Undertaking 83 **Exhibit No. _____**

Potomac to provide their view as to what carbon price would be required to make hydro more economic than coal (4654).

RESPONSE:

Potomac Economics interprets this question to be asking whether some carbon price level can cause hydro to be dispatched lower in the "competitive supply stack" relative to coal. By "competitive supply stack," we mean the economic merit-order from low to high as-offered cost in MISO markets under competitive offers (no market power).

Competitive hydroelectric power offers are based on inter-temporal opportunity costs so that limited reservoir capacity is offered to the market in order to maximize revenues, i.e., offered so that it is selected only in the highest-priced on-peak hours. This, in turn, can depend on reservoir levels because the optimal participation in MISO markets will depend on the amount of water in that can be converted to power in a given year.

Under existing natural gas and coal prices, coal is lower in the competitive supply stack than natural gas CCGT capacity. Therefore, in order for hydro units to selected in the highest-priced hours in a given year, hydro would be offered optimally at an offer corresponding to the heat rate of a natural gas-fired CCGT. In this way, the market will select hydro capacity only during the highest-priced on-peak hours. In years when reservoirs are higher, offer may be slightly lower in order to sell in a larger share of the on-peak hours.

Hydro resources would offer at costs lower than coal-fired capacity if coal-fired capacity evolved to be the on-peak marginal resource displacing natural gas and CCGT capacity. The attached table shows the level of carbon cost that would be necessary to cause the average coal unit to be more expensive than the average MISO CCGT unit. We use projected fuel costs for 2020 (in 2013$) and average operating characteristics, we calculate a carbon cost of $37 would make the marginal operating cost of a CCGT lower than the marginal operating cost of a coal unit.

It is not likely, at least in the immediate term (next ten years), for coal to completely displace natural gas capacity during on-peak hours. This simply because there is not enough natural gas capacity to serve all base-load needs and coal capacity will continue to be committed and operated for the bulk of base load hours. However, if coal costs are higher than CCGT costs,

hydro units may offer below the cost of coal in order to optimize the use of water supply. But there will still likely be large quantities of coal used in base load so the hydro units will be in the supply stack mixed in with coal and natural gas units on the margin during peak hour. This will depend on the reservoir levels and the relative costs of natural gas and coal capacity.

Table

	MISO-Wide Average								
Unit Type	**Fuel Delivery (/MMBtu)**	**Commodity (/MMBtu)**	**Heat Rate (Btu/KWh)**	**Fuel Cost (/MWh)**	**Carbon Cost (/T)**	**Emission Factor (T/MMBtu)**	**Emission (/MMBTU)**	**Emission (/MWh)**	**Marginal Cost w/Carbon Price (/MWh)**
CCGT-Average	$0.50	$4.32	9000	$43.38	$37.00	0.053	$1.96	$17.62	$61.00
Coal Avg	$1.50	$1.07	10000	$25.70	$37.00	0.096	$3.57	$35.65	$61.35