# Business-centric data solutions for safeguarding American animal agriculture

L. Estberg*, J. Luxton, K. Spiegel, A. Pelzel-McCluskey, B.L. Gomez & J.L. Vanden Eng

Veterinary Services, Animal and Plant Health Inspection Service, United States Department of Agriculture, 2150 Centre Avenue, Fort Collins, CO 80526-8117, United States of America

*Corresponding author: leah.estberg@usda.gov

**Summary**

Business-centric solutions to data-related problems often yield the greatest positive impacts and improvements to enterprise operations but are challenging to design and implement at scale within government agencies. The core mission of the United States Department of Agriculture – Animal Plant Health Inspection Service – Veterinary Services (USDA APHIS VS) is to safeguard American animal agriculture, and effective data management underpins these efforts. As our agency works to facilitate data-driven decision making in animal health management, we continue to leverage a blend of best practices from Federal Data Strategy initiatives and the International Data Management Association (DAMA) framework to support operational excellence in data management. This paper describes three case studies focused on strategies to improve animal health data collection, integration, reporting, and governance for an animal health authority. These strategies have enhanced the way USDA's Veterinary Services executes its mission and core operational activities for disease prevention, detection, and early response to support containment and control.

**Keywords**

Animal health – Automation – Business process improvement – Data collection – Data governance – Data management – Integration – Reporting – Standardisation.

## Introduction

In 2019, the United States (US) Federal Government Office of Management and Budget announced the creation of the first ever coordinated and integrated Federal Data Strategy (FDS). This began a 10-year initiative to provide a US government-wide vision of how agencies should manage and use federal data. The FDS mission is to '*fully leverage the value of federal data for mission, service, and the public good by guiding the Federal Government in practicing ethical governance, conscious design, and a learning culture*' [1]. The FDS framework consists of ten principles, 40 practices, and 20 action steps to guide federal agencies on data management and use (Table I). The full framework is available online [1]. Although designed for senior executive level leaders in federal agencies, specifically Chief Data Officers, the principles and practices have broad and cross-cutting applications to teams, programmes, and projects at all levels of a federal agency.

The United States Department of Agriculture (USDA) is one of many federal agencies implementing and adhering to the FDS framework. Within the USDA, Animal and Plant Health Inspection Service (APHIS) Veterinary Services (VS) has identified and created ways to introduce or continue to apply these principles and practices to animal health data and information systems. VS's mission is to improve the health, productivity, and quality of life for animals and people, and maintain and promote the safety and availability of animals, animal products, and veterinary biologics [2]. VS encompasses a vast number of activities including: comprehensive surveillance for numerous animal commodity groups and disease programmes, laboratory information services, One Health, emergency preparedness, animal movements and traceability, veterinary accreditation, and other emerging issues. To accomplish programme goals, VS collaborates

with local, State, tribal, national, and international partners. Underpinning many of these activities, VS leverages animal health data and information systems as strategic assets to deliver on its mission, serve the public, and steward resources.

Effective use of data requires a strong data management framework that provides actionable details for the collection, storage, structure, and maintenance of an organisation's data and information systems. Better data management leads to improved data quality and access, increased productivity, cost efficiency, data security, and informed decisions for operational planning [3]. The Data Management Association (DAMA) International created a data management framework with ten core functional areas which organisations can use as a guide for data management strategy and implementation [3]. At the core of the framework is data governance, but it also includes security; architecture; database operations; document and content management; data development; reference, master, and metadata management; data quality; integration and interoperability; and data warehousing and business intelligence [3].

VS's approach to govern, manage, and protect data leverages both the principles and practices listed in the FDS and the DAMA framework core functional areas in order to promote efficient and appropriate data use and to optimise the value of animal health data in support of programme activities. The data maturity process has been cyclical – establish a baseline, gain support, collaborate, and refine continuously. Operationally, common FDS principles used by VS programmes include: ensure relevance (FDS principle #4), harness existing data (FDS principle #5), anticipate future uses (FDS principle #6), and demonstrate responsiveness (FDS principle #7) [1]. Collectively these four principles represent conscious design, a process that creates a product that is responsive to the needs of the programme. By integrating FDS principles and practices with the DAMA data management functional areas, animal health programmes are better positioned to develop flexible data solutions that meet and adapt to business needs, rather than adjust or limit their business processes to conform to information technology (IT) systems.

This paper examines three case studies focused on animal health programme activities' data needs to demonstrate how VS uses the DAMA framework and FDS principles to harness the value in existing data. These examples were selected because they resulted in data products and solutions that met the user requirements of animal health authorities, while supporting effective and efficient animal health management processes. Use of the DAMA framework and FDS principles, demonstrated by these examples, may be helpful for other countries' animal health authorities as they aim to take advantage of data to support regulatory and management decisions, while navigating the challenging space between information technology, data management, and animal health.

## Case studies

### Improving data quality with knowledge management and standardisation

#### Avian influenza testing cooperator reporting example

Within the US, State Animal Health Officials and poultry industry partners perform testing for avian influenza (AI) as part of a VS-organised cooperative arrangement for AI surveillance. The cooperators are allowed to use the funding provided to pay for testing at any public laboratory of their choosing (e.g., university lab, NAHLN lab, referral lab). This AI testing programme complements several other systems in the United States of America (USA) [4, 5, 6]. All testing that is funded by this programme must be reported to APHIS on a quarterly basis. Additionally, any positive AI test results, regardless of the funding source, must be reported to APHIS VS immediately. While this system has been very successful at supporting claims of disease freedom, the process of collating and reporting this data has been labour-intensive. A recent project aimed to improve the efficiency and data quality of AI reporting by using data standards and developing a knowledge management strategy.

Data management not only sets the foundation for how IT systems share and integrate information but also supports efficient and effective

collection and use of the information [6]. Understanding and defining business rules (i.e., business concepts and governance) is integral to data management. Business rules can be approached with a knowledge management strategy and the development of a concept model. Effective business rules often apply a vocabulary standard. The vocabulary must be more than a simple listing of terms but also include modelled relationships between terms to fully depict the underlying knowledge (e.g., each report is submitted by a contributor who is affiliated with a cooperator located in a State). A concept model focuses on structuring business data entities according to the connections between them. A strong vocabulary standard, supported by clear business language and definitions, along with an underlying concept model help lay the groundwork for data quality. Together, they provide an integrated point of knowledge and ensure all business rules and other forms of communication (e.g., business policies, IT requirements) are consistently expressed.

For this surveillance programme, a modernisation effort resulted in replacing a spreadsheet-based reporting tool which required time-consuming manual review and correction of invalid test results with an online data entry system including data quality enforcement rules. Development of the modernised system and a 'best practice' knowledge management strategy resulted in a set of vocabulary terms, definitions, and business rules that served as the base for the IT system and automated data quality support. In addition to providing meaning and coherency to business rules, processes, and IT system requirements; the well-structured (modelled) vocabulary also supported the expression of the AI surveillance guidelines and policy in a robust yet approachable form for the animal health workforce.

The strategy used to develop the modernised AI system followed perspectives and guidance from books [7, 8], training resources offered by the Business Rules Solutions company (https://www.brsolutions.com/company), and the Business Rules Community online newsletter (https://www.brcommunity.com/index.php). For example, the modernised AI surveillance reporting tool implemented the

recommendation to treat any aspect of operational business knowledge that might change over time as a business rule rather than a vocabulary term [7]. A business rule's purpose is to shape (govern) day-to-day business activity and prevent undesirable situations that could occur [7], whereas a vocabulary term is a concept which is shared based on its definitional criteria [8] but does not describe any actions to impact business activity.

The value of applying the recommendation for separating rules from terms became apparent as the project progressed and two types of VS stakeholders were identified and engaged [9]. The first type of stakeholder is responsible for the support of system operation including the ownership of the data collected and manages the cooperative agreement system and guidelines. This stakeholder group has a strong interest in developing business (governance) rules that maximise data accuracy and minimise the need for manual correction of data errors. The business rules collected from this group (e.g., the total number of pooled bird specimens allowed for ACIA testing – which may change over time as testing guidelines are updated) served as the basis for the data management IT system requirements [10] and contributed to improved data quality in the modernised tool. The second type of stakeholder, responsible for ownership of the vocabulary, had the broadest knowledge and created the vocabulary terms (e.g., which traits are used to classify types of birds tested). This stakeholder group has a strong interest in developing accurate definitions and making them available to cooperators using the modernised reporting tool [11]. By engaging stakeholders directly and intentionally, the outcomes contributed to improved data quality, because cooperators are able to review and confirm their understanding of terms. Well-defined terms are crucial since the data may eventually be integrated with other avian testing data or systems.

Knowledge sharing between VS AI disease subject matter experts, stakeholders involved in the surveillance programme, and IT team members can reduce the chance of discrepancy between surveillance policy and services offered by information systems [12]. By focusing on a well-structured vocabulary and guidelines, VS stakeholders were

able to ensure essential business needs were accurately represented and accounted for in the modernised system. Both the legacy and modernised reporting tools require manually entering quarterly data for up to roughly 20 cells depending on what was tested by the cooperator. However, the modernised system supports online data entry and executes automated quality control with the application of business rules, (such as detecting incorrect number of birds tested relative to the number of tests performed for the quarter) (Figure 1). It saves time by eliminating the need for manual review and requesting corrections. In addition, the vocabulary terms and definitions are made accessible in the modernised system (Figure 2). This also contributes to the quality of the data as it improves the chance that system users share the same understanding of terms. Moreover, the experiences gained from this knowledge-based approach instilled confidence in the data collected and reported by the information system for all stakeholders who have an interest in using high quality evidence for reaching export trade agreements with foreign partners.

## Enhancing surveillance with reporting system development

### Equine infectious anaemia example

Equine infectious anaemia (EIA) is a potentially fatal blood-borne disease caused by the EIA virus (EIAv) and often naturally transmitted via blood-feeding insect vectors [13]. It affects members of the Equidae family (horses and related equids), is present in many countries, and creates significant negative economic burden [14]. Initial exposure to EIAv causes an acute stage of infection with severity ranging from mild fever to sudden death [13]. If survived, chronic and inapparent stages of infection follow, and infected equids become lifelong, contagious carriers of EIAv [13]. No vaccine or effective treatment is currently available for EIA, limiting disease management options to permanent isolation or euthanasia; as a result, prevention of infection is critical for overall control of EIA and protection of the equine industry [13]. During the past five decades of EIA control in the USA, surveillance, widespread testing, and management of infected horses have proven to be the best methods for prevention of EIA transmission [14, 15].

Surveillance and testing are key components of EIA control, especially given the variable clinical severity of EIA [15]. In 2019, VS released new guidance for EIA testing efforts [16] which built upon prior successes and aimed to further reduce EIA prevalence by enhancing oversight of EIA testing. EIA testing is restricted to laboratories specifically trained and approved by USDA's National Veterinary Services Laboratories (NVSL), and the new guidance enhanced inspection, documentation, and reporting standards. An important component of this guidance requires over 400 approved EIA testing laboratories to report monthly totals of EIA tests and summary results to the VS equine health team via EIA monthly reports [16].

VS developed a new laboratory reporting pipeline to facilitate data collection, integration, and reporting of the large number of EIA reports required to be submitted each month as part of the new guidance standards. During initial stand-up, NVSL's existing master list of EIA-approved laboratories and contact information was used to support communication with the laboratories. The equine health team engaged in outreach with the EIA testing laboratories, to set expectations and the basis for reporting. Early on, the team recognised that EIA testing laboratories have a diversity of technology for data handling and a diversity in IT skills among staff, thus general and widely available tools were necessary for laboratories to create and submit their EIA monthly reports to VS. The laboratory reporting pipeline was developed based on these requirements and included: Microsoft Excel and email as the primary tools for report creation and submission; programmatic steps to access, curate, and process reports; natural language processing (NLP) algorithms to achieve data standardisation; and data-marts for internal reporting and analyses on the received data [17, 18].

Limited time was available given the immediate effective date of USDA policy requiring monthly summary reporting from the laboratories, so in lieu of a complex information system, a highly customised, lightweight Excel workbook was created as a template for EIA monthly reports and included data validation rules, reference data, and user hints to expedite and support accurate reporting [19]. Laboratories complete monthly reports of aggregate level data (e.g.

total number of tests, and total number of positives) and send them to a VS equine health email inbox, where the reports are automatically downloaded, and the data are cleaned, combined into a single dataset, and loaded into a VS data system. The data management process included automatically omitting and flagging duplicate reports and files with errors for review. Laboratories with clearance to access VS systems are also provided with an alternative option to directly enter their monthly reports into a VS data system. The integrated data pipeline automatically combines results from both reporting options into a single dataset and cleans and processes the data to ensure accuracy on summary reports. For example, one data management step automatically standardises laboratory contact information using an NLP algorithm (term frequency–inverse document frequency [TF-IDF]) by comparing data on the reports against the NVSL-maintained master list of EIA testing laboratories [20, 21]. Finally, the prepared data are visualised and analysed across various metrics including testing numbers, test types (enzyme-linked immunosorbent assay [ELISA] *vs* agar gel immunodiffusion [AGID]) and results (positive, negative) and the summary results are published for internal and public audiences (https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/equine/eia/equine-infectious-anemia).

The laboratory reporting pipeline has been successfully operating since 2019, shortly after the updated guidance was released [16]. This pipeline provided two key lessons in data quality. First, Microsoft Excel workbooks are desirable for their general familiarity and flexibility, but this is a disadvantage for reporting which requires standard, consistent data formatting. Second, receiving reports via email was fast to stand-up, but also created challenges for backtracking faulty reports to the original submitter. To address these two broad issues, strong relationships and communication with laboratory directors and staff was critical; likewise, the implementation of automated data management procedures have proven invaluable. In the future, it is planned to shift all laboratories to direct data entry into the VS system using a simple online data entry form which is currently in use by a small number of laboratories that already have access to VS systems. This transition will eliminate the two data quality issues described.

Even in its current format, annually this new pipeline receives reports of several millions of test results for EIA surveillance, successfully contributing to EIA control efforts in protection of the equine industry (Figure 3).

## Building efficiencies using digital tools

### Approval of livestock markets example

Livestock transportation and concentration points such as slaughter plants and livestock markets handle large numbers of animals as they move within these centralised and structured places. Federal oversight and accurate tracing of animal movements at these locations is essential to disease traceability efforts.

To qualify and operate as a federally approved livestock market, the legal operator of the facility must sign and execute an agreement and comply with the US Code of Federal Regulations [22]. This agreement safeguards the livestock and facility operations, by ensuring the market is complying with record keeping, identification, cleaning and disinfecting, facility and equipment, and livestock handling regulations. It also secures access to conduct necessary activities for disease detection and traceback, as well as facility cooperation and notification of livestock that are known or suspected to be infected with any infectious, contagious, or communicable disease.

The VS Animal Disease Traceability (ADT) program is dedicated to implementing a comprehensive animal disease traceability system to help identify and locate animals and trace their movements in the event of an outbreak. The ADT program also supports the authority to ensure interstate animal movements comply with federal regulations [22, 23, 24, 25, 26, 27, 28, 29, 30], and continuously develops and provides new tools to make traceability activities more efficient and effective. Recently, the ADT program put forth an effort to modernise livestock markets agreements to a more streamlined electronic process.

Prior to 2021, the established process for approval of livestock market inspections and agreements used paper forms and wet ink signatures

transmitted by the US Postal Service mail or by emailing the scanned documents after signature. An APHIS field officer would visit a facility, review the agreement with the facility owner/operator, and retain an ink-signed copy of the agreement. The APHIS field officer would then send the agreement to the respective area veterinarian in charge, who would send the agreement to the State Animal Health Official, and subsequently to the APHIS Administrator (or an official designee) for final approval and signature. The APHIS ADT program retained the paper copies, maintained the list of approved markets in the USA, and shared the list on a public website. This was a time-consuming process and depended on many manual steps for each agreement, including mailing, emailing, or hand-delivering copies of agreements to the required approving officials. After final approval, the records were manually stored and updated as necessary using paper files and spreadsheets for over 1,200 federally approved livestock markets in the USA.

The main goal of the modernisation project was to introduce and adapt new technology and systems to improve the efficiency, effectiveness, and accuracy of the livestock market agreement process. The new process for agreements updates the former process in three important ways: 1) it uses a fully electronic form, 2) it automates data curation and collation, and 3) it includes an interactive real-time dashboard (map) on a public website.

The electronic form gives users the option to enter data while online or offline on smartphones, tablets, or laptop computers. It improves the value of information gathered by incorporating data quality checks and assisted form completion at the time of data entry, removing the possibility of erroneous or missing fields that need to get sent back for completion. It also facilitates and speeds data entry by providing the ability to select a market facility from a standard list of premises (reference data) and prepopulating the corresponding fields. In addition, the electronic form streamlines the signature routing workflow by sending email notifications to the approving officials, who can then log in and sign the form digitally. The form now stores data in a tabular electronic format which enables the automation of data management

and reporting processes. Scripts and routines clean and collate the data, summarise the results, and update the list of approved markets daily. Facility locations are geocoded to create a map and table with pinpoints of approved livestock markets on an interactive dashboard available on a public website (Figure 4, https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/sa_livestock_markets/ct_approved_livestock_markets). With electronic data, agreement records can be easily managed and accessed via an electronic library/repository of signed agreements. ADT program staff can readily query and analyse the approved agreement information and have additional metrics to assist with programme logistics and operations. For example, a separate internal dashboard was created for APHIS personnel to track the signature routing and completion of the agreements. Also, staff can review the dates of a market's inspections to determine when an inspection should be scheduled in the future.

To implement the change from paper to electronic records and maintain an accurate list of all approved markets, the ADT program modified their policy and set a firm timeline for switching to this new electronic form and approval process. Following this switch, the average time to completion for an agreement has been reduced from weeks/months to days/hours. Not only has this project improved the inspection process, but also it gives VS more real-time control and oversight of the markets to help with disease control and prevention.

## Discussion

The three case studies presented here illustrate several activities where VS programme needs, and processes did not fit into an existing information system. Each example varied greatly in terms of problem area, environment, and diversity of stakeholders; however, the resulting solutions all used a business-centric approach that followed business analysis best practices (https://www.iiba.org/about-iiba), applied FDS principles and practices, and leveraged DAMA data management framework core functions. By using this business-centric approach to knowledge management, system development, and process improvement; VS programmes developed unique and flexible data

solutions to meet and adapt to business needs, rather than adjusting business processes to fit IT systems.

Each case study highlights the application of several FDS suggested practices [1], together with the DAMA data management framework [3], to help animal health programmes leverage the value of their data. The first case study applied knowledge management techniques including mutually agreed upon vocabulary, definitions, and rules, to simplify and improve avian influenza surveillance reporting. Key FDS practices evident in this case study were leveraging data standards (# 20), designing data for use and reuse (# 29) and supporting federal and non-federal stakeholders (# 39 and 40). The second case study described development of a new EIA monthly laboratory reporting pipeline designed to accept data from a large, diverse group of laboratories and automatically prepare the information for stakeholders. Crucial FDS practices applied in this case study were to assess and balance the needs of stakeholders (# 2), identify opportunities to overcome resource obstacles (# 22), and leverage partnerships (# 36). The final case study introduced new technologies into an approved livestock market agreements approval process, automating the reporting process and greatly reducing the time needed to process agreements. Two essential FDS practices introduced here were increase capacity for data management and analysis (# 27) and align quality with intended use (# 28). Collectively, deployment of these solutions strengthened VS programmes' ability to effectively and efficiency complete core operational activities. These practices and framework may be helpful for other animal health authorities to leverage as they consider their own data management challenges.

Like many other countries, USDA APHIS Veterinary Services is cultivating a business-centric approach to continuous improvement of data management and use. This ensures animal health programme needs are met by developing data products and solutions built to meet user requirements and support business processes, rather than adjusting business processes to use existing systems. Inherent in this goal, VS is using conscious design when building data solutions guided by four FDS principles: ensure relevance, harness existing data, anticipate

future uses, and demonstrate responsiveness [1] to maximise the value in existing data. In this way, VS is better positioned to create efficient and effective solutions that integrate with an existing portfolio of information systems and improve VS' ability to achieve programme goals.

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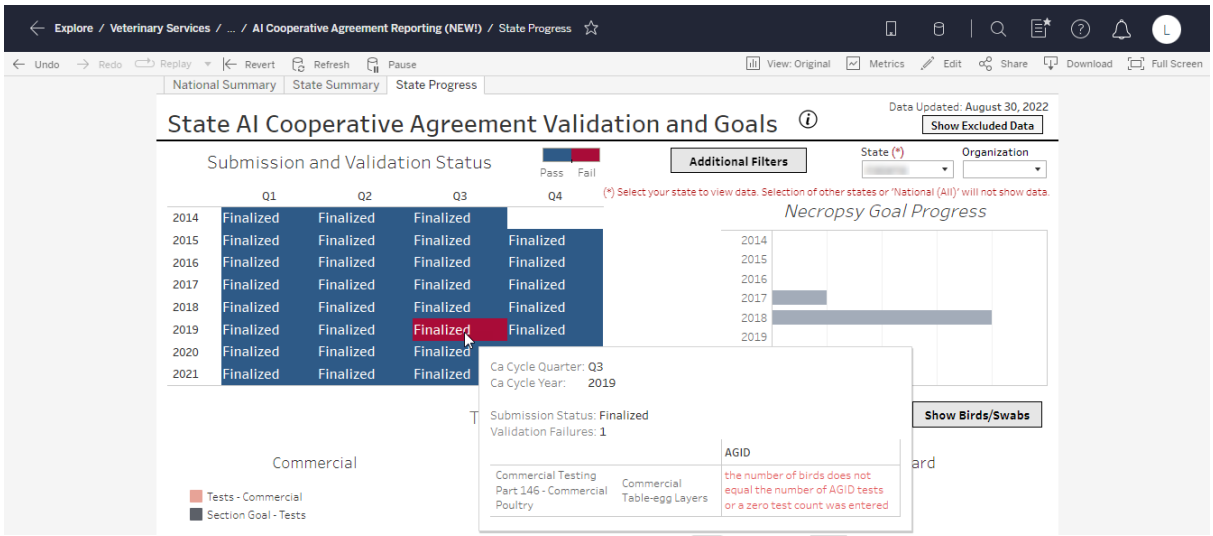
**Table I**

**Federal data strategy principles**

(See [1] for detailed descriptions)

| | |
|---|---|
| **Ethical governance** | |
| 1 | Uphold ethics |
| 2 | Exercise responsibility |
| 3 | Promote transparency |
| **Conscious design** | |
| 4 | Ensure relevance |
| 5 | Harness existing data |
| 6 | Anticipate future uses |
| 7 | Demonstrate responsiveness |
| **Learning culture** | |
| 8 | Invest in learning |
| 9 | Develop data leaders |
| 10 | Practice accountability |




AI: avian influenza

**Figure 1**

**Avian influenza testing validation**

The cooperator may visualise the quarters and years in which their submitted reports failed at least one business rule (red cell). If they hover over the red cells they will see the listing of rules not successfully validated (depending on type of bird or facility sampled and type of testing performed). System access parameters are established by the administrator to allow cooperators to only view the data for their own State

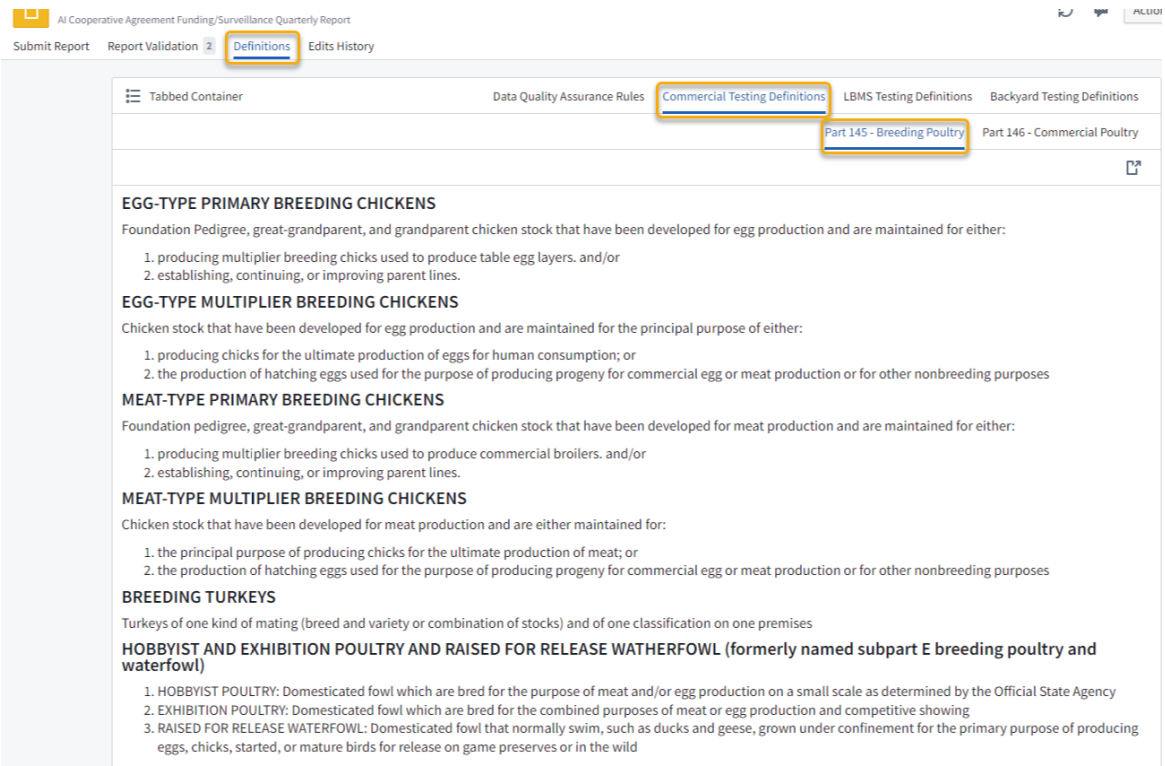



**Figure 2**

**Avian influenza testing vocabulary terms and definitions**

Vocabulary terms and definitions were made accessible to cooperators in the modernised system to create a common understanding of the meaning of the types of birds and facilities sampled

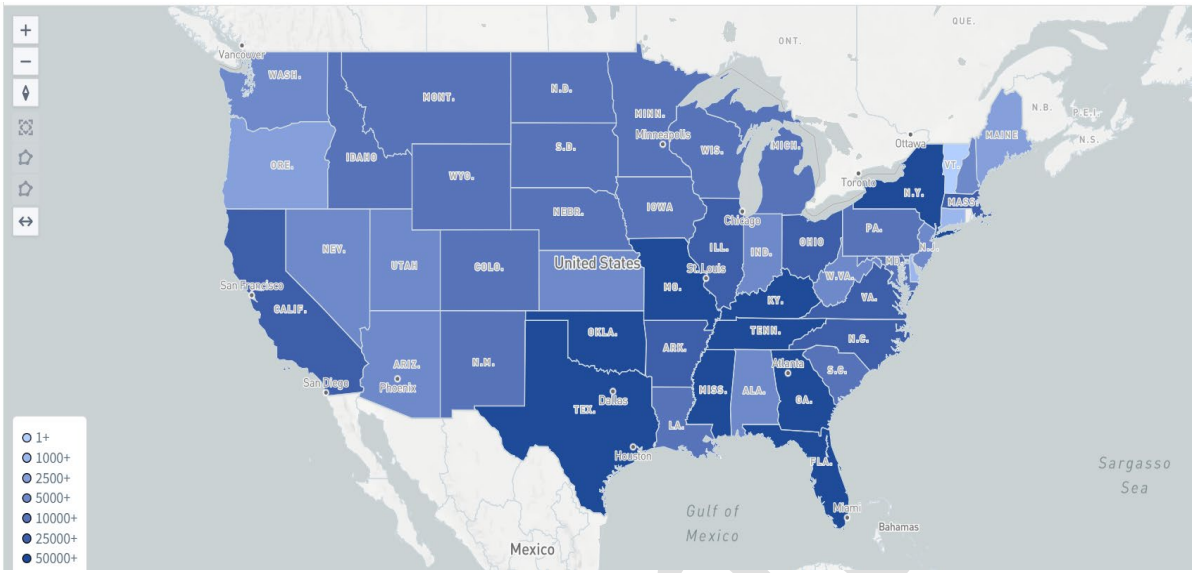



**Figure 3**

**Geographic distribution of number of equine infectious anaemia (EIA) tests conducted by laboratory state in 2021**

Map internally available to Veterinary Services (VS) and State Animal Health Officials as a reporting output within the EIA module of VS's Data Integration Services system. A total of 1,391,792 tests were reported by laboratories through the new EIA data pipeline in calendar year 2021


**Figure 4**

**Federally approved livestock markets**

Interactive map of all United States of America federally approved livestock markets available at (https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/sa_livestock_markets/ct_approved_livestock_markets)