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# National Bovine Brucellosis Surveillance Plan



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**Prepared by:**

United States Department of Agriculture  
Animal and Plant Health Inspection Service (APHIS) – Veterinary Services (VS)  
Center for Epidemiology and Animal Health – Surveillance Design and Analysis Unit  
In collaboration with the USDA-APHIS-VS Ruminant Health Center

## Executive Summary

Brucellosis is a contagious disease of livestock and wildlife caused by bacteria of the genus *Brucella*. Brucellosis presents challenges in managing animal and public health, and adversely impacts international trade. Brucellosis occurs primarily in cattle, bison, and swine, although cervids, goats, sheep, and horses are also susceptible to the disease. In cattle and bison, the specific disease organism of concern is *Brucella abortus* (*B. abortus*).

Since 1934, the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) has cooperated with the U.S. livestock industry and State animal health authorities to eradicate brucellosis from the United States (Ragan, 2003). Through the years, many surveillance strategies have been used in attempts to eradicate this disease, including testing cows and bulls at slaughter, first-point testing (at livestock markets, shows, sales, buying stations, etc.), and whole herd, on-farm testing. These surveillance strategies have proven successful. By 2007, the Nation's herd prevalence was at an all-time low of less than 0.0001 percent (USDA APHIS VS, 2014). APHIS has officially designated all 50 States as Class Free for bovine brucellosis, since July 2009, despite recent detections in the three Greater Yellowstone Area (GYA) States of Idaho, Montana, and Wyoming, which likely occurred due to wildlife spillover. While all GYA States remain Class Free, the GYA remains the primary focus for brucellosis in livestock because the disease is endemic in wild elk and bison in the GYA. There is currently no evidence that brucellosis has spread outside the GYA.

Even though the program has succeeded in eradicating brucellosis from U.S. domesticated cattle and bison, continued surveillance is needed to detect any resurgence or reintroduction of the disease and to prove to trade partners that the United States is free of brucellosis. This national plan describes the baseline surveillance activities required to meet the overarching goals of the USDA's National Bovine Brucellosis Surveillance Program, specifically by:

- Detecting *B. abortus* infection with 95 percent confidence that the prevalence level does not exceed 1 infected animal per 100,000 animals (0.001 percent).
- Providing data to the World Organisation for Animal Health (WOAH) and international trading partners for disease-freedom recognition.

The following lists the performance standards to ensure that brucellosis surveillance goals are met:

- a) The total number of adult cattle and bison sampled from inspected U.S. establishments are sufficient to detect, with 95 percent confidence, a 0.001 percent or higher prevalence level among the U.S. cattle and bison slaughter population.
- b) At least 95 percent of all samples collected within each 12-month period are of suitable quality for testing, packaged and shipped according to protocol, and be accurately associated with the animal identification collected with the sample.
- c) At least 90 percent of the reactors identified through samples collected at slaughter establishments in each 12-month period are traceable to the herd of origin within 15 days of notification of nonnegative results (9 CFR Part 78).
- d) Samples collected from cattle and bison include information related to animal type (beef, dairy, or bison), age, sex, and location to allow for potential analysis in future surveillance evaluations.

- e) Samples collected and submitted as part of the slaughter surveillance component are representative of the animals presented for slaughter during that month. Samples should be collected continuously, and surge testing at the end of a contract or the end of a fiscal year should be avoided.
- f) The brucellosis program's data manager compiles slaughter-testing data and reports it to stakeholders each month.
- g) Data should be collected and reported at least annually from each of the non-slaughter surveillance components: export, on-farm testing, livestock market testing, enhanced passive surveillance/laboratory abortion testing, and brucellosis testing of stray cattle in cooperation with the cattle fever tick program.

Risk-based targeted slaughter surveillance is the primary surveillance component used in this plan, though other targeted surveillance components are essential for the plan's success. States and Veterinary Services (VS) officials may use their discretion if or when to implement targeted surveillance in high-risk areas. Alternative introduction pathways will continue to be monitored through a variety of existing surveillance programs, such as mandatory testing before cattle transfers from the Designated Surveillance Areas, testing of cattle strays along the U.S.-Mexico border, and rigorous passive surveillance by accredited veterinarians reporting clinical cases. The plan may be adjusted to increase efficiency of the surveillance activities or to target specific higher-risk areas.

# 1. Introductory Information

## Disease Description

Bovine brucellosis is a contagious, infectious, and communicable disease of domesticated cattle, usually caused by the bacteria *Brucella abortus* (*B. abortus*). Brucellosis also affects bison, elk, yak, domesticated bison, African buffalo, and various African antelope species.

## Etiology

Brucellosis results from infection by various *Brucella spp.*, which are gram-negative facultative intracellular coccobacilli (short-rod bacteria). The disease in cattle is caused almost exclusively by *B. abortus*, although *B. suis* or *B. melitensis* are occasionally suspected. Although eight biovars of *B. abortus* are recognized, only biovars 1, 2, and 4 have been found in the United States. The phenotypic biovar designations have been replaced by whole genome sequencing (WGS), as the WGS data show that biovar designations are no longer epidemiologically relevant. These organisms can remain viable for several months in water, aborted fetuses, manure, wool, hay, equipment, and clothes, and they survive longer in low temperatures, particularly below freezing.

## History and Distribution

*B. abortus* is found in cattle-raising regions worldwide, with some exceptions: *B. abortus* has been eradicated in Japan, Canada, Australia, New Zealand, and several Northern and Central European countries (WOAH, 2018a). Veterinary Services (VS) established a national brucellosis program to safeguard the health of domestic livestock, maintain the economic viability of the U.S. cattle industry in national and international trade, protect public health, and ensure food safety. The goal of the program is to eradicate brucellosis from the United States. The National Brucellosis Eradication Program has been and remains a high priority for USDA APHIS.

In 1934, a cooperative State-Federal campaign to control brucellosis in U.S. cattle was launched to assist the cattle industry during the Great Depression. At that time, 11.5 percent of adult cattle were brucellosis reactors (i.e., tested positive) (Ragan, 2003). In 1954, Congress officially appropriated funds for a national program, supporting the organization of a comprehensive State-Federal cooperative effort to eradicate brucellosis from domestic cattle herds. Throughout the 1960s and 1970s, the program evolved, incorporating changes in both program management and field activities to meet the changing needs of States and industry as marketing opportunities developed and disease eradication progressed. Changes included “down-the-road” (i.e., systematic) herd testing; use of calfhooed and adult vaccination; use of new and better serology tests; testing of cattle at first point of concentration; implementing the concept of local control; placing emphasis on epidemiology and adjacent and community herd testing; and affected herd management (Ragan, 2003; Lopes, 2010). By 1989, 27 States were classified as brucellosis free. However, finding the last vestiges of infection in livestock had become tedious, difficult, and costly.

In 1989, at the request of the National Cattlemen’s Association, an in-depth review of the program by VS led to a Rapid Completion Plan with the goal to have all 50 States brucellosis-free within 5 years. This plan identified several program elements critical to achieving disease eradication (Congress, 1989). Using increased Congressional funding, the plan concentrated on herd depopulation, particularly in smaller herds; the use of whole-herd vaccination in larger herds; depopulating the larger vaccinated herds that continued to maintain infection; and placing an

increased emphasis on epidemiology. Due in large part to the Rapid Completion Plan, the number of infected herds fell below 1000 for the first time in 1990 and below 100 by 1995 (Baskin, 1998).

In 1997, the program again underwent an extensive review by VS that reaffirmed eradication goals and developed the Brucellosis Emergency Action Plan (BEAP). This plan continued to emphasize depopulating affected herds, enhanced surveillance, epidemiology, and herd management but added rapid response strategies for handling brucellosis eradication and surveillance activities. Nonnegative results were treated as a priority and managing new cases as an emergency action. The BEAP was not established because of a sudden brucellosis crisis, but rather because it had become clear that achieving eradication was within reach.

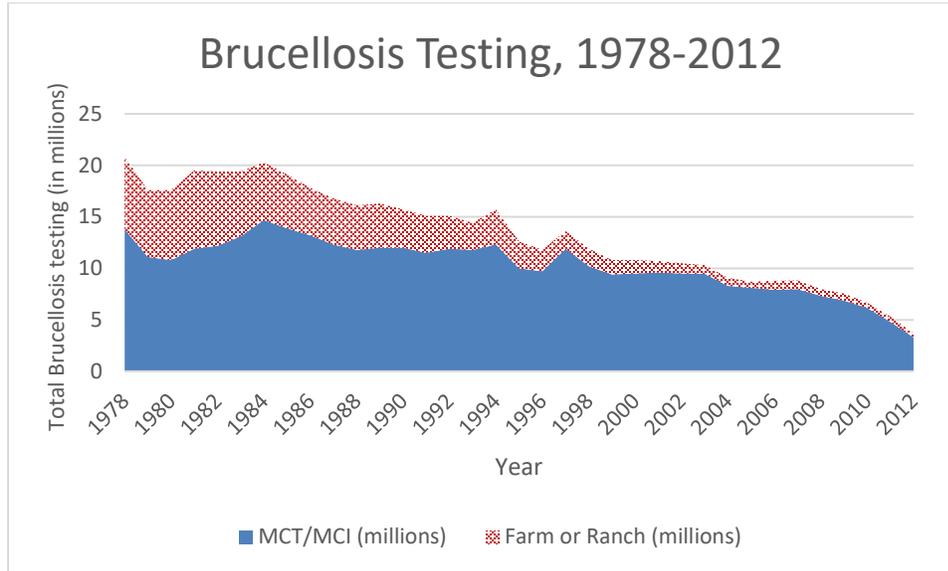
The mitigation efforts were working; there were only 85 affected herds in the United States in 1987. The last year that brucellosis was detected within a dairy operation was in 1998, and by the end of 2000, there were no known affected cattle herds in the United States. However, three affected herds were identified in 2001 and were quickly depopulated (Ragan, 2003). By 2007, the national herd prevalence hit an all-time low of 0.0001 percent (1 affected herd in approximately 1 million cattle herds) (USDA APHIS VS, 2014). Over the next decade, occasionally affected herds were identified and depopulated. The last year that a positive herd was found outside of the GYA was 2011. VS continues to use the program elements identified in the BEAP.

Bovine brucellosis is now primarily a geographical disease. Currently, all 50 States, Puerto Rico, and the U.S. Virgin Islands are designated Class Free for brucellosis (USDA APHIS VS, 2014). The GYA is the only known location within the United States where *B. abortus* is still present, specifically in the area's wild bison and elk. While the disease is endemic in wild elk and bison in the GYA, it occurs in livestock herds only occasionally as a spillover event from wildlife exposures (Rhyan et al., 2013). Since 2006, all the affected cattle and bison herds detected within the GYA have been attributed to wild elk spillover. On average, brucellosis is detected in the GYA in 0.01 percent (2.2/25,000 herds) of herds per year, with only one to five cows per affected herd (USDA APHIS, 2014).

## Surveillance History

The original sampling strategy for slaughter surveillance was a census-based plan designed for disease eradication. From 1978 to 2012, 95 percent of all cull cows were sampled (average of 5-7 million head annually) at the top 40 adult kill plants. During that timeframe, over 466 million samples were collected and tested (figure 1). These samples represented animals tested on farms, ranches, and at slaughter and livestock markets under the Market Cattle Identification program (MCI) (USAHA, 1972-2018).

In 2007, APHIS' Center for Epidemiology and Animal Health (CEAH) conducted an evaluation focusing on bovine brucellosis surveillance in States that had been classified as Class Free for more than 5 years. This evaluation found redundancies in the original surveillance strategies. For example, CEAH's evaluation determined that first-point testing and brucellosis ring testing were redundant when combined with slaughter surveillance because market and dairy cattle are often tested repeatedly, providing no greater value over the original negative test. This finding led to the decision to remove the requirement for twice-yearly brucellosis ring testing of dairy cattle herds producing milk for sale in States that have been Class Free for 5 or more years and do not have brucellosis in wildlife. The plan also recommended reducing slaughter surveillance and eliminating Federal funding for first-point testing in low-risk States. In addition, this plan called for consolidating laboratory testing and using a standardized testing protocol for all slaughter surveillance samples.



**Figure 1. Number of brucellosis samples collected in the United States from 1978 to 2012**

From 2008 to 2010, CEAH reevaluated the slaughter surveillance recommendations to improve the efficiency and cost-effectiveness of this component. The objective was to describe a strategy that would maintain confidence that brucellosis was present in less than one animal per million in the national domesticated cattle and bison herds. This new sampling approach moved away from the census-based sampling originally designed for disease eradication to one that would demonstrate national disease freedom using a risk-based approach. Using statistical sampling for slaughter surveillance based on the national cattle herd size, this strategy, when implemented several years later, resulted in an approximate 50 percent reduction in the number of slaughter surveillance samples collected. The plan eliminated State-by-State census sampling while still effectively demonstrating the national herd's disease-free status. This surveillance strategy exceeded the international standards set by the WOAHP for a country recognized as disease-free for brucellosis.

The prevalence of *B. abortus* in the national domesticated cattle and bison herds was close to zero, though continued surveillance in the designated surveillance areas (DSAs) within the GYA was needed to detect any spillover of the disease from wildlife into domesticated herds. This continued surveillance would prove to trade partners that the United States was free from brucellosis outside of the separately managed DSAs within the GYA. The surveillance requirements for a DSA depend on various epidemiological and ecological factors such as the prevalence of the disease in the wildlife population, risk of contact with domesticated herds, geographic features, and environmental factors that influence the risk to domesticated cattle and bison. Because of these differences, this national plan does not specifically cover surveillance efforts in DSAs. States with a DSA sign an annual memorandum of understanding (MOU) with the USDA, which describes their brucellosis management plan. The MOUs help to ensure that infected or potentially exposed animals do not leave the DSA and enter the national herd. States that appropriately manage their brucellosis management plans (BMPs) maintain their free status.

CEAH's recommendations in 2010 transitioned the program surveillance from States' geopolitical boundaries to boundaries determined through science, epidemiology, and risk assessment. The

plants recommended to collecting the samples at slaughter either had a high percent of cattle slaughtered in their establishment that originated from the GYA, referred to in the remainder of this document as the GYA catchment, or processed a high number of cull animals. In 2012, the first slaughter surveillance reduction occurred, decreasing the total number of representative cattle slaughter plants from 40 to 9 and representative bison slaughter plants to 2. These included plants in California, Colorado (bison only), Idaho, Minnesota, Nebraska, Pennsylvania, Texas, and Utah.

Approximately 11 million samples were collected after the first reduction in 2012 and before the next evaluation of the plan in 2018 when CEAH investigated further reduction of surveillance sampling. Through this evaluation, CEAH determined that because no brucellosis cases had been detected on a U.S. dairy since 1998 and no cases had been detected outside the GYA since 2011, slaughter surveillance could be further reduced to five targeted plants (four cattle, one bison). Doing so would still meet WOAH international surveillance standards while saving over \$1 million annually. The plants were chosen by their geographic footprint, their GYA catchment, and their ability to reliably collect testable samples. The evaluation found that from 2012 through 2018 approximately 91 percent of samples collected and tested were from cattle outside of the GYA States. This resulted in a recommendation to continue sampling at the slaughter plants with the largest GYA catchment and, therefore, the highest likelihood to process a brucellosis-infected animal, and to eliminate sampling at the plants with a low to zero GYA catchment (table 1) (USDA-APHIS, 2018). In FY 2019, the slaughter plants in Nebraska, Pennsylvania, Texas, and Wisconsin were removed from the slaughter surveillance program because they were not processing many cattle from the GYA, though one plant in Texas continued to sample for 6 months to ensure surveillance minimums would be met. The slaughter plants collecting samples in FY 2020 were one plant in California, one bison plant in Colorado, two plants in Idaho, and one plant in Utah and were selected for their GYA catchment and percentage of culled animal processing (table 2).

**Table 1. Percent of GYA catchment samples tested for *B. abortus* from 2012 through 2019, by State of slaughter facilities used for sampling.**

Slaughter facility State	Percent of GYA catchment samples
California	23.0
Idaho*	51.0
Minnesota	10.0
Nebraska	7.0
Pennsylvania	0.0
Texas (2 plants)	2.0
Utah	98.0

\*One plant was new in FY 2019 and is expected to increase the percentage of GYA samples over time.

**Table 2. Approximate percentage of GYA catchment in FY 2019 and approximate percentage of cull animals processed in FY 2019, by State of slaughter facilities used for *B. abortus* sampling.**

State	Approximate percentage of GYA catchment FY 2019	Approximate percentage of cull animals processed FY 2019
California	52	80
Colorado (1 bison)	6.2	52
Idaho (2 plants) *	54	97, 87
Utah	76	96

\*One plant was new in FY 2019 and is expected to increase the percentage of GYA samples over

### Epidemiology

*B. abortus* is usually transmitted between animals through contact with placentas, fetuses, fetal fluids, and vaginal discharges from infected animals. Transmission can occur after an abortion or full-term calving. Animals can become infected by ingestion and through the mucous membranes or broken skin. Although cattle are usually asymptomatic after their first abortion, they can become chronic carriers. *Brucella* organisms can be shed in the milk of infected animals for a variable length of time, but in many cases for the life of an infected animal (Merck Veterinary Manual, 2020). In addition, the organisms can be transmitted to calves directly from their mother in-utero and through ingestion of contaminated milk. Venereal transmission of *Brucella* organisms is rare, but it may occur by artificial insemination. In newly affected unvaccinated cattle herds, infection can spread rapidly, and many abortions may occur. Vaccination is usually effective in preventing abortions and might prevent infection. Nevertheless, large exposure doses may overwhelm vaccination-induced immunity.

As mentioned previously, the GYA presents the highest risk of transmitting brucellosis to domesticated cattle and bison populations. This region is comprised of three states: Idaho, Montana, and Wyoming. Each state has developed and implemented specific BMPs. These plans are developed by State animal health partners in collaboration with fish and game departments within the states. The plans are reviewed and endorsed annually by USDA-APHIS-VS. Each BMP consists of multiple surveillance components. These components include annual cattle herd testing, slaughter surveillance, wildlife surveillance through hunter-supplied samples, and live wildlife programs using radio-collar tracking mechanisms and wildlife testing. Each BMP outlines how DSA boundaries will be drawn in response to a positive finding outside the DSA, as well as the immediate response actions. These BMPs are designed and implemented to focus on disease eradication efforts through prevention and surveillance, rapid and timely disease response, and disease management in areas of increased risk for brucellosis. The BMPs keep brucellosis from spreading within the DSA and ensure that infected or potentially exposed animals do not leave the DSA and enter the national herd.

### Clinical Signs

The most frequent manifestation of brucellosis in cattle is abortion, which usually occurs during the second half of pregnancy (WOAH 2018a; Acha and Zyfres 2003). Other clinical signs include stillborn or weak calves, retained placentas, decreased milk yield (estimated 20 to 25 percent

loss), decreased fertility, orchitis, epididymitis, and infertility (Acha and Zyfres, 2003). Cows often abort after their first exposure to *B. abortus*. Subsequent parturitions are usually normal, although an estimated 10 to 25 percent of infected cows will abort a second time. Nonpregnant cows and bulls are usually asymptomatic. Heifers with latent asymptomatic infection may abort or give birth to infected calves and, therefore, play an important role in maintaining disease in a herd. Calves that acquire the infection vertically or by ingesting contaminated milk may remain serologically negative and show no sign of the disease. Infected bulls may develop systemic signs of infection, including fever, anorexia, and depression. The outcome of infection in cattle depends on age, reproductive and immunological status, natural resistance, route of infection, infectious challenge, and virulence of the infective strain (Carvalho Neta et al., 2010).

More information on clinical signs may be found at:

<https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/cattle-disease-information/national-brucellosis-eradication>

## Prevention

Brucellosis may be avoided by employing good sanitation and management practices. Use of an approved vaccine (i.e., RB51 in the United States) can increase protection of a herd. Vaccination alone, however, may not prevent herd infection because immunity is not absolute. Good husbandry practices are important in reducing the risk of disease entering a herd and include:

- Carefully selecting replacement animals.
- Ensuring that newly purchased stock test negative before entering the herd or are placed in isolation and tested within 10 days of arrival. These animals enter the herd at the same level of testing as the herd and must be included in any remaining herd tests.
- Preventing contact and commingling with herds of unknown status or those with brucellosis.
- Preventing contact and commingling of wildlife known to be reservoirs of brucellosis,
- Laboratory testing to diagnose the cause of abortions, premature births, or other clinical signs.
- Proper disposal (burial or burning) of placentas and nonviable fetuses.
- Disinfecting contaminated areas.

## 2. Purpose and Rationale for Surveillance

Adequate surveillance is a critical part of any disease eradication program. Brucellosis is typically a chronic disease, with variable and sometimes long incubation periods. Clinical signs may not be present and, when they are, are not specific for brucellosis. Due to these challenges, a multifactorial surveillance approach is needed, as there is no one method of surveillance that can be used as the sole surveillance strategy.

Historically, brucellosis surveillance and related activities were conducted with the goal of disease eradication. The surveillance strategies used over the years have been successful, and brucellosis is now considered eradicated from U.S. domesticated cattle and bison herds. With a near-zero prevalence level in domesticated cattle and bison populations outside of the GYA, the surveillance focus has shifted to demonstrate disease freedom through the targeting of the populations most at risk: domesticated cattle and bison from within the GYA.

This national plan describes the baseline surveillance activities required to meet the overarching goals of the USDA's National Bovine Brucellosis Surveillance Program, specifically to:

- Detect *B. abortus* infection with 95 percent confidence should the prevalence level exceed 1 infected animal per 100,000 animals (or 0.001 percent).
- Provide data to document disease freedom at that level.

Current WOAHP standards to qualify for brucellosis disease-free status require that a country's rate of brucellosis infection does not exceed 0.2 percent of their cattle herds (WOAHP, 2018b). Current U.S. surveillance is designed to detect at 0.001 percent animal-level when applied to a representative population. U.S. surveillance is targeted at cattle and bison from the GYA, increasing the sensitivity of our surveillance system and therefore, the 0.001 percent is a conservative prevalence threshold for the detection capability of our system. According to the USDA's National Agricultural Statistics Service (NASS), approximately 43.1 million cows that have calved (dairy and beef), bulls over 500 pounds, and commercial bison were present on U.S. farms as of January 31, 2020 (USDA-National Agricultural Statistics Service (NASS), 2020; USDA-NASS, 2017). Accordingly, at the very most, a 0.001 percent annual infection rate would correspond to infection in 431 separate herds (0.056 percent of the 770,317 herds in the United States), if each herd had only one animal infected ( $0.00001 * 43.1 \text{ million} = 431 \text{ animals}$ ). The surveillance sampling at this level exceeds the international standard for detecting whether brucellosis is present in more than 0.2 percent of the Nation's herd.

The rationale for conducting surveillance for bovine brucellosis includes the following:

**Economic Impact on Industry**—The impacts of brucellosis infection, such as reduced beef and milk production and the costs of eradication efforts, have cost the U.S. livestock industry billions. Analysts estimate that every \$1 spent on eradication saves \$7 that would otherwise be lost because of infection (Seleem et al., 2010). Since the National Brucellosis Eradication Program was implemented more than 50 years ago, the cumulative reduction of brucellosis infection in the U.S. cattle herd has resulted in an increased supply of both beef and milk. In addition, annual losses from lowered milk production, aborted calves, and reduced breeding efficiency have decreased from more than \$400 million in 1952 to less than \$1 million to date. Studies have shown that if eradication program efforts were stopped, the costs of producing beef and milk would increase by an estimated \$80 million annually in less than 10 years.

**Public Health Concern**—Brucellosis is a zoonotic disease and, therefore, its control and prevention in animals is essential in reducing risk of human infection; *B. abortus*, *B. melitensis*, and *B. suis* are highly pathogenic for humans (WOAHP, 2018b). In humans, brucellosis (or undulant fever) presents as a nonspecific flu-like illness, and clinical signs range from mild to severe. People can become infected by consuming unpasteurized dairy products that have the bacteria or through direct contact with contaminated tissues associated with calving or abortion from infected cattle. Humans can also become infected by inhaling infectious aerosolized organisms (Corbel, 2006). Because of the potential for aerosolization and possible weaponization of infectious organisms and the nonspecific nature of the initial symptoms in people, both APHIS and the Centers for Disease Control and Prevention (CDC) consider *B. abortus*, *B. melitensis*, and *B. suis* as select agents. Select agents are biological agents or toxins with the potential to pose a severe threat to public, animal, or plant health or to animal or plant products. Brucellosis is also considered an occupational disease for people who work with infected animals, particularly farmworkers, veterinarians, ranchers, and meatpacking employees.

### 3. Surveillance Objectives

The objectives of national brucellosis surveillance are:

- Detecting brucellosis in domesticated cattle and bison.
- Providing metrics to aid in decision-making, evaluating compliance with program standards, and progress toward regulatory goals.

APHIS uses slaughter and other targeted surveillance to meet the objectives.

#### Slaughter Surveillance

APHIS will continue to use slaughter surveillance to meet surveillance objectives, specifically targeting blood samples collected from cattle 24 months of age and older that are capable of reproducing. Slaughter establishments within a Brucellosis Management Area will test eligible cattle, or bison 12 months of age and older. Sampling will be conducted at federally inspected slaughter establishments selected for their GYA catchment and percentage of culled cattle they process. VS will review the slaughterhouses annually to ensure that sampling adequately reflects the risk to the national herd. Approved brucellosis laboratories will test the samples using official diagnostic tests, including buffered acidified plate antigen (BAPA) and fluorescence polarization assay (FPA) serologic tests in series (Gall and Nielson, 2004). (Refer to the [Sampling Methods section](#) of this document for more information on the [slaughter surveillance sampling strategy](#).)

#### Other Targeted Surveillance

State and VS animal health officials may implement other targeted surveillance activities in areas deemed to be higher risk. The samples acquired through these activities are used to meet the minimum sampling requirements. Examples of these activities follow:

- On-farm surveillance —Includes samples collected by federally accredited veterinarians. Samples are taken from domesticated cattle or bison that present for reproductive issues (e.g., aborted fetuses or failure to breed) or other case-compatible clinical signs, from routine testing done on animals traveling outside a DSA, and from routine whole-herd testing.
- Livestock market surveillance —Includes targeting sampling at collection points by federally accredited veterinarians. Samples are taken from domesticated cattle or bison that present reproductive issues (e.g., aborted fetuses or failure to breed) and from presale testing of animals slated for transport across State lines.
- Enhanced passive surveillance (EPS) —Non-disease-specific surveillance designed to detect anomalies in animal health that may warrant further investigation. In addition, EPS may provide a means for a specific diagnosis through the collection and analysis of specific body system-associated clinical signs (i.e., syndromes) in animal populations.
- Export-related surveillance —Required testing of animals exported from the United States provides another active surveillance component.
- Cattle Fever Tick Eradication Program (CFTEP) — Includes samples from all cattle strays captured by both Federal and State mounted patrol inspectors near the U.S.-Mexico border (USDA-APHIS, 2018).

## 4. Expected Outcomes

Continuing the National Bovine Brucellosis Surveillance Plan is expected to produce several important outcomes, one of which is the ability to detect brucellosis-infected domesticated cattle and bison in targeted subpopulations at 95 percent confidence of a prevalence level of 0.001 percent or higher. Detection at this low level ensures that actions can be taken to eliminate infection from the national herd, as described in the National Bovine Brucellosis Surveillance Plan standards document. In addition, the detection of affected herds may identify high-risk areas that warrant additional targeted surveillance. The plan will also meet and exceed the internationally accepted surveillance activities recommended by the WOA. Such an outcome facilitates trade by assuring trading partners that domesticated cattle and bison and the products they generate are brucellosis-free. Decision-makers can use the data and other information generated to adjust future surveillance activities designed to increase the effectiveness and efficiency of the brucellosis program and to guide future regulatory activities.

## 5. Stakeholders and Responsible Parties

Responsible parties include:

- Center for Epidemiology and Animal Health (CEAH), Surveillance Design and Analysis Unit: Evaluating, updating, and reporting the national surveillance plan
- VS Ruminant Health Center and the National Veterinary Services Laboratories (NVSL): Surveillance implementation and oversight, training, communication, and surveillance reporting
- VS field staff, Area Veterinarians-in-Charge (AVICs), State animal health officials: Surveillance implementation and communication with local producers and industry
- Private veterinary practitioners who first suspect and diagnose brucellosis
- Veterinary diagnostic laboratories that test samples and report results

Stakeholders include the responsible parties and:

- All sectors of the cattle industry, including producers and producer organizations, market operators, marketing organizations, processors, and processor organizations
- Animal health officials and organizations, including the United States Animal Health Association (USAHA)
- State government entities, including departments of agriculture (or equivalent), departments of natural resources (or equivalent), divisions of wildlife and departments of public health
- USDA Food Safety and Inspection Service
- U.S. taxpayers, who ultimately fund brucellosis surveillance and benefit from disease freedom and minimized public health risk
- Foreign trading partners

## 6. Population Descriptions and Characteristics

Adult intact domesticated beef, dairy cattle, and commercial bison in the continental United States are the populations of interest for brucellosis surveillance. As of January 31, 2020, the number of cows and heifers (dairy and beef) that had calved and the number of bulls (dairy and beef) over 500 pounds totaled 42.8 million (table 3; USDA-NASS, 2020). Overall, the U.S. cattle industry consists of 768,542 herds with breeding cows (USDA-NASS, 2017). In addition, there are 183,780 commercial

bison on 1,775 operations (USDA-NASS, 2017). The western half of United States has most beef herds, while eastern half has most of the dairy herds. Most U.S. beef operations have from 1 to 49 head of cattle, but the largest percentage of beef cows are in herds with 100 to 499 head. Most U.S. dairy operations also have 1 to 49 head, but the largest percentage of dairy cows are in herds with 1,000 to 2,499 head (table 4).

In the GYA States, the number of cows and heifers that have calved (dairy and beef), the number of bulls (beef and dairy) over 500 pounds, and the number of commercial bison total about 3.5 million head (USDA-NASS, 2017). Overall, there are 24,791 herds with breeding cows in the GYA States (USDA-NASS, 2017). In addition, the GYA States contain 177 commercial bison herds with 47,546 bison (USDA-NASS, 2017). Most beef operations in the GYA States have from 1 to 49 head, but the largest percentage of beef cows are in herds with 100 to 499 head. Most of the dairy operations also have 1 to 49 head, but the largest percentage of dairy cows are in herds with 5,000 head or more (table 5).

This report predominantly addresses U.S. adult beef and dairy cattle, both cows and bulls. Commercial bison are also represented, via slaughter sampling at one plant that processes bison; however, bison comprise less than 1.5 percent of the total sample volume (e.g., 27,639 bison samples were collected in 2017). NASS does not track bison, but because they are occasionally tested at slaughter, calculations in this document include bison samples collected for brucellosis testing and in the overall United States bovine population.

Since 2011, over 19 million samples have been tested for brucellosis, and no infections in bison or cattle outside of the GYA have been found. The prevalence of brucellosis in cattle outside the GYA is estimated at 0.0001 percent. Due to this extremely low prevalence, USDA evaluated the brucellosis program in 2018. The evaluation showed that by concentrating testing on the higher-risk population in the GYA and reducing the number of lower-value surveillance samples obtained from cattle outside the GYA, the total number of samples collected annually could be drastically reduced. The extremely low prevalence level in the national herd is, in part, due to the intensive testing conducted over the years. It can, therefore, be inferred that continuing to focus on finding and identifying disease in the GYA population will keep the national herd disease-free.

**Table 3. U.S. cattle inventory as of January 1, 2020, by cattle class (NASS 2020)**

Cattle Class	Total
Beef cows that have calved	31,316,700
Milk cows that have calved	9,334,600
Bulls 500 pounds or more	2,237,400
<b>Total</b>	<b>42,888,700</b>

**Table 4. Number of U.S. cattle and dairy operations, as a percentage of inventory and by size of operation (NASS 2017)**

Beef Operations (# Head)	Number of Operations	Percent Inventory	Dairy Operations (# Head)	Number of Operations	Percent Inventory
1-49	576,735	27.2	1-49	28,411	7.7
50-99	80,411	16.7	50-99	12,137	9.4
100-499	65,962	38.9	100-499	10,587	22.3
500-999	4,538	9.2	500-999	1,511	10.2
1,000-2,499	1,202	5.1	1,000-2,499	1,239	18.7
2,500-4,999	147	1.7	2,500-4,999	525	16.6
5,000+	51	1.1	5,000 or more	189	15.1
<b>TOTAL</b>	<b>729,046</b>	<b>100.0</b>	<b>TOTAL</b>	<b>54, 599</b>	<b>100.0</b>

**Table 5. GYA States: Number of U.S. cattle and dairy operations, as a percentage of inventory and by size of operation (NASS 2017)**

Beef Operations (# Head)	Number of Operations	Percent Inventory	Dairy Operations (# Head)	Number of Operations	Percent Inventory
1-49	13,491	8.6	1-49	902	8.6
50-99	2,926	7.8	50-99	91	1.0
100-499	5,939	48.7	100-499	187	7.7
500-999	794	19.5	500-999	64	6.5
1,000-2,499	239	12.0	1,000-2,499	61	14.9
2,500-4,999	28	2.4	2,500-4,999	28	13.7
5,000+	6	1.0	5,000 or more	35	47.6
<b>TOTAL</b>	<b>23,423</b>	<b>100.0</b>	<b>TOTAL</b>	<b>1,368</b>	<b>100.0</b>

## 7. Case Definition

### 1. Disease Information

**1.1** Bovine brucellosis is a contagious zoonotic disease generally caused by the Gram-negative bacterium *Brucella abortus*, although *B. suis* and *B. melitensis* may also cause brucellosis in cattle. The disease is an economically important cause of abortions in cattle that also infects bison, elk, and buffalo. The organism is excreted in uterine discharges and milk and is distributed worldwide wherever cattle are raised; it is believed to have been successfully eradicated from Japan, Australia, New Zealand, some European countries, and Canada. The United States is close to achieving eradication, but wildlife hosts in some regions are preventing complete eradication.

Common clinical signs include abortions, stillbirths, retained placentas, orchitis, epididymitis, and rarely arthritis. Brucellosis in humans, called undulant fever, causes a serious, debilitating, and sometimes chronic disease.

### 2. Laboratory criteria

**2.1 Agent isolation and identification:** Presumptive identification of *Brucella* spp. may be made by modified acid-fast staining of organisms and demonstration of *Brucella* spp. morphology in aborted material or vaginal discharge, especially when supported by serological tests.

*Brucella* spp. should be isolated using plain or selective media inoculated with uterine discharges, aborted fetuses (stomach contents, spleen, and/or lung), udder secretions, or selected tissues (such as lymph nodes or reproductive organs). Species and biovars should be identified by phage lysis and by cultural, biochemical, and serological criteria. PCR can provide a complementary and bio-typing method.

**2.2 Serology:** Serological tests are generally considered suitable tests only for screening herds and individual animals. Commonly used tests include the Rose Bengal test, buffered acidified plate agglutination (BAPA), complement fixation (CF), fluorescence polarization assays (FPA), competitive and indirect enzyme-linked immunosorbent assay (ELISA), the milk ring test, and the brucellin skin test. The indirect ELISA or milk ring test performed on bulk milk samples is effective for screening and monitoring dairy cattle.

### 3. Case definition:

**3.1 Suspect case:** A susceptible species that has:

- 3.1.1** Clinical signs consistent with infection with *B. abortus*, OR
- 3.1.2** Epidemiological information demonstrating exposure to *B. abortus*, OR
- 3.1.3** Serum or milk ring test results suggest infection but are inconclusive.

**3.2 Presumptive positive case:** A suspect case in which:

- 3.2.1** Serum or milk test results indicate that the animal has been exposed to and infected with *Brucella* spp., OR
- 3.2.2** *Brucella* organisms are identified microscopically, OR
- 3.2.3** Paired samples demonstrate a significant rise in the serological titer

**3.3 Confirmed positive case:** A presumptive positive case:

- 3.3.1** From which *Brucella abortus* is isolated and identified at NVSL or another laboratory identified by the Secretary of Agriculture.
- 3.3.2** A positive confirmatory antigen test (PCR) performed by NVSL

## 8. Data Sources

In conjunction with data collected under this brucellosis surveillance plan, VS and State animal health officials may decide to collect additional surveillance data. These collections can include data from source and at-risk populations through testing, movement controls, slaughter surveillance, or other appropriate management practices that mitigate risks.

### Slaughter Surveillance Data

Title 9, Code of Federal Regulations (CFR), Parts 78, 71.21, and 310.2 pertain to the collection of samples and/or official identification. Individual-animal identification should also link to marketing records (e.g., invoices and test charts) to support the trace of tested cattle back to their herds of origin. Test results are generated at approved laboratories, and each laboratory maintains the data in its record system (e.g., the Laboratory Information Management System or other database). Laboratories approved to test brucellosis slaughter samples under this plan will provide testing data to State and Federal animal health officials, who generally keep the data in a state database as well as the VS Surveillance Collaboration Services (SCS) database.

### Other Targeted Surveillance Data

In addition to the data that VS collects at slaughter, states may collect data from other targeted surveillance activities as part of their animal health plans. These stakeholders currently keep much of this data in various databases (table 6).

**Table 6. Data sources for brucellosis surveillance in the United States**

Surveillance Component	Data Source
Slaughter surveillance	<ul style="list-style-type: none"> <li>• Diagnostic laboratory database (e.g., LIMS)</li> <li>• State animal health database</li> <li>• Federal database (e.g., SCS) and spreadsheets maintained by Ruminant Health staff</li> <li>• Industry database such as slaughter establishment database</li> </ul>
On-farm and livestock market surveillance	<ul style="list-style-type: none"> <li>• VS SCS and other VS data repositories</li> <li>• State animal health database</li> </ul>
EPS livestock markets	<ul style="list-style-type: none"> <li>• State animal health database</li> <li>• Spreadsheets submitted to Ruminant Health Center</li> <li>• SCS</li> </ul>
Laboratory-based component (abortion screening)	<ul style="list-style-type: none"> <li>• Diagnostic laboratory database (e.g., LIMS)</li> <li>• State animal health database</li> </ul>
Stray cattle	<ul style="list-style-type: none"> <li>• Annual National Cattle Fever Tick Eradication Program reports</li> </ul>

On-farm and livestock market surveillance—Data from brucellosis test charts are entered into State databases either manually or via mobile information management (MIM) hand-held devices. Required data are then uploaded from State databases into SCS.

Laboratory-based surveillance (abortion screening)—Currently, all data associated with abortion screening are held within each approved laboratory's record-keeping database (e.g., LIMS).

Export testing data—Each approved laboratory maintains records of export testing in its record-keeping database (e.g., LIMS).

## 9. Sampling Methods

### Slaughter Surveillance

In the targeted surveillance area (GYA States), there are approximately 3.5 million head of cows and heifers that have calved (dairy and beef), bulls over 500 pounds, and bison (USDA-NASS, 2017). In the GYA States, the cattle industry consists of approximately 24,791 herds with breeding cows (USDA-NASS, 2017). In addition, there are 47,546 bison on 177 operations in the GYA States (USDA-NASS, 2017). Based on the size of cattle and bison populations in GYA States, 315,000 cattle (Cannon, 2001) should be tested from the GYA region to ensure 0.95 probability of detection in one animal in 100,000 (0.001 percent prevalence), assuming a testing regime with 93 percent sensitivity and perfect specificity (USDA-APHIS, 2018) and assuming independence among cattle tested. Slaughter surveillance improves the probability of brucellosis detection because GYA cattle and bison are at a higher risk for exposure to brucellosis and brucellosis-infected animals are more likely to be culled. Thus, detection at the 0.001 percent infection level in the targeted slaughter population results in detection at a prevalence threshold of less than 0.001 percent in the general (bred) population.

VS will periodically evaluate and select slaughter establishments for participation in the sampling program based primarily on their GYA catchment and by their cost and efficiency to the program. VS will set the number of samples each participating slaughter facility is expected to process annually. The number of samples may increase or decrease each year, based on an analysis of the previous year's data and other historical surveillance information.

As the wildlife within the GYA presents the highest risk of reintroducing brucellosis into U.S. cattle and bison populations, samples from that area are considered of higher testing value. Most of the slaughter plants chosen for brucellosis sampling specialize in culled beef and dairy cattle, adding to the surveillance value of each of those samples. In FY 2019, approximately 38 percent of bison and cattle slaughtered at the selected plants originated from the States within the GYA (USDA APHIS VS, 2019). Most slaughter samples collected from cattle and bison originating from non-GYA States have a lower sampling value due to the lower potential prevalence in the population and the decreased risk of brucellosis introduction from area wildlife.

Outside of the GYA, across the remaining 47 States and two Territories (Puerto Rico and U.S. Virgin Islands), there have been no brucellosis detections since 2011. The low incidence between and within herds inside of the GYA, and the extended absence of detections outside the GYA, depict a disease trajectory that has reached a minimum. Risk assessments have indicated further that the situation is well controlled and likely to remain stable (USDA APHIS, 2014). In the 2018 USDA APHIS document, "An Evaluation of Bovine Brucellosis Surveillance and the Impact of Proposed Reductions on Federal Brucellosis Surveillance Objectives," USDA-APHIS proposed multiple options to reduce the number of national slaughter brucellosis tests performed while still maintaining the existing U.S. brucellosis surveillance objectives of detecting brucellosis in domesticated cattle and bison and providing metrics to aid in decision-making, evaluating compliance with program standards, and progress toward regulatory goals. The purpose of reducing the national slaughter surveillance was to continue to meet or exceed those surveillance objectives, while decreasing the financial burden of the program.

In FY 2019, the national slaughter sampling strategy was changed to collect from only 4 of the top 40 federally inspected cattle slaughter plants based on their GYA catchment. The plants are in Utah (this plant closed permanently in August 2021), Idaho, California, and a bison-only slaughter plant

in Colorado. The selected slaughter plants can meet the surveillance objectives while minimizing the cost and maximizing efficacy of the program. These plants can collect an adequate number of testable and traceable samples and provide the widest geographic distribution, based on the supply chain with plants that have high GYA and culled cattle catchments, while continuing to sample a representative of the non-GYA population. Prior to this reevaluation, approximately 91 percent of slaughter samples tested had low surveillance value, meaning they were samples taken from lower risk, non-GYA cattle or bison populations (Camacho, 2018). By focusing surveillance efforts on the plants that slaughter the highest number of GYA cattle (including culled animals), the subpopulation that has the highest likelihood of having brucellosis, the percentage of these high surveillance value GYA samples increased in FY 2019 from 9 percent to 38 percent of samples tested. It is anticipated that in FY 2020-2021 the percentage of GYA catchment samples will increase to approximately 50 percent. Though the total number of slaughter surveillance samples has been reduced from the non-GYA states, sampling totals will continue to exceed the minimum requirement set in the WOA's Terrestrial Animal Health Code of detecting *B. abortus* infection with 95 percent confidence that the prevalence level in the United States does not exceed 0.2 percent of the cattle herds in the country, although with reduced geographic coverage.

### **Other Targeted Surveillance**

Samples will be collected from other targeted surveillance efforts specific to higher-risk areas or from surveillance components previously described. These efforts may include mandatory testing prior to cattle transfers from the DSAs within the GYA States, testing of cattle strays along the U.S.-Mexico border, and rigorous passive surveillance by accredited veterinarians reporting clinical cases (testing open cattle or those known to have aborted a fetus seen on-farm or at a market, and others). The reintroduction of *Brucella* from reservoir wildlife in the GYA region, and from the introduction of foreign cattle, present the highest risks for reintroducing *Brucella* to the national herd. Surveilling cattle strays between Mexico and Texas has not produced a *Brucella*-positive in the last 10 years. On average, stray cattle captured between the United States and Mexico number approximately 80 head annually (USDA APHIS Ruminant Health Center, 2020). The reintroduction of *Brucella* by wildlife is currently addressed through the previously discussed BMPs implemented in Idaho, Montana, and Wyoming. Sampling methods will be described in specific operational plans beyond the scope of this national plan. Targeted sampling through non-slaughter surveillance components provides additional representation of the national population not attained through slaughter sampling. By using a strategy to target and maximize the high-surveillance value GYA slaughter samples along with the other targeted surveillance streams, APHIS will maintain its ability to detect brucellosis with confidence, exceeding historic targets.

## **10. Data Analysis and Interpretation**

Numerous groups within VS analyze data, including national brucellosis staff, field, and area office personnel, and CEAH personnel. Efforts should continue to make these analyses more efficient using newer analytic tools available across VS.

## **11. Data Presentation and Reports**

States are required to submit annual reports to the national brucellosis staff for monitoring. District epidemiologists and staff from the VS Ruminant Health Center and CEAH will compile cattle

slaughter data from the selected Federal slaughter establishments to report on the status of surveillance activities throughout the United States.

## 12. Implementation, Budget, and Evaluation

### Surveillance System Implementation

APHIS began implementing this updated national surveillance plan in FY 2021.

### Resources

APHIS' brucellosis program is now funded through a cattle health, commodity-specific line item instead of the brucellosis program line item. The current line item provides flexibility for directing funds to cattle programs that need it most and should provide adequate funds to meet the brucellosis program's goals and objectives.

Resources essential to the success of the brucellosis program include national brucellosis staff, district epidemiologists, VS area office staff, district epidemiology officers, VS and State animal health field personnel, NVSL, FSIS personnel, and CEAH personnel. Additional external resources include select State diagnostic laboratories approved to perform the official tests.

### Surveillance Plan Performance Metrics

Performance metrics assure that surveillance activities are effectively and efficiently meeting the national surveillance program goals. The performance metrics for national brucellosis surveillance follow:

- a) The number of adult cattle and bison sampled from inspected U.S. establishments are sufficient to detect with 95-percent confidence a 0.001 percent or higher prevalence level among the U.S. cattle and bison slaughter population.

The strategy for national brucellosis slaughter sampling describes how the detection threshold meets surveillance goals. Considering the reproductive problems associated with brucellosis and those animals with reproductive problems are likely to be culled from a herd, it follows that brucellosis infected animals are more likely to be culled. This subpopulation of cull cows (dairy and beef), bulls, and bison form a target population with a higher likelihood of having brucellosis-positive animals compared with the general population. Using samples collected from this targeted population allows inference regarding the prevalence of brucellosis in the U.S. domestic cattle and bison population. If the prevalence is shown with 95 percent confidence to be less than 1 in 100,000 animals per year in the targeted (higher risk) population, it is reasonable to conclude with the same level of confidence that the prevalence in the general population is equal to or lower than this 1 per 100,000 benchmarks.

- b) At least 95 percent of all samples collected within each 12-months are of suitable quality for testing, be packaged and shipped according to protocol, and be accurately associated with the animal identification collected with the sample.

The success of the slaughter surveillance program relies on the proper collection, packaging, and shipping of all samples from this targeted population. These procedures should be done according to slaughter surveillance procedures (APHIS Guidance Document

6602.1) to ensure that samples arrive at the laboratory in testable condition. Equally important, each blood sample must accurately correlate with the official animal identification of any infected animals. Official animal identification allows officials to trace infected animals back to their herd of origin, where testing will be done and additional reactor animals promptly removed, when appropriate.

- c) At least 90 percent of the reactors identified through samples collected at slaughter establishments in each 12-months are traceable to the herd of origin within 15 days of notification of non-negative results.
- d) Samples collected from cattle and bison include demographic information related to animal type (beef, dairy, or bison), age, sex, and location to allow for potential analysis in future surveillance evaluations.

The current focus is the collection of samples from higher-risk animals; specifically, animals from within the GYA States. These animals are at most risk due to spillover from wildlife to domesticated herds. It is important that the samples collected from slaughter and other non-slaughter components represent the demographics of cattle and bison within the GYA States. This allows for the targeted sampling to represent the risk for each animal category (beef/dairy, bison, sex, age, etc.).

- e) Samples that are collected and submitted as a part of the slaughter surveillance component are representative of the animals presented for slaughter during that month. Samples should be collected continuously, and surge testing at the end of a contract or the end of a fiscal year should be avoided.

Sampling should be conducted consistently to ensure that the targeted slaughter surveillance population, cattle, and bison from the GYA, are sampled as a true representative of the demographics in the targeted subpopulation. Without consistent sampling, surge sampling may occur, which could create a difference between the demographics of animals sampled and the demographics of animals slaughtered. Surge sampling may skew and ultimately reduce the number of high-risk samples collected and tested.

- f) The Brucellosis Program collects and reports slaughter testing data each month to the internal stakeholders.

The success of the brucellosis surveillance program relies on the accurate collection and reporting of data. Gathering and reporting data each month will help detect issues and provide guidance in areas in which sampling expectations are not being met. This process will ensure that data from multiple sources are formatted and reported accurately and consistently, and that the data will be processed on time.

- g) Data is collected and reported by the program data manager to the stakeholders at least annually from each of the non-slaughter surveillance components (i.e., export, on-farm testing, livestock market testing, enhanced passive surveillance/laboratory abortion testing, and cattle tick fever surveillance testing of stray cattle).

Collating accurate and reliable data and reporting them to stakeholders is the cornerstone of the national brucellosis surveillance plan. Each surveillance component should be

collated and reported at least yearly to ensure transparency in the processes. This reporting will allow for real-time adjustments for stakeholders and VS staff, ensuring that each of the surveillance components reliably supports the national brucellosis surveillance plan. In addition, this information will assist the decision-making process and the allocation of resources based on non-slaughter testing needs, while at the same time demonstrating geographic representation across the United States and providing information regarding potential testing bias.

### **Surveillance System Evaluation**

The brucellosis surveillance system should be evaluated regularly by CEAH and the VS Ruminant Health Center to determine how well the system fulfills its stated goals, objectives, and metrics and meets accepted standards. The evaluation process will identify system strengths and areas for improvement. This surveillance plan should be evaluated within 3 years of its implementation, FY 2024, and every 5 years thereafter.

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## List of Acronyms Used

APHIS	Animal and Plant Health Inspection Service
AVIC	Area Veterinarian in Charge
BAPA	Buffered acidified plate antigen
BEAP	Brucellosis emergency action plan
BMP	Brucellosis management plan
BRT	Brucellosis Ring Test
CDC	Centers for Disease Control and Prevention
CEAH	Center for Epidemiology and Animal Health
CFR	Code of Federal Regulations
CFTEP	Cattle Fever Tick Eradication Program
DSA	Designated Surveillance Area
EPS	Enhanced Passive Surveillance
FPA	Fluorescence polarization assay

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FSIS	Food Safety and Inspection Service
GYA	Greater Yellowstone Area (includes areas of Idaho, Montana, and Wyoming)
LIMS	Laboratory Information Management System
MCI	Market Cattle Identification
MIM	Mobile Information Management
MOU	Memorandum of Understanding
NASS	National Agricultural Statistics Service
NVSL	National Veterinary Services Laboratories
SCS	Surveillance Collaboration Services
USAHA	United States Animal Health Association
USDA	U.S. Department of Agriculture
VS	Veterinary Services
WOAH	World Organization for Animal Health