Agricultural Nutrient Nonpoint Source Credits: A Comparison of State Crediting Procedures

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Introduction

For over 30 years, the Chesapeake Bay has been the focus of concerted federal and state efforts to improve water quality conditions through the reduction of nutrient discharges. Despite these long-term efforts, water quality standards established for the Bay have not been achieved. Recently, a Presidential executive order, court decision, and the issuance of a basin-wide TMDL (total daily maximum load) have put new pressure on Bay states to devise implementation strategies in order to reach nutrient reduction goals.

Virginia and Pennsylvania have developed nutrient trading programs as a part of their water quality management programs for the Chesapeake Bay. Both states include agricultural nonpoint sources in their emerging nutrient trading programs. Several bills in Congress (S.1816 and H.R. 5509) promote the development of interstate trading programs as a way to facilitate achievement of water quality goals. Any interstate trading effort will require federal and state water program managers to reconcile differences between state programs. If successful, the Chesapeake Bay would be the first application inter-state water quality trading anywhere in the United States.

A fundamental element of any water quality trading program is the procedure used to commodify the nutrient reduction services, in the form of a nutrient credit, generated by agricultural sources. Defining nutrient credits involves a minimum of three general items: quantifying nonpoint source load changes, identifying a baseline from which to measure and credit reductions, and identifying trading ratios that may be imposed to ensure water quality equivalency between trading sources. State crediting procedures can differ at each step. Significant differences in nutrient crediting procedures could produce considerable discrepancies in the number of credits any particular farm could generate, substantially impacting the cost of producing a credit, farmer participation rates, and water quality outcomes.

The objective of this paper is to compare and evaluate agricultural nonpoint source crediting procedures between the Pennsylvania and Virginia nutrient trading programs.[1] Differences in farm-level credit production across states will be evaluated for agricultural operations, holding nutrient reduction technologies and watershed characteristics constant. The implications of the analysis for the participation of and economic impact for the farm sector in trading and the potential impact on water quality will be discussed.

[1] Maryland is also developing a trading program that includes nonpoint sources, but the crediting procedures have not yet been finalized.

Agricultural Nonpoint Source Credits

While the concept of effluent trading program is conceptually straight-forward, the diversity in the design and implementation is quite large (Shabman et al. 2002; Woodward and Keiser 2002). For example, different approaches can be used to define the transferable commodity. One type of trading program allows for a system of reallocation of effluent load control responsibilities within (or under) a predefined effluent load cap. Such a trading program grants dischargers authority to transfer allowances to other dischargers subject to the cap. Allowances may be defined when the cap is set by allocating a fixed number of discharge authorizations to all the sources under the cap, with the sum of the authorizations equaling the cap.

The second approach involves defining the transferable commodity only after actions are taken by a discharger. Effluent reductions achieved beyond an identified "baseline" (over compliance) generate a credit that can be then traded. Unlike allowances which are defined in advance, credits are only created by the voluntary actions of the discharger (Shabman et al 2002; Horan and Shortle 2010). In water quality programs, this situation universally applies to sources that face no mandatory regulatory or effluent control limits, typically considered to be nonpoint source discharges from agricultural operations. The load reductions eligible for trading by a nonpoint sources are calculated as the difference between effluent load and a defined baseline level of discharge.

A number of discretionary policy choices are required to define nonpoint source credits. Defining a credit requires an approved credit-generating methodology including how to quantify nonpoint source loads. Conceptually loads may be expressed as a measurement of pollutant load (lbs per acre over a given time period) or as a minimum set of technologies (BMPs) or by estimated loads based on observable changes in inputs a potential credit supplier implements (Horan and Shortle 2010). Since direct measurement of nonpoint source loads are typically thought to be cost prohibitive, quantifying changes in nonpoint source discharges is typically done with modeled load estimates.

Credit calculations also require identification of a baseline. Nonpoint source baselines are not regulatory requirements, but benchmarks from which to measure changes in nonpoint source loads. Baselines may be defined as the estimated load being discharged by a particular source at particular time. Conversely, baselines may be defined by a specific minimum level of effluent control performance or technology adoption that must be achieved by the credit generating source. For example, EPA guidance suggests nonpoint source baselines in impaired watersheds should be consistent with the level necessary to achieve ambient water quality standards (USEPA 2007; Ribuado et al. 2009).

Defining baselines has implications both the cost of generating a nonpoint source credit and the achievement of water quality objectives (Ribaudo et al. 2009; Stephenson et al 2009). Baselines are closely related to the additionality concept. Additionality is defined as load reductions that occur as a result of a trade, but would not have occurred in

absence of a trade. Additionality assures that net nonpoint source pollutant loading reductions are achieved as a result of a trade. In point source-nonpoint source trading, violation of additionality could occur when a nonpoint source receives credits for actions that have already been implemented for reasons unrelated to any possible trade. If the agricultural operation can then sell these credits to a regulated point source, then no additional on the ground effluent reductions are achieved to offset the higher point source load. More rigorous baselines would be expected to provide greater assurance that additionality is achieved.

Trading programs must also translate spatial and source heterogeneity of pollutant loads into equivalent water quality results, called equivalence (Stephenson et al 2009). Quantifying discharges for any particular source or classes of sources might have different degrees of certainty surrounding measurement of actual effluent load discharge. Measurement uncertainty is expected to be different between sources that measure effluent load directly (point source) and those sources (e.g. nonpoint sources) where effluent loads are quantified by models. In addition, nonpoint source are typically thought to exhibit greater variability in loads (e.g weather related events). Water quality trading programs often develop and impose uncertainty trading ratios to address differences in uncertainties with the measurement or quantification of effluent load.[2]

Overview of Pennsylvania and Virginia Agricultural Nutrient Credit Programs

Although state nutrient credit programs have the same basic conceptual elements, Virginia and Pennsylvania have fairly disparate programs in terms of specificity of baseline procedures, equivalency policy, and credit calculation.

In general terms, Virginia and Pennsylvania define baselines for agricultural sources by identifying a minimum number of best management practices that must be implemented prior to generating credits. The number and stringency of the baselines, however, differ considerably across the two states. Virginia requires implementation of five minimum BMPs for any agricultural operation. These minimum control measures include developing and implementing an approved nutrient management plan, an approved soil conservation plan, planting of winter cover crops, livestock exclusion from streams, and a 35 feet minimum riparian buffer (Virginia Department of Environmental Quality 2008). Baselines in Virginia are derived from statutory requirements. Under Virginia law, nonpoint source credits are defined as reductions in nutrient loads above and beyond reductions required by state law or called for by Virginia's plans to meet Chesapeake Bay water quality goals (called "tributary strategies") (§62.1-44.19:15.B.1b). The minimum baseline practices are those practices most frequently selected (identified) by the state as necessary to meet state tributary nutrient reduction goals.

By comparison, Pennsylvania defines attainment of the baseline as being compliant with state nutrient management standards, as verified by a certified nutrient manager. In addition, Pennsylvania requires land owners to meet one of three baseline (called

[2] Trading ratios required to account for differential spatial impacts are sometimes called "attenuation ratios"

"thresholds") before credits are granted. For farm operations that apply manure, the credit generator must not apply any manure within 100 feet of surface waters. Those farms that do not apply any manure, farms must apply commercial fertilizer at or below recommended agronomic rates. Second, baseline may be met through the establishment of a minimum 35 ft vegetative buffer along surface waters. Finally, a 20% reduction in the farm's overall nutrient balance beyond the amount under state management standards maybe selected as a baseline requirement (Pennsylvania Department of Environmental Protection, 2006).

Once farm operations have achieved baseline, both Virginia and Pennsylvania use water quality models, or calculations derived from water quality models, to quantify the nutrient reductions and credits generated by specific nutrient reducing activities. In Virginia, nutrient reductions are assigned to a specific set of practices identified by regulatory agencies. Nutrient credits can be generated by planting early cover crops, reducing nitrogen by 15% on corn, implementing a continuous no-till system of nutrient management, converting agricultural land to less nutrient intensive uses (land use change measured after at July 1, 2005), or a combination of the listed practices. Nutrient reductions are published in look-up tables provided by the DEQ, and denominated in terms of per acre reductions of pounds of nitrogen and phosphorus reaching the Bay (called "delivered" loads). Nutrient reduction values are published for all combinations of the BMPs and vary within and across watersheds within the state. The published nutrient reduction values are derived from loading rates and BMP efficiency values contained in the Chesapeake Bay watershed model and do not include the load reductions achieved through the application of baseline BMPs (Virginia DEQ 2008). Agricultural credit suppliers calculate the number of acres under each BMP then multiply by the value given in the table to give the total pounds of delivered nutrients reduced.

Pennsylvania's credit quantification procedure is somewhat more complex. Credit calculation worksheets are available from the Pennsylvania Department of Environmental Quality and are facilitated by a credit calculator called NutrientNet (available for download online in spreadsheet form). Users enter source specific information about a farm operation and the worksheet calculates credits generated from the applicable BMPs (Pennsylvania DEP, 2007). Information within the worksheet includes identification of the specific baseline requirement being applied, cropping and acreage information, nitrogen application rates and types, soil type, residual nitrogen, and applicable watershed segment. The watershed segments are differentiated according to attenuation factors, which compensate for the natural loss of nutrients and sediments as they are transported to the Chesapeake Bay. The attenuation factors are multiplied by the estimated site load reduction to determine the number of credits created. The parameters of the NutrientNet worksheet are based upon (with some modifications) loading estimates and BMP nutrient efficiency factors contained in the Chesapeake Bay watershed model.

Credit suppliers generate credits by implementing BMPs identified in the nutrient calculator spreadsheet. Common BMPs available to Pennsylvania farms include conversion of land from conventional till, conservation till, hay, or pastureland to riparian forested buffers; implementation of conservation plans and conservation tillage; planting

of early cover crops; retirement of highly erodible land; fencing livestock out of streams; and reduced fertilizer applications. Drop-down menus within the spreadsheet ensure that users are able to take advantage of multiple possible credit generating activities (Chesapeake Bay Program, 2007).

Virginia and Pennsylvania use different nonpoint source crediting procedures to ensure equivalency of water quality outcomes. In Virginia, the total nonpoint source credits available for sale to a regulated point source are adjusted by a 2:1 uncertainty trading ratio (a point source must purchase 2 pounds of nonpoint reductions in order to increase point source discharge by a pound). The 2:1 trading ratio is required by Virginia statute and is intended to reflect differences in certainty of load quantification between point and nonpoint sources. Pennsylvania does not apply any uncertainty trading ratio. Pennsylvania, however, does require that a nonpoint source credit supplier retire 10% of all credits traded (1.1:1 "retirement" ratio). Virginia does not apply a similar concept. The table below summarizes the major points of each nutrient credit-trading program for the two states.

Table 1: Summary of Credit Calculation Procedures, Pennsylvania and Virginia

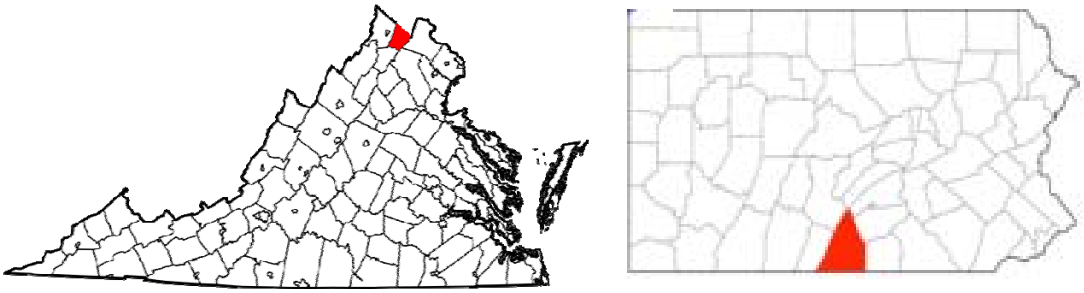
Credit Definition	Pennsylvania	Virginia
Nonpoint Source Baseline	Compliance with nutrient management standards plus and one of three baseline requirements	5 minimum BMP practices (nutrient & soil conservation plans, stream fencing, riparian buffer, cover crop)
Nutrient Quantification Procedure	Credit calculation worksheet calculates load reductions delivered to the Bay from the implementation of different BMPs.	Look-up table detailing delivered pounds per year of nutrients to the Bay reduced for a 4 conservation practices and land conversion
Trading Ratio (for equivalency)	None	2 non-point source credits required to offset 1 lb of point-source nitrogen discharge
Other trading ratios	Retirement Ratio- 10% of credits generated are retired	None

Farm Level Comparison

In order to demonstrate the differences between the Pennsylvania and Virginia nonpoint source credit trading programs, an illustrative farm is used to compare outcomes across the states. Each hypothetical farm aims to generate credits on a 50-acre corn field, bordered on one side by approximately 1,476 feet of stream. Both farms are located in the Potomac-Shenandoah watershed as well as the Valley-Ridge physiographic province (See Figure 1). The Virginia farm is west of Interstate I-95 with a hypothetical location of

Clarke County, while the Pennsylvania farm is centrally located along the southern border of the state in a location in Franklin County. Both fields have soils of the silt-loam family with slopes between three and eight percent (USDA Web Soil Survey, 2009). Both operations assume that the farm remains in agricultural crop production. Conceptually, this farm scenario holds all physical characteristics constant. Application of identical farm management practices at the same location and within the same watershed would generate the same nutrient load to the Chesapeake Bay. The goal is to compare how the different state programs would credit agricultural landowners differently for the same changes in nutrient outcomes.

Figure 1: Location of Hypothetical Comparative Farms



In order to meet the Virginia baseline, the Clarke County farm implements an approved nutrient management plan & soil conservation plan, plants winter cover crops, and installs a 35 ft riparian buffer. After installing the buffer along the stream, the farm loses 1.2 acres of cropping area, leaving 48.8 acres for corn production. As the corn yield potential for the Virginia farm, as well as the Pennsylvania farm, is around 130 bushels per acre (USDA Web Soil Survey, 2008), the nutrient management plan for the Clarke County farm would advise medium fertilizer application rates of 130 pounds of nitrogen, 60 pounds of phosphorus, and 60 pounds of potassium, none of which to be applied before March 1 of each year (VA DCR 2005). Also under the nutrient management plan, a winter cover crop is planted by October 25th and killed between the dates of March 15 and May 15. Field management will be continuous no-till, per the specifications of the soil conservation plan.

Once these practices are implemented, the farmer can consider options to generate credits. In this investigation, the farm has three alternatives: plant an early cover crop, reduce nitrogen on the crop by 15%, or do both in combination (no till is assumed to be required under the soil conservation plan). The nutrient reductions and credits generated under each of the three practice alternatives are shown in Table 2. Early cover crops reduce nitrogen load (delivered the Bay) 51 pounds while reduced fertilizer applications lessens nitrogen load by 127 pounds per year. The application of the 2:1 trading ratio, however, means that the number of credits available for trade is half these amounts.

Table 2: Number of Transferable Credits Generated by Virginia Farm

	Lbs. Nitrogen Reduced per acre (Delivered Load)	Total lbs Nitrogen Reduced (Delivered load)	Credits Generated (with Trading ratio)
Early Planted Cover Crop	1.1	51.3	25.6
15% Nitrogen Reduction on Corn	2.6	126.9	63.5
Early Planted Cover Crop & 15% Nitrogen Reduction on Corn	3.4	167.4	83.7

The procedure for determining credits for the Franklin County, Pennsylvania farm involves the use of NutrientNet, as described above. In order to compare across farms, the Virginia baseline situation was translated into NutrientNet with several assumptions. First, the baseline (threshold) requirement is assumed to be a 35-foot riparian grass buffer, equivalent to 1.2 acres. Identical to the Virginia scenario, 48.8 acres are available for corn production with an expected yield of 130 bushels per acre. Commercial fertilizer applications are assumed to be the same as the Virginia scenario and no manure applications are assumed to occur on the field. The tillage method is assumed to be conservation till.

Since the Virginia baseline is more stringent than Pennsylvania's, applying the Virginia baseline requirements (continuous no-till, cover crops) will generate transferable credits for the Pennsylvania farm operation. Cereal cover crop planted at the typical time in late fall, in addition to continuous no-till, reduces nitrogen losses by an estimated 97.8 lbs/year to the edge of the watershed segment, and 66.8 lbs/yr nitrogen load reduced to the Chesapeake Bay. The application of the 10% Pennsylvania reserve requirement leaves 60 credits available for sale.

Next, additional nutrient reducing practices used in Virginia are applied to the hypothetical Pennsylvania farm. For the early cover crop BMP, the planting date is changed from late to early, generating an additional 19 credits, for a total of 79 available to trade. A 15% reduction on nitrogen generates a total of 151 credits available to trade a year, and a combination of both BMPs provides 157 credits per year (see Table 3).

Table 3: Number of Transferable Credits Generated by 50 acre Pennsylvania Field

	Lbs. Nitrogen Reduced/ac (Delivered Load)	Total lbs Nitrogen Reduced (Delivered load)	Credits Generated (with Trading ratio)
Virginia Baseline	1.4	67	60
Early Planted Cover Crop + Va Baseline	1.8	88	79
15% Nitrogen Reduction on Corn + Va Baseline	3.4	168	151
Early Planted Cover Crop & 15% Nitrogen Reduction on Corn	3.6	174	157

Table 4 provides a comparison of credit generation for the hypothetical farm situation under both the Virginia and the Pennsylvania programs. It is evident that the Pennsylvania program provides more credits for the same activities. The Virginia requirements that would just bring the Clarke County farm to baseline would allow the Franklin County farm to generate 60 credits. In Virginia, a 15% reduction in nitrogen application would generate 64 credits while in Pennsylvania the identical action would produce 151 credits for sale (2.3 times more than the Virginia farm). The use of an early cover crop in Virginia generates 26 credits, as opposed to the 79 available in Pennsylvania (more than 3 times more than an equivalent Virginia farm). Finally, the Clarke County farm earns 84 credits from combining both the early cover crop and the 15% nitrogen reduction, in opposition to the 157 credits earned in Franklin County.

Table 4: Comparison of Credits Generated by VA and PA across standard practices

	Credits Generated for entire 50 acre field	
	Virginia	Pennsylvania
Virginia Baseline (nutrient management, buffer, soil conserve plan, cover crop	0	60
Virginia Baseline + 15 % fertilizer reduction	64	151
Virginia Baseline + Early cover	26	79
Virginia Baseline + 15% reduction + early cover	84	157

The large differences between nonpoint source credits can be largely attributed to the existence of the 2:1 uncertainty trading ratio in Virginia and the different state baseline requirements. Removing all trading ratios would significantly reduce the differences between the credits generated by application of cover crop and 15% nitrogen fertilizer

reduction. Absent trading ratios, a 15% reduction in fertilizer applications would produce 127 credits for the Virginia farm and 168 credits for the Pennsylvania farm. The remaining difference would more than likely be attributed to differences in baseline requirements rather than differences in the way nonpoint source loads are estimated. Interestingly, the combination of the two conservation practices (15% N reduction + early cover crop) without trading ratios would produce nearly identical credits for the two farms.

While analyzing credit generation using the Pennsylvania NutrientNet spreadsheet, it was clear that reducing the nitrogen application weighed heavily into the credit calculations. Altering nitrogen applications above or below 15% is not an option available to Virginia farmers, though the possibility is open in Pennsylvania. Table 5 represents the credit generation elasticities in Pennsylvania in relation to the application rate of nitrogen. For example, simply reducing nitrogen application rates by 5% creates a 50% increase in credits, for a high elasticity of 10. As more nitrogen is reduced, the elasticities of the credits fall, demonstrating a general decreasing trend. Future work could investigate the magnitude and value of the yield loss of these reductions against the potential value of credits creation.

Table 5: Pennsylvania Credit Elasticities in relation to application rate of nitrogen

% Reduction of Credits	Nitrogen application (lbs/ac)	Credits Generated	% Change in Credits	Credit Elasticity*
0%	130	60		
5%	123.5	90	+50%	10
10%	117	121	34.44%	6.5
15%	110.5	151	24.79%	4.5
20%	104	182	20.53%	3.5
25%	97.5	224	23.08%	3.7
30%	91	269	20.09%	3.0

* (% Change in credits)/(% change in application rate)

Agricultural Nonpoint Source Credit Creation in Pennsylvania and Virginia

The discussion above indicates that identical activities and farm practices can yield large differences in the number of nonpoint source credits generated. The different crediting practices have obvious implications for the incentives of land owners/farm managers to engage in a nonpoint source credit activity.

Evidence to date highlights large differences in agricultural nonpoint source credit generating activity between the two states. Since 2007, one agricultural nonpoint source credit project has been certified and implemented in Virginia. The project converted agricultural land into forest and produces 188 nitrogen credits annually (376 pounds of nitrogen reduced) (Virginia DEQ 2008b). By contrast, over 156,000 nitrogen credits have been approved and implemented in Pennsylvania (see Table 6). These totals represent credits created, not the number of actual credits sold to buyers (many credits go

unsold). Of this total, nearly 89,000 credits have been certified from the installation of cover crops and no-till. Depending on date of cover crop planting and the content of soil conservation plans, these same projects may or may not produce credits in Virginia.

Pennsylvania also certifies credits before a project is actually implemented. According to most recent data, over 3 million agricultural nonpoint nitrogen credits have been certified but not yet implemented in Pennsylvania (see Table 6). Pennsylvania certifies projects that are not traditional field level conservation projects (like those described above). Over 97% of all certified credits in Pennsylvania are being generated by proposed and implemented manure export and manure processing projects (see Table 6). Pennsylvania grants credits toe entities that transport manure out of the Chesapeake Bay watershed. Projects that process manure (digesters, for example) represent the largest percentage of certified credits.

The manure export and treatment practices also highlight the different approaches to baselines and crediting procedures between the two states. Although there have been some proposals to treat manure in Virginia, regulatory officials have yet to approve credits from such a project. Virginia baselines require that nutrients, commercial fertilizer and manure, be applied at agronomic rates. Eliminating manure applications do not necessarily reduce farm nutrient loads if the farm is assumed not to be applying excess nutrients before the project. To generate credits in Virginia, a farm would need to demonstrate a net reduction in nutrient losses, counting both commercial fertilizer and manure, from the agronomic recommended baseline. Pennsylvania follows a similar logic, but appears to make different assumptions about the differences in the amount of total nitrogen available for crops between commercial fertilizer and manure.

Table 6: Nonpoint Source Credits Certified in Pennsylvania (2007-Sept 2010)

	# Nitrogen Credits	% of Total
Status of Nonpoint Source Credits		
N Credits Certified, Planned (not implemented)	3,128,307	95%
N Credits Certified & Projects Implemented	156,424	5%
N Credits Certified, Status Unknown	5,392	>1%
TOTAL	***3,290,123***	***100%***
Nitrogen Credit Generation Methods		
Cover Crops or No Till	88,985	2.7%
Other Farm Conservation Projects	6,344	0.2 %
Manure Export	1,399,838	42.5%
Manure Processing/Treatment	1,794,954	54.6%
TOTAL	***3,290,123***	***100%***

*Pennsylvania DEP, Proposal Registry, September 22, 2010. Totals represent single and multiple year projects. Credit trades (sales) are not included in the above summary.

Conclusions

This analysis found that farms implementing identical conservation practices and producing the same effluent load outcomes generate different quantities of credits across the two states. An identical Pennsylvania crop farm may generate 2 to 3 times more tradable credits than an identical farm operation in Virginia. The differences can largely be attributed to differences in trading ratios and baseline requirements. Virginia credit policies also provide farm operators with fewer initial choices on how to generate credits, but both states allow for agricultural operations to generate credits through other means/practices not explicitly recognized by state guidance.

Large differences in the number of agricultural nonpoint source credits certified also exist between the two states. Pennsylvania has certified over 3 million nitrogen credits between 2007 and 2010 while Virginia has approved less than 200. Numerous plausible reasons may explain these large differences. Crediting procedures obviously produce greater financial incentives for Pennsylvania operators, a result consistent with other work (Ribuado et al. 2009). Other possible explanatory factors also exist. Credit certification and transaction costs may differ between states. Credit demand conditions may also differ, but demand in both states have been weak and/or highly speculative.

The Pennsylvania nonpoint source program provides farmers greater opportunity to benefit financially from a nutrient trading program. However, all point-nonpoint source trades should generate neutral water quality outcomes (nonpoint source reductions should offset increases in point source load). Nonpoint source baselines are established, in part, to ensure that nonpoint sources generate net reductions in nutrient loads (additionality). More analysis is needed to identify the changes in farm nutrient discharges that would occur with and without a trade. Trading ratios are established to account for greater uncertainty in quantifying nonpoint source loads. Given the substantial differences in baseline policies and trading ratios, the level of assurance that neutral water quality outcomes are achieved during a trade might also be expected to differ across states. The magnitude of these uncertainties has yet to be determined and additional investigation in this area is needed.

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