# Comments from MDE on Algal Flow Way Technologies

I've done an initial review and here are some of my comments:

1) I did not see if there was an offset for when harvests are conducted, which reduce biomass and the amount of reductions in the default values. (I think it was a question of whether the equations are influenced by an average vs. total capacity of the practice given that when harvested, the amount of nutrient uptake by the leftover algae is likely much less than a system full of growing algae.)

Or are the equations assuming full growth at all times, with respect to the seasonality?

The panel would like to emphasis how simple the algorithm is for calculating AFT nutrient removal. All that is needed is biomass harvest (in units of g/m2/day) multiplied by the nutrient content (in units of %N or P)...This makes this BMP very transparent and VERY Easy to verify nutrient removal capacity. The report is written with conservative language but based on lots of field experiments and lots of published results, the AFT removes nutrients at a high rate when operated under appropriate conditions, and we hope the reviewers understand this from the text...

We are assuming this is a question on the default credit only, because the direct sampling credit is based on production weights and direct subsampling of nutrient and sediment content. Direct sampling requires a composite of multiple subsamples across the harvested biomass to represent average characteristics (page 16). Reporting dry weight of biomass (and TP and TN content) integrates nutrient removal over the entire harvest cycle, capturing seasonal variations and differences in production that might occur for any number of reasons (page 14).

For both approaches, the winter season is not included, we use a growing season of 240 days. "The Panel also used the equation to calculate the average annual nutrient reductions likely achieved by an AFT, but recommended that these average reductions be calculated using a growing season of 240 days because algal production typically diminishes or stops during colder months" – page 13

Both approaches use the same units of measure: productivity is expressed as grams of dry weight per meter squared per day, multiplied by the percent nutrient content of the dry biomass expressed as grams of dry weigh of nutrient per gram of dry weight, multiplied by growing season in days at 240, and then multiplied by units of measure to get to pounds per surface area of flow-way. Productivity and growing season are expressed on a daily scale, this can be viewed as an offset for when harvests are conducted.

2) What is the overall efficiency of this practice? There is no mention of to what degree it actually benefits water quality. Only states a default of lbs/acre/year.

The expert panel concluded that estimates of mass N and P content in harvested biomass generally provided scientifically sound values for estimating the nutrient removal effectiveness of any system. To determine an efficiency, influent/effluent sampling would be used and the panel concluded this type of sampling may not accurately reflect the total nutrients and sediments removed by AFTs because algae cultivation rates drive nutrient and sediment reductions, and

those rates change with the degree of the slope, screen dimensions, seasons, flow rates and slope length. One efficiency applied against an ambient nutrient concentration would not reflect variations in algal production across all the flow-way designs.

To get an idea of removal from the sites already established in the watershed, the reports states, "The range of nitrogen removed was 689 lbs/acre/year to 1,251 lbs/acre/year, while the range of phosphorus removed was 25 lbs/acre/year to 130 lbs/acre/year (see Tables 3 and 4)."

To summarize, overall efficiency can be done easily with an AFT but the numbers are not really relevant, as they might be for other kinds of BMPs. For the AFT, the water is flowing fast across the turf and net uptake of nutrients just doesn't show up clearly by comparing influent and effluent concentrations. Instead, the load rate is relevant (influent concentration x water flow rate) and can be compared with biomass harvest nutrient removal rates, but this kind of efficiency doesn't really relay what the reviewers might be asking....Ultimately I think what is important is the absolute nutrient removal rate, not the efficiency of removal, when a BMP is considered. As to the reviewer comment, the report does precisely mention to what the AFT "actually benefits water quality" and it is quantified by the absolute nutrient removal rate that is easily measured.

3) Also is acre/year only for the surface area of the AFTs? or is there some implied upland benefit for non-tidal AFTs.

The calculation to determine the pounds reduced is again the surface acreage of the AFT in operation each year. The total pound reduction is then applied against the proportion of upland acres.

4) Also, would there be any transfer of nutrient load depending on the end use of the algal by-products? (e.g. use as feed or fertilizer) and how would that be modeled?

The report states that "acceptable uses include disposal in a landfill or displacement of nutrients through fertilizer resale and/or applications under a nutrient management plan, animal feed, etc." (page 19).

**Ask Jeff and Oliva and Matt**

5) What other possible side effects of the practice will occur as you start to increase the size of these? I'm thinking in terms of how it would affect infiltration of rainfall, does this become an impervious surface?? Specifically in areas that were not impervious before like agriculture or rural areas?

Yes, this would become an impervious surface in the sense that infiltration into subsurface flow and groundwater would be impeded and could be implemented on landuses that were pervious. There is that potential. However, most of the small-scale systems already in the watershed were constructed on existing impervious surface (parking lot). Also as the additional considerations section of the report discusses, landuse alterations were considered by the panel and the Habitat GIT. The language in the report specifically states, "It is the

recommendation of the Habitat GIT and expert Panel that forested parcels be avoided as sites for AFT facilities to reduce habitat and wildlife impacts." Ultimately, it is the responsibility of each jurisdiction's permitting agency to determine eligible locations for AFT facilities. Forest Conservation Act, Critical Area Laws, and other such protective measures are in place for Maryland and any AFT would be required to abide by those regulations.

Overall, this comment is relevant. The AFT does create impervious surface. However, there is no nutrient runoff in this case since the algae take up any nutrients added from the rain events. Of course, there is less infiltration and this is unavoidable we think. If this became a big issue, we might design a way to infiltrate effluent from the AFT but this won't be an issue until large areas of AFT are constructed.

6) Sediment reductions seems to be based on the algae mass and not correlated to the sediment in the water at the intake. This is not representative of actual sediment reduction that a BMP would remove from the watershed. Depending on the location of the scrubber sediment, especially fines, could be from other sources.

We recommend removing the sediment reduction unless it is shown that the AFT is removing sediment from the watershed not just a reduction based on weight of the ash.

Algal flow-ways have been shown to also remove sediment from the water column. Sediment is removed from the influent water by attachment to the filamentous algae or substrate and settling of sediment from the water column at the base of the raceway. Settled sediment is not included in the credit as it was assumed large flow events would wash this deposited sediment back into the receiving surface water.

There is an accumulation of inorganic material deriving from mineral sediments as well as the inorganic matrices of organisms (e.g., diatom frustules) captured in the total sediment fraction. The following equation is used in the report to only equate sediment reductions to the inorganic mineral sediments:

(Harvested Solids (kg) – Ash-Free Solids (kg)) x (% Inorganic Content) = Sediment (kg) Removed

The critical parameter in the equation is the % Inorganic Content. The ash content of harvested algal biomass contains both biogenic and non-biogenic inorganic materials. The main biogenic materials are silica shells (frustules) of diatoms, while the main non-biogenic materials are inorganic sediments that become attached to the algae and the screens. Since diatoms often are the dominant taxa in harvested algal biomass, their contribution to the total ash content is accounted for and removed from the % Inorganic Content term in the above equation in order to estimate sediment removal rates reliably. Thus the weight of the ash is not the sediment credit, only the non-biogenic materials are credited.

*The panel report was edited to include language that better describes the sediment credit. Page 14, third sentence in first paragraph and the second paragraph were added.*

To summarize, sediment removal rates are much less clean nutrient rates, but significant amounts are removed and we have done the best we can to estimate the rates. Based on experience, some panel members disagree with the report when it is suggested that captured sediments are flushed out during storm events but we have very little data on this so perhaps it is best to leave the language conservative.

7) AFT should not start to receive credit until it is shown that they are actually growing algae.

We agree and trusted the jurisdictions would utilize verification protocols to help ensure production! The direct sampling credit would require lab results that would be derived from actual harvested biomass. But the panel also included measures for anyone utilizing the default credit. In Appendix C, the verification requirement for AFT requires jurisdictions to submit in an annual report a description of how harvested biomass was stored, description of the end-use of the biomass and the operation and harvest dates. The panel also included language that would only allow an AFT to receive credit once algae is growing, "Jurisdictions may also wish to consider requiring receipts of biomass weight for any biomass leaving the operation."

Dave Montelli from West Virginia also called with two questions:

8) Who receives credit for the nutrient and sediment reductions?

The second sentence in the report states "Only operators that transport the nutrients and sediment offsite for end use or disposal, or apply the nutrients according to a nutrient management plan are eligible for this credit."
It is up to each jurisdiction to determine if a permit holder, private group , or any other entity is awarded the credit. *The report was edited to articulate that credit eligibility is to be determined by each jurisdiction. Page 19 new subsection called Credit Eligibility.*

9) Can the AFT be simulated in the model as a "negative pipe" instead of an upslope or adjacent landuse credit? This is just a question and Dave stated he was comfortable approving the report with the credit as is, he is just hoping this could be done in the future in case AFT systems become large contributors to water quality improvement.

Jeff and Olivia are tackling this one