NDSU NORTH DAKOTA STATE UNIVERSITY

January 7, 2015

North Dakota Industrial Commission
ATTN: Renewable Energy Development Program
State Capitol – Fourteenth Floor
600 East Boulevard Ave
Bismarck, ND 58505

RE: Project Title: Developing a Biomaterial Industry in North Dakota
PI: Dr. Nancy Hodur

Dear North Dakota Industrial Commission,

A proposal for the above-referenced project in the amount of $364,158 is hereby submitted on behalf of Dr. Nancy Hodur.

Please accept this transmittal letter as a binding commitment on behalf of North Dakota State University to complete the project as described in the attached application should this project be selected for funding.

The proposal has been administratively approved by North Dakota State University. Questions should be directed to Jill Mackenzie at 701.231.8045, or email ndsu.research@ndsu.edu.

Sincerely,

Jill Mackenzie

Jill Mackenzie
Award and Program Officer

SPONSORED PROGRAMS ADMINISTRATION
NDSU Dept 4000 | PO Box 6050 | Fargo ND 58108-6050 | 701.231.8045 | Fax 701.231.8098 | ndsu.research@ndsu.edu

Shipping address: Research 1, 1735 NDSU Research Park Drive, Fargo ND 58102

Application

Project Title: Developing A Biomaterials Industry In North Dakota

Applicant:: Department of Agribusiness and Applied Economics, North Dakota State University

Principal Investigator: Nancy M. Hodur, PhD

Date of Application: December 31, 2014

Amount of Request: $364,158

Total Amount of Proposed Project: $728,316

Duration of Project: one year

Point of Contact (POC): Nancy Hodur

POC Telephone: 701-231-7357

POC Email: nancy.hodur@ndsu.edu

Renewable Energy Program

North Dakota Industrial Commission

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ABSTRACT

Objective:

The objectives of this project are to:

1. Complete a Front End Engineering Design (FEED) for a commercial scale AFEX processing Depot
2. Evaluate and identify suitable locations and market potential for AFEX Depots in North Dakota.
3. Provide outreach and education and conduct an evaluation of agriculture producers' willingness to supply biomass and livestock operators' willingness to feed AFEX-treated biomass in North Dakota.

Expected Results:

At the conclusion of this project we will have secured a firm for construction and have a robust design and plan for construction of the pioneer AFEX Depot with cost estimate of ±10%. Best potential locations for AFEX Depots will be determined based on refined estimates of biomass supply, market potential as a livestock feed and secondary market opportunities. Other considerations such as incentive programs and potential business structures will be examined to determine if those considerations represent significant considerations in potential locations for AFEX Depots. Interview and focus groups with the various stakeholder groups will provide input into both locational considerations and crop and livestock producers' willingness to either supply biomass or feed AFEX-treated biomass pellets. A significant outreach program will be undertaken to educate and inform key stakeholder groups of the AFEX technology and potential uses.

Duration:

Project will be completed in one year from project initiation.

Total Project Cost:

$728,316

Participants:

Key participants in this project are the North Dakota Agricultural Experiment Station (NDAES) and MBI. The NDAES has an extensive history of research on priority issues affecting North Dakota agriculture. MBl is a critical partner with an extensive history of commercializing biotechnologies.

Objectives:

MBI has developed an Ammonia Fiber Expansion (AFEX) reactor technology from laboratory to pilot scale. Based on the success of pilot studies MBI is moving forward with the design and construction of the first commercial scale Depot. Following final de-risking at the pioneer Depot, the commercialization plan is to begin deployment of multiple depots throughout the United States, including North Dakota. The first step in this process is to develop the engineering design necessary to begin construction. Therefore, North Dakota State University, in collaboration with MBI, proposes to develop a Front End Engineering Design (FEED) for the pioneer commercial AFEX Depot near MBI, and begin planning for development of a North Dakota Depot. The objectives of this project are to:

1. Complete a Front End Engineering Design (FEED) for a commercial scale AFEX processing Depot
2. Evaluate and identify suitable locations and market potential for AFEX Depots in North Dakota.
3. Provide outreach and education and conduct an evaluation of agriculture producers' willingness to supply biomass and livestock operators' willingness to feed AFEX-treated biomass in North Dakota.

Methodology

Objective 1: Front End Engineering and Design:

The objective of this study is to complete a FEED study using Front-End Loading (FEL) methodology that will allow identification and adoption of necessary changes early in the planning effort, when changes can be made at low cost. To optimize resources and expedite theprocess, the effort will be divided into three FEL phases, with increasing level of detail and cost in each successive phase and stage gate review at the end of each phase.

As part of a recently-completed U.S. Department of Energy (DOE) project MBI, along with project partner Idaho National Laboratory (INL), have developed a concept for a depot-scale commercial plant to convert raw biomass feedstocks to AFEX-treated pellets. The basis of the concept is a depot with capacity to convert 100 tons of baled biomass (dry matter) with moisture less than 20 percent to AFEX-

treated biomass pellets with moisture less than 15 percent. The Front-End Loading (FEL) Stages for AFEX Depot FEED effort are described in Appendix A. This material is confidential.

Objective 2: Evaluation of Suitable North Dakota Locations and Market Potential

Proximity to markets, availability and cost of inputs, transportation systems, business climate and tax structure, and potential synergies with other plants and facilities are all factors that can affect location selection and market potential for agriculture processing plants. An AFEX Depot represents a blend of supply- and demand-orientated agricultural manufacturing; therefore, both supply-side factors and demand-side factors affect location decisions and will be evaluated.

Biomass Supply:

Key factors related to the supply of biomass include crop production, current use for biomass and producer's willingness to supply biomass. As part of previous work funded by the North Dakota Industrial Commission (NDIC No. R010-022), biomass production, total recoverable biomass from wheat straw and corn stover and biomass feedstock cost was estimated using yield data, the Harvest Index Formula and published biomass recovery rates. Findings revealed that sufficient quantities of recoverable biomass are available in every region of the state to support multiple AFEX Depots. However additional factors can affect biomass availability. Alternative uses such as livestock bedding, supplemental feed, and aftermath grazing can affect localized biomass availability. Previous research also suggested producer willingness to supply biomass varied regionally (NDIC No. R001-003). Producers in some regions were hesitant to remove biomass because of the nutrient and moisture retention value of biomass. The research team would revisit producer willingness to supply biomass and alternate uses of biomass through a series of interviews and focus groups with potential biomass suppliers (crop producers) in regions of the state that are identified as having adequate biomass production to supply an AFEX Depot. Secondary data on alternative biomass uses are less robust, but to the degree data is available, it will be used to refine estimates of total available biomass.

Potential Markets:

Given that previous assessments of available biomass suggests ample biomass to support multiple AFEX Depots, development and commercialization will likely be driven by demand. The most likely initial market for AFEX-treated biomass will be ruminant animal feed. AFEX improves digestibility of biomass and initial feeding trails show no significant difference between cattle fed a standard corn-based diet and cattle fed with AFEX-treated corn stover substituted for 30 percent of the corn (Blummel et al., 2014). North Dakota ranks 10th in nation for beef cow inventory, however most of the state's beef industry is characterized by cow-calf operations. While most of the calves produced in North Dakota are fed to finished weights in other states, livestock producers do background cattle in place (on ranch) in addition to commercial backgrounding and finishing lots in North Dakota. In order to identify potentially suitable locations the research team will conduct an inventory of the size and location of licensed commercial backgrounding and finishing operations and make an assessment of the market potential of livestock operators that background in place. In addition to identifying the market potential for AFEX pellets, the research team will gauge producer willingness to feed AFEX pellets through a series of personal interview and focus groups with commercial backgrounding operations and livestock producers. Additional feeding trials will be required to fully quantify feed value (Petry 2014).

The location of potential secondary markets for AFEX pellets, namely existing corn ethanol plants will also be considered when identifying potential locations for AFEX depots. MBI has shown excellent fermentability of AFEX-treated corn stover pellets to make ethanol. Results are comparable to ethanol production from non-cellulosic sugars and the process has been demonstrated at pilot scale (3,000 L). MBI has also shown similar fermentability for production of bio-based chemicals. The presence of secondary markets could be a key consideration when identifying potential location for AFEX depots.

Other Considerations:

The business model and development incentives are also key considerations in location decisions. While financing, cost-sharing, or interest buy-down programs may be available at the state level, those programs are not likely to have local stipulations aside from locating and remaining in North Dakota. However, many local communities in North Dakota have economic development programs, and often offer substantial financial incentives to new manufacturing facilities. Regional development funds, managed by regional trade centers, vary considerably by city and region in North Dakota, and the applicability of both state programs and local incentives would be included in the evaluation of suitable plant sites in North Dakota.

Options for ownership structures include private ownership through an agribusiness or feed manufacturing firm (e.g., Purina Mills), a producer-owned cooperative (i.e., closed co-op like American Crystal Sugar Coop), or an existing cooperative without closed ownership (e.g., Cenex/Harvest States). Each has relative advantages and applicability. The research team will explore the relative merits of each as they would apply to a system of AFEX Depots with regional commercial feed distribution managers, existing elevator and grain handling managers, and potential owners of a closed-cooperative, such as landowners and/or livestock producers.

Outreach:

While North Dakota State University has been working with MBI on commercialization of AFEX technologies since 2003, previous conversations focused on biomass supply and the end use of pretreated biomass as feedstock to a commercial biorefinery. With the relatively new application of AFEX-treated biomass as feed for ruminant livestock, it is likely that most livestock producers in North Dakota know or understand little about the technology. While producers in North Dakota are accustomed to feeding a wide variety of feedstocks, such as wheat mids, sugarbeet tailings, and DDGs from ethanol production, producers will need to become familiar with the product. Further, the

relatively small size of the AFEX Depots (100 or 200 tons per day) changes the supply-side dynamic which may positively affect producer willingness to supply biomass. A significant outreach effort is needed to inform agriculture producers, crop and livestock grain handling managers, feed distribution outlets, and other agribusiness firms of the applicability and potential market opportunities of a system of AFEX Depots. As part of that process, feedback from crop and livestock producers, landowners, and agribusiness firms will be a necessary prerequisite to finding acceptance for the use of biomass and willingness to invest in the technology. An outreach effort would consist of a combination of presentations to various stakeholder groups, development of circulars and electronic media, and use of focus groups.

Anticipated Results:

At the conclusion of this project we will have secured a firm for construction and have a robust design and plan for construction of the pioneer AFEX Depot with cost estimate of ±10%. Best potential locations for AFEX Depots will be determined based on refined estimates of biomass supply, market potential as a livestock feed and secondary market opportunities. Other considerations such as incentive programs and potential business structures will be examined to determine if those considerations represent significant considerations in potential locations for AFEX Depots. Interview and focus groups with the various stakeholder groups will provide input into both locational considerations and crop and livestock producers' willingness to either supply biomass or feed AFEX-treated biomass pellets. A significant outreach program will be undertaken to educate and inform key stakeholder groups of the AFEX technology and potential uses.

Facilities:

No new facilities are anticipated. MBI will work with an engineering, procurement and construction partner (EPC) partner to complete work on engineering and design elements for a commercial scale AFEX Depot. Technology development at MBI takes place in a 120,000 square –foot,

state-of-the-art R&D center, including a 20,000 square-foot pilot plant. The fully equipped facility is capable of supporting multiple projects in microbiology, molecular biology, bioprocess engineering, and material science and is well suited to conduct laboratory and pilot scale research, development and production. Support and administrative services are integrated into the facility to efficiently coordinate project development.

Resources:

The project is a continuation of a collaboration led by the North Dakota Agriculture Experiment Station and MBI. The goal of that collaboration is the development of a biomaterial industry in North Dakota. Dr. Nancy Hodur will serve as principal investigator (PI) and Dean Bangsund will service a co-principal investigator for NDSU. Dr. Bernie Steele, Director of Operations, will serve as PI for MBI. Curriculum Vita available upon request.

Techniques to be Used, Their Availability and Capability:

The AFEX reactor concept has been demonstrated at pilot-scale (1 ton/day) using both wheat straw and corn stover. Experiments have shown that moist biomass can be used to absorb and separate ammonia from an inert sweep gas in a manner that effectively leads to treatment of the biomass. This reactor has been used to produce the multi-ton quantities of treated biomass needed for initial animal feed trials, pelleting, and pilot-scale fermentation tests. Data from operation of the pilot-scale reactor will be used to develop the FEED for the commercial scale Depot.

Environmental and Economic Impacts while Project is Underway:

During the pilot-scale FEED study for the NDIC a preliminary National Environmental Policy Act (NEPA) analysis was completed (see final report) and did not identify any significant environmental impacts for this type of project. An updated NEPA analysis will be completed for the commercial scale Depot following development of the FEED. The economic impact while the project is underway will be the direct employment of the personnel involved as shown in the budget.

Ultimate Technological and Economic Impacts:

The AFEX Depots as described in this project are instrumental to developing advanced feedstock logistics systems for utilization of biomass in the production of bio-based fuels, chemicals and materials (U.S. DOE BETO MYPP, 2014). This advanced feedstock logistics concept realizes the need for local biomass production, harvest and preprocessing to produce a commercially viable commodity feedstock that can be transported, stored and handled using existing infrastructure. The AFEX process is unique in that it results in a highly densified dry product that is easily digested by ruminant animals and can be easily fermented for production of fuels and chemicals. The process also is unique in that it can be economically scaled down. Economic impacts include increased business activity from activities related to construction and operations of the AFEX depot, increased income for crop producers from the sale of agricultural biomass, alternate feed source and reduced feed costs for livestock producers. Direct economic impacts represent payments to North Dakota entities for most inputs for production; wheat straw, corn stover, natural gas, ammonia, electricity, water and labor. Previous research funded by the NDIC estimated total operational impacts (direct and secondary) to be $13.3 million, for a 110-tons per day AFEX depot, and $133 million for a ten depot system (each 110-tons per day), respectively. The largest impacts would accrue to the Household and Retail Sectors. A 110-tons per day depot would employ 16 full time equivalent workers (NDIC No. 010-022)

Why the Project is Needed:

A major untapped resource is agricultural biomass, the non-edible crop residues such as stalks and leaves that remain after grains are harvested. About 2 billion to 3 billion tons of biomass is produced every year. Biomass is composed mostly of sugar polymers that are tightly bound and intertwined with an indigestible structural material, lignin. If these sugars could be readily accessed, the biomass could potentially be converted into animal feed and renewable fuels and chemicals.

There are several major challenges in capturing the value of agricultural biomass: 1) cost-effectively altering the biomass to an upgraded form in which the constituent sugars are easily accessible, 2) handling, storing and hauling low-density biomass from the field to the site of eventual use, and 3) establishing the upgraded biomass as a readily tradable commodity with clear economic value for the diverse players involved in its production, processing and use. AFEX™, our transformative biomass processing technology, addresses the first challenge by using ammonia to treat agricultural biomass at moderate pressures and temperatures. AFEX increases sugar access substantially; while only 20 percent of the sugars are accessible in untreated biomass, the accessible sugar *quadruples* to nearly 90 percent as a result of AFEX treatment. AFEX-treated biomass can be easily and economically pelletized to increase its bulk density by a factor of 10, resulting in grain-like handling characteristics and improved transportation economics.

A biomass processing Depot concept has been proposed as one way to reduce costs and overcome many of the logistic challenges of the lignocellulosic biomass feedstock supply chain (Eranki et al., 2011; U.S.DOE BETO MYPP, 2014). In this concept, raw biomass harvested from farmland is transported relatively short distances to small-scale depots for processing into denser and more uniform stable commodities. Those commodity feedstocks can then be stored economically and transported. The AFEX technology will be implemented at local “Depots,” which will receive the raw biomass from farms located within a 5-10 mile radius. The AFEX pellets, which have a long shelf life and 8-10 times greater density than raw biomass, can be economically stored and shipped from depots to markets using existing grain infrastructure, addressing the second challenge.

The AFEX pellets can be used both as a feed for ruminant animals or as a feedstock for sugar-based fermentations to produce industrially important fuels and chemicals. Testing has validated the efficacy in both applications. Preliminary feeding trials suggest pre-treated biomass can be substituted for corn and achieve equivalent weight gain and carcass quality (Blummel et al., 2014). AFEX has been

shown to be a highly effective pretreatment for corn stover and a wide range of other agricultural residues and energy crops, including *Miscanthus*, switchgrass and wheat straw (Bals et al., 2010). AFEX treatment has also been shown to mobilize lignin to act as a natural binder, facilitating densification of biomass (Dale et al., 2011).

STANDARDS OF SUCCESS

Deliverables for this project include a complete design for construction of a pioneer AFEX Depot with cost estimates ±10% and specific criteria to selection of potential Depot sites in North Dakota. The results of this project will allow construction of the pioneer Depot, which itself will serve as a demonstration facility to attract investors in Depots for North Dakota and the rest of the United States.

Findings will identify the best possible locations for AFEX pretreatment facilities in North Dakota, taking into consideration biomass supply, potential markets and other considerations such as secondary markets, potential development incentives. Deliverables include an outreach strategy that informs and introduces stakeholder groups to AFEX technology, the Depot concept and the potential opportunities associated with a biomass industry in North Dakota. The potential value to North Dakota of commercializing the technology can be measured both quantitatively and qualitatively. From an economic impact viewpoint, the AFEX concept can add value to existing agricultural biomass. The economic value to the state is straightforward in that it could create additional employment in local areas, potentially expand the tax base, and be another economic development opportunity for those communities and regions that rely heavily on agriculture. From a qualitative perspective, a number of benefits can accrue to early adopters of new technology, and North Dakota could position itself as leader in the development of new technologies to better utilitize biomass.

BACKGROUND/QUALIFICIATIONS

Key participants in this project are the North Dakota Agricultural Experiment Station (NDAES) and MBI. The NDAES has an extensive history of research on priority issues affecting North Dakota

agriculture. MBI is a critical partner with an extensive history of commercializing biotechnologies. The AFEX technology was originated by Professor Bruce Dale at Michigan State University, who has been researching the science underpinning AFEX for over two decades. In 2010, MBI made a significant design breakthrough, resulting in a novel reactor with reduced capital and operating cost. In 2011, the NDIC funded work on design and construction of the novel AFEX prototype. Based on the success of this prototype, MBI developed an initial engineering design for a pilot AFEX reactor and won a $4.3M U.S. DOE award to scale up the technology from laboratory prototype (10 liter) to pilot scale (2 X 450 liter). In 2013, MBI commissioned the pilot AFEX reactor and initiated shakedown operations. The pilot reactor has been used to refine the technology and support small-scale animal feed trials and biorefinery applications development.

MANAGEMENT

The key project participants have been working together in efforts leading to the present undertaking for the past 8 years. In this context, the project team has established a management system featuring (1) regular (generally at least weekly) e-mail communications, (2) periodic (at least quarterly) reviews of progress, and (3) publication of research findings and outreach efforts upon completion of key milestones.

TIMETABLE

Project will be completed in one year from project initiation. See timeline below.

Timeline	**Month**											
Description	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
FEL-1: Contract with Engineering, Procurement and Construcion (EPC) partner	■	■										
Completed AFEX Depot project scope and charter that address throughput, biomass types, biomass handling and storage			■									
Complete preliminary mass and energy balances for the Depot			■									
FEL 2: Complete design of depot-scale biomass handling, ammonia recovery, reactor, pelleting train				■								
Complete preliminary Depot layout, project schedule					■							

Timeline (cont.)	Month											
Description	**1**	2	3	4	5	6	7	8	9	10	11	12
Complete preliminary Depot cost estimate (±30%)					■							
FEL 3: Complete equipment specifications for vendor quotes						■						
Complete 3-D CAD model of the Depot							■					
Complete Depot construction plan							■					
								■				
Complete Depot cost estimate (±10%)								■				
Inventory licensed commercial backgrounding and finishing lots				■	■	■	■					
Identify potential secondary markets				■	■	■	■					
Crop producer focus groups to evaluate wiliness to supply biomass							■	■	■	■		
Livestock producer focus groups to evaluate wiliness to feed AFEX pellets							■	■	■	■		
Evaluation of other considerations									■	■		
Outreach Program				■	■	■	■	■	■	■	■	■
Document Preparation									■	■	■	■

BUDGET

Funds Requested from the ND Industrial Commission - $364,158

Funds requested by NDSU: $114,158. NDSU salaries and fringe benefits are for Research Scientist and Assistant Research Professor to complete work to assess market potential and best potential locations of AFEX processing depots as detailed in the proposal Travel for in-state mileage, accommodations, per diem and other expenses related to personal interviews, focus groups and other meetings related to the project Printing and materials are for document preparation expenses. Indirect charges are calculated at 45 percent of modified total direct costs. For the purposes of this project, modified total direct costs includes all direct costs and the first $25,000 of the subaward to MBI. Subaward costs requested by MBI: $250,000. Salaries and fringes including salary and fringe benefits for MBI research personnel including scientists, engineers, machinist, operators and project managers for activities related to the completion of a FEED study for commercial scale AFEX processing depots. Travel costs are for travel from Michigan to North Dakota for project meetings (1 person, 1 trip) and for

reporting project results in North Dakota (1 person, 1 trip). Engineering, procurement and construction services for design and engineering activities for a commercial scale AFEX processing depot as detailed in Appendix A to be completed and certified by a licensed professional engineering firm as required by law.

Matching funds provided by MBI - $364,158:

MBI will pay $82,000 in salaries and fringe for MBI research personnel including scientists, engineers, machinist, operators and project managers for activities related to the completion of a FEED study for commercial scale AFEX processing depots as detailed in the proposal. Total cost for engineering, procurement and construction services will be $387,000. Of this amount, $163,000 will be paid from the Industrial Commission grant funds and the remainder ($169,056) will be paid by MBI. MBI's proposed indirect cost rate (based on fiscal year 2013 figures) is 137.98% and is applied to salary, benefits and materials

Budget Item	NDIC Share	Applicant Share	Total Cost
NDSU			
Wages	$48,670		$48,670
Benefits (30 percent)	$14,601		$14,601
Travel	$7,500		$7,500
Printing, materials, communications	$200		$200
Indirect Costs (45 percent)	$43,187		$43,187
NDSU Subtotal	$114,158		$114,158
MBI Subcontract	$250,000	$364,158	$614,158
NDSU Total	$364,158		$728,316
MBI Subcontract			
Salary and Fringe Benefits	$82,000	$82,000	$164,000
Travel	$5,000		$5,000
engineering, procurement and construction services	$163,000	$169,056	$387,000
Indirect Costs (137.93%)	$0	$113,102	$113,103
MBI Total	$250,000	$364,158	$669,103
Project Summary			
NDIC Share (NDSU total costs)	$364,158		
Matching (50% max.)	$364,158		
Project Total	$728,316		

CONFIDENTIAL INFORMATION

Details of the FEL development stages are found in Appendix A and are considered confidential. The description contains information regarding technical design options that are critical to commercialization and competitive advantage of the AFEX Depots and are considered "Know-how" and not protected by patents.

PATENTS/RIGHTS TO TECHNICAL DATA:

MBI and Michigan State University retain all current Intellectual Property Rights related to AFEX pre-treatment technology.

REFERENCES:

Bals BD, Murnen H, Allen M, Dale BE. 2010. Ammonia fiber expansion (AFEX) treatment of eleven different forages: improvements to fiber digestibility *in vitro. Anim. Feed Sci. Technol.* 155(2–4), 147–155.

Dale, BE, B. Ritchie, and D. Marshall. 2011. Patent Application US046525

Blummel, M., B. Steele, and B.E. Dale. 2014. Opportunities from second generation biofuel technologies for upgrading lignocellulosic biomass for livestock feed. CAB Reviews. 9,41. In press.

Eranki, P.L., Bals, B.D., Dale, B.E., 2011. Advanced regional biomass processing depots: A key to the logistical challenges of the cellulosic biofuels industry. Biofuels Bioprod. Bioref. 5, 621-630.

NDIC No. 001-001. Developing a Biomass Industry in North Dakota.

NDIC No. 010-022. Developing a Biomass Industry in North Dakota. http://www.nd.gov/ndic/renew-project.htm

Petry, Tim. 2014. Person Conversation. Fargo: North Dakota State University Cooperative Extension Service, Livestock Specialist.

U.S. DOE Bioenergy Technologies Office. Multi-Year Program Plan. November 2014

Appendix B: Tax Liability/Tax Affidavit

NDSU NORTH DAKOTA STATE UNIVERSITY

December 23, 2014

To Whom It May Concern,

North Dakota State University regularly pays taxes to the State of North Dakota for state income tax withholding, state sales taxes collected, and unrelated business income taxes. To the best of my knowledge, North Dakota State University is current and paid up on all tax liabilities with the State, with no past due balances.

Sincerely,

Ramona Adams

Ramon Adams
Associate Controller

ACCOUNTING OFFICE | DIVISION OF FINANCE AND ADMINISTRATION
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