Alberta Agricultural Waste Characterization Study

Final Report, August 2013

Prepared by
sonnevera international corp.
PO Box 23, Bluffton, AB T0C 0M0
403.843.6563 | cseidel@sonnevera.com

Initiated by Alberta Agriculture and Rural Development, funding for this project was provided through Growing Forward 2, a federal, provincial, territorial initiative. The views and opinions expressed in this report are not necessarily those of Agriculture and Agri-Food Canada or Alberta Agriculture and Rural Development.

Executive Summary

In 2013, CleanFARMS Inc., in partnership with Alberta Agriculture & Rural Development (ARD) through Growing Forward 2, a federal, provincial, territorial initiative, initiated an Alberta Agricultural Waste Characterization Study, focusing on non-durable, inorganic waste generation on Alberta farms. This study attempts to characterize and quantify significant sources of paper and plastic waste on Alberta farms, utilizing a combination of market information and field generation estimates.

Major waste sources are a result of the two major types of farms in Alberta:

- grain farms – 29% of Alberta's farms
- cattle operations (cow/calf farms and feedlots) – 28% of the province's farms

Thus, the study focuses on agricultural films like low density polyethylene (LDPE) (silage plastics, grain bags) and on polypropylene (PP) twine. The main paper waste sources were identified as packaging products like multi-walled paper bags (for feed, seed, supplements, minerals, etc.) and cardboard packaging (boxed agricultural film products, pesticides, etc.).

Estimated quantity ranges for the primary sources of inorganic agricultural waste in Alberta are summarized below:

	Estimated Total Annual Generation (tonnes)
Plastic Film Waste	
Bale Wrap	550 to 1400
Grain Bags	700 to 1800
Greenhouse Film	60 to 160
Silage Plastic	1500 to 2300
Total Ag Film Waste	**3260 to 6360**
PP Twine	2000 to 6000
Net Wrap	450 to 700
Polypropylene Totes	275 to 300
Pesticide Containers	620
Sanitation Containers	4
Total Plastic Ag Waste	**6600 to 14,000**
Paper Waste	
Paper and Multi-Walled Bags	630 to 815
Cardboard	650 to 800
Total Paper Ag Waste (rounded)	**1300 to 1600**
Total Ag Waste	**7900 to 15,600**

Table of Contents

Table of Figures

Table of Tables

1 Introduction

CleanFARMS is a not-for-profit industry stewardship organization committed to environmental responsibility through the proper management of agricultural waste (CleanFARMS 2013). After conducting agricultural waste studies in British Columbia, Saskatchewan, Manitoba, Ontario and the Maritimes (New Brunswick, Nova Scotia, PEI), CleanFARMS initiated a similar study to be completed for Alberta in 2013.

In partnership with Alberta Agriculture and Rural Development (ARD), with funding for this project provided through Growing Forward 2, a federal, provincial, territorial initiative, and under the guidance of a project steering committee consisting of a range of stakeholders, CleanFARMS engaged sonnevera international corp. to conduct an Alberta Agricultural Waste Characterization Study, focusing on quantifying agricultural plastic and other non-durable inorganic waste generated and managed on Alberta farms.

1.1 Background

Alberta has a variety of farms, as identified in the Agricultural Statistics Factsheet (Alberta ARD 2012) and illustrated in Figure 1, which may generate inorganic waste as part of their operations. This study attempts to identify and quantify significant sources of these inorganic wastes from Alberta farms.

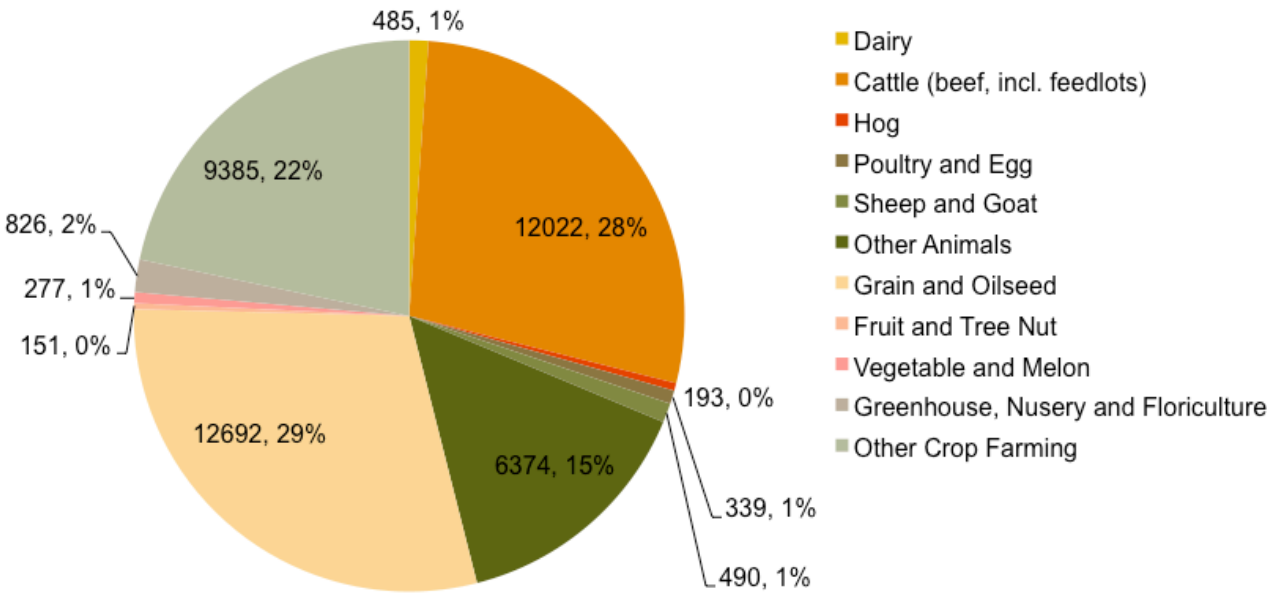

Figure 1: Number of Farms of Different Types in Alberta in 2011 (Statistics Canada 2012)

Agriculture is an important part of the Alberta economy, accounting for 1.8% of the provincial GDP in 2011 (Government of Alberta 2013). The 2011 Census of Agriculture revealed a total of 43,234 farms exist in Alberta, ranging in size from under 10 acres to over 3,520 acres (Statistics Canada 2012), averaging 1,168 acres. Statistics Canada classifies each census farm based on the commodity or group of commodities accounting for 50% or more of the farm's total annual receipts (Statistics Canada 2012). According to this system, two types of farming dominate in Alberta (Figure 1): grain and oilseed crops (29%) and the livestock industry (28%). In fact, Alberta is the largest beef producing province in Canada, hosting 39.8% of the national cattle herd (Alberta ARD 2012).

Although a variety of wastes may be generated on Alberta farms, the main components of waste are assumed to stem from the predominant grain and beef production industries. Thus low density polyethylene (LDPE) film (bale wrap, silage plastics and grain bags) and polypropylene (PP) (baler) twine were the focus of the study. Other waste streams, such as paper and plastic bags and totes for products like seed, feed, fertilizer, minerals and salts, cardboard packaging, greenhouse film and high density polyethylene (HDPE) containers used for sanitation products were also considered. Other sources considered less than significant were not estimated, as their contribution is immaterial to the overall tonnage generated on Alberta farms. Example of such materials include plastic stretch film used to wrap pallets of goods, and plastic packaging on individual items such as rolls of net wrap. Durable products, such as posts, tire and wire were considered outside the study scope and therefore were also not counted within this research.

1.2 Project Objectives

The intent of the Alberta Agricultural Waste Characterization Study was to develop a characterization of significant sources of on-farm agricultural waste (inorganic) in Alberta, to identify opportunities for increased waste reduction and diversion in this sector.

The study does not consider the existence or accessibility of recycling programs or provide any assessment of waste management practices.

2 Methodology

In order to understand the waste generation occurring on Alberta farms, and quantify the amounts of paper and plastic waste generated annually on Alberta farms, a variety of tasks were undertaken.

The research presents an Alberta-specific estimation of agricultural waste generation utilizing resources such as:

- Statistics Canada Agricultural Census Data (2011)
- Canadian Importers Database (Industry Canada)
- Alberta Agriculture & Rural Development publications
- Previous studies regarding waste on farms
- Internet searches
- Industry and Subject Matter Experts

The materials profiled in this report include the following:

Plastic sources:

- low-density polyethylene (LDPE) products such as silage wrap, grain bags or plastic tote bags
- polypropylene (PP) products including twine, woven plastic mini-bulk bags or totes
- high density polyethylene (HDPE) jugs, pails and drums

Paper sources:

- lined and unlined paper bags

Generation estimates used a combination of sales information, as well as usage estimates based on field information. It was felt that this approach would provide the most reasonable range of quantities, mitigating the inherent errors associated with one individual form of research.

2.1 Previous Studies

Two previous studies have estimated plastic agricultural waste in Alberta. Most recently, the Government of Alberta hired IPSOS REID to conduct an *Agricultural Plastics Recycling Producers Survey* (2012) which interviewed 660 Alberta farmers about current practices. The survey results indicated 375 of these farms (56%) used one or more types of plastic in a 12-month period, and identified the most commonly used plastic as baling twine (Government of Alberta 2012). Based on interview responses from farmers, combined with estimated mean weights of various plastic applications, it was estimated that about 3,000 metric tonnes of twine, silage covers, grain bags, bale wrap and silage or bale tubes are generated annually on Alberta farms. It is important to note that the methodology used in this study does not allow a direct comparison to the current report.

The second relevant estimate of agricultural plastic generation is found in the *Agricultural Plastics Recycling Pilot Project* published by the Recycling Council of Alberta (RCA) in 2009. The report primarily concerns a recycling pilot project for agricultural plastics, but also contains The Alberta Plastics Recycling Association (APRA) estimate of plastic waste generation on farms, based on research into sales of these materials into Alberta. APRA estimated between 3000–4000 tonnes of polypropylene (twine and cord) and 4300–5000 tonnes of polyethylene material (silage bags and covers) were sold into Alberta in 2007 (RCA 2009).

The methodology and content of similar CleanFARMS studies, conducted in British Columbia, Saskatchewan, Manitoba, Ontario, and the Maritimes, were also reviewed and applied to this project. These reports can be found on the CleanFARMS website at www.cleanfarms.ca/resources.

2.2 Expert Consultation

A range of industry and subject matter experts were consulted to obtain information and perspective. A list of these experts is provided in Appendix A.

2.2.1 Industry Experts

To gain additional insight into the types and amounts of waste agricultural materials generated and their application within the Alberta marketplace, the study identified and attempted to engage a variety of industry experts, including producer organizations and agricultural plastic and paper product manufacturers, importers, distributors and retailers. Initial identification of these organizations and businesses was established via the internet. Some industry experts did not respond to the invitation to participate and others declined to contribute. Interaction with willing industry experts was conducted via email and telephone. As the study progressed, individuals suggested or were asked to identify other important industry experts.

To reduce the amount of error in estimating annual tonnages through calculations or individual farm estimates, manufacturers, distributors and retailers were contacted to obtain Alberta specific sales data. Industry experts also assisted in understanding waste resulting from product packaging and delivery to farms.

2.2.2 Subject Matter Experts

In order to understand the variety of types of farming occurring in the province, and identify their potential waste streams, subject matter experts were consulted. This included some farm owners and operators, Alberta Agriculture and Rural Development staff, research scientists, animal nutritionists and technologists.

These individuals were instrumental in calculating estimations of waste generation in cases where manufacturers were difficult to identify or unwilling to supply sales data, or the market had a variety of equivalent products with no dominant manufacturer (i.e., sanitation products).

2.3 Steering Committee

A Steering Committee was established in the early stages of the project to combine a variety of important perspectives on agricultural waste. Farm supply retailers, manufacturers, government representatives, plastic recyclers and a variety of organizations were invited to participate. For a complete list of Steering Committee members, please see Appendix B.

Two conference call meetings were held with available Steering Committee members, CleanFARMS general manager, and the sonnevera team. The first, held May 2, 2013, introduced the proposed methodology for the project and facilitated discussion to refine the list of investigated materials and determine the specific materials utilized in the Alberta agriculture industry. The second, held July 3, 2013, presented the draft report to the committee and highlighted project findings. This meeting provided involved parties with an opportunity to identify areas requiring further work, such as potentially missed farm-generated waste components, and contribute suggestions for further follow up.

Once feedback was compiled, the Steering Committee was convened for an in-person meeting August 15 in Lacombe, Alberta, to provide a final review of the report and discuss desired next steps.

3 Waste Characterization

Descriptions of the sources of paper and plastic agricultural waste considered, as well as the respective estimated tonnages follow. General categories include plastics such as film products (bale wrap, grain bags, greenhouse covers, and silage film), net wrap, twine, woven bags and plastic containers, as well as fibre products such as paper bags and cardboard. In order to limit the scope to a reasonable undertaking, only waste sources deemed to be significant were included.

3.1 Description of Plastic Wastes and Packaging

3.1.1 Bale Wrap

Bale wrap and/or silage wrap is a type of stretch film utilized to contain hay, straw or silage. It is predominantly used in the dairy industry, where nutritional content is paramount to milk production (Yaremcio 2013). Bale wrap may come on a plastic or cardboard core, estimated by industry experts to be approximately 1.2 kg (Mazurenko 2013). This product comes in a 0.95 kg cardboard box (Mazurenko 2013).

3.1.2 Grain Bags

Grain bags are a LDPE film product, used for temporary crop storage. These bags provide easy storage for bumper crops and reduce transport costs for crops from land far from grain bins. Each grain bag comes in an individual box, estimated to be 6.4 kg (Mazurenko 2013).

3.1.3 Greenhouse Film

Greenhouse film products are typically manufactured from LDPE and are used for greenhouse cover (roofing and walls). The film is delivered in rolls, with an average unit weight of 0.025–0.029 pounds per square foot.

3.1.4 Net Wrap

Net wrap is a knitted high density polyethylene (HDPE) netting alternative to baler twine is used on hay and straw bales (Syfilco 2013). Popularity of net wrap has grown in some markets, as it allows faster baling, and reduces spoilage and leaf loss (OMAFRA 2013). Net wrap may come on a plastic or cardboard roll, with sizes from 7000 to 9500 feet in length, and an average weight of 0.002 pounds per square foot, and is normally packaged in a film bag.

3.1.5 Silage Plastic

Silage plastic refers to agricultural LDPE films used as silage covers or silage bags.

Silage bags form long tubes, similar in appearance to grain bags. They are primarily used by the dairy industry. Silage bags come folded up in a 6.44 kg cardboard box (Mazurenko 2013). Silage covers are LDPE sheeting for utilized in covering bunkers or pits, as well as ground piles. Silage covers come on either a plastic or cardboard core (2.1 to 12.4 kg) (Hessey and Mazurenko 2013).

3.1.6 Twine

Polypropylene twine is used for baling hay and straw, and comes in different sizes weighing from 0.001 to 0.006 pounds per foot, delivered in spools of 4000 to 28,000 feet (Rucci 2013). It may come wrapped in a plastic film as individual spools, or packaged one or two spools per cardboard box. Sisal twine, made from natural sisal plant fibers, was not considered in this study.

3.1.7 Polypropylene Woven Bags and Mini-Bulk Bags or Totes

Agricultural products may come in 25 kg capacity polypropylene woven bags, or in larger polypropylene weave, 1-tonne capacity mini-bulk bags (MBBs). Items commonly sold polypropylene woven bags include pesticides, bulk seed or feed, and fertilizers.

3.1.8 Sanitation Products

Sanitation products, including detergent and disinfectants, may be used in the dairy, poultry and hog industries. There are a plethora of options and sizes of containers for use, depending on the farm size and requirements. Sanitation products come in powdered and liquid forms and are available in HDPE containers like 4 L jugs, 5 kg pails, 20 L pails, 55 L or 205 L drums, and 1000 L totes. Some sanitation products, like soap, may come in cardboard boxes when bought in multiple jugs.

3.1.9 Pesticides

Pesticide and herbicide containers are also available in a variety of sizes, from smaller quantity bottles (<1 L) and jugs (1-10 L) to larger scale pails (20 L), drums (205 L) and totes (450 L or 1000 L). Typically, two 10 L jugs will come packaged in a cardboard box.

3.1.10 Engine and Hydraulic Oil

Oil containers are typically made from HDPE and come in a variety of denominations: <1 L bottles, 1 L and 4 L jugs, 20 L pails, and bulk. Smaller containers may also generate cardboard box packaging waste.

3.2 Description of Paper Wastes

3.2.1 Paper Bags

There are two types of paper bags used in agriculture: unlined paper bags and plastic lined or multi-walled paper bags. These may be used for products including seed, supplements, minerals and salts.

3.2.2 Cardboard Packaging

Numerous agricultural products come in cardboard packaging as previously mentioned; silage and grain bags each come individually packaged in a cardboard box, silage covers and net wrap are on a plastic or cardboard core, multiple spools of twine are often purchased in a box, pesticide containers typically come two per box, and insecticide may also be purchased in a plastic lined cardboard box.

3.3 Description of Animal Health Product Packaging Wastes

The importance of animal health and subsequent maintenance is bound to generate some waste on Alberta farms. Plastic and glass bottles from vaccinations and medical treatments as well as boxboard cartons and informative paper inserts with instructions or advertisements all contribute to waste generation.

4 Estimated Waste Tonnages

As previously discussed, the two significant plastic sources considered were LDPE agricultural films, and PP twine. Primary estimates for these materials came from industry experts, both from sales and field research perspectives. Manufacturers and suppliers of products resulting in other waste streams were more difficult to identify and contact for data.

Wherever possible, key stakeholders and industry experts were contacted for sales estimates to provide a base generation amount. Waste generation per unit of production was also estimated based on the type of farming activity and the required inputs. Alberta farms vary in size and operation, and different management practices and styles may lead to utilization of different products and thus different generation rates. Calculations formulated to estimate the annual waste tonnage generated involve standard product unit weights and rely heavily on subject matter expert input.

The detailed calculations and assumptions used to make these estimations are outlined in Appendix C and Appendix D. It should be noted that quantifying waste using calculations based on estimated usage is subject to error and should be considered an iterative process.

4.1 Estimated Plastic Waste Tonnages

Manufacturers, retailers and distributors contacted were asked to estimate the average annual tonnage of each type of product sold into Alberta. These estimates are relevant to the current market, but exact sale figures per year were not collected. Since some known retailers / distributors were non-responsive or hesitant to provide estimated sales figures, industry experts were asked to provide market size estimations in addition to sales data.

It should be noted that adverse weather and/or pest conditions affecting crop production and market competition from international (typically Asian) imports sold privately off-farm affect the sales of agricultural plastics. These factors were not considered in detail for this analysis.

4.1.1 Bale Wrap

From discussion with and data collection from industry experts, the estimated annual tonnage of bale and silage wrap sold into Alberta is 550 to 900 tonnes. This includes primarily bale wrap, and some silage wrap plastic.

Prior to using bale wrap, bales are bound by twine or net wrap. Although either of these products may be used, industry experts estimate that net wrap is becoming more popular for this purpose but mainly twine is used in Alberta (Mazurenko 2013). Continuous baling occurs with both large square and round bales, and some rows are bale wrapped two bales high (Mazurenko 2013). For the purpose of calculating an estimated tonnage of waste bale wrap generated per annum, it was assumed that only single rows of round bales were wrapped continuously (see Bale Wrap tab in Unit Weight Estimates, Appendix C). It was further assumed that only large round bales were made utilizing bale wrap.

In accordance with the previously stated assumptions, estimates of bale wrap and associated twine waste generation were calculated for both continuous and individual bale wrapping. Based on subject matter and industry expert data (see Appendices Subject Matter & Unit Weights for exact references) it was assumed that 77% of baled hay is made into round bales, of which 14% is continuously wrapped with bale wrap and 1% is individually bale wrapped. Waste bale wrap from individually wrapped bales is between 100–150 tonnes per year, generating 11–15 tonnes per year of associated twine waste. Continuous wrapping of bales generates significantly more waste, as it is estimated to be used more than individual style (Yaremcio 2013). The amount of wrapping utilized will also vary from farm to farm as it is the personal preference of the operator. Calculations estimate between 950–1400 tonnes of bales wrap waste and 148–212 tonnes of associated twine waste are generated from continuous bale wrapping in Alberta (see Bale Wrap tab in Unit Weight Estimates, Appendix C).

Table 1 compares the industry expert and calculation-based estimations for bale wrap waste generation in Alberta.

Table 1: Annual Alberta Waste Bale Wrap Estimates

Type of Estimate	**Estimated Annual Tonnage of Waste Bale Wrap in Alberta** (tonnes/year)
Industry Submitted Data	550 to 900
Calculation Based	950 to 1400

4.1.2 Grain Bags

Based on collected sales figures and industry expert estimates of market size, a range of 1400 to 1800 tonnes of grain bags are sold annually into Alberta. Some farmers use only grain bags to store harvested crops, while others use them for temporary storage during a bumper crop year (Kruidhof 2013). In addition, some distributors have heard of farmers using grain bags to store bulk fertilizer on location (Hoogewonink 2013). In reality, this tonnage may be higher since some known retailers / distributors were unwilling to provide estimated sales figures. Some industry and subject matter experts indicated that annual sales continue to increase year after year, suggesting market growth and increased use. Equipment manufacturers also indicated increased sales of grain bagging equipment. Therefore, it is reasonable to assume that the amount of this category of waste plastic will continue to grow.

Calculated estimates for annual grain bag generation show between 700–1450 tonnes are used. Industry and subject matter experts suggested that a 10 ft diameter x 250 ft length grain bag is a standard size; depending on the crop type and density, this bag would hold around 12,000–12,900 bushels (Hoogewonink and Grain Bag Storage Systems 2013). The calculated estimate of generated grain bag waste is based on 10–20% of the estimated 2011 harvested canola, wheat, oats and barley crops (ABARD 2012) being stored in grain bags. Grain bags may well be used for other crops, such as peas and corn, but it is uncertain how much of this practice occurs. For more information and to see these calculations, please see Subject Matter Expert Estimations, Appendix D. As aforementioned, some distributors have heard of farmers using grain bags to store bulk fertilizer on location (Hoogewonink 2013) and some websites also promote this idea (Grain Bag Storage System 2013). The calculated estimate listed here does not account for grain bags used to store fertilizer.

Calculated estimates and industry expert estimates for annual grain bags usage are shown below in Table 2. Assumptions required to derive this tonnage are based on consultation with industry and subject matter experts (Subject Matter Expert Estimations, Appendix D and Unit Weight Estimations, Appendix C).

Table 2: Annual Alberta Waste Grain Bag Estimates

Type of Estimate	**Estimated Annual Tonnage of Waste Grain Bags in Alberta** (tonnes/year)
Industry Submitted Data	1400 to 1800
Calculation Based	700 to 1450

4.1.3 Greenhouse Film

No industry expert sales estimate of greenhouse film in Alberta was obtained, however a calculation based estimate was created (Subject Matter Expert Estimations, Appendix D). This estimate was verified

by subject matter and industry experts (Spencer and Mazurenko), however is considered low by industry market size estimations.

Greenhouse plastic (LDPE film) covers generally last 3–5 years, depending on film quality and weather conditions (Spencer 2013). Industry and subject matter experts agree that on average these greenhouse covers are replaced every 4 years (Spencer and Mazurenko). Using this 1/4 average as a basis, assuming some margin to account for curvature and walls, approximately 20–50% of the greenhouse area would need replacing per year. Greenhouses often double their film covering, to account for air inflation (Mazurenko 2013). This was accounted for directly in the unit weight estimate for greenhouse film (Unit Weight Estimations, Appendix C)

Based on assumptions from consultation with industry and subject matter experts, the calculated estimate of Greenhouse generated film waste (Table 3) is 60–150 tonnes per year.

Table 3: Annual Alberta Waste Greenhouse Film Estimate

Type of Estimate	**Estimated Annual Tonnage of Waste Greenhouse Film in Alberta** (tonnes/year)
Calculation Based (1)	60–150

Other wastes from the horticulture, silviculture and greenhouse industries, include: plastic growing mediums like plastic mulch, plastic bags, and ground sheeting; periodically replaced circulation ducting, dripper hoses and lines. These waste streams were not considered in this study in part because of difficulty tracking the use and replacement of these items. Subject matter experts also advised that the waste generation would be relatively insignificant.

4.1.4 Net Wrap

The estimated annual net wrap sales in Alberta, after consultation with industry experts about sales, is reported as 500 tonnes. This estimate is low, since known importers and distributors of net wrap products were unwilling to provide sales data and no net wrap market size estimates were obtained. While some manufacturers and retailers believe netwrap will one day exceed twine as a baling material, estimated sales of twine (4000 to 8000 tonnes) continue to exceed those of net wrap (500 tonnes). Net wrap is compatible with round bales, but is not considered a feasible binding material for large square bales (Sherman and Yaremcio 2013).

A calculation based estimate was also constructed to verify the 500 tonne estimate from manufacturers, distributors and retailers data. Using the calculation based method, assuming 77% of hay bales are large round bales, and 20% of those bales are made using net wrap; the annual net wrap waste generation in Alberta ranges from 450 to 700 tonnes (Baling Waste Generation Est tab in Appendix D – Subject Matter Expert Estimations). As shown in Table 4, the cumulative sales data from industry experts falls within this calculated range.

Table 4: Annual Alberta Waste Net Wrap Estimates

Type of Estimate	**Estimated Annual Tonnage of Waste Net Wrap in Alberta** (tonnes/year)
Industry Submitted Data	500
Calculation Based	450 to 700

4.1.5 Silage Plastic

Alberta produces significant silage as feed for cattle, in 2011 approximately 3.9 million tonnes were made, primarily from barley and oats (ABARD 2013). Industry expert estimates of market size and collected sales data indicate that the provincial silage plastic market (covers and bags) is in the range of 1500 to 2300 tonnes per year. The associated plastic/cardboard core waste from silage covers and cardboard box waste from silage bags could not be estimated because information regarding sales was collected as one unit (silage plastic).

Silage plastic waste generation, via a calculation based method, is estimated to be about 1750 tonnes (Subject Matter Expert Estimations, Appendix D). This value considers silage storage practices in the province and the number of cattle fed silage as a percentage of their diet, for a given period of time. It also utilizes an adjusted pound of plastic waste per cow per year generation factor, based on the work conducted by the Environmental Risk Analysis Program at Cornell University (Levitan and Barros 2003). The adjusted factor (4.2 lb/cow) is a conservative estimate as it assumes that only silage cover plastic is utilized in traditional bunker or ground pile style silage storage systems; however subject matter experts estimate between 5–10% of silage in Alberta is stored in silage bags or silage wrap, mainly in the dairy industry (Yaremcio 2013). Table 5 compares these industry and calculation based estimates.

Table 5: Annual Alberta Waste Silage Plastic Estimates

Type of Estimate	**Estimated Annual Tonnage of Waste Silage Plastic in Alberta** (tonnes/year)
Industry Submitted Data	1500 to 2300
Calculation Based	1750

4.1.6 Twine

Data collected from manufacturers, distributors and retailers estimates the annual tonnage of twine sold in Alberta to be between 4000 to 6000 tonnes. This estimate is reflective of Alberta sales and of market size estimations, since data from some known importers, manufactures and retailers was unobtainable.

In order to verify this estimate, industry and subject matter estimations were used in conjunction with an Agricultural census value of total tame hay crop production in 2011 (ABARD 2013). Estimations of the percentage of bales made using twine and the percentage of each type of bale (large square, round, small square) allowed a per unit based calculation estimation to be created. This calculation estimates the annual tonnage of twine from hay bales to be in the range of 1400–2100 tonnes (Table 6), as evident in Appendix D – Subject Matter Expert Estimations. This estimate is low, since a lack of statistical data on straw production and subject matter experts' reluctance to estimate a value prevented the inclusion of straw bales in the calculation. Assumptions regarding distribution of bale type and the amount of twine used per bale are subjective and could also be potential sources of error. In some cases, hay farmers have developed new management techniques, like a system that uses a baler to bind 12 small square bales together for easier shipment and handling (Toews 2013). This type of adapted, relatively new method utilizes more twine than traditional baling methods and is not accounted for in this calculated estimate. Therefore, it is reasonable to assume that the upper limit of this twine estimate is more realistic than the lower, resulting in a revised estimate of 2000 – 2500 tonnes.

The calculation-based estimate assumes that total hay production is split between 20% large square bales, 77% round bales and 3% small square bales, based on subject matter and industry matter expert opinions (see Appendices for details). It is assumed that 100% of the square bale production (large and small) is made using baler twine, while 65% of the round bales produced are made with twine. Please see Appendices for further details regarding unit weights and estimated bale sizes (Appendix C).

Table 6: Annual Alberta Waste Twine Estimate

Type of Estimate	**Estimated Annual Tonnage of Waste Twine in Alberta** (tonnes/year)
Industry Submitted Data	4000 to 6000
Calculation Based	2000 to 2500

4.1.7 Polypropylene Woven Bags and Mini-Bulk Bags or Totes

Internet research and industry expert consultation revealed that many bags used for packaging come from China or Vietnam. Agrisac Inc., a company with suppliers in both China and just outside of Montreal, Canada shows variety of products on their website (Agrisac Inc. 2013) for the livestock and horticulture markets, such as polypropylene woven bags for feed, paper bags for supplements and polyethylene bags for fertilizer.

There are a variety of types of bags used in the agriculture industry and a variety of sizes as well, ranging from 20 or 25 kg bags to 1000 or 2275 kg totes.

In general, industry suppliers and distributors of bags were hesitant or non-responsive to inquiries about sales figures. A calculation based estimate places the polypropylene totes (1000 kg capacity) waste generated between 275–300 tonnes (Table 7). This estimate was produced by consulting various subject matter and industry experts (Subject Matter Experts, Appendix A), with specific consideration of the hog, poultry and cattle (beef and dairy) industries. This total also incorporates estimates of polypropylene tote waste generated from wheat, barley and canola seed bags from a national study conducted by Agrirecup (Lajeunesse 2013). The Canada-wide Agrirecup study also estimated that an additional 20 tonnes of other types of seed, fungicide and insecticide bags are generated in Alberta, however this tonnage is not included as no information regarding the material type of these bags was available.

Table 7: Annual Alberta PP Tote Waste Estimate

Type of Estimate	**Estimated Annual Tonnage of PP Tote Waste in Alberta** (tonnes/year)
Calculation Based (1)	275 to 300

Note: 1. Estimate for polypropylene 1 tonne totes only, does not include any fertilizer packaging.

4.1.8 Pesticide Containers

Pesticide and herbicide containers are also available in a variety of HDPE container sizes, from smaller quantity bottles (<1 L) and jugs (1–10 L) to larger scale pails (20 L), drums (205 L) and totes (450 L or 1000 L).

The estimated annual HDPE waste generated from pesticides in Alberta is 620 tonnes (Table 8). This value is based on CleanFARMS estimates on annual pesticide sales in Alberta and assumes 2.5 gallon (9.46 L) HDPE plastic packaging. The associated cardboard waste, generated from pesticide packaging, is estimated to be approximately 492 tonnes per year (Table 11, Section 4.2.2).

Table 8: Annual Alberta Pesticide Container Waste Estimate

Type of Estimate	Estimated Annual Tonnage of Pesticide Container Waste in Alberta (tonnes/year)
Calculation Based (1)	620

Note: 1. Based on CleanFARMS estimate of annual Alberta sales

4.1.9 Engine and Hydraulic Oil

In Alberta oil products have an environmental handling charge (EHC) incorporated into their sale price, to help cover the costs of responsible collection and recycling of these materials. The Alberta Used Oil Management Authority (AUOMA) is the not-for-profit Delegated Administrative Organization (DAO) that oversees the collection. While they do track the amount of containers returned throughout the province, in 6 separate zones, they do not have farm specific data.

Since oil products can potentially be purchased and containers returned at a variety of locations, no valid estimate was possible at this point in time.

4.1.10 Sanitation Product Containers

A variety of sanitation products and packaging in the form of HDPE jugs, pails, drums and totes, may be used on various farms. Larger items, such as 1000 L totes of teat dip or 200 L drum of foot bath solution used in dairy barns have a container deposit program in place, with manufacturers receiving empty containers for reuse. These programs often backhaul empty containers when refilled supplies are delivered to the farm. These items were not considered in this study since they are reused.

Products purchased in smaller quantities, like detergents or soaps, come in various denominations of HDPE jugs and pails. Since there is no dominant brand or manufacturer of these smaller products and farm management practices and types (laying hen barn vs. broiler barn; hog feeder barn vs. hog farrowing barn, etc.) may differ in terms of use, estimations are variable at best. In consultation with subject matter experts and individual farmers, calculations of annual HDPE waste generation on farms were compiled (Table 9).

This consultation concluded that relatively little HDPE waste is generated on hog, poultry or dairy farms. Most waste comes from detergent or disinfectant product packaging, used periodically to clean and disinfect barns, feeders and water lines. Other products, like manure thickening additives, come in 5 gallon pails but its use is minimal (57 mL per 4000 L manure). The predominant sizes of containers were 20 L (5 gallon) pails which are generally all reused on farms, and 4 L jugs.

Table 9: Annual Alberta HDPE Waste Estimate

Type of Industry	Estimated Annual Tonnage of HDPE Sanitation Product Packaging Waste in Alberta (tonnes/year)
Poultry Industry (1)	1.8
Dairy Industry (2)	1.4
Hog Industry (3)	0.6
TOTAL	3.8

Notes: 1. Calculated based on subject matter expert and farm estimates (Schneider 2013). See Poultry Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

2. Calculated based on farm estimates (sonnevera 2013). See Dairy Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

3. Calculated based on subject matter expert and farm estimates (Beltranena 2013). See Hog Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

4.2 Estimated Paper Waste Tonnages

Paper waste on Alberta farms is comprised of multi-walled paper bags from products like feed, minerals, loose salts and supplements, as well as cardboard packaging from a variety of items including boxed pesticide, twine and secondary waste like cardboard cores used in rolls of silage plastic.

4.2.1 Paper Bags

Paper bag waste on farms originates from products like seed, feed, minerals, loose salts and supplements. Given the vast variety of retailers and suppliers, in combination with reluctance to provide sales estimates, only calculation-based estimates were obtained (Table 10). Using various subject matter and industry experts, the estimated annual tonnage of paper bags ranges from 600 to 780 tonnes. Specifically, dairy, beef, hog and poultry farms were considered in this calculation. Subject matter experts advise that most bags are 25 kg multi-walled paper bags (Yaremcio 2013); however, no verification of this was possible. Thus, it should be noted that this estimate may include plain paper, multi-walled, and potentially some polywoven bags.

It should be noted that this estimated range is likely less than the actual amount, given that various types of farms purchasing product in bags were not considered in this study. For example, bison, elk, horses and sheep all require some type of feed, mineral, supplement and salt rations.

Table 10: Annual Alberta Multi-Walled Paper Bag Waste Estimate

Type of Estimate	Estimated Annual Tonnage of Bag Packaging Waste in Alberta (1) (tonnes/year)
Poultry Industry (2)	5
Cattle Industry (3)	220 to 400
Hog Industry (4)	20 to 25
Seed Bags (5)	365
Other Bags (5)	20
Calculation Based	630 to 815

Notes: 1. Includes plain paper and multi-walled paper bags.

2. Calculated based on subject matter expert and farm estimates (Schneider 2013). See Poultry Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

3. Calculated based on farm estimates (sonnevera 2013). See Beef Bag Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

4. Calculated based on subject matter expert and farm estimates (Beltranena 2013). See Hog Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

5. Data provided by Agrirecup (2012).

4.2.2 Cardboard Packaging

The estimated total cardboard packaging waste generation per year, is 650 to 800 tonnes. This is less than the actual tonnage produced, since cardboard cores and boxes associated with silage bags and silage covers could not be accurately estimated. Table 11 below shows the different components of cardboard waste generators considered and their respective amounts. For additional details, see Cardboard Waste Gen Est tab in Subject Matter Expert Estimations file, Appendix D.

Table 11: Annual Alberta Cardboard Waste Estimate

Associated Product	Estimated Annual Tonnage of Tote Waste in Alberta (tonnes/year)
Pesticide Boxes	500
Twine Boxes	65 to 130
Bale Wrap Boxes and Cores	45 to 70
Grain Bag Boxes	55 to 70
TOTAL	650 to 800

4.3 Estimated Animal Health Product Packaging

The Canadian Animal Health Institute (CAHI) identified four main types of animal health products packaging: boxboard cartons, paper inserts, glass bottles and plastic bottles. Table 12 lists the estimated quantities of distributed packaging in Alberta in 2012 (CAHI 2013). Please note that these estimates are

for distribution only and do not equate to waste generation. Some animal health products have shelf lives longer than 1 year, therefore it is difficult to estimate how much is used per year and subsequently also impossible to relate distribution figures to waste generation.

Table 12: Animal Health Product Packaging Distributed in Alberta in 2012 (CAHI 2013)

Type of Packaging	**Boxboard Cartons** (tonnes)	**Paper Inserts** (tonnes)	**Glass Bottles** (tonnes)	**Plastic Bottles** (tonnes)
Quantity (1)	6.5	0.7	76	11

Note: 1. These estimated quantities are for animal health products *distributed* in Alberta in 2012 and do not represent an estimate of waste generation in 2012.

5 Summary of Waste Characterization

The following annual tonnages are a compilation of those contained in the previously outlined Estimated Waste Tonnages.

5.1 Plastic Agricultural Waste

Plastic Film Waste	**Estimated Total Annual Generation** (tonnes)
Bale Wrap	550 to 1,400
Grain Bags	700 to 1,800
Greenhouse Film	60 to 160
Silage Plastic	1,500 to 2,300
Total Ag Film Waste	**3,260 to 6,360**
PP Twine	2,000 to 6,000
Net Wrap	450 to 700
Polypropylene Totes	275 to 300
Pesticide Containers	620
Sanitation Containers	4
Total Plastic Ag Waste	**6,600 to 14,000**

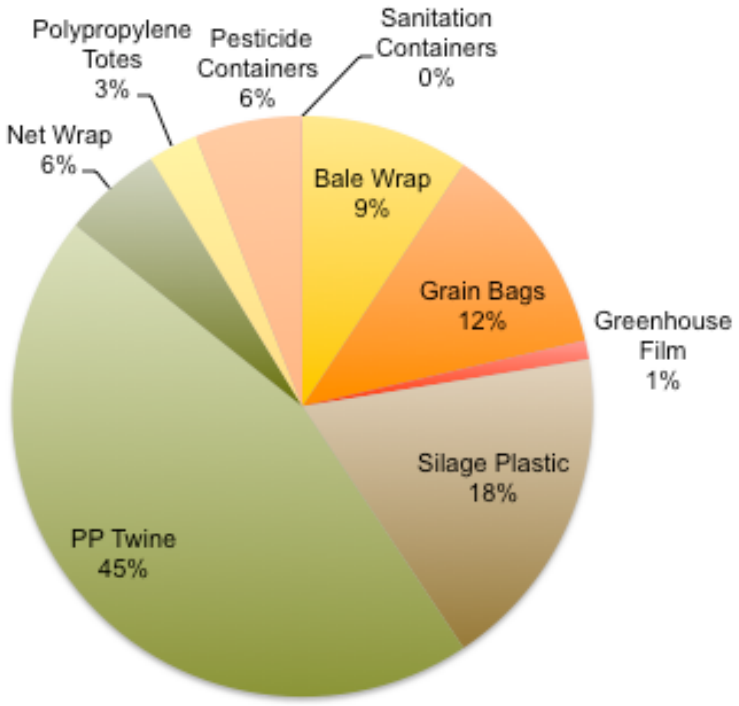

Figure 2: Plastic Agricultural Waste Breakdown (average)

5.2 Paper Agricultural Waste

Paper Waste	**Estimated Total Annual Generation** (tonnes)
Paper and Multi-Walled Bags	630 to 815
Cardboard	650 to 800
Total Paper Ag Waste (rounded)	**1,300 to 1,600**

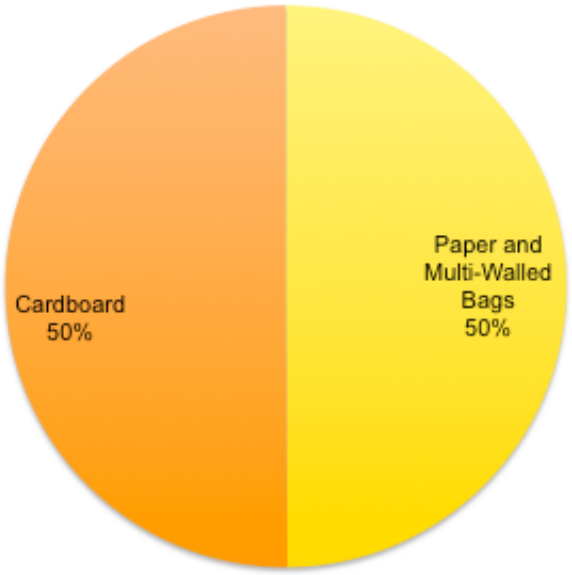

Figure 3: Paper Agricultural Waste Breakdown (average)

APPENDICES

Appendix A – Subject Matter Experts Contact List

Industry Experts:

ADM Alliance Nutrition
1310 41 St N Lethbridge, AB T1H 153
(403) 320-2659

Agrirecup
Christine Lajeunesse
lajeunessec@agrirecup.ca

Association of Alberta Agriculture Fieldmen
Geoff Thompson – President
Lac Ste. Anne County – Agricultural Services Manager
(780) 785-3411

Alberta Cattle Feeders' Association
Bryan Walton
(403) 250-2509
bwalton@cattlefeeders.ca

Alberta Chicken Producers
Erna Ference – Board of Directors Chair
(780) 488-2125
eference@platinum.ca

Alberta Used Oil Management Authority (AUOMA)
Roger Jackson
(780) 414-1514
RJackson@usedoilrecycling.ca

Canadian Animal Health Institute
Tracey Firth – Programs Director
(519) 763-7777
tfirth@cahi-icsa.ca

Amity Ag-Enterprises Inc.
Rick Hoogewonink
(780) 348-5355
rickmh@amityag.com

AT Films Inc.
Calvin Mazurenko – Managing Director
(780) 450-7761
CalvinMazurenko@atfilmsinc.com

Bridon Cordage
Jade Sherman – Marketing Manager
(507) 320-7027
JSherman@bridoncordage.com

Canadian Hay & Silage
Hans Kruidhof
(780) 206-4666
hans@canadianhayandsilage.com

Cargill Animal Nutrition
235 36 St N, Lethbridge, AB T1H 5R8
(403) 329-0787

Chinook Silage Covers
Chris Vossevelt
(403) 634-4030
springdale1@live.com

Committed Ag Supply
Michael Schooten
(403) 382-4816
mike@committedagsupply.com

Federate Cooperatives Ltd (FCL)
Trevor Carlson
(306) 244-3117

Flaman Agriculture
Jeff Freisen
(780) 995-3400

Integra Plastics Inc.
Jeany Hesse
1-800-578-5257

Neeralta Manufacturing Inc.
John Wierenga
(780) 305-0338

PolyExcel
Jerry Nolin
(403)-201-5257

PowerFill
Danny Cameron
(780) 387-6262
danny@powerfill.net

Syfilco
Tony deBoer – President
1-877-235-1233
tony.deboer@syfilco.on.ca

United Farmers of Alberta (UFA)
Jeff Rucci
(403) 570-4366
jeff.rucci@ufa.com

Jeff Einarson
jeff.einarson@ufa.com

Vanderberg Hay Farms Ltd.
Steven Joosse
(403) 824-3010

Subject Matter Experts:

Animal Nutritionists

Jamie McAllister – Ruminant Nutritionist
jamie@championfeeds.com

George Qiao – Monogastrics Nutritionist
george@championfeeds.com

Alberta Agriculture & Rural Development Ag-Info Centre Specialists
310-FARM or (403) 742-7901

Harry Brook – Crop Specialist
Harry.Brook@gov.ab.ca

Rob Spencer – Commercial Horticultural Specialist
Robert.Spencer@gov.ab.ca

Barry Yaremcio – Beef Forage Specialist
Barry.Yaremcio@gov.ab.ca

Alberta Agriculture & Rural Development Researchers

Eduardo Beltranena – Monogastrics Research Scientist
(780) 427-4567
eduardo.beltranena@gov.ab.ca

Brenda Schneider – Poultry Research Technologist
(780) 415-0827
brenda.schneider@gov.ab.ca

Government of Saskatchewan Agriculture Knowledge Centre

Brent Flaten – Integrated Pest Management Specialist
(306) 694-3727

Hay Farmer

Warren Toews
(780) 915-0870
hayseller@hotmail.com

Town of Stettler Director of Ag Services

Quinton Beaumont
(402) 742-4441

Appendix B – Steering Committee Members

NAME	AFFILIATION	EMAIL
Anne Auriat	Edson Recycling Depot	edsonrecycle@telus.net
Tasha Blumenthal	Alberta Association of Municipal Districts and Counties	tasha@aamdc.com
Dale Chrapko	Alberta Agriculture and Rural Development	dale.chrapko@gov.ab.ca
Grant Cameron	Alberta Plastics Recycling Association	g.m.cam@telus.net
Barry Friesen	CleanFARMS	friesenb@cleanfarms.ca
Reuben Joosse	Alberta Agriculture and Rural Development	reuben.joosse@gov.ab.ca
Kevin Kernaghan	Merlin Plastics	kkernaghan@merlinplastics.com
Russel Muenchrath	Wheatland County	russel.muenchrath@wheatlandcounty.ca
Tammy Nygaard	Drumheller & District Solid Waste Management Association	tnygaard@telusplanet.net
Scott Nicol	Alberta Environment and Sustainable Resource Development	scott.nicol@gov.ab.ca
Joanne Walroth	Rocky View County	jwalroth@rockyview.ca
Dave Whitfield	Alberta Environment and Sustainable Resource Development	dave.whitfield@gov.ab.ca
Terry Vankampen	Bridon Cordage	tvankampen@bridoncordage.com
Jeff Rucci	UFA	jeff.rucci@ufa.com
Linda McDonald	Alberta CARE	executivedirector@albertacare.org

Appendix C – Unit Weight Calculations

See Excel file “Unit Weights Estimations_Final.xlsx”

Appendix D – Subject Matter Expert Estimates

See Excel file “Subject Matter Expert Estimations_Final.xlsx”

Appendix E – References

Agrisac Inc website. 2013. Accessed June 25 and available online at: http://www.agripak2m.com/agrisacen/index.html

Alberta Agriculture and Rural Development. 2012. Agricultural Statistics Factsheet. Accessed 10 June 2013 and available online at: http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/sdd12807/$FILE/Ag_Stats_Factsheet_2012.pdf

Alberta Agriculture and Rural Development. 2012. 2011 Census of Agriculture for Alberta - Provincial Highlights. Accessed 13 January 2013 and available online at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sdd14183/$file/ARD_Ag_Census_2011.pdf?OpenElement

Government of Alberta. 2012. *Agricultural Plastics Recycling – Agricultural Producers Survey* – Final Report. Accessed June 25, 2013 and available online at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/com14387

Government of Alberta. 2013. AlbertaCanada.com website. Economic Results. Accessed 20 June 2013 and available online at: http://albertacanada.com/business/overview/economic-results.aspx

Grain Bag Storage System website. 2013. What is a Grain Bag? Accessed June 24 and available online at: http://www.grainbagsystem.com/#/what_is_a_grain_bag/

Levitan, Lois and Barros, Ana. 2003. Recycling Agricultural Plastics in New York State. Environmental Risk Analysis Program, Cornell University. 2nd Edition, March 11, 2003 (1st Edition February 28, 2003). Accessed 27 May 2013 and available online at: http://environmentalrisk.cornell.edu/C&ER/PlasticsDisposal/AgPlasticsRecycling/

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). 2013. Net Wrap or Twine? Accessed online 1 May 2013 and available online at: http://www.omafra.gov.on.ca/english/crops/field/news/croptalk/2006/ct_0906a7.htm

Recycling Council of Alberta. 2009. *Agricultural Plastics Recycling Pilot Project* – Summary Report. Accessed June 25, 2013 and available online at: http://www.recycle.ab.ca/reports

Statistics Canada. 2012. 2011 Census of Agriculture, CANISM table 004-0005. Accessed 28 June 2013 and available online at: http://www5.statcan.gc.ca/cansim/a26

Statistics Canada. 2012. Table 2.7 Farms, by farm type and by province, 2011. Accessed 28 June 2013 and available online at: http://www.statcan.gc.ca/pub/11-402-x/2012000/chap/ag/tbl/tbl07-eng.htm

ULINE Shipping Supply Specialists website. 2013. 2.5 Gallon F-Style Jugs - Natural. Accessed June 22 and available online at: http://www.uline.ca/Product/Detail/S-12759/Jars-Jugs-and-Bottles/2-1-2-Gallon-F-Style-Jugs-Natural