# Precision Nutrient Management Using a Systems Approach in Karsts Geology in Jefferson, Berkeley and Morgan Counties, West Virginia By Mary Beth Bennett<sup>1</sup>, Tom Basden<sup>2</sup> Craig Yohn<sup>3</sup>

# Abstract

This project was a comprehensive approach to nutrient management in highly vulnerable soils using GPS technology with a set of proven conservation practices. Producers demonstrated a willingness to adopt these precision and adaptive management practices increasing the effectiveness of their nutrient management planning and implementation. Eleven producers participated in 9 practices on their farms with cost share being provided. The practices used were: Yield monitor, Manure hauling, Split Nitrogen Application, Nitrogen Evaluation, Late Season Corn Stalk Test, Cover Crop Planting, Precision Soil Sampling, Variable Rate Application of P & K and Variable Rate Application of Lime.

The top practice was Yield Monitoring followed by Manure Hauling. A distant third was Split Nitrogen Application. When producers were asked to rank the same practices they tended to rank the practices they used. Dairy producers ranked Manure hauling first while other producers ranked Cover Crops first followed closely by Yield monitoring. Based on discussions with producers at the conclusion of the project, several producers said that they would like to continue with several of the Precision agriculture practices. Several would like more programs on the GPS component and how they might better use it in their farming practices. This desire to utilize these practices and have more technical support over the long term will only be accomplished if a sustainable cost share program is put in place to provide confidence to farmers and commercial enterprises that their investment in precision practices and technologies is not short lived. Based on these results several of these practices should be offered to farmers in West Virginia under the USDA NRCS EQIP program.

# National Conservation Innovation Grant Precision Nutrient Management Using a Systems Approach in Karsts Geology in Jefferson, Berkeley and Morgan Counties, West Virginia Final Report December 2012

# **Project Background**

The Eastern Panhandle of West Virginia is an area with a large percentage of its highly

productive and usable agricultural lands underlain with a limestone or Karsts geology. This

geology is well known for underground streams that are fed by sinkholes and fissures that rise to

<sup>&</sup>lt;sup>1</sup> West Virginia University

<sup>&</sup>lt;sup>2</sup> West Virginia University

<sup>&</sup>lt;sup>3</sup> University of Maryland

the surface and create open vectors for nutrients and sediments to directly impact groundwater quality. Surface water is vulnerable to surface water runoff which can carry nutrients and sediment, but in this geology it is influenced also by the many springs that are fed by groundwater. Through the use of technology and proven conservation practices this vulnerability can be greatly reduced through the measured application, placement and sequestration of free nutrients.

Tools to improve nutrient efficiency have been used throughout the Mid-Atlantic region for more than twenty years. Programs and tools such as IPM, ICM, PSNT, CSNT, manure testing, spreader calibration, tissue testing, chlorophyll meters and the split application of nitrogen have all been used as parts of the well developed nutrient management plan. Precision soil sampling and nutrient application have also been introduced to producers over the last three years in West Virginia. While these tools have been used in piece and part in the Eastern Panhandle of West Virginia there has not been a comprehensive approach to nutrient management. This is in part due to the lack of incentives to adopt these practices on a consistent basis. In West Virginia, there are cost share programs for the development of nutrient plans under EQIP, there are no cost shares for the components that make a nutrient management plan effective. Over 85% of the management of nutrients in the region is completed with the recommendation and application by commercial custom applicators. This affects acres that are managed with split application, the acres that are precision sampled and have nutrients applied at a variable rate and the development of comprehensive nutrient management plans that include sampling of manures and soil, incentives to move animal manures beyond the perceived economic distance from the farmstead, the use tools to measure residual nitrogen or the use cover crops to sequester nutrients.

Pennsylvania, Virginia and Maryland now provide incentives to producers to accomplish a more comprehensive approach to nutrient management. None of the states address the use of precision soil sampling and the variable rate application of nutrients other than possibly nitrogen at a variable rate. The use of satellites for geo-referenced data collection, computers to convert the data to soil fertility maps, and machines for the site-specific application of nutrients has resulted in the development of a new farming system called precision agriculture. Precision agriculture's viability has been evaluated for weed control, insect control, nutrient needs and yield estimates through infrared photography and the use of yield monitors on combines.

Precision nutrient management is grid or zone sampling followed by variable rate application and it can allocate lime and fertilizer phosphorus (P) and potassium (K), within the field. Field areas with greater fertility receive less while areas with lower fertility receive more. Precision nutrient management can reduce input costs when identifying more fertile areas, while optimizing the probability of an economic response to lime and fertilizer by identifying less fertile field areas (1). In the past precision nutrient management has not been widely used on relatively small acreages. The use of zone sampling and variable rate application of nutrients to reduce inputs or increase production, while protecting water quality should be demonstrated and adopted by producers in the Eastern Panhandle and become a funded EQIP standard for forage and row crop agriculture. Precision agriculture includes a process of data collection, conversion of data to knowledge, and application of the knowledge to site-specific management within field boundaries. In a study completed in 2008 in Jefferson County, nearly 700 acres of crop and forage land was sampled by precision and conventional methods. The results showed that the precision recommendations would have applied more lime to more acres, more phosphorous to fewer acres and less potassium to fewer acres (2). This information was distributed to producers throughout the Eastern Panhandle, through newsletters, two fact sheets and two field days. It was also presented at three regional meetings, and the 2008 International Conference on Precision Agriculture. The principle investigator was invited to the National Extension Risk Management Conference and the 2009 Joint Agricultural International Conference in the Netherlands. These results more importantly, have increased to over 2,000 precision sampled acres, application of nutrients at a variable rate on 1600 acres, seen no less than three combines have geo-referenced yield monitors installed and the purchase of other hardware and software by at least two other farms with no cost share. At a fall 2008 field day on precision agriculture, 50 producers, industry representatives and government officials attended. When asked, those attending said that they 55% "strongly agreed" they would use some form of precision agriculture within the next six months When asked the same question with the possible incentive of a 50% cost share on the cost of using the tool, just over 87% agreed or strongly agreed they would use the tool. Seventy three percent agreed or strongly agreed they would purchase a piece of precision agriculture equipment if there was a 50% cost share. The adoption of this technology is directly tied to farmers and commercial applicators being provided a financial incentive to reduce the risk of the initial investment in equipment and training. The use of precision application of nutrients allows for more uniform and accurate distribution of nutrients throughout the field. For example, areas of over and under application will be prevented. For those areas having residual nutrients due to drought, over optimistic yields or other environmental setbacks, cover crops will be used to sequester those nutrients. It should be noted that the original Project Leader left his position early in 2011 leaving the position of Agriculture and Natural Resource Agent vacant in Jefferson County. At that time the project became the responsibility of an agent

in another county without the technical expertise Craig Yohn had in this area making management of the grant challenging.

## **Original Project Objectives**

- Precision Soil Sampling, Recommendation Cost Share Precision Demonstrate a cost share program on crop and forage land with willing producers who want to measure the variability of nutrient levels within fields. These producers will agree to follow recommendations from the WVU Soil Testing lab in accordance with the West Virginia NRCS 590 Nutrient Management Standard and utilize variable rate application to place the nutrients where they are required. Samples will be sent to a certified lab rather than WVU for analysis.
- 2. Variable Rate Application of Nutrients Cost Share Demonstrate the willingness of participants to take precision soil sampling results and apply nutrients (Lime, P, and K) on a variable rate based on the zone sampling recommendations of the WVU soil testing lab and in accordance with the West Virginia NRCS 590 Nutrient Management Standard.
- <u>3.</u> Nitrogen Use Efficiency Cost Share Nitrogen Efficiency will be demonstrated in row crops through the integrated use of several proven practices used by willing producers. These practices will be used together and not used separately to achieve this goal.
  - a. Apply the proper rate. This will be accomplished through assessment of the previous crop and animal manure application using the Pre-Sidedress Nitrate Test (PSNT) (*corn and previous manure application only*), Leaf Chlorophyll Meter (LCM), or Tissue Test. (*corn, small grain*) and utilize Late Season Corn Stalk Nitrate Test (CSNT) (*corn only*) to measure the level of residual nitrogen (3).

- b. Apply nitrogen timed to crop demand. Apply nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months (*all non-legume crops*). This will be accomplished through the use of split or side dress application of nitrogen on and the use of real time red and near infrared technology to determine nitrogen application rate (*wheat and corn*).
- c. Plant cover crops to sequester nitrogen. The purpose of the cover crop is to sequester as much unused nitrogen and phosphorous as possible. The goal is to sequester nutrients not used by the mature growing crop or grow nitrogen for a future crop. The target of this effort will be corn fields and wheat fields that are not being double cropped with soybeans.
- **<u>4.</u>** Producer Purchase of Precision Technology Cost Share. Demonstrate a cost share program that provides precision technology to farmers. Utilize GPS oriented yield monitoring, variable rate of nutrients and variable rate planting.
- 5. Commercial Custom Fertilizer Application Operation Incentives Demonstrate a cost share program which provides incentive for commercial applicators to adopt precision soil analysis and application of nutrients. This includes retrofitting of equipment, addition of new equipment and software.
- **<u>6.</u>** Education Design and conduct no less than two mandatory educational programs to teach participating producers and commercial applicators about various aspects of a comprehensive nutrient management program utilizing precision technology.
- <u>7.</u> Animal Manure Use Efficiency through Offsite Transfer Demonstrate a cost share program that encourages farms with concentrated animals and a waste storage facility to

encourage the transporting of farm produced manures off the farmstead to eligible fields that the farmer may manage or to another cooperating producer.

### **Project Methods and Materials**

**Objective 1. Precision Soil Sampling, Recommendation Cost Share** Precision agriculture is used to improve the agronomic, environmental and economical perspective of crop management from in-field variability. This management requires the use of a GPS (Global Positioning System) and information management tools such as GIS (Geographic Information System) to assess management information and understand variations. The objective is to sample 3,000 acres of forage and cropland using a zone sampling technique to ascertain levels of pH, P, K, Ca and Mg through Mehlich I analysis. Precision soil sampling and recommendation includes all of the following:

- Precision soil sampling (zone) or "smart sampling"

- Analysis through a Certified Lab using Mehlich I analysis

- Recommendations based on West Virginia University Soil Testing Lab in accordance with the NRCS 590 Nutrient Management Standards.

Development of database and maps which interpolate sample results and provide files to producers which then will be used to variably apply nutrients to their small fields.
The results of this work and other precision sampling done over the last several years though out West Virginia will be used to develop pre sampling protocol to determine if a field should be sampled precision or not. This will compliment work done by Grove and Schwab at the University of Kentucky (1) to develop an EQIP approved practice for precision sampling and variable rate application of nutrients.

**Objective 2 - Variable Rate Application of Nutrients Cost Share** Utilize precision sampling or a GPS based yield monitoring system to collect field-specific crop data, and a software/record keeping system that analyzes that data. Nutrients shall be applied based on West Virginia Soil Testing Lab and West Virginia NRCS 590 Nutrient Management Standards. An exception will be made to the 590 standards as precision samples will be analyzed with a Mehlich I test through a certified lab rather than WVU. This analysis will be used to reallocate field inputs on 3,000 acres which may include variable rate fertilizer, lime, animal manure and/or variable rate planting.

### **Objective 3 - Nitrogen Use Efficiency**

### Apply the Proper Rate of Nitrogen

- Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history or yield monitor data for predominant soil types within the field. *(all non-legume crops)*; Adjust nitrogen application based on previous manure use and/or green manures *(all non-legume crops)*. Depending on growing crop and type of nutrient(s) used, implement in-season nitrogen adjustments based on Pre-Sidedress Nitrate Test (PSNT) *(corn and previous manure application only)*, Leaf Chlorophyll Meter (LCM), or Tissue Test. *(corn, small grain)* on 100 fields. Utilize Late Season Corn Stalk Nitrate Test (CSNT) *(corn only)* on 100 fields. The Late Season Corn Stalk Nitrate Test is a reliable end of season indicator of crop N status. It provides a good assessment of whether the crop had the right amount of N or too much N or whether it ran out of gas. This information combined with records of N management can be very useful for making future management decisions.

### Apply Nitrogen Timed to Crop Demand

- Apply nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months (*all non-legume crops*); Split or side dress application of nitrogen with no more than 50 lbs. of commercial nitrogen applied per acre at planting (*corn and wheat*). Rates will be tied to one of the three tests cost shared namely Pre-Sidedress Nitrate Test (PSNT) (*corn and previous manure application only*), Leaf Chlorophyll Meter (LCM), or Tissue Test. (*corn, small grain*) or utilization of real time red and near infrared technology to determine nitrogen application rate on the crop (*wheat and corn*) on 3,000 acres.

### Cover Crop Planting to Sequester Nitrogen

The purpose of the cover crop is to sequester as much unused nitrogen as possible. Fields found to be in the optimum or excess range according to the Penn State Late Season Corn Stalk Nitrate Test would be eligible for this program. A second eligible practice is the planting of a cover crop after small grain harvest. This could include annual grasses, legumes and forage radishes. The goal is to sequester nutrients not used by the mature growing crop or grow nitrogen for a future crop on 3,000 acres.

### **Objective 4 – Producer Purchase of Precision Technology Cost Share**

Demonstrate a cost share program to provide producers with precision technology including hardware and software to collect field-specific crop data, and evaluate data to improve nutrient allocation on eight farms. Hardware may include yield monitors, light bars, GPS guidance etc. A software/record keeping system that analyzes data which may be used to recommend variable rate fertilizer, lime, and/or variable rate planting would be eligible for cost share. GPS/record keeping is done with commercial software. There are numerous software programs on the market that a program participant may use. **Objective 5 - Commercial Custom Fertilizer Application Operation Incentives** Provide consultation and services that utilize GPS and GIS systems that collect field-specific nutrient data that allow the variable application N, P, K and lime and variable rate planting. Utilize software/record keeping systems that analyzes that data which may be used to recommend variable rate fertilizer, lime, and/or variable rate planting. This system involves the development and use of an extensive record keeping system of crop management and yield data inputs using GPS technology to ensure the most efficient production is achieved. GPS/record keeping is done with commercial software. There are numerous software programs on the market that a program participant may use. **To be eligible, operations must serve producers participating in this Conservation Incentive Grant.** 

**Objective 6** – **Education.** Provide no less than two mandatory workshops for producers and commercial applicators which provide an overview of precision agriculture. Workshop for participating producers will include an introduction to zone sampling, the NRCS 590 Nutrient Management Standard, the development of maps, software and hardware demonstrations and the benefits of split application of nitrogen. Commercial applicator workshop will include how to take and manage zone samples, a review of the NRCS 590 Nutrient Management Standard, how to install hardware, calibrate variable rate spreaders, use software and develop maps for variable rate application.

**Objective 7 - Animal Manure Use Efficiency through Offsite Transfer** This is for farms with concentrated animals and a waste storage facility where an excess of nutrients is identified on the farm with the facility. This will provide an opportunity to reduce the cost of transporting farm produced manures off the farm to eligible fields that the farmer may manage or to another cooperating producer. Crop field must be greater than one mile from the end of the private road

for the farmstead and have a nutrient management plan on file. Participating farmers will keep records on loads, spreader capacity, acres treated, manure analysis and nutrients applied based on the analysis.

### **Location and Size of Project Area:**

The Eastern Panhandle is a diversified agriculture with 169,633 (35%) of the nearly 489,000 acres in farms. Jefferson County has the smallest land area but the largest percentage in farms (53%) while Berkeley and Morgan have 36% and 15% in farms respectively. The area has seen a shift to more row crop and less orchards and animal agriculture. Over 42% of all lands have a karsts geology which is vulnerable to surface water infiltration through sinkholes and fissures. Made up of the three most eastern counties in West Virginia, each is bordered by the Potomac River with Jefferson County also having the major tributary Shenandoah River inside its borders. All counties are within the Chesapeake Bay Watershed.

## **Cooperator Participation:**

This project will reach no less than 60 producers and eight commercial applicators affecting nutrient management on no less 10,000 acres and possibly as many as 15,000 acres through the various programs (9% of farm acres) being offered.

# **Project Management**

This pilot project will be managed by the West Virginia University Extension Service. The primary objective of the project is to demonstrate how a comprehensive program to manage nutrients through financial incentives can impact the proper rate and placement of nutrients on row crop and forage lands. The project director was Craig Yohn, Extension Agent and Certified Crop Advisor in Jefferson County. Mr. Yohn was the lead evaluator of the impact of

participation in this project. He was also the major provider of technical assistance. Farmer recommendations were made by consultants with custom applicator companies that serve the Eastern Panhandle. Technical assistance will also be provided by Mr. Tom Basden, WVU Extension Specialist,- Nutrient Management, Dr. Ed Rayburn, Extension Forage Specialist, Dr. Eugenia Pena-Yewtukhiw, WVU Assistant Professor in Soil Science, regional custom applicators and certified crop advisors and technicians with the various software and hardware providers for precision agriculture. WVU Extension Agents Mary Beth Bennett and Denis Scott will provide informational support to clientele in their perspective counties. Mary Beth Bennett will also be assisting with the program evaluation and the writing of the final reports and development of an EQIP protocol. This project is a cooperative effort between government, extension, private enterprise and the many cooperators that will be participating in this project. Please note that the original Project manager left his position as project manager and technical assistant to the project early in 2011.

# **Project Benefits and Transferability**

This project was centered on the expansion of practices that could be adopted by the West Virginia State Technical Committee as part of the field nutrient management standard #590. It also will demonstrate the importance of combining practices to reduce the impact of nutrients on ground and surface water. West Virginia presently has no permanent EQIP program for the management of nutrients and this grant will set the bar to adopt such a program.

# **Project Evaluation**

A total of eleven (11) Jefferson County Producers completed practices and paperwork required for participation in the grant program. Table 1 summarizes participation by practice. Each practices successes and barriers to greater adoption will be discussed.

	Practice	Grant Acres	Acres	% of allocated	Producers
		Allocated	Completed	Acres	
1	Yield Monitor/ Variable	4575 acres	5256 acres	115%	9
	Rate Corn Planting				
2	Manure Hauling	4000 miles	4164 miles	104%	2
3	Split Nitrogen	2500 acres	1199 acres	48%	6
	Application				
4	Late Season Corn Test	60 fields	27 fields	45%	5
5	Cover Crop Planting	2500 acres	1071 acres	43%	5
6	Precision Soil Sampling	2500 acres	794 acres	32%	5
7	Variable Rate P & K	2500 acres	338 Acres	21%	4
8	Nitrogen Application test	60 fields	11 fields	18%	3
9	Variable Rate Lime	2500	338 acres	14%	2
	Application				

Table	1
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Precision Soil Sampling – Monies to sample 2500 acres of forage and cropland was budgeted. A total of 793.49 acres were sampled with recommendations developed and returned to the producer. Evaluation/Recommendation: Precision soil sampling only occurred through the use of an independent consultant. Since most acres in commercial agriculture in the grant area are under the influence of one of three commercial fertilizer enterprises, it was difficult to entice more participation. Precision soil sampling did not occur on more acres for two reasons: there was not a demonstrated reason to precision soil sample (yield maps) and there was not a reliable service being offered to variably apply nutrients based on the precision soil sampling. It is recommended that this practice be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier III level. Variable rate applications of lime and fertilizer - Monies to apply 2500 acres of Phosphorous or Potassium and 2500 acres of Lime requirements have been budgeted. A total of 528.62 acres had a variable application of phosphorous and potash while 337.69 acres had variable rate lime applied for a total of 866.31 acres. **Evaluation/Recommendation:** Variable rate application of nutrients was accomplished through the use of an independent contractor that transported equipment more than 250 miles to provide the service. This economically could not be sustained over the course of the grant and no local commercial applicator or producer was willing to invest in the technology during the period of the grant. **It is recommended that this practice be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier III level and be coupled with precision soil sampling and/or several years of yield maps.** 

**Nitrogen Evaluation for Corn**\ **Split Application of N** – Monies to evaluate 60 fields for assessing additional nitrogen after the initial application and apply additional N to 1,375 acres was allocated. A requirement of the program was that no more than 50 pounds of N be applied at planting. 40 fields applied for the practice, but most of the fields had applied more than 50 pounds at planting which made them ineligible for the program. Eleven fields totaling 1199 acres qualified for the two programs. Several of the fields that were evaluated did not need additional N and all fields applied less N than would have been applied if the evaluation had not been made. The total commercial N not applied was 28,097 pounds. This saved producers over \$14,000 in nitrogen costs. Evaluation/Recommendation: Split application of nitrogen was influenced by the ability of the commercial applicator to make only one pass in the spring and apply the recommended phosphorous and or potassium without applying more than 50 pounds of

nitrogen in the liquid form. Technology to apply greater than 100 pounds of nitrogen in a split application also influenced how much was applied in the spring. It is recommended that this practice be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier II level and be coupled with a PSNT test for producers that utilize animal manures.

Late Season Corn Nitrate Test\ Cover Crop - Monies were allocated for 60 fields to be evaluated for late season corn nitrate testing. Fields must be in the optimum or high range to qualify for the cost share on cover crops. If the acreage was in soybeans, the acreage also qualified for the cover crop program. All acreage must be planted by October 15<sup>th</sup>. Thirty eight fields applied for the testing program, and 1,600 acres applied for the cover crop program. Twenty seven fields performed the late season stalk test. Cover crops were planted before October 15<sup>th</sup> on 490 acres of harvested soybean and 580.8 acres on harvested corn for a total of 1070.8 acres in cover crops. **Evaluation/Recommendation:** During the grant period research came to bear that showed that there is not a significant correlation between the nitrates found in the stalk and the nitrogen reserves found in the soil. Early on, it was also discovered that there can be as much or more nitrogen loss from soybean fields as corn fields and planting of cover crops was added to the cover crop program. When this grant was developed only NRCS offered a cover crop incentive program and it was only for acres where there was a potential for erosion. When funding from this grant became available, additional cover crop programs were being offered by the state and NRCS to sequester nutrients. These programs offered a higher payment per acre and did not require that a late season corn stalk nitrate test be taken. This greatly reduced the grants ability to meet its goal. It is recommended that the practice of taking a

late season corn stalk nitrate test not be continued to qualify for cover crop cost sharing. Research has shown the benefit of this practice and the state has provided funding to encourage the practice.

Utilizing Precision Technology (Yield Monitor & Variable Rate planting) – Monies were allocated to pay producers on 4,575 acres to utilize yield monitoring and variable rate planting equipment to affect the production of crops and application of nutrients based on the potential or actual production within a field. Two farms planted approximately 368 acres of corn at a variable rate based on soil types, elevation and previous yield maps. Acres yield monitored totaled 4,888 for nine producers. **Evaluation/Recommendation:** Two separate and distinct activities were part of this practice and built on each other to improve nutrient efficiency. Yield monitoring was utilized by the most producers and had the greatest number of participating acres. It has been shown that yield information is the basis from which other decisions are made. Yield monitors were purchased by three producers during the grant period and through custom harvesting involved other farmers and acres in the grant. One custom producer recruited his grandson to help produce maps from the data collected expanding involvement in precision agriculture across generations. Corn, soybean and wheat crops were harvested with combines that used yield monitors. Reported yields were broken down as follows: Wheat yield on 560 acres averaged 53 bushels per acre for six producers. Corn yield on 2230 acres averaged 94 bushels per acre for nine producers. Soybean yield on 2098 acres averaged 34 bushels per acre for nine producers.

Yield Monitor/	Wheat	Corn	Soybean	Total Acres
Farm	Yield Acres	Yield Acres	Yield Acres	Monitored
Farm 1	90	426	234	750
Farm 2	69	290	309	668
Farm 3	103	269	268	640
Farm 4		457	354	811
Farm 5		370	380	750
Farm 6	121	43	67	231
Farm 7	42	81	211	334
Farm 8	135	104	118	357
Farm 9		190	157	347
Totals	561	2230	2098	4888

Table 1

A yield monitor survey was given to those producers and the following results were tallied: Eight surveys were completed. The average years gathering data in this manner was 2.4 years. All used an outside source while 38 percent used their own equipment and 63 percent used custom harvesters to collect the data. All producers used an outside consultant to create the maps. Maps were created by field, by farm, and by crop. This was a teachable moment as nutrient management and the development of a nutrient management plan is at the field level. The range of yields shown the map was what was expected although the maps did show areas of yield concern that would not have been recognized otherwise because the producer was not in the combine. In 2010 the maps also showed the impact on yield of a new pest – Brown Marmorated Stink Bug. When asked how the yield maps will be used 57 percent indicated they used the information to choose varieties, 88 percent said they will use the information to adjust planting populations and 75 percent indicated they will adjust nutrients for next year's crop. Sixty-two percent said the data will be used to develop strategies to combat losses from deer. Seventy five percent of participants said they would use the maps to variably apply P and K requirements if the service was available. Based on the yield maps, 100 percent look forward to compare yields between this year and next and 63 percent would like to further investigate the

availability of variable rate application of nutrients. Fifty percent would like to pursue precision soil sampling and two producers would like to see maps that show profit per acre. This survey confirms the value of the yield monitor information in the management of nutrient and cultural practices across crops.

One producer had been collecting GPS data to calculate hay yields which was converted to nutrients removed. This was accomplished through the concentrated effort of the former Extension Agent and the use of several computer programs. Hay acres harvested with GPS referencing could not be easily converted to yield and nutrients removed without this support and was abandoned when the Extension Agent retired. While the industry has since developed yield monitors on a commercial scale for large square balers, the technology is not yet available for the more popular round baler. It is recommended that the practice of supporting the use of yield monitors be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier II level. The second activity in this practice involved the use of yield data to create a prescription to change planted corn population based on several known variables within the field. One producer who also provided custom harvest and planting led the way in the area of evaluating yield information to change planted corn population and varying nitrogen application. Two farms planted approximately 368 acres of corn at a variable rate based on soil types, elevation and previous yield maps. This practice is the ultimate level of the use of the technology. It is recommended that the practice of supporting the use of yield monitors be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier III level.

**Manure Hauling** – A program was developed to encourage dairy producers to haul liquid manure more than .5 miles away from the farmstead where it was created. A payment of \$2.50

per loaded mile was developed with an allocation of \$10,000 for this practice. Two dairy farms participated in this program. Evaluation/Recommendation: Of the 4,000 miles allocated 4,164 have been driven moving more than 4.6 million gallons of liquid dairy off the farmstead. Both of these farms utilized custom applicators which provided a real cost to moving manure away from the fields that surround the farmstead and historically had gotten most of the manure. Manure samples were taken, and application was made within the needs of the growing crop. The cost share covered approximately 22% of the cost of hauling and spreading the manure. While only two farms participated, it would be more widely used when there is a greater requirement for the development and use of nutrient management plans and a phosphorous index that may limit the application of animal manures to fields closest to where it is produced. The purpose of this practice is not to move nutrients out of the watershed which would be very expensive with liquid manures, but to redistribute nutrients to where they can be best utilized in an environmentally responsible manner within the watershed. It is recommended that the practice of supporting the use of yield monitors be offered through an EQIP Nutrient Management Financial Assistance Practice at the Tier III level.

### **Overall Project Evaluation**

An evaluation tool used to conduct face-to-face interviews with producers involved in the project to determine how these practices were viewed by the cooperators and if these practices would be continued if 1) if funding ceased, or if 2) these practices became part of a long term EQIP program. Other questions answered include:

• Have producers increased or reduced inputs?

• Have producers changed management practices based on the additional information gathered through the precision tools?

Other measures of success include acres receiving animal manures beyond the farmstead, nitrogen use reduced due to the nitrogen efficiency practices and the use of legumes as cover crops, greater average yields and more efficient use of P and K by managing application based on precision sampling and monitoring yields.

See the evaluation survey and results below and on the following pages

# CIG Project Evaluation Questions and Results

Answer Yes or No to the following question (please notice there are two parts to each practice)

1. Would you continue the following practices?

	If Funding ceased		If part of long term EQUIP Program		
10 -Precision Soil Sampling	Yes	No	Yes	No	
	3	7	8	2	
10 - Variable Rate application	If Funding ceased		If part of long term EQUIP Program		
of Lime	Yes	No	Yes	No	
	2	8	9	1	
10 - Variable Rate application	If Fundin	g ceased	If part of long term	n EQUIP Progra	m
of Phosphorous or Potassium	Yes	No	Yes	No	
	3	7	6	4	
8 - Nitrogen Evaluation for cor	If part of long term	n EQUIP Progra	m		
Split Application of N	Yes	No	Yes	No	
	3	5	5	3	
9 - Late Season Corn Nitrate	If Fundi	ng ceased	If part of long terr	n EQUIP Progra	m
Test	Yes	No	Yes	No	
	2	7	6	3	

	If Funding ceased		If part of long term EQUIP Program		
9 - Cover Crop Planting	Yes	No	Yes	No	
	5	4	7	2	
	If Funding ce	ased	If part of lon	g term EQUIP	Program
10- Yield Monitoring	Yes	No	Yes	No	
	4	6	10		
	If Funding ce	ased	If part of lon	g term EQUIP	Program
9 - Manure Hauling	Yes	No	Yes	No	
	1	8	3	6	

- Due to your involvement in the CIG Project have your inputs increased or decreased?
   4 Producers indicated an increase in inputs and 4 indicated their inputs decreased, while 3 indicated it was about the same.
- 3. Have you changed management practices based on the additional information gathered through the precision tools? YES 6 NO 5 Doing most of the practices before grant. Refined them. Planting more cover crops. Unroll hay rolls where nutrients are needed in pastures and/or hay fields.
- 4. For animal producers dealing with manure Have you seen a benefit to hauling manure and applying it according to precision sampling and monitoring methods? YES NO 1 indicated not sure and one indicated maybe.
- 5. Have you adapted your equipment to be able to do any of the practices listed in question 1? If so what have you done? One producer purchased equipment to update what he already owned.
- 6. Have you purchased new equipment to be able to do any of the practices listed in question 1? 4 producers bought new equipment to help with yield monitoring.
- If you purchased or adapted equipment to be able to do any of the practices listed in question 1 would you be willing to work with other producers in the area to do more precision work? YES 3 NO 1 (one indicated if paid)

If Yes above how many producers would you be willing to help? 2, 4 and 4 producers

8. How much did you know about Precision Agriculture by the practices listed in Question 1 at the beginning of the project?

None	A Little	A Lot	Previously involved
1	9		1

9. Would you be willing to do additional precision field work to gather more information should funds become available? YES -9 NO -0 MAYBE -2 - Continue what I do; Hay yield monitoring & mapping.

- 10. Would you be willing to share what you learned by participating in this project? YES - 10 NO - 1
- 11. Where there any constraints to participating in the project?
  6 producers indicated working fields, accessing fields to plant and harvesting crops due to weather
  1 producer indicated not having commercial applicators to do variable rate application of P, K & Lime.
  Lack of computer knowledge to handle practices with GPS Programming.
  Need tech person.
  Losing agent
- 12. Is there any additional information we can provide to you in regards to the practices involved in this project? Not that they could think of at the time, maybe later. Ran out of funding on project. Next time –need well educated tech support.
- 13. Please rank the practices below in their order of importance to you and your farm with 1 being the highest and 8 being lowest (Number 1 8)
  - <u>4</u> Precision Soil Sampling
  - <u>3</u> Variable Rate Application of Lime
  - \_7\_\_\_ Variable Rate application of P & K
  - <u>5</u> Nitrogen Evaluation for Corn/Split Application of N
  - 8 Late Season Corn Nitrate Test
  - <u>1</u> Cover Crop Planting
  - <u>2</u> Yield Monitoring
  - <u>6</u> Manure Hauling
- Note that Manure Hauling ranked highest among the 2 livestock producers who hauled manure under the grant

Constraints to report - The 2011 crop year was a difficult year for producers due to the wet crop

year. Several producers were impacted by the weather in applying N, P & K as well as

harvesting crops in the fall. Early in 2011 the initial Project Leader retired from his position with

WVUES. With the retirement the person most knowledgeable about this new technology and its

impact on the management of nutrients was lost. The project became the responsibility of an

agent in another county lacking the technical expertise the first project leader had, thus making management of the grant challenging.

The final report will discuss the number of producers who participated in state and federal cover crop cost share programs that were made available after this grant was conceived and funded.

Outreach – An informational program on the basics and potential use of precision equipment was held with over thirty producers and government agency personnel in attendance. Team member Tom Basden presented a poster on the grant at the 66<sup>th</sup> International annual Soil and Water Conservation Society Conference in Washington, D.C. July 17 -20, 2011. Please find it attached.

## **Environmental Impacts**

Nearly 50% of the agricultural area in the eastern Panhandle is a karsts geology that is vulnerable to nutrient contamination from nutrient runoff. There are also two major tributaries to the Chesapeake Bay that have many tributaries that are influenced by groundwater quality and runoff. At this point in time there are little if any incentives for producers to manage the susceptibility of groundwater and surface water to nutrient contamination.

The use of precision sampling and variable rate application of nutrients, the use of yield monitors to measure nutrient removal and improving nitrogen efficiency will all lessen the risk of nutrient movement. This combined with the strategic use of cover crops to hold nutrients in place or build nitrogen for future crop needs all combine to improve the efficiency of nutrients used to grow forage and row crops. This grant has shown that producers are willing to use new and innovative practices if they are given credit, but they need assistance with payments for what they are doing or attempting to do based on several of their comments. As indicated earlier

several producers purchased new equipment in order to do yield monitoring and knowing many of the producers they are adapting their equipment to meet their needs and to help make farming more productive in their daily lives with an effort to conserve their valuable resources.

# Recommendations

Based on the findings of this project it is evident that producers would like to continue some of the practices that were utilized under this project. Producers look at several of the practices as being beneficial to their farms. Rankings on the final survey indicate that cover crop planting, yield monitoring, variable rate application of lime and precision soil sampling are practices that they would like to see continued under a cost share program. Manure hauling is very important to the 2 producers who completed this practice.

One producer indicated that he had been doing some of the practices before he was involved in the grant and he was likely to continue to do the same practices but cost share would make these efforts more economically feasible. Several practices such as yield monitoring, precision soil sampling, variable rate lime application and phosphorous or potassium received more negative responses if funding ceased while indicating that they would be more likely to continue the practices if part of and EQIP program with cost share. Discussions with the producers indicated that it was difficult to find a custom contractor to help apply the variable rate application of phosphorous and potassium while several producers did invest in purchasing yield monitor equipment to go with their custom harvest equipment. An added benefit of the yield monitor practice is that an elderly producer has involved his grandson in helping him map the yields and provided an interest in agriculture that may not have been there prior to the project. It is also providing some additional income for those producers who have purchased equipment and custom harvest for other producers.

The development of an educational program to provide greater awareness of proper use and impacts on nutrient, cultural and financial management of the farm is strongly expressed by the producers who participated in the grant. It is also strongly expressed by producers and commercial applicators that the need for a long term financial assistance program to encourage the adoption of precision agriculture practices to improve nutrient management will provide an incentive for a long term commitment to precision agriculture.

Based on the results of this project it is recommended that a three tier cost share program be adopted. Such a program exists in the state of Maryland and provides an excellent guide for West Virginia. It separates practices into the basic needs of any nutrient management program (nutrient management plan, soil tests, average crop yield information) and moves forward with more progressive means of managing nutrients in two additional tiers that require greater financial and management input by the participating producer.. The Maryland EQIP CBWI-Nutrient Management Financial Assistance Program is attached.



Maryland EQIP CBWI - Nutrient Management \_ inancial Assistance

Participant Name: No./Tract No.:

NRCS in Maryland wants to reward producers who implement nutrient management techniques that go beyond the minimum requirements of the Nutrient Management standard (590). For all Tiers the participant must have or obtain a current nutrient management plan developed by a certified nutrient management consultant and implemented in accordance with Maryland State law. The plan must also meet the minimum requirements of the Maryland NRCS 590 Nutrient Management standard and be reviewed and/or updated annually by a certified nutrient management planner. For the purpose of this document, Environmental Quality Incentives Program will be known as EQIP and Chesapeake Bay Watershed Initiative will be know as CBWI.

Producer will implement Nutrient Management Practices on the same acres for 3 years throughout the contract period, meaning the producer will enroll a specific field(s) and nutrient management practices chosen will occur <u>only on the selected acres</u> in the contract. Nutrient management practices will not follow a specific crop across tracts and fields. <u>Your EQIP or CBWI Contract can include no more than</u> \$50,000 for Nutrient Management payments for the options listed below.

#### <u>Tiers</u>

To be eligible for the Tiers list below the producer must implemented Nutrient Management Plan according to: field specific soil test analysis based on Um crips of Maryland Guidelines, nutrient budget, and record keeping. Nutrient budget includes crops grown, anticipated and actual crop yields, types and quantities of nutrients applied (including animal waste), and dates of application, and the use of any green manure crops.

#### Tier# I A:

#### Basic Field Crops Nutrient Management w/ Out Manure

🔲 - Tier #IA

\$13.05/ac X 3 years @

\_\_\_\_\_acres

1

All the following groups of practices (listed as Items 1 and 2) must be applied, depending on crops grown. Tier# IA is only to be used by producers using inorganic/commercial fertilizer as their primary source of nutrients for their crops. This tier can only be used with crop rotations where a high nitrogen using crop is grown 2 out of 3 years.

#### 1. Apply the <u>Proper Rate</u> of Nitrogen

- Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history or yield monitor data for predominant soil types within the field. *(all non-legume crops)*
- Depending on growing crop and type of nutrient(s) used, implement inseason nitrogen adjustments based Leaf Chlorophyll Meter (LCM), or Tissue Test. (corn, small grain)
- Calibration of Nutrient Application Equipment to ensure correct amount of nutrients are applied to the crop. (all crops)

### Maryland EQIP CBWI - Nutrient Management .nancial Assistance

#### 2. Apply Nitrogen <u>Timed</u> to Crop Demand

- Apply nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months. *(all non-legume crops)*
- Split or sidedress application of Nitrogen with no more than 50 lbs. of commercial nitrogen applied per acre at planting *(non-irrigated non-legume crops)*. Split application of commercial nitrogen with no more than 50% of total nitrogen needs of the crop applied at planting. *(irrigated non-legume crops)*
- If Urea containing fertilizers are used, utilize coated urea or urease inhibitors. (applicable to commercial fertilizer use)

Tier #1 B:

Basic Field Crops Nutrient Management w/ Manure & Commercial Fertilizer

🗌 - Tier # I B

<u>\$19.91/ac X Swears @</u>\_\_\_\_

acres

All the following groups of practices (listed as Items 1, 2, and 3) must be applied, depending on crops grown. This scenario is to be used by producers using inorganic/commercial fertilizer along with organic sources (<u>manure/compost</u>) as their primary source of nutrients for their crops.

- 1. Apply the Proper Rate of Nitrogen
  - Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history or yield monitor data for predominant soil types within the field. *(all non-legume crops)*
  - Depending on growing crop and type of nutrient(s) used, implement in-season nitrogen adjustments based Leaf Chlorophyll Meter (LCM), or Tissue Test. *(corn, small grain)* Calibration of Nutrient Application Equipment to ensure correct
  - amount of nutrients are applied to the crop. (all crops)

#### 2. Apply Nitrogen Timedato Crop Demand

Appendix nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months. *(all non-legume crof)* 

Spectra states application of Nitrogen with no more than 50 lbs. Commercial nitrogen applied per acre at planting *(non-irrigated non-legume crops)*. Split application of commercial nitrogen with no more than 50% of total nitrogen needs of the crop applied at planting. *(irrigated non-legume crops)* 

• If Urea containing fertilizers are used, utilize coated urea or urease inhibitors. (applicable to commercial fertilizer use)

#### 3. Improved Manure Management

 If manure is utilized, inject or incorporate within 12 hours of application. Plug or spike aerators (such as Aerway®), seed bed conditioners and vertical till (such as Turbotill<sup>TM</sup>) may be used for incorporation. Note: Dry poultry manure may be surface applied with no incorporation.

#### Maryland EQIP CBWI - Nutrient Management Inancial Assistance

However, minimal incorporation is still recommended due to reduced phosphorus losses in runoff and associated water quality benefits

- Adjust nitrogen application based on previous manure use and/or green manures. (all non-legume crops)
- Depending on growing crop and type of nutrient(s) used, implement inseason nitrogen adjustments based on Pre-Sidedress Nitrate Test (PSNT) (corn only).

#### <u>Tiers II Advanced Nutrient Management or Precision/Decision Agriculture</u> To be eligible for Tier II, the producer must currently be implementing the following items:

 Nutrient Management Plan according to: field specific soil test analysis based on University of Maryland Guidelines, nutrient budget, and record keeping. Nutrient budget includes crops grown, anticipated and actual crop yields, types and quantities of nutrients applied (including animal waste), and dates of application, and the use of any green manure crops.

#### Tier II:

Advanced Field Crops Nutrient Management w/ out Manure

🗌 - Tier IIA



All the following groups of practices (listed as items 1, 2, and 3) must be applied, depending on crops grown. This scenario is only to be used by producers using inorganic/commercial fertilizer as their primary source of nutrients for their crops.

#### 1. Apply the Proper Rate of Nitrogen

- Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history or yield monitor data for predominant soil types within the field. (all non-legume crops)
- Depending on growing crop and type of nutrient(s) used, implement in-season nitrogen adjustments based Leaf Chlorophyll Meter (LCM), or Tissue Test. *(corn, small grain)*
- Calibration of Nutrient Application Equipment to ensure correct amount of nutrients are applied to the crop. (all crops)

### 2. Apply Nitrogen <u>Timed</u> to Crop Demand

- Apply nitrogen as close to crop uptake as possible avoiding any application of nitrogen during the winter months. (all non-legume crops)
- Split or side dress application of Nitrogen with no more than 50 lbs. of commercial nitrogen applied per acre at planting *(non-irrigated non-legume crops)*. Split application of commercial nitrogen with no more than 50% of total nitrogen needs of the crop applied at planting. *(irrigated non-legume crops)*
- If Urea containing fertilizers are used, utilize coated urea or urease inhibitors. (applicable to commercial fertilizer use)

# Maryland EQIP . CBWI - Nutrient Management \_ .nancial Assistance

## 3. Nutrient Application Efficiency

- Precision Agricultural may includes all of the following:
  - Utilize GPS/record keeping/yield monitor using GPS/GIS software.
  - Geo-referenced Light Bar to help improve efficiency overlaps and skips in the application of nutrients. *(all crops)*

vanced Field Crops Nutrient Mana	igement w/ Manure & Commercial Fertilizer	
🗋 - Tier # II B	\$29.95/ac X 3 years @a	cres
The all following groups of practic depending on crops grown. This inorganic/commercial fertilizer as primary source of nutrients for the second state of Nitro Proper Rate of Nitro Develop a yields, yie types with Depending implement Meter (LC) Calibration amount of 2. Unity Nitrogen Timed to Crop Apply nitrogen amount of commercise of commercise of commercise of commercise of commercise of commercise and the second state of the second state	tices (listens I tems 1, 2, 3, and 4) must be applied, s scenario is to be used by producers using long withinorganic sources ( <u>manure/compost</u> ) as the eir crops. Pre-Season estimate of Nitrogen based on expected d history or yield montor data for predominant soil in the field. ( <i>all non-legane crops</i> ) g on growing crop and type of nutrient(s) used, t in-season nitrogen adjustments based Leaf Chlorop M), or Tissue Test. ( <i>corn, small grain</i> ) n of Nutrient Application Equipment to ensure correct nutrients are applied to the crop. ( <i>all crops</i> ) <b>Demand</b> gen as close to crop uptake as possible avoiding any of nutrients during the winter months. ( <i>all non-legun</i> dress application of Nitrogen with no more than 50 ial nitrogen applied per acre at planting ( <i>non-irrigat</i> <i>crops</i> ). Split application of commercial nitrogen with n 50% of total nitrogen needs of the crop applied at <i>rigated non-legume crops</i> ) aining fertilizers are used, utilize coated urea or urea <i>upplicable to commercial fertilizer use</i> )	neir I Dohyl ect me Ibs. ed ith ase
<ul> <li>Precision Agricult</li> </ul>	ural includes all of the following:	
- Utilize GP software.	S/record keeping/yield monitor using GPS/GIS	
- Geo-refere skips in the	nced Light Bar to help improve efficiency overlaps e application of nutrients. <i>(all crops)</i>	and

## Maryland EQIP . CBWI - Nutrient Management ... nancial Assistance

#### 4. Advanced Manure Management

- If manure is utilized, inject or incorporate within 6 hours of application. Plug or spike aerators (such as Aerway®), seed bed conditioners and vertical till (such as Turbotill™) may be used for incorporation. Note: Dry poultry manure may be surface applied with no incorporation. However, minimal incorporation is still recommended due to reduced phosphorus losses in runoff and associated water quality benefits
- Adjust nitrogen application based on previous manure use and/or green manures. (all non-legume crops)
- Depending on growing crop and type of nutrient(s) used, implement inseason nitrogen adjustments based on Pre-Sidedress Nitrate Test (PSNT) (corn only),

Advanced Nutrient Management for Specialty Crops

Specialty

\$45.82/ ac 33 years @ \_\_\_\_\_acres

The all following groups of practices (listed as items 1, 2, and 3) must be applied, depending on crops grown. This scenario is only to be used by producers growing specialty crops such as: <u>vegetables</u>, orchards, nursery stock, etc.

#### 1. Apply the Proper Rate of Nitrogen

- Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history or yield monitor data for predominant soil types within the field. *(all non-legume crops)*
- Depending on growing crop and type of nutrient(s) used, implement in-season nitrogen adjustments based Leaf Chlorophyll Meter (LCM), or Tissue Test.

Calibration of Nutrient Application Equipment to ensure correct amount of nutrients are applied to the crop. (all crops)

- 2. Apply Nitrogen Timed to Crop Demand
  - Apply nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months. *(all non-legume cross)*

*(non-irrigated non-legume crops)*. Split application of the crop applied at planting. *(irrigated non-legume crops)*.

- If Urea containing fertilizers are used, utilize coated urea or urease inhibitors. (applicable to commercial fertilizer use)
- 3. Nutrient Application Efficiency
  - Precision Agricultural may includes all of the following:
    - Utilize GPS/record keeping/yield monitor using GPS/GIS software or the use of satellite, aerial imagery or infrared technology.

### 

Nutrient Management for Organic Operations						

🗌 Organic

\$64.06 / ac X 3 years @ \_\_\_\_\_acres

The all following groups of practices (listed as Items 1, 2, and 3) must be applied, depending on crops grown. This scenario is to be used by producer who is currently certified organic or transitioning to organic production as outlined by the EQIP organic guidelines.

#### 1. Apply the Proper Rate of Nitrogen

- Develop a Pre-Season estimate of Nitrogen based on expected yields, yield history of yield monitor data for predominant soil types within the first. (all non-legume crops)
- Depending on growing crop and type of nutrient(s) used, implement in-season nutrogen achievents based Leaf Chlorophyll Meter (LCM), or Tissue less
- Calibration of Nutrient Application Equipment to ensure correct amount of nutrients are applied to the crop. (all crops)
- Annual testing for nutrient analysis of all manure and compost used.

#### 2. Apply Nitrogen <u>Timed</u> to Crop Demand

• Apply nitrogen as close to crop uptake as possible avoiding any application of nutrients during the winter months. *(all non-legume crops)* 

#### 3. Improved Manure Management

- If manure is utilized, inject or incorporate within 12 hours of application. Note: Dry poultry manure may be surface applied with no incorporation. However, minimal incorporation is still recommended due to reduced phosphorus losses in runoff and associated water quality benefits
- Adjust manure / compost application based on previous manure/ and or compost use along with any previously used green manures or legumes. (all non-legume crops)

#### **Producer Certification**

I understand that I am not eligible for EQIP or CBWI payments for practices or activities that I (or persons working for me) have already implemented on acreage proposed for enrollment.

Payments for all practices listed above are the amounts NRCS will financially assist producers for the implementation of nutrient management technology to the level indicated above.

Producer only has <u>ONE TIER</u> to choose from. Producer may not select several tiers in a contract.

I certify that the above "checked" ( $\checkmark$ ) scenario are <u>not</u> currently used on the acreage that I want to enroll in EQIP or CBWI. I also certify that I will maintain a <u>current</u> Nutrient Management Plan developed by a certified nutrient management consultant and implemented in accordance with Maryland State law.

Note: Financial assistance rates for beginner or limited resource and socially disadvantaged farmers will be slightly higher than the rates indicated above.

Applicant Name:		_
Applicant Signature:	Date:	
File this completed application in	the producer's case file.	



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