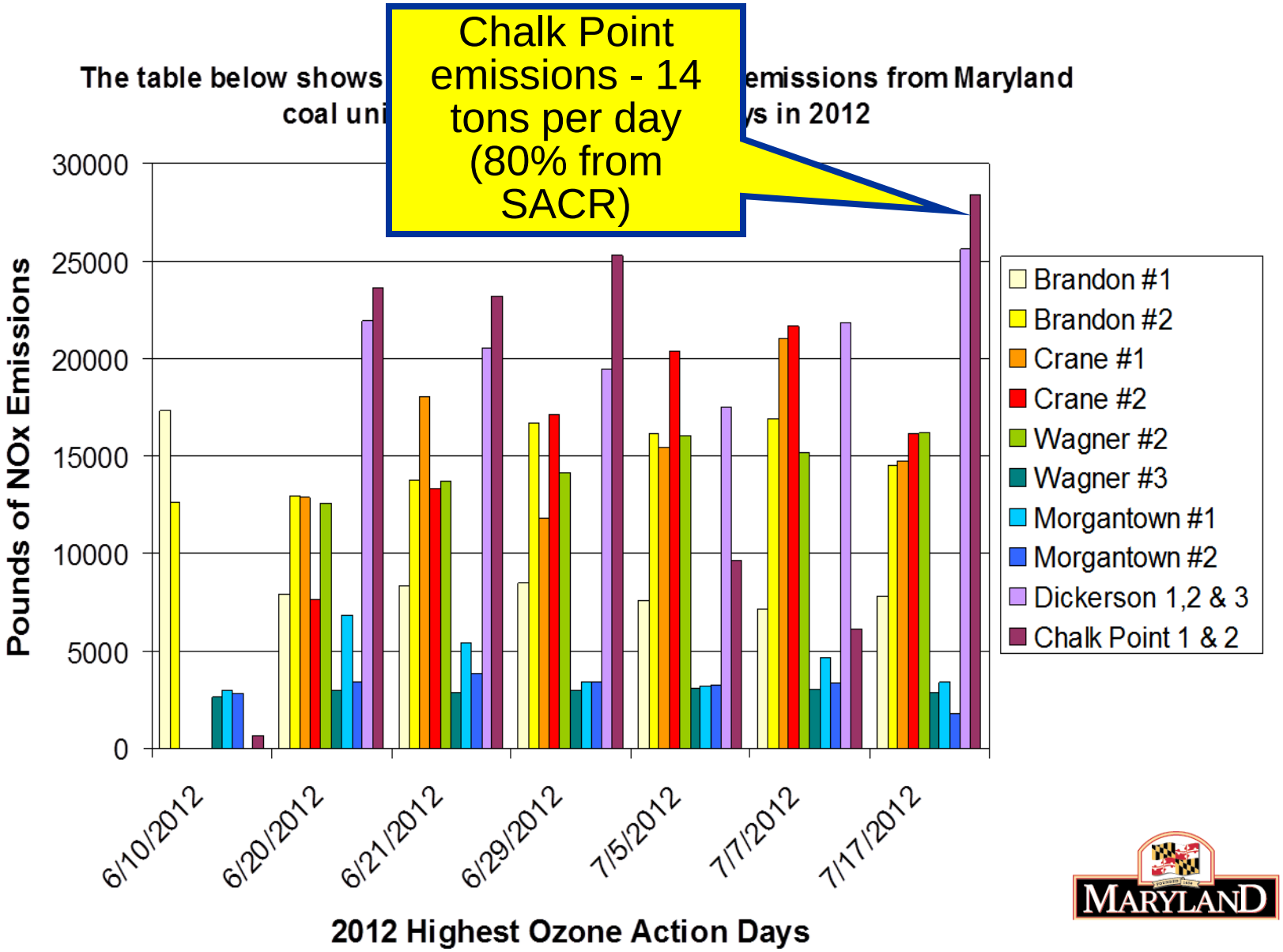
- Both units experience excellent operation and run controls all year long
- Current thinking - 24 Hr Rolling Avg NOx Emission Limit of 0.05 to 0.08 lb/mmBtu for Unit 1
- Current thinking - 24 Hr Rolling Avg NOx Emission Limit 0.06 to 0.10 lb/mmBtu for Unit 2

Chalk Point

- Built in 1964, Boiler types:
  - Units 1 and 2 are both coal burning Combustion Engineering Wall fired units
  - Units 3 and 4 are oil fired
- Installed a SCR control system on Unit 1 in 2008 ($60M) and a SACR control system on Unit 2 in 2006 ($20M)
- Total capacity = 2000 MW

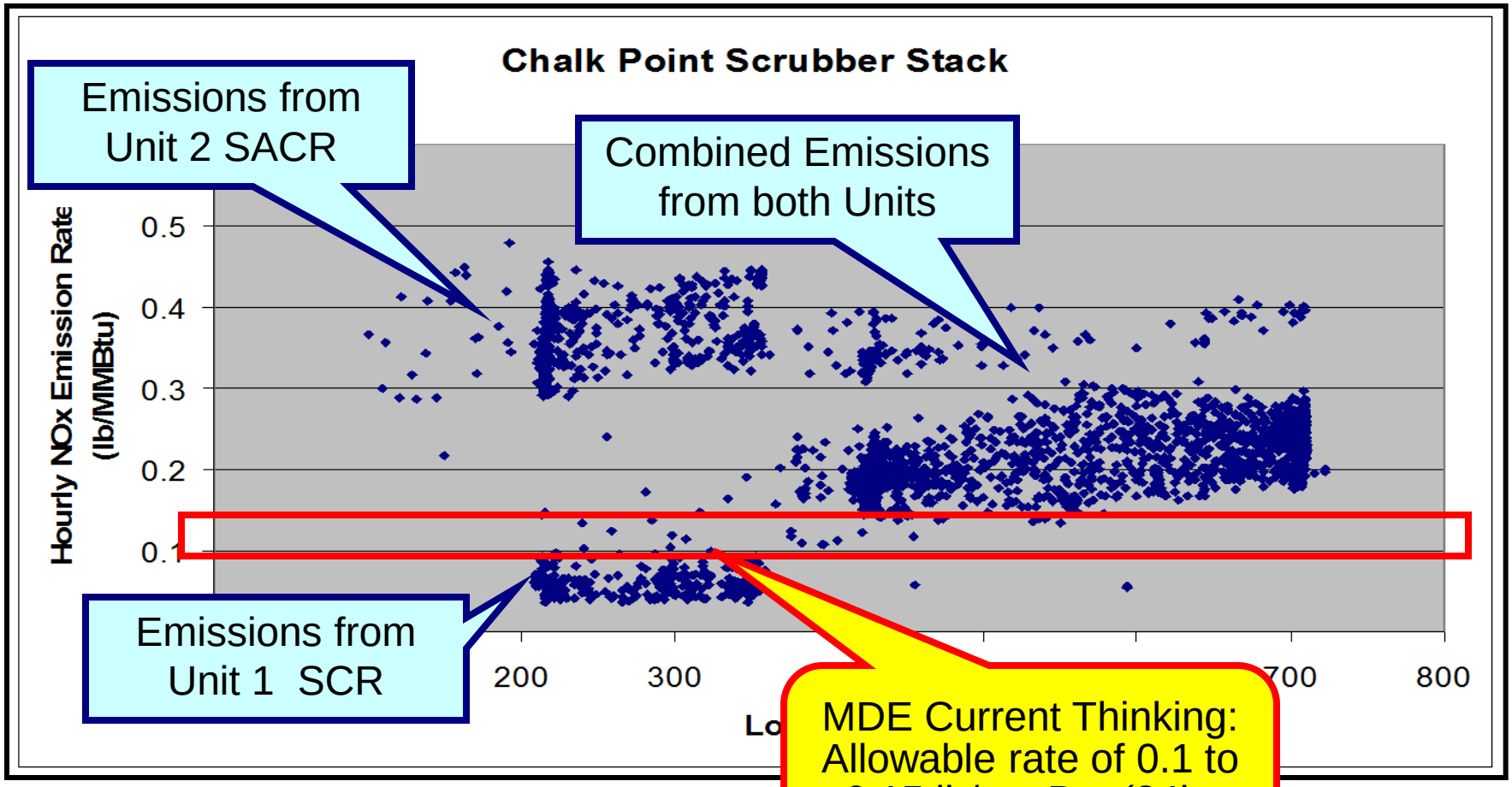
Unit	Capacity (MW)	NOx Controls	Old NOx RACT 30-Day Rolling Ave. (lb/mmBTU)	HAA Facility Allowance (Tons)	2012 Ave. NOx Emission Rate (lb/mmBTU)
Chalk Point Unit #1 Wall Fired Fuel: Coal	355	Low NOx Burners, Over Fired Air, and SCR	0.80	Annual – 1,166 Ozone - 611	Annual – 0.063 Ozone - 0.068
Chalk Point Unit #2 Wall Fired Fuel: Coal	355	Low NOx Burners, Over Fired Air, and SACR	0.80	Annual – 1,223 Ozone - 657	Annual – 0.368 Ozone - 0.343
Combined Stack (Both Units 1 & 2)	710	As listed above	0.80	Annual – 2,389 Ozone - 1,268	Annual – 0.229 Ozone - 0.201

NOx Emissions on Peak Ozone Days



Chalk Point - 2012

Current Controls – SCR on Unit 1 – SACR on Unit 2
Both Units discharge through a common stack



Deeper Reductions at Chalk Point 2

- In filings with the U.S. Securities and Exchange Commission, GenOn Energy (now NRG) discussed plans to add SCR control technology at Chalk Point Unit 2 by the 2018 to 2021 timeframe
- Because of Maryland's severe ozone nonattainment problems, MDE believes these controls need to be implemented in a timeframe consistent with the CAA's attainment deadlines
- SCRs at Chalk Point 2 would significantly reduce NOx
  - 0.08 to 0.10 lb/mmBtu
- Operational by 2015 to support Moderate area attainment needs

Chalk Point - Conclusions

- SACR Selective Auto Catalytic system on Unit 2 much less efficient then SCR on Unit 1
  - Results in high peak day NOx emissions
- Current thinking:
  - Through 2015 - 24 Hr Rolling Average NOx Emission Limit of 0.10 to 0.15 lb/mmBtu for combined stack.
  - By 2015 - 24 Hr Rolling Average NOx Emission Limit of 0.08 to 0.10 lb/mmBtu for combined stack.

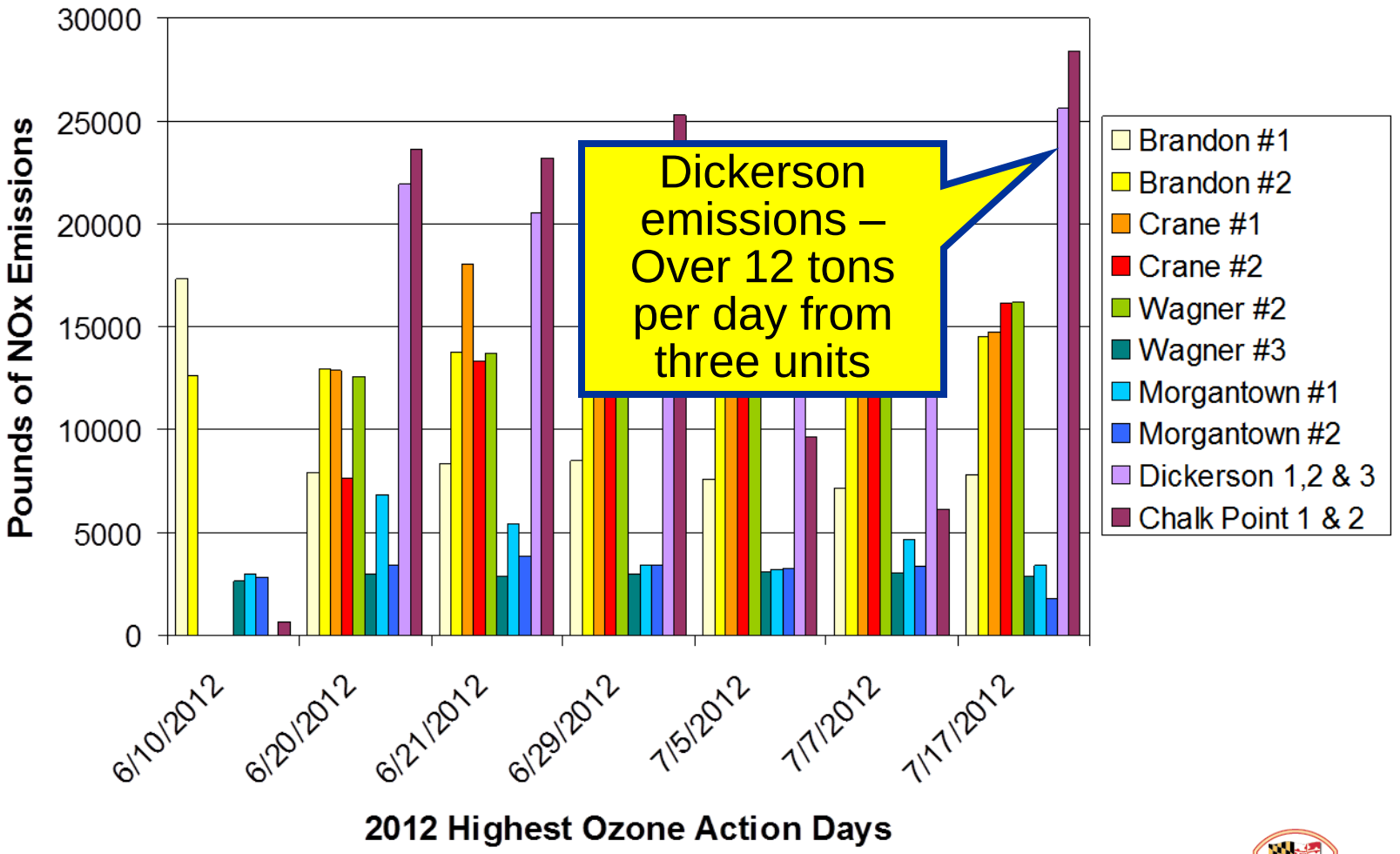
NRG - Dickerson

- Built in 1960
- Boiler types
  - Units 1,2, & 3 are both coal burning Combustion Engineering T-fired units
- Installed a SNCR control systems in 2009 ($15M)
- Total capacity = 570 MW

Unit	Capacity (MW)	NOx Controls	Old NOx RACT 30-Day Rolling Ave. (lb/mmBTU)	HAA Facility Allowance (Tons)	2012 Ave. NOx Emission Rate (lb/mmBTU)
Dickerson #1 T Fired Fuel: Coal	190	LNCFS III, and SNCR	0.80	Annual – 554 Ozone - 257	Annual – 0.26 Ozone - 0.26
Dickerson #2 T Fired Fuel: Coal	190	LNCFS III, and SNCR	0.80	Annual – 607 Ozone - 274	Annual – 0.26 Ozone - 0.26
Dickerson #3 T Fired Fuel: Coal	190	LNCFS III, and SNCR	0.80	Annual – 575 Ozone - 259	Annual – 0.25 Ozone - 0.26
Combined Stack: Units 1, 2, & 3	570	As listed above	0.80	Annual – 1,736 Ozone - 790	Annual – 0.26 Ozone - 0.26

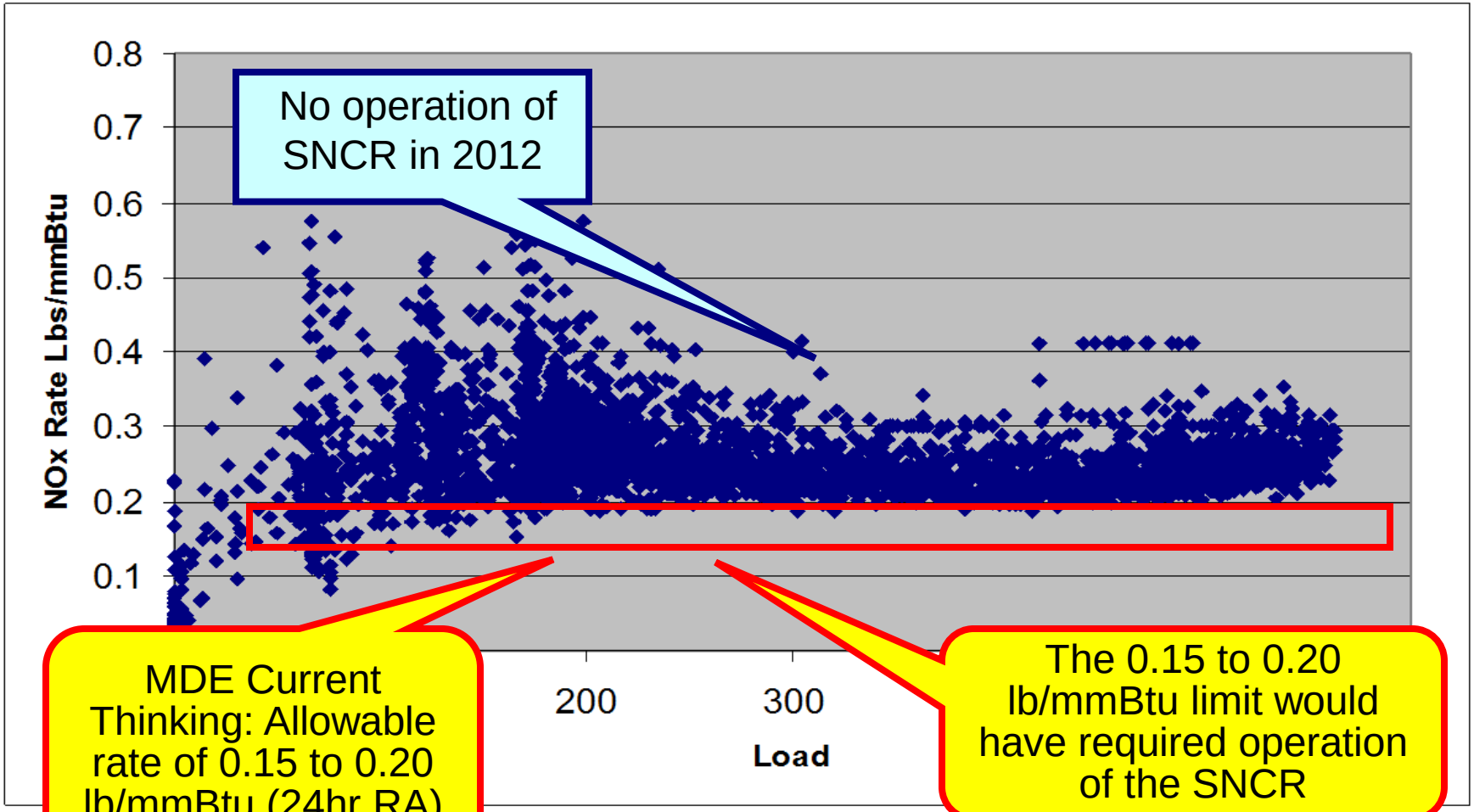
NOx Emissions on Peak Ozone Days

The table below shows the unit-by-unit, daily NOx emissions from Maryland coal units for the 7 worst ozone days in 2012



Dickerson Units 1 2 & 3 - 2012

Current Controls - SNCR

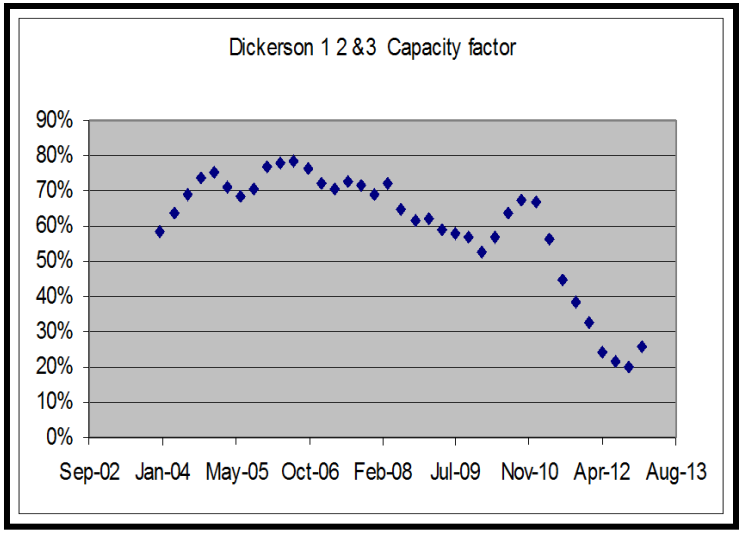


Deeper Reductions at Dickerson

- In filings with the U.S. Securities and Exchange Commission, GenOn Energy (now NRG) discussed plans to add SCR control technology at Dickerson by the 2018 to 2021 timeframe
- Because of Maryland's severe ozone nonattainment problems, MDE believes these controls need to be implemented in a timeframe consistent with the CAA's attainment deadlines
- SCRs at Dickerson would significantly reduce NOx
  - 0.08 to 0.10 lb/mmBtu
- Operational by 2015 to support Moderate area attainment needs

Dickerson – Conclusions

- Dickerson has not ran SNCR since 2009
- 2009 testing of SNCR showed a 15 -20% drop in NOx Rate
- Capacity factor significantly decreased at Dickerson
- Current thinking
  - Through 2015 - 24 Hr Rolling Avg NOx Emission Limit of 0.15 to 0.20 lb/mmBtu
  - By 2015 - 24 Hr Rolling Avg NOx Emission Limit of 0.08 to 0.10 lb/mmBtu



NRG – Current MDE Thinking

Short-Term NOx Limits

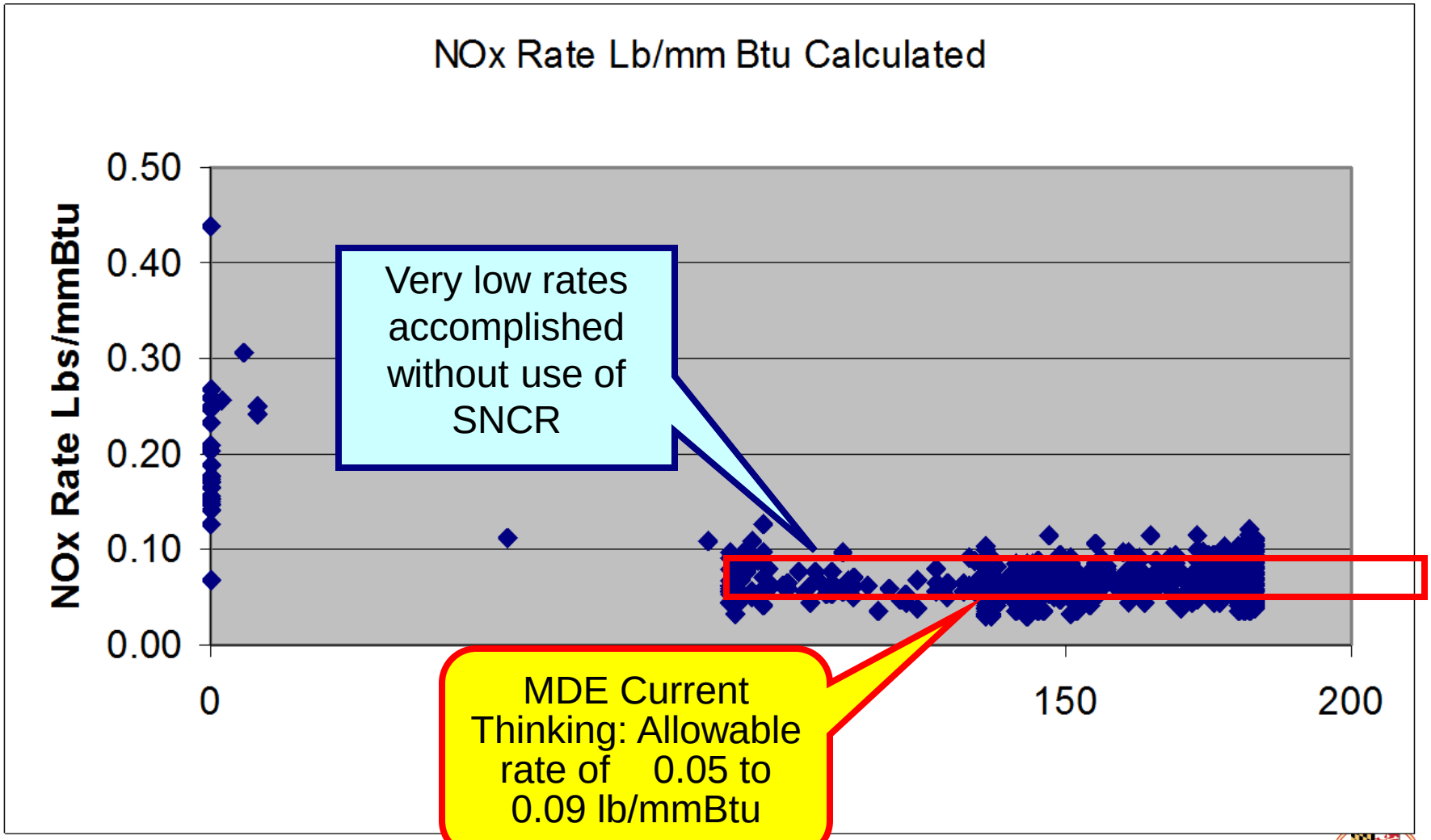
Coal Fired Units	Old NOx RACT	MDE Current Thinking Updated NOx RACT
Chalk Point 1 & 2 Common Stack (SCR & SACR)	0.80 lb/mmBtu 30 Day Rolling Average	0.1 to 0.15 lb/mmBtu 24-hr Rolling Average By 2015 – 0.08 to 0.10 lb/mmBtu 24-hr Rolling Average
Morgantown 1 (SCR)	0.70 lb/mmBtu 30 Day Rolling Average	0.05 to 0.08 lb/mmBtu 24-hr Rolling Average
Morgantown 2 (SCR)	0.70 lb/mmBtu 30 Day Rolling Average	0.06 to 0.10 lb/mmBtu 24-hr Rolling Average
Dickerson 1,2 & 3 Common Stack (SNCR)	0.70 Lb/mm Btu 30 Day Rolling Average	0.2 to 0.25 lb/mmBtu 24-hr Rolling Average By 2015 – 0.08 to 0.10 lb/mmBtu 24-hr Rolling Average

AES Warrior Run

- Built in 2000
- Boiler types
  - ABB Combustion Engineering coal fired circulating fluidized bed (ACFB)
  - Well controlled by inherently low emitting design of fluidized bed boiler.
- Total capacity = 205 MW

Unit	Capacity (MW)	NOx Controls	NOx RACT 30-Day Rolling Average (lb/mmBTU)	HAA Facility Allowance (Tons)	2012 Average NOx Emission Rate (lb/mmBTU)
Warrior Run #1 Fluid Bed Fuel: Coal	290	SNCR	n/a	n/a	Annual – 0.08 Ozone - 0.07

AES Warrior Run - 2013



AES Warrior Run – Conclusions

- Very low rates accomplished with inherently low emitting design of the fluidized bed boiler
- Warrior Run is not included in HAA
- SNCR is not operated
- Current thinking - 24 Hr Rolling Average NOx Emission Limit – 0.05 to 0.09 lb/mmBtu

Alternative NOx RACT Concept

… being considered

- Averaging within a system for NOx and ozone makes sense if averaging results in peak day reductions equal to or greater than the reductions from unit-by-unit limits
- MDE is continuing to analyze an option that may provide flexibility while achieving equal or greater reductions
- Current thinking – Alternative RACT:
  - System-wide average rate of 0.10 lb/mmBtu as a 24-hour rolling, and
  - System-wide average rate of 0.08 lb/mmBtu as a 30-day rolling average

Next Steps - NOx

- Continue to analyze hybrid SCR/SNCR system at Crane
- Continue to analyze SCR controls at Chalk Point and Dickerson
- Continue to analyze system-wide alternative RACT
- Continue to work with EPA on start-up/shut-down issues
- Continue to work with stakeholders on proposed limits
- Suggest that December meeting focus solely on NOx RACT limits