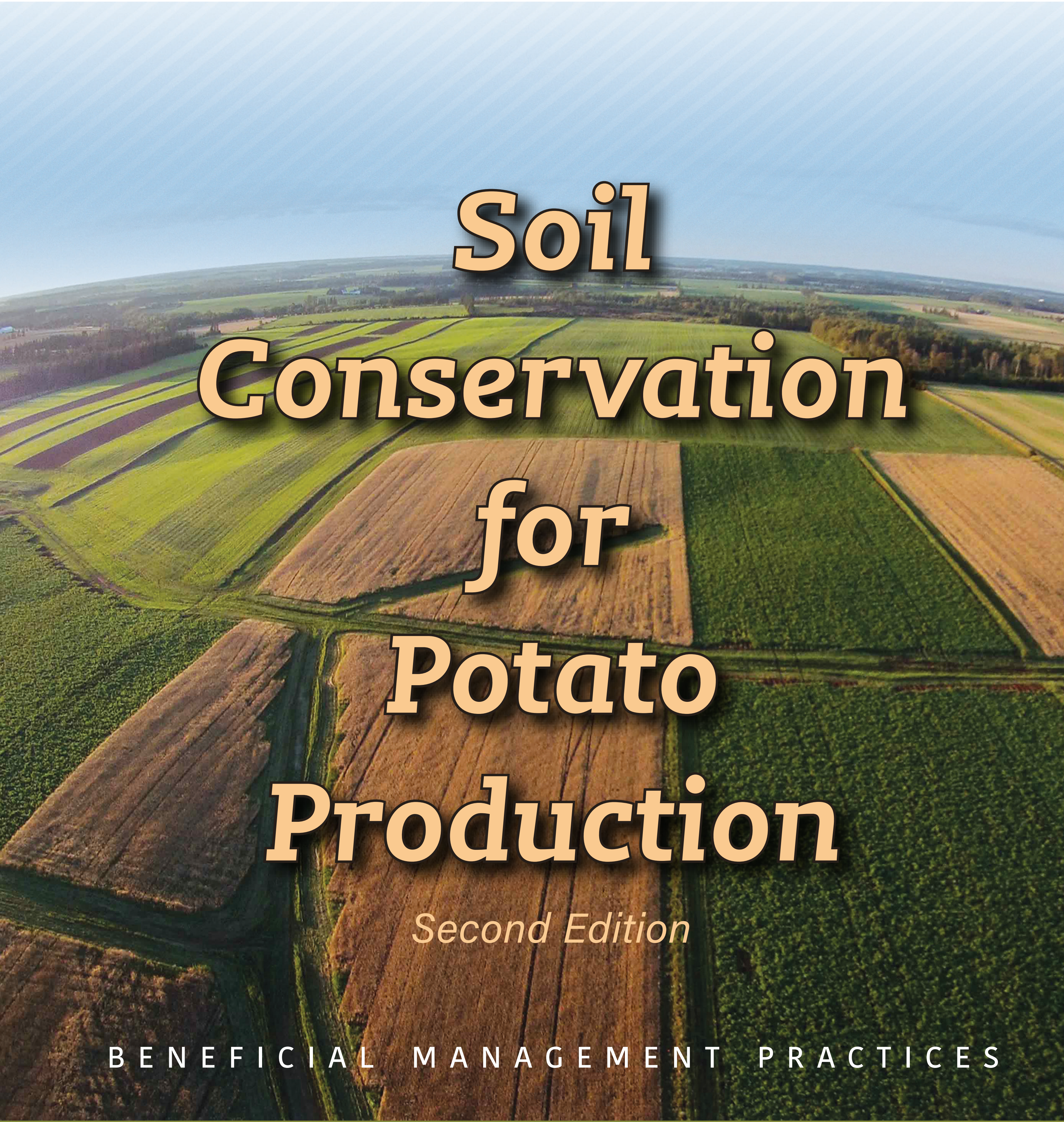

Soil Conservation for Potato Production

Second Edition

BENEFICIAL MANAGEMENT PRACTICES

Prince Edward Island
CANADA

Agriculture & Land

Environment, Energy
& Climate Action

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2021/04/09

Soil Conservation for Potato Production

The success of agriculture on Prince Edward Island hinges on the top few centimeters of its soil. Conserving and building this resource is particularly challenging for those engaged in potato production. With the pressures of climate change and the province's naturally erodible soils, resources valuable to plant production: soil particles, organic matter, plant nutrients, and pesticides, can be transported off the field when runoff occurs. These sediments can get deposited in downstream locations where they have the potential to degrade the local environment.

This practical guide has been prepared to help farmers avoid causing long-term damage to the soils they cultivate and to assist them in reducing conflicts with other natural resource users.

Enhanced Environmental Farm Plans

This publication updates a document originally designed to be used as a technical reference for completing an Environmental Farm Plan (EFP). The EFP process was developed by farmers under the leadership of the Atlantic Farmers Council. It is a tool to help farmers develop a plan for operating their farms in an environmentally sustainable, socially acceptable and economically viable way. The planning process begins with an individual farm review under each of the following categories:

- soil and site characteristics
- farmstead and homestead
- livestock and poultry
- soil and crop management
- sensitive ecological areas.

Potato field in bloom.

(Photo: Ryan Barrett PEI Potato Board)

In 2012, the EFP program was streamlined through new and improved computer software. As a result of this change, the EFP now includes more detailed GIS mapping of fields, properties, buffer zones, and infrastructure.

A key element of the enhanced EFP process is the development of an action plan, through which farmers prioritize areas of concern, analyze their individual situation and decide what can be done and when. The EFP Planning Officer guides participants through the process and offers advice on where to access technical support to execute the action plan.

Participation in the program ensures eligibility for federal/provincial programs such as the Canadian Agricultural Partnership, Farmland Finance Program and Future Farmer Program. All plans are valid for five years, and participation in the program is free for producers. For more information on the Enhanced Environmental Farm Plan process, visit the **PEI Federation of Agriculture** website or contact an EFP Planning Officer at 902-368-7289.

PEI ENHANCED ENVIRONMENTAL FARM PLAN

Integrated approach to soil conservation

Cost-effective soil conservation requires a practical integrated approach to soil management. Any single conservation practice can decrease erosion rates. However, by integrating a number of soil conservation practices through a well-established farm plan, a least-cost solution can be implemented. The answer to any soil degradation problem will vary from farm to farm and from field to field. The challenge for potato farmers is selecting the most beneficial management practices to sustain the farm's long-term viability, from both productivity and economic perspectives. This agroecosystem approach will also address many off-farm environmental quality concerns.

An integrated erosion control system.

(Photo: PEI Department of Agriculture & Land)

Technical support for soil conservation

The PEI Department of Agriculture and Land's Sustainable Agriculture Section offers engineering support to landowners wishing to install soil conservation structures on their properties, along with integrating agronomic practices such as crop rotation, winter cover cropping, reduced tillage or residue management. Funding is available for approved land management systems through the **Agriculture Stewardship Program** under the Canadian Agricultural Partnership (CAP).

ALUS program

> *Beneficial management practices integrate principles of production, business goals, sustainability, and environmental quality in farm resource management systems*

Cropland that is removed from crop production for ecological reasons can be enrolled in the PEI Alternative Land Use Services (ALUS) program. Such reasons include:

- to expand the buffer zone
- to retire high slope land
- to establish permanent grassed headlands
- to establish soil conservation structures

For a complete list of services eligible for funding, visit the **ALUS program** website.

Understanding the Basics

The soils of Prince Edward Island are relatively shallow, acidic, naturally low in organic matter, and highly erodible. They require careful nurturing to provide their optimum economic and social return to PEI.[1]

Important soil properties

The four major components of a mineral soil are: air, water, mineral matter and organic matter. The approximate proportion by volume of each constituent is illustrated in Figure 1.

Mineral matter

The largest part of a mineral soil by volume is mineral material. Mineral material is classified by size; i.e., sand, silt and clay. Soil texture or particle size distribution refers to the proportion of sand (2.0-0.05 mm), silt (0.05 – 0.002mm) and clay (less than 0.002mm)[2] particles that make up the mineral component of a particular soil.

Sand, sandy loam, clay loam, clay, etc., all describe soil texture. The agricultural soil types on PEI are loams to fine sandy loams. They are high in silt and fine sand but low in clay.

Air and water

The amount of air and water space in the soil is referred to as the soil porosity. Two things affect porosity: soil texture and soil structure. A well-structured soil generally has good porosity. Ideally, the soil should contain even amounts of air and water space.

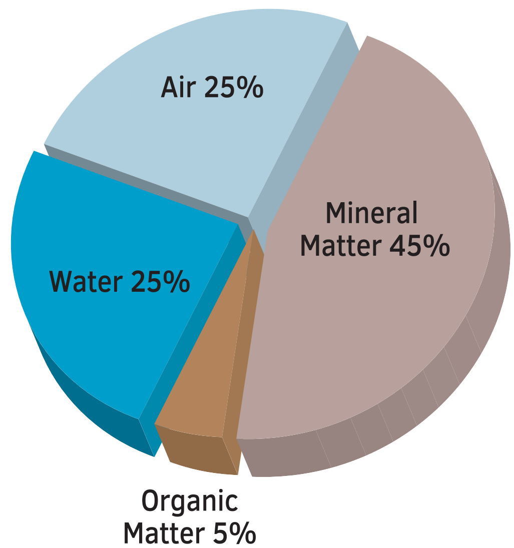


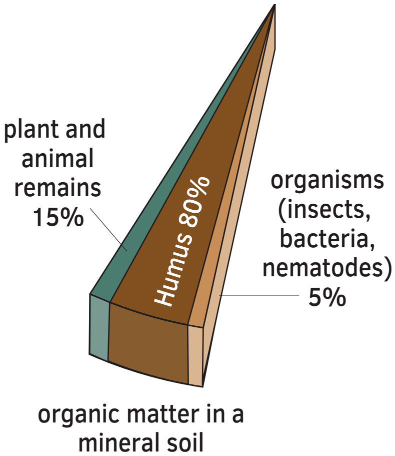
Fig 1: Major components of a mineral soil.

(adapted from Selker & Or[3])

Particle Size Distribution of Some PEI Potato Soils[2]

Soil Type	Clay	Silt	Fine Sand	Total Sand
O'Leary	16	33	25	51
Charlottetown	10	27	27	63
Culloden	5	10	27	85

1. Whiteside, G.B., Soil Survey of Prince Edward Island, Canada Department of Agriculture, PEI Department of Agriculture. Queen's Printer. 1966.
2. J.I. MacDougall, C. Veer, F. Wilson, *Soils of Prince Edward Island.* Land Resource Research Centre Contribution No. 83-54, Research Branch Agriculture Canada 1988, P.191.
3. Soil Hydrology and Biophysics, John Selker, Dani Or. Creative Commons Attribution-Non Commercial 4.0 Share-Alike International Licence.



Distribution of soil organic matter constituents in a mineral soil.

Organic matter

Organic matter is that fraction of the soil composed of anything that once lived. It accounts for less than 5% of topsoil. Organic matter improves soil structure and increases the soil's ability to hold water. Humus is a relatively stable organic component making up about 80% of all soil organic matter. It improves soil structure by helping the soil store water and nutrients and reduce erosion. Humus also makes the soil easier to work and attractive to soil life. Because humus does break down eventually, soil organic matter must be continually replaced by adding plant residue or organic waste products such as manure.

Plant and animal remains, which decompose quickly, make up another 15% of soil organic matter. Soil life such as earthworms, insects, bacteria and nematodes make up the remaining 5%.

The amount of organic matter in the soil is affected by management practices. Excessive tillage and poor crop rotations speed up the loss of organic matter. Crop residues and manure addition, combined with good crop rotations and reduced tillage, help maintain or improve organic matter levels. The nutrient balance improves as the organic matter level increases as does yield potential. Improved soil structure also increases porosity and helps soils resist compaction.

Soil pH

Soil pH refers to the level of acidity in the soil. A pH of 7 is considered to be neutral. Soils with pH numbers above 7 are alkaline, while those with pH numbers below 7 are acidic. In other words, the lower the number, the more acidic the soil. Soil pH influences nutrient availability as well as microorganism and disease organism activity in the soil.

Various sized soil seives used in particle size analysis of a soil sample.

(Photo: Flikr-Government of PEI)

Cation exchange capacity

The cation exchange capacity is a measure of the ability of the soil to hold certain nutrients. It plays a role in soil fertility. Cations are positively-charged elements such as potassium, calcium, magnesium and hydrogen. They are held on the negatively-charged surfaces of organic matter and clay particles in the soil. There is a constant exchange of cations between the soil particles and the soil water. The cations held on soil particles act as a nutrient resource, constantly re-supplying the soil solution with needed nutrients. High cation exchange capacity increases soil fertility and resilience.

Soil structure

Soil structure refers to how various soil particles (sand, silt and clay) are arranged together in larger clumps by binding substances such as minerals and decayed organic matter. These clumps are known as ***soil aggregates***.
A well-structured soil has high aggregate stability, meaning aggregates stay together when wet, resisting breakdown by wind and water, thus reducing erosion and crusting.

The ***permeability*** of a soil refers to the rate at which water can pass through it. A soil with good structure has good permeability and, therefore, good internal drainage. A highly permeable soil has less erosion potential than soils with a low permeability.

Good soil structure and high aggregate stability also increase the ability of soils to resist compaction. ***Compaction*** is a reduction in soil porosity caused by excessive tillage and wheel traffic of heavy field equipment, especially on wet fields. Compaction restricts water infiltration, air movement in the soil and root growth, thereby reducing soil productivity and yields. Reducing soil compaction and improving of soil structure is a long-term rehabilitation process.

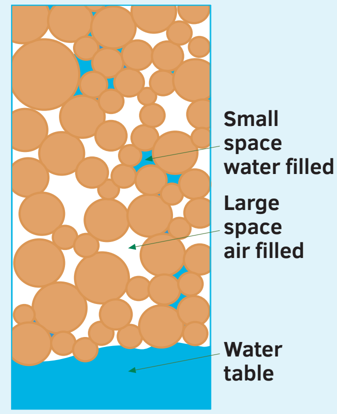
In potato production, compaction can result in:

- degradation of soil structure
- more misshapen tubers
- reduced crop vigor and inconsistent yields
- reduced rooting depth
- higher susceptibility to drought conditions

Nature of PEI soils

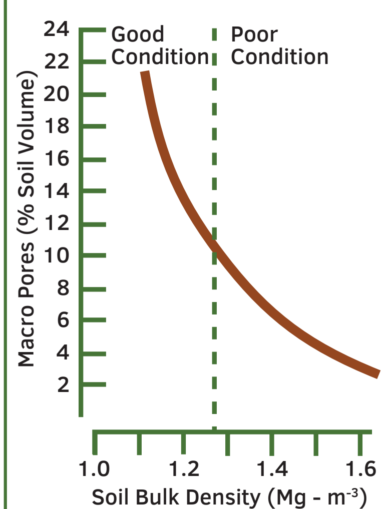
With their comparatively uniform drainage patterns and stone-free upper layers, PEI's main agricultural soil types have a major advantage over many in the Maritime region. These soils are well suited to most crops grown in the region. There are, however, some major limitations to these soil types; e.g., low natural fertility, medium to low natural organic matter levels and restricted rooting depths due to a naturally occurring compacted zone in the subsoil.[7]

Soil Structure



A well-structured soil with loose, blocky structure. Large air-filled spaces (macropores) should occupy 12% of soil volume.

Soil Compaction



Increasing soil compaction reduces the volume of large air-filled macropores in Island soils.

7. J.I. MacDougall, C. Veer, F. Wilson, *Soils of Prince Edward Island.* Land Resource Research Centre Contribution No. 83-54, Research Branch Agriculture Canada 1988, Pp.35,43.

Organic Matter in PEI Soils

Organic Matter Level %	Biological Activity %[a]	Soil Structure %[b]	Relative Erosion Potential[c]
1	60	10	100
2	70	30	89
3	85	55	78
4	100	100	65

a. Microbial biomass index.
b. Wet sieving index.
c. Taken from determination of the K factor in the Universal Soil Loss Equation.

Most of PEI's agricultural soils currently have organic matter contents of 2-3%. Long- term Department of Agriculture and Land monitoring indicates soil organic matter levels have shown a general decline from the beginning of the monitoring program in 1998 through to 2015, but have remained relatively unchanged from 2015 to 2018.[8]

Soils that contain a high percentage of very fine sand and silt size particles erode more easily than those with either high clay or coarser sand content.

Prince Edward Island soils, with deep water tables and adequate to rapid permeability, are considered well-drained to excessively well-drained. Excessively well-drained soils are more common in the southeastern part of the province. Most Island soils have low subsoil permeability, yet they are still considered well-drained to moderately well-drained because they seldom remain saturated for long periods during the summer. In these soils, adequate drainage results from excess water draining downslope, moving sideways through the entire depth of the upper layer of soil. At lower ends of fields, it may seep into streams and rivers or saturate lowlands.

Due to the long-term effects of climate and vegetation, Prince Edward Island soils are strongly acidic.

Climate change impacts

Soil conservation requirements are closely linked to climate. Climate change will increase the variability of PEI's weather patterns, resulting in more extreme events, and longer periods of drought. These conditions will create new challenges for soil conservation.

Changing rainfall patterns

PEI's annual precipitation is expected to decrease in the medium term. Precipitation events will occur less frequently but each will be more intense. The risk of soil erosion is greatest when these high intensity rainfall events occur on fields with little residue or crop cover to protect the soil.

8. Nyiraneza, Judith & Thompson, Barry & geng, Xiaoyuan & He, Juanxia & Fillmore, Sherry, A. E. & Stiles, Kyra. (2017). *Changes in soil organic matter over 18 years in Prince Edward Island, Canada.* Canadian Journal of Soil Science. 97. 10.1139/CJSS-2017-0033.

Freeze-thaw cycles

Freeze-thaw cycles are expected to increase in the short term but will decline over the longer term as winter temperatures rise. These cycles put Island soils at a high risk of erosion. Subtropical air currents can produce rapid temperature changes of 25 degrees Celsius or more in January and February, causing exposed surface soil particles to potentially thaw while lower layers remain frozen. The risk of topsoil being washed away is most critical when the top 20 to 50 mm of soil has thawed and rapid snowmelt leading to heavy runoff occurs. Even soils with normally good permeability can experience high runoff rates when the subsoil remains frozen.

Potatoes must be harvested when mature to ensure a high quality, marketable product. Late maturing varieties still account for a significant portion of the Prince Edward Island potato crop, leaving little time after harvest to establish a cover crop. To reduce the risk of erosion over the winter, alternative erosion control measures must be considered for fields harvested too late to grow cover crops

Effect of wind on soil erosion

PEI's weather can also be relatively windy. Bare soils are at risk to wind erosion in areas with little hedgerow or forest protection.

With climate change, extreme precipitation events are expected to increase.

(Photo: Don Jardine, UPEI Climate Lab)

Topography

The PEI landscape can be described as gently rolling. A hilly area through the central part of the province contains the highest point of land at 135 metres above sea level. However, with about 75% of the land surface less than 45 metres above sea level, most of the province is gently rolling rather than hilly. Despite this topography, soil erosion can still be a problem. Long gentle slopes can allow a high volume of water to accumulate, resulting in greater erosion potential.

Slope Length and Steepness Combination Resulting in Equivalent Erosion Potential[a]

Degree of	Slope Length	
Slope %	**Metres**	**(Feet)**
8	25	(83)
6	55	(180)
5	95	(310)
4	240	(790)

a. Taken from determination of the I.S. factor in the Universal Soil Loss Equation.

All fields have a natural erosion potential based on climatic conditions, soil type and topography. The table shows combinations of slope length and steepness conditions with similar erosion potentials. Using the Charlottetown soil type as an example, any field with slope lengths and steepness conditions greater than any of the combinations in the table is highly erodible. Such fields must be very well managed if erosion levels are to be kept within tolerable limits. Due to the difficulty in controlling runoff on steep land, row crop (e.g., potatoes, turnips, and carrots) production is not permitted where the slope exceeds 9% unless farmed with a high-slope management plan as per the regulations of the ***Environmental Protection Act*** (R.S.P.E.I. 1988, Cap.E-9).

Rolling topography typical of PEI's central region.

(Photo: Flikr-Government of PEI)

Land tenure

Much of the Island's farmland is divided into long, narrow properties. Early in its history, farms were generally laid out in the Acadian and Quebec fashion. Each property had a small frontage on shoreline, stream bank or road and extended well back to provide the acreage. Land was deeded in this pattern which can still be seen today. As a result, simple soil conservation practices such as cross-slope cultivation, strip cropping and terracing are difficult to implement on individual farms without field consolidation. Watershed drainage patterns do not respect property boundaries, therefore co-operation among neighbours is often required.

To practice good crop rotation, farmers need a sufficient land base to produce the necessary volume of marketable potatoes to meet their financial obligations. Leasing land for potato production is common on PEI. Producers often have less incentive to adopt soil conserving practices on rented land because there may be no long-term commitment involved. In a recent opinion poll on implementing beneficial management practices, rented land was cited as one of the highest barriers to installing permanent soil conservation measures in a field.[9]

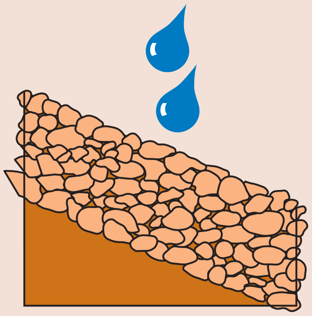
An artifact of PEI's traditional tenure system: long narrow properties bordering a waterbody.

(Photo: Flikr-Government of PEI)

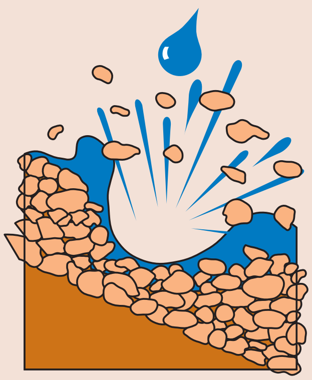
9. **BMP Grower Consultation Survey Summary, Agri-Watershed Partnership, April 2020.**

Soil Erosion

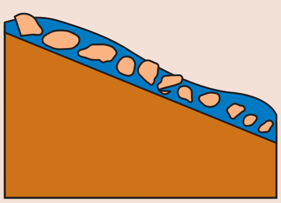
Processes associated with soil erosion by water



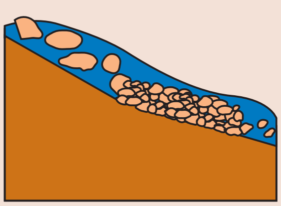
a) raindrop impact



b) detachment



c) transport



d) deposition

Soil erosion has been identified as the number one environmental problem on PEI.[10]

Soil erosion is defined by three major physical processes: detachment, transport and deposition. When an external force (usually wind or raindrops) hits unprotected soil, its aggregates break apart and the aggregate material disperses. The constituents of these aggregates – organic matter, the finer mineral particles and the nutrients bound to them and any other product adsorbed to the soil particles – will be carried by the transport medium (wind or rainwater) and eventually deposited at another location. PEI soils have naturally poor aggregate stability and are highly vulnerable to aggregate fragmentation from these external forces.

Erosion by water

Soil erosion by water is the most significant form of erosion on the Island, mainly due to the intensity of rain received and the sloping terrain being farmed. Also, PEI's soils have naturally low organic matter levels, a subsoil with poor structure and a compacted layer or pan that reduces infiltration. The freeze-thaw cycle during winter also makes bare soils more susceptible to erosion by water.

a) precipitation event
b) impact of raindrops breaks apart soil aggregates
c) transport medium carries the dispersed fine particles downslope
d) fine particles are deposited when the carrying capacity of the transport medium is decreased.

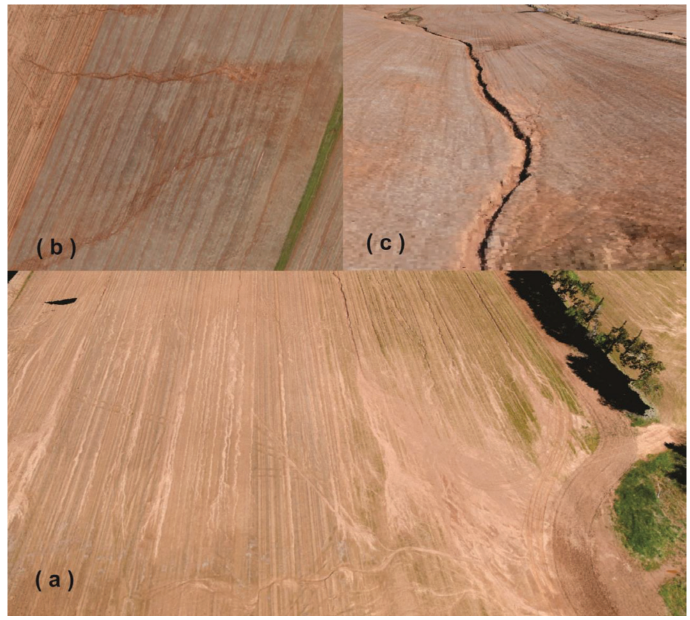
10. *Stewardship & Sustainability A Renewed Conservation Strategy for Prince Edward Island.*

Soil erosion by water can be divided into sheet, rill, and gully erosion:

Sheet erosion, which occurs uniformly over an area of land, is difficult to detect in the field yet the soil loss can be very large. A 1 mm (0.04") thickness of soil loss over 1 hectare (2.47 acres) amounts to 16 tonnes (17.6 tons). Soil conservation measures capture sheet erosion in a controlled manner before rills and gullies form.

Rill erosion occurs when flow is concentrated and small channels are formed. If uncontrolled, rills can form larger channels, called gullies. Potato drills can cause rill and gully erosion to form more quickly by providing a channelized flow path between the rows, especially during intense rainfall events in the cropping season. Although the shallow 25-150 mm (1-6") channels formed by runoff water do not hinder operation of farm equipment, rill erosion is Prince Edward Island's most significant form of soil loss.

Gully erosion is the most visible form of erosion in fields, caused when rill erosion channels concentrate. With gullies, large amounts of soil are removed from relatively small areas of the field. This type of erosion generally occurs in areas where water collects in natural surface depressions. Ephemeral or short-lived gullies form higher in the slope and can be worked out by tillage equipment. Ephemeral gullies combine to form a gully. Gullies can be anywhere from 15 cm (6") to over 2 m (6.5 ft) deep and several metres wide. They may extend to the depth of the bedrock.



Types of erosion by water found on PEI. (a) rill erosion with large area of deposition, bottom right. (b) some rill erosion transitioning into ephemeral gully erosion. (c) gully erosion.

(Photo: PEI Department of Agriculture & Land)

Erosion by wind

Soil erosion by wind occurs when the soil is dry and recently loosened by cultivation or during the winter when the frozen ground is exposed to the wind due to lack of snow or vegetative cover. Although wind erosion is difficult to measure, its effect is apparent in the winter as soil deposits are visible in the snow.

Erosion by tillage

Tillage erosion occurs when any implement that throws soil is operated. When used on hillslopes, the tillage implement and gravity work together to move soil downwards. Over time, this activity causes a gradual downhill shift of topsoil. Eventually, considerable subsoil can be exposed on hilltops and upper slopes.

Wind erosion during winter months.

(Photo: PEI Department of Agriculture & Land)

The Challenge

Potato production involves significant soil disturbance. Tillage-intensive field preparation, insufficient biological activity, lack of crop diversity and harvesting operations can have an adverse effect on soil structure, causing soil compaction problems and resulting in reduced water infiltration rates and high erosion.

Technological advances have greatly increased the accuracy of soil erosion prediction. Computer models such as the RUSLE (Revised Universal Soil Loss Equation), enhanced Geographical Information Systems, Global Positioning System (GPS) and the use of drones have helped many Island potato farmers assess the full scope of erosion on their land.

Erosion as an indicator of soil health

Adverse weather events, such as intense rainfall and high wind, are the main causes of soil erosion in agricultural settings. As long as there is weather, there is potential for soil to move away from the field. Excess soil erosion, one of many symptoms of poor soil health, further depletes the soil resource, creating a positive feedback loop, with subsequent erosion events occurring at a faster rate. By focusing on soil building principles – e.g., cover cropping, increased crop residue, higher crop diversity, and reduced tillage – excessive erosion can be curbed. With increased root residue and cover cropping, the soil is more effectively held in place by roots, greatly reducing the potential for an erosion event. The residue is eventually decomposed, leading to an increase in soil organic matter (SOM) which, combined with a higher diversity of root exudates, allows the soil to bind together more effectively; this binding process is called aggregation. Healthy soil has a high number of stable aggregates which protect at-risk soil particles from all forms of erosion.

Healthy soils support a variety of crops.

(Photo: Ryan Barrett, PEI Potato Board)

PEI Soil Health Test

The PEI Soil Health Test can help producers assess the health of their soil. It can increase understanding of the limitations and stressors on the soil resource and provide producers with information to assist them in adapting their management practices to address any identified deficiencies. Soil health testing is offered by the **PEI Analytical Laboratories**.

Aggregate stability test - one of the several soil health indicator tests conducted at the PEI Analytical Laboratories. After being subjected to a rainfall simulator, the soil in the left sieve retained only 20% of its soil aggregates. The healthier soil in the right sieve retained 63% of its aggregates, indicating greater aggregate stability. Greater aggregate stability increases a soils resistance to breakdown during stress, such as an extreme precipitation event.

(PEI Department of Agriculture & Land, PEI Soil Health Test - ***How to Interpret Your Results***.)

On-farm impacts of soil loss

Healthy soil is one of our most valuable natural capital assets. Soil health can greatly impact a crop's productivity. Climate change is producing more unpredictable weather patterns, resulting in greater yield variability. Healthy soils with high organic matter and microbiological activity are more resilient to disease and experience less year-to-year variability due to shifting climate conditions.

In order to continue to provide nutritious food in a sustainable manner, more focus needs to be put on conserving and replenishing current soil systems so they can weather a wider range of climate events. From a global viewpoint, supporting soil building techniques can also alleviate pressure from food insecure regions by strengthening soil resiliency and, in turn, empowering local producers.

Due to its key role in the carbon cycle, healthy soil continues to play a vital role in combatting and adapting to climate change. Not only is soil organic carbon (SOC) the backbone of healthy soils, it is also an important carbon sink. Soil carbon is very stable and can stay sequestered for centuries, allowing greenhouse gases (CO_2) to be taken up by plants, and eventually introduced into the SOC fraction through microbial decomposition. As global policies attempt to shift towards carbon neutral industries, there may be additional financial imperatives to consider in the future.

At the farm level, the topsoil is the most important resource for a potato producer. Beneficial management practices that reduce erosion are part of a broader integrated soil management system that improves overall soil health. Such practices benefit potato production in a variety of ways; e.g., improved drainage, improved moisture holding capacity, enhanced pest management, improved crop yield and quality and, ultimately, long-term profitability.

Approx. 50 tons of topsoil lost on this 1 acre x 1 acre section of cropland due to rill and gully erosion.

(Photo: PEI Department of Agriculture & Land)

Costs associated with soil loss

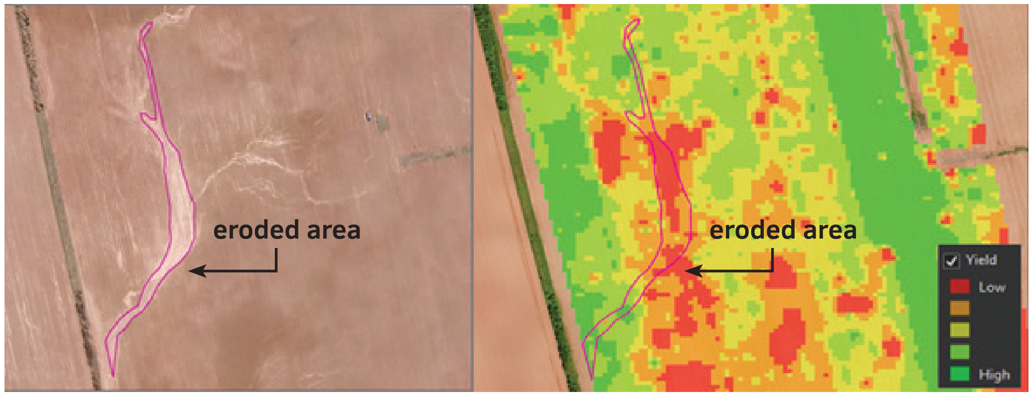
Studies have found that the soil resource represents about 30% of the total farm assets.[11] Soil loss by erosion results in a direct economic loss because it removes the most productive surface layer of soil and leaves the less productive layers exposed.

Fine particles and organic matter are the first to be lost through erosion. Because they are lighter, fine particles are more readily detached from the soil surface by rain, more easily transported by runoff, and more likely to be blown away by strong winds in the absence of snow cover or cover crops. Fine soil particles are important for their role in cation exchange and providing nutrients to crops. The removal of the finer soil particles and organic matter can reduce aggregate stability and weaken the remaining structure of the soil. Much of a soil's inherent resilience and function can be compromised by the erosion process.

Research conducted in 1996 on three agricultural sub-watersheds of PEI's Wilmot River revealed that, on average, nutrients worth \$3.42 (estimated to be \$6.67 in 2020 dollars[12]) were lost for every tonne of soil loss. In 1998, research using GPS yield monitoring technology indicated that potato yields can decrease by as much as 50% on highly-eroded areas of a field relative to non-eroded areas in the same

11. *Crop Rotation in Atlantic Canada Potato Production Systems*, Eastern Canada Soil & Water Conservation Centre, 1993.
12. Farm input price index, Quarterly -Table: 18-10-0258-01, *Geography*: PEI 2002-2020, Statistics Canada, Consumer Price Index, annual average, *Geography*: PEI, Table: 18-10-0005-01, 1996-2002, Statistics Canada.

field.[13] More recent studies using drones and GPS have further demonstrated the effect of eroded areas on yield.



Recent investigations into the costs associated with soil erosion using drone and GPS Yield monitor.

(Evan MacDonald, PEIDAL, New Tools in Soil Conservation, 2019 PEIIA Agronomy Conference- Building Resiliency in a Changing Agriculture Industry)

Organic matter loss

Organic matter, which is concentrated in the top few centimeters of topsoil, plays a major role in the soil's ability to hold moisture. When topsoil is eroded, the moisture holding capacity of the remaining soil is reduced. This diminished capacity is particularly troubling for potato producers due to the increasing frequency and length of dry periods during the summer growing season. The subsoil also has less organic matter and fewer available nutrients which means that larger amounts of fertilizer are needed to improve fertility. Soils are harder to manage because of poor structure due to low levels of organic matter. These situations can only be improved slowly, over time, with careful management and sometimes at considerable cost.

Natural vs. agricultural-induced erosion rates

The erosion of soil by water is a naturally occurring process. As rainfall strikes the soil surface, aggregates are degraded and soil particles make their way overland to streams, lakes, and eventually to the ocean. Under most undisturbed natural conditions, the rate of soil loss or erosion is lower than that at which new soil is formed.

Removal of natural vegetation, as happens with row crop production, changes the rate of soil loss due to:

- reduced protection of soil from the impact of rainfall
- reduced rate of water infiltration meaning that that more water must flow over the soil surface
- reduced root mass holding the soil in place diminishing resistance to the eroding action of flowing water

In dense grass-covered fields, such as a well-cultivated cover crop, the rate of soil loss may actually be less than under natural forested conditions due to a dense root zone holding the soil in place. Natural conditions, however, have more root diversity in the soil. In addition to holding soil in place, a diverse grouping of root profiles allows the

13. K.R DeHaan, G.T Vessey, D.A Holmstrom, J.A MacLeod, J.B Sanderson, M.R Carter, *Relating potato yield to the level of soil degradation using a bulk yield monitor and differential global positioning systems*, Computers and Electronics in Agriculture, Volume 23, Issue 2, 1999, Pages 133-143, ISSN 0168-1699.

soil to be "naturally tilled" over time, by each root type, reducing compaction and increasing biological activity. The roots of each plant also have their own cocktail of exudates which contribute to, among other things, the formation of aggregates. By supporting crop and microbial diversity, growers can protect their investment from erosion while building a healthier soil.

Modern agricultural strategies such as intensive tillage, biocidal pest management and heavy monoculture, also negatively affect the soil's microbial biodiversity. A diverse and active microbiological community is vital in supporting nutrient cycling, aggregate stability, and over all crop productivity in an agricultural setting. Any long-term management practice is obsolete without consideration for healthy soil microbiota.

Present erosion rates vs. regeneration rates

Soil erosion and soil formation occur at the same time. Research has indicated that in temperate regions, such as Prince Edward Island, it can take 300 to 500 years for 2.5 cm (1 in.) of soil to form under natural conditions. In order to maintain long-term agricultural productivity, the erosion rate should not be greater than the soil formation rate. This is called the tolerable soil loss rate. In Atlantic Canada, the tolerable soil loss rate is 7 tonnes/ha/year (3 tons/acre/year).[14]

A field losing 4 mm (0.16") of soil by sheet erosion loses a total of 50 tonnes/ha (22 tons/acre). This loss over a period of one year may not appear to be a serious problem; however, when projected over a period of 40 years, 16 cm (6") of topsoil would be lost.

Field trafficability and drainage

Operating machinery in a field becomes difficult when severe rainstorms cause rill and gully erosion. Money, time and effort are required to repair the damage and improve trafficability in the field; however, even when this is done, the loss of topsoil will continue to negatively impact productivity.

When soil particles are detached, carried by runoff and deposited at lower elevations, they are sorted by the movement of the water. Therefore, deposited sediments at the bottom of a field tend to be uniform in size rather than the range

14. Wall,G.J., D.R. Coote, E.A. Pringle and I.J. Shelton (editors). 2002. RUSLEFAC — *Revised Universal Soil Loss Equation for Application in Canada: A Handbook for Estimating Soil Loss from Water Erosion in Canada.* Page 5, Executive Summary. Research Branch, Agriculture and Agri-Food Canada. Ottawa. Contribution No. AAFC/AAC2244E.

of sizes found in their natural state. These similar-sized soil particles lock together, impeding the natural drainage of surface water. Lower ends of eroded slopes frequently exhibit surface drainage problems.

Summary of on-farm impacts of soil erosion:

- reduced depth of the topsoil layer, especially on knolls
- reduced organic matter levels
- reduced soil fertility
- loss of costly inputs such as fertilizers and pesticides
- reduced water holding capacity
- poor drainage in areas of silt deposition
- reduced ability to work fields due to gullies
- reduced long term viability

Off-farm Impacts of soil erosion

Whether the source be agriculture, highway construction or land development, keeping sediment out of Island watercourses has become a top priority for all stakeholders. In an era where consumers place a high premium on sustainably produced products, the importance of reducing the impacts from runoff on nearby watercourses and wetlands cannot be overstated.

Fish and wildlife are important to the Prince Edward Island environment and their abundance also contributes to the Island economy through tourism, sportfishing, hunting and trapping. Sedimentation of watercourses impacts aquatic health causing habitat destruction, increased water temperatures, poor water quality, diminished diversity of wildlife and overall poor environmental health. Excess sediments in wetlands negates their important ecosystem function of purifying water, acting as carbon sink, stabilizing river/coastal habitats and linking groundwater and surface water in the hydrological cycle.

Siltation affects recreational fisheries on the upper reaches of the North River.

(Photo: PEI Department of Agriculture & Land)

Further downstream, PEI's coastal estuaries, often referred to as nurseries of the sea, are some of the most productive shellfish grounds in North America. Siltation reduces the recreational and commercial viability of shellfish populations in these coastal zones. Sedimentation has caused estuaries to become shallower, warmer and more prone to detrimental algae growth, resulting in diminished saltmarsh and eelgrass habitats which, in turn, impacts the ecological health and climate change resiliency of these habitats.

The destination of eroded soil and all the materials removed by the erosion process are key concerns for farmers. Deposition within the field boundary can create several on-site issues. Off-site deposition in an aquatic ecosystem can have wide-ranging impacts as contaminants adsorbed to soil particles can profoundly affect fish populations at all life stages.

Summary of off-farm impacts of soil erosion:

- harmful effects on fish and wildlife habitats
- buried shellfish beds
- reduction in coastal water depth for aquaculture, navigation and recreation
- acute mortality of freshwater biota from soil-bound contaminants migrating to stream
- die-off of aquatic organisms due to low-oxygen condition (anoxic events) in estuaries caused by algae growth from nutrient over-enrichment
- reduced drainage in ditches and culverts and sedimentation on public and private properties.

PEI freshwater fish

Groundwater-fed springs provide our Island's waterways with the cool water necessary for native brook trout and Atlantic salmon as well as rainbow trout, a species introduced to the Island in the 1900s.

Brook trout are found in almost all waterways in the province. In the fall season these fish seek spring-fed areas (groundwater upwellings) to lay eggs, as the water temperature remains consistently at 7-8ºC all year round. As they grow, some will travel to saltwater to feed before returning to freshwater to spawn. These "sea-run" trout are a favorite for Island anglers.

Atlantic salmon spend the first two years of their life in freshwater before travelling to the ocean and as far away as Greenland to feed and grow. They then migrate back to the stream in which they were born to spawn. Canada's Committee on the Status of Endangered Wildlife lists Atlantic salmon as a species of concern and cites freshwater habitat destruction as being a contributing factor.

Photo: Flikr-Government of PEI)

Watershed groups on PEI

There are 24 community-based watershed groups on the Island. These grassroots organizations improve and protect PEI's environment by engaging local stakeholders (farmers, landowners, industry, communities) in finding solutions to local environmental problems. They practice watershed management by looking at the impacts on land, water and biological communities and recognizing that stressors can be multi-scale and cumulative. Visit the **PEI Watershed Alliance website** for more information.

Working together to find solutions:

Watershed groups devote significant resources to stream rehabilitation efforts focused on addressing the impacts of sedimentation. While these efforts help localized habitat and wildlife, improvements can quickly be negated if significant sediment continues to enter the watercourse. When stakeholders from both the uplands and riparian zones collaborate on an issue, longer term solutions can be found.

Stream rehabilitation work. (Photo: PEI Watershed Alliance)

Assessing Soil Conservation Management strategies

Soils Conservation Strategy Based on Risk of Erosion

Risk	Strategies
Low	**Crop Rotation**
Moderate	**Conservation tillage** **Residue management** **Spring primary tillage** **Cover cropping** **Cross slope farming**
High	**Conservation structures** **Terraces** **Grassed waterways** **Farmable berms** **Hedgerows**

A soil conservation strategy must be based on a knowledge of the risk of erosion on a particular field. Fields at low risk for runoff can often be managed with agronomic measures only and still achieve sustainable soil loss rates. As the risk of runoff increases, more intensive conservation measures may be required. Integrating a number of beneficial management practices is the most cost-effective approach to addressing risk of runoff. High risk fields require strategies that build on low and moderate risk strategies.

When making decisions on land management strategies for any particular field, a producer has many considerations. Cost, land tenure, rotation, soil loss goals, and risk are all important factors. Choosing an appropriate soil conservation strategy requires an accurate calculation of the soil loss on the field and how implementing various measures will affect that soil loss.

There are many easy-to-use soil prediction models available today. One that is widely used, and is the model of choice for PEI soil conservationists, is the RUSLE model. The **R**evised **U**niversal **S**oil **L**oss **E**quation has been in use, in one form or another, for more than 50 years and has been used in soil conservation system design on PEI since the 1970s.

The RUSLE model relies on local soil and climate data to produce an accurate estimate of soil loss in a particular field. While easy to use, it models complex relationships between crop growth, soil cover, above and below-ground biomass, soil properties, climate, and topography.

Using erosion prediction models like RUSLE allows the producer or conservationist to enter various soil management strategies and instantly see the response in soil loss on the field being analyzed. Often several measures can be integrated into a single plan for a least-cost solution.

When reviewing options with a farmer for soil conservation in a particular field, a soil and water engineer or soil conservationist, will use the RUSLE model to determine what options, used alone or in combination, will give the desired soil loss rate.

Factors for RUSLE model

The RUSLE model is an equation represented by the factors:

A = RKLSCP where:

A is the soil loss predicted, sustainable soil loss is 7 tonnes/ha/year (3 tons/acre/year)

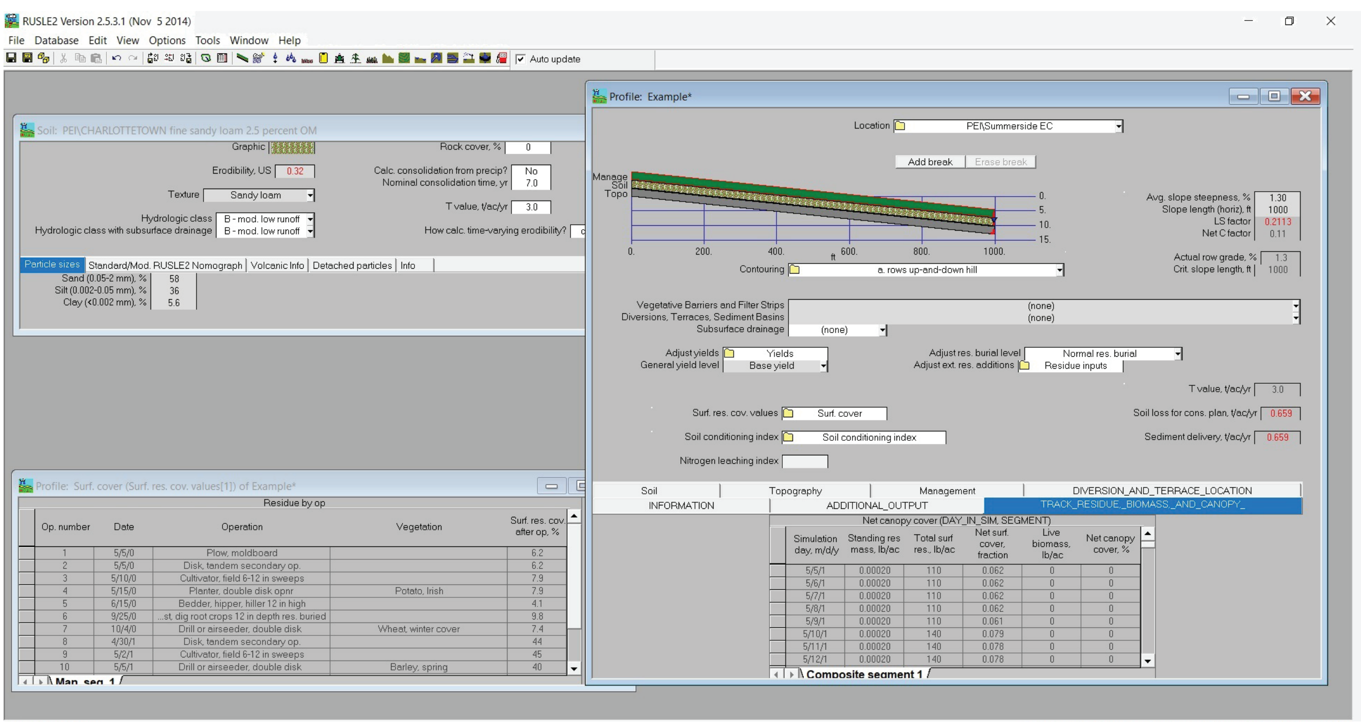
R is a rainfall factor derived from local long term rainfall records,

K is soil erodibility factor, derived from site-specific PEI soil report data

LS is slope length factor, a site-specific factor which can be adjusted with soil conservation structures

C is the site-specific cover factor adjusted by crop rotation choices, type of tillage used and practices like cover cropping or mulching

P is support factor such as cross-slope farming, or strip cropping



Screenshot of Typical RUSLE Analysis

Assessing Soil Conservation Strategies Using RUSLE

Soil loss rates can be affected by adjusting some of the factors accounted for in the RUSLE model. While the climate **R**, soil type, **K** and slope component of the L**S** factor, cannot be changed, other factors can. The cover factor **C** is adjusted by varying the crops used in the rotation, and the amount of cover left on the soil by tillage choices. The support factor, **P**, can be adjusted by choosing to farm across slope. **LS** can be adjusted by altering the slope length, using farmable berms or terraces.

In the following example using the RUSLE model, the impact of various agronomic soil management strategies on soil loss rates is illustrated. **Table 1** is a RUSLE analysis for a field with a 4% slope and farmed up & down the hill. The soil erodibility factor **(K)**, rainfall factor **(R)**, practice factor **(P)** (up and down slope), are set to 0.38, 90, and 1 respectively. The Soil loss rate **A** is set to 7 tonnes/hectare/year (3 tons/acre/year). Each additional measure increases the length of slope that can be farmed and still maintain the 7 tonne/ha/year (3 tons/acre/year) soil loss rates.

Maximum slope length (farming up and down 4% slope) while maintaining sustainable soil loss

Rotation/Management	150 300 450 600 750 900
3 yr potato/grain(u.s.)[1]/ hay: conv. tillage[2]	110m (360 ft.)
3 yr potato/grain(u.s.)/ hay: residue managed[3] or winter cover	192m (630 ft.)
3 yr potato/grain(u.s.)/ hay: residue managed[3] and winter cover	244m (800 ft.)

1. Grain(u.s.) - grain underseeded
2. Conventional tillage - fall primary tillage, spring secondary tillage
3. Residue Management - 30% residue coverage

One of the advantages of using the RUSLE model for PEI soil conservation planning is the wealth of high-resolution base data available. Local values for climate, soils and topography are available from various GIS sources here on PEI. For more information, contact the PEI Department of Agriculture & Land.

Geographical Information Available for RUSLE analysis:

Soils Data - 1:10,000 Field Scale Soil Mapping

Topography - 0.5m LiDAR mapping

High resolution Orthophoto base mapping

Climate Data Environment Canada – 4 Climatic regions for Rainfall Intensity

Soil Conservation Beneficial Management Practices

BMP *- Utilize strategies to minimize runoff. This approach is critical for maintaining the health of the soil and preventing sedimentation in waterways.*

Crop rotation

Good soil conservation begins with adequate crop rotations. Crop rotation is the foundation upon which other runoff control practices, such as strip cropping, residue management and mulching are based. Good crop rotation involves planting cereals, green manure and/or forage crops in sequence with potatoes.

Crop rotation is also key to improving product quality and lower production costs. Longer rotation periods can improve both total and marketable potato yields. Studies from around the world have consistently shown that yields can be increased by reducing potato cropping frequencies.

Lengthening the rotation in potato production systems can produce the following benefits:

Underseeded grain stubble in a 3-year rotation.

(Photo: PEI Department of Agriculture & Land)

Improved soil organic matter levels help feed the living soil biota, contributing to a healthier soil ecosystem. This improvement, in turn, enhances many soil functions such as aggregation, nutrient cycling, disease resistance and increasing moisture-holding capacity.

Increased rooting depth due to improved soil structure provides plants with a potentially greater nutrient and moisture supply and ensures a healthier, more vigorous crop.

Reduced soil compaction resulting in both improved soil drainage and moisture holding capacity, with less surface runoff. Intensive cropping of potatoes, requiring heavy equipment, is a major cause of soil compaction. Cereal, green manure and/or forage crops require fewer field operations.

Improved soil fertility when rotations with legumes such as clover reduce the nitrogen-fertilizer requirements and increase yields.

Mustard crop in bloom.

(Photo: Ryan Barrett, PEI Potato Board)

Reduced incidence of disease, insects and fungi in potato production systems. Rotations can break the cycle of pests, reducing the need for costly alternative control measures.

Factors to consider

Potatoes, carrots and turnips, etc. are all designated as row crops under the PEI *Agricultural Crop Rotation Act* (ACRA). The Act states that row crops may not be grown more frequently than once in every three years, unless done so with an approved ACRA crop management plan. For any rotation where a row crop is grown more frequently than provided for in the legislation, such a plan must contain measures to ensure soil loss levels do not exceed the tolerable limit of 7 tonnes/ha/year (3 tons/acre/year), averaged over the length of the proposed rotation. For more information on ACRA crop management plans, producers should contact the **PEI Department of Agriculture and Land**.

Tillage

Potato producers can choose from a wide range of tillage equipment. The combination of equipment used and the time of year can have a dramatic impact on erosion rates.

Producers who perform conventional tillage with a moldboard plow followed by spring discing and harrowing should consider delaying plowing until spring. Doing so will ensure that no wind or water erosion will occur during the winter prior to potato production. Also, the benefits from the nitrogen that was produced by the previous crop, if it was a legume, will be maximized. If spring plowing is not possible, fall plowing with winter cover (covered later in this booklet) is an option. Producers can further minimize soil erosion by adhering to general tillage tips.

General tillage tips

Natural or constructed hollows in fields handling concentrated flows of water should not be tilled. It is recommended that at least a 10-metre width in the centre of gullies be left in permanent sod. If gullies are continuously planted with potatoes, the resulting crop from that area will be low yielding and prone to soft rot, causing problems in storage. Farm equipment will also be able to travel through grassed (untilled) gullies much sooner during wet conditions.

Fields that have received a fall application of glyphosate should not be moldboard plowed. Rainfall simulator research has shown that erosion rates are severe on fields that have been tilled with traditional practices following glyphosate application.

If plowing cross slope with a roll over plow, turn all furrows uphill in order to reduce tillage erosion.

Residue management

***BMP** - Utilize tillage systems that increase the percentage of crop residues left on the surface to protect the soil from the erosive effects of extreme rainfall events and to improve soil moisture retention and soil health.*

Many Island producers are now practicing conservation tillage prior to planting potatoes. Conservation tillage or residue management as it is often referred to, can be practiced on any field going into potato production where the previous crop was a forage, green manure or cereal. The objective of residue management is to leave the maximum amount of plant residue from the previous crop on the soil surface after each stage of cultivation. The ideal proportion of ground cover left on the soil is 30%.

The final residue level depends on the original amount available; the tillage implements used, the number of tillage passes, and the depth and speed at which tillage was performed. Conventional tillage, which includes fall moldboard plowing along

Spring view of a residue managed plot (top) compared to a conventionally tilled plot (bottom) planted in the same field with the same slope.

(Photo: PEI Department of Agriculture & Land)

with spring discing and harrowing, will result in less than 3% of the soil surface being covered with residue from the previous crop after potato planting. By following recommended residue management practices, producers can obtain the ideal 30% surface residue cover after potato planting.

Residue left on the soil surface reduces erosion by:

- Protecting the soil from the impact of raindrops and the resulting movement of soil particles and crusting.
- Acting as small dams or windbreaks, slowing the movement of water and wind across a field and reducing their ability to carry soil.

For residue managed potato production, tillage requirements must be tailored to the previous crop in the rotation, as described in the following sections.

Following a non-underseeded cereal crop

- Harvest the cereal crop with a combine equipped with a straw chopper and spreader. In order to maximize potential residue levels, the straw must be left on the field, chopped and uniformly spread so that it does not pose problems during potato planting and harvesting.
- Perform a tillage pass with a primary residue tillage implement as soon as possible after cereal harvest. Unharvested grain that is lying on the ground will get excellent soil contact, germinate and produce an excellent cover crop before winter.
- In the spring, perform a single pass with a tillage implement that is capable of cutting residue, tilling the soil to an acceptable working depth, and producing a level seed bed.

Combine chopping and spreading straw.

(Photo: PEI Department of Agriculture & Land)

A number of commercial tillage implements can perform the tasks required for spring conservation tillage in a single pass. Be careful to select a working width that matches available tractor horse-power.

Following a green manure crop

- Do not till in the fall if the green manure crop is an annual as the coming frost will terminate the crop.
- In the spring, performing one pass with a primary residue tillage implement is all that is usually required. In some cases, a pass with a field cultivator may be used.

Following glyphosate-killed forages

Residue managed potato production, on land where the previous crop was a forage, involves the use of the herbicide glyphosate and considerably less tillage than under conventional systems.

- Apply glyphosate at the recommended rate of 3.5 - 5 litres/hectare in the fall in advance of residue management.
- Ideally, do not perform any fall tillage so crop residue levels are maximized and 30% residue cover is achieved after planting potatoes the following spring. The herbicide replaces the need for fall tillage and when spring arrives the forage residue is on the soil surface.
- For earlier planted fields, consider fall tillage the year prior to potatoes to ensure the soil is warmer at planting time. Use a primary residue tillage tool over a moldboard plow to obtain some residue cover over the winter and spring months. However, crop residue coverage after planting potatoes will be greatly reduced as a result of this tillage.
- Winter cover can easily be improved by broadcasting a cereal winter cover crop during or after the primary residue tillage pass.
- In the spring, achieve an acceptable seedbed for potatoes by a single pass with the same combination tillage implement recommended for residue management following cereal production. The first pass should be performed several days prior to planting so the soil can dry out and warm up. The second pass, if desired, should be performed just prior to planting and is commonly done with a s-tine harrow with a rear mounted leveler or field cultivator.

The below photo shows the effectiveness of glyphosate compared to the area which was missed by the sprayer.

(Photo: PEI Department of Agriculture & Land)

A conservation tillage implement at work.

(Photo: Ryan Barrett, PEI Potato Board)

Planting potatoes into a residue managed field.

(Photo: PEI Department of Agriculture & Land)

Following an underseeded cereal crop

Residue managed potato production techniques, on land where the previous crop was an underseeded cereal, will depend on the underseeding mix used.

- During the combine operation, cut the cereal crop less than 15 cm (6 in) above ground level. Chop the straw and uniformly spread over the field.
- If the field contains grasses, apply glyphosate in the fall to perform residue management. Tillage requirements would be similar to those for residue managed potato production following a forage crop.
- If the forage stand contained only perennial legumes—such as red clover, crimson clover or alfalfa—till the field in mid-to late-October with a chisel plow equipped with straight points and a rear mounted spike tooth leveler or rolling basket. Spring tillage requirements, prior to planting potatoes, would be similar to those used with non-underseeded cereals. The perennial legume will be actively growing when spring tillage is performed, but can be easily controlled with herbicides after the potatoes have been planted.

Benefits of residue management

- Reduced tillage and lower costs, since fewer equipment passes are required in a conservation tillage system. In addition, reducing the number of heavy equipment passes over the field minimizes soil disturbance, allowing the soil's biological communities to remain more intact while reducing potential for compaction issues.
- Reduced soil erosion - surface runoff volume and speed is minimized, water infiltration is improved and soil structure is stabilized. Studies have shown erosion losses to be 18 times lower after potato planting under conservation tillage than under conventional tillage.
- Improved soil moisture levels due to higher residue levels reducing the amount of surface runoff as well as the amount of moisture lost through evaporation.

Producers have questioned possible linkages between common scab found on potatoes and residue managed tillage. Although results are not completely clear, research conducted between 2004 and 2016 by the PEI Soil and Crop Improvement Association and the PEI Department of Agriculture and Land showed that in most cases there has not been a significant statistical difference in scab incidence between the two practices. In a small number of replications, the level of scab was markedly higher when conservation tillage was used, but in most cases the amount was equal or only slightly higher. There was too much variability between the replications to conclude either way. Producers whose markets are very sensitive to common scab, should select less susceptible common scab varieties, avoid residue management on fields with a known history of common scab and/or monitor soil pH levels.

Other factors to consider

The following factors associated with implementing conservation tillage should be considered:

- New practices may require different tillage equipment.
- Tillage must be carried out at the proper time and performed correctly.
- Implementation may change herbicide requirements.
- Under normal spring conditions, tillage on residue managed fields will be delayed by several days early in the planting season; if fields are worked when soil moisture levels are too high, clods will develop, and soils will become compacted.
- If residue from the previous crop has a high carbon-to-nitrogen ratio then top dressing with supplemental nitrogen may be required during the growing season. Tissue nitrogen levels should be monitored.
- Double disc openers and closers on planters should be adjusted to ensure proper seed placement and depth. Producers may wish to install trash cutting or whipping attachments to planters.
- Harvesters used on residue managed fields must be equipped with good trash removing features.

Winter cover

***BMP** - Whenever possible, soil should have cover over the winter months.*

High rates of soil loss can occur during the fall, winter and spring after a potato production year. A winter cover, using either a cover crop or a mulch, protects the soil during this vulnerable period and, if practiced properly, significantly reduces erosion rates.

Cover crops following potato harvest

Planting a winter cover crop is the most cost-effective method of providing a cover for early harvested potato fields. This recommendation also applies to other low-residue, late-harvested crops such as carrots, soybeans or silage corn. The time of harvest is the most important factor in deciding what crop to use and how to plant it.

The earlier a cover crop is established, the greater its erosion control benefits. Early maturing varieties of potatoes should be grown on the fields at greatest risk of erosion. These fields will receive the best cost benefit from the erosion protection offered by a winter cover crop.

Crops used

Although spring cereals such as oats and barley germinate quickly, they are killed by early frost. Very little surface residue will remain the following spring unless the crops are planted by mid-September and considerable biomass is produced before the cooler weather arrives. The living root mass and early regrowth of a cover crop that can survive the winter will result in much better erosion control in the spring. In addition, this living green crop will help to build organic matter and stable aggregates in the soil.

Fall rye and winter wheat are excellent choices for cover crops following a potato harvest. Both will emerge and grow in cooler soil temperatures than other crops. In addition to providing good cover, both produce a cereal grain the following year. Winter wheat is a more valuable cereal grain crop, but it does not grow as aggressively if planted late in the fall. Newer options being explored in PEI include winter barley or winter triticale for fields harvested before October 1. Brassica crops, such as mustard and winter canola, are not recommended for fields harvested after mid-September.

Further options and more detailed information on winter cover crops can be found on the **Cover Crop Decision Tool for Eastern Canada** website. This interactive

Drilling in a winter wheat cover crop.

(Photo: Dan MacEachern, AAFC)

tool allows the user to input site specific information such as soil texture, drainage, planting dates and goals (soil erosion, bio-fumigation, weed control, etc.) and receive a ranked list of options.

Establishment techniques

Cover crops can be established on harvested potato land in three ways:

- Preparing a seedbed and drilling in the cover crop immediately after potato harvest.
- Broadcast seeding after potato harvest followed by a light cultivation pass that levels the soil surface.
- Broadcast seeding 1-3 days before potato harvest and no tilling other than incorporation by the potato harvester.

Drilled cover crop

Cover crops established after the potatoes are harvested should be planted immediately to maximize the erosion control benefits. The latest recommended seeding dates will vary from year to year across the province depending on soil type, local climatic conditions, field exposure and the species of cover crop being grown. **Table 2** provides the recommended seeding dates for most of the province, based on long-term weather records, for drilled cover crops established after potato harvest.

Drilled winter wheat following an early potato harvest gives a good uniform growth before the winter.

(Photo: PEI Department of Agriculture & Land)

Table 2:
Latest recommended seedling dates for drilled crops.

Annual Ryegrass: September 7

Spring Cereals: September 26

Winter Wheat: October 7

Fall Rye: October 14

Table 3:
Recommended seedling rates for drilled cover crops.

Annual Ryegrass:
25-35 kg/ha (23-32 lbs/acre)

Winter Wheat or Fall Rye:
135-150 kg/ha (120-135 lbs/acre)

Table 4:
Latest recommended seedling dates for broadcast cover crop.

Spring cereals: September 30

Winter Wheat: October 10

Fall Rye: October 15

Seedling rate:
140-180Kg/ha (125-160 lbs/acre)

Seedbeds must be prepared for all drilled cover crops by performing a single tillage pass with either a chisel plow and leveler or a combination tillage implement that can cut trash, till to the desired depth and level a seed bed. Cover crops planted with a grain drill should be seeded in a cross-slope direction to avoid rill erosion between the rows of seed. Cover crops will experience less winter kill if planted on well-drained fields with south facing slopes. **Table 3** provides recommended seeding rates for drilled cover crops.

If a year of forage is to be included in the crop rotation, either legumes or grasses can be broadcast seeded into the winter cereal the following April when there is still frost in the ground. Red clover should be seeded at a rate of 9-11 kg/ha (8-10 lbs./acre); timothy at a rate of 7-9 kg/ha (6-8 lbs./acre) and perennial ryegrass at a rate of 11-23 kg/ha (15-20 lbs./acre).

Broadcast cover crop

Cover crops that are established by broadcast seeding should be planted at a higher seeding rate because some of the seed will not be viable due to poor soil cover. If the cover crop is broadcast seeded after potato harvest, followed by a light tillage pass that levels the soil surface, the recommended seeding dates are shown in **Table 4**. Recommended broadcast seeding rates for winter cereals are 140-180 kg/ha (125-160 lbs./acre). Research has indicated that excessive disturbance of the soil surface, beyond these dates, can lead to increased levels of erosion if the cover crop does not become well established before fall freeze up.

Broadcasting seed before potato harvest will accelerate germination by a couple of days as the potato harvest operation will provide soil cover for the seed. The operator must be careful not to broadcast too far in advance of potato harvest, as weather-related delays may result in the cereal crop sprouting before the harvest, damaging seedlings and significantly impacting establishment rates.

Broadcasting winter wheat prior to potato harvest.

(Photo: PEI Department of Agriculture & Land)

Spring cereals (barley, oats, wheat) will not survive the winter; therefore, no additional management is needed in the spring. Winter cereals (rye, winter wheat) can either be left to grow as a cash crop or can be terminated in advance of planting a different crop.

Cover crop broadcast before harvest operation.

(Photo: Johanna Kelly, Kensington North Watersheds Association)

If terminating a winter cereal, timing and method is important. Both fall rye and winter wheat should be terminated early by herbicide and/or tillage to discourage regrowth of volunteers in the following crop. Mowing in the vegetative stage may encourage tillering and regrowth. Mowing is most effective if the crop has just turned to the reproductive stage (heading out but before seed viability). Volunteers may not be a concern if growing a spring cereal for livestock feed, but are more of an issue if growing milling wheat or rye. Cover crops have the added benefit of reducing the level of nitrates leaching into the groundwater as they use some of the residual nitrogen left in the soil profile after the potato harvest.

Cover crop benefits

- Controls erosion by reducing the impact of raindrops on the soil surface
- Slows the surface flow of water, thus reducing erosion and increasing the soil's ability to absorb water
- Holds soil in place, preventing surface loss of nutrients or pesticides
- Adds organic matter and improves soil structure (i.e., improves soil health attributes)
- May provide nitrogen for next crop (legumes cover crops)
- May use residual nutrients applied to the potato crop (fall cover crops)
- May suppress weed growth (vigorous cover crops)
- Reduces the potential for wind erosion

Management considerations associated with cover crops

- A significant portion of potato acreage is harvested too late to establish a cover crop (after October 15)
- There are extra labour and equipment requirements during a busy harvest season
- Caution should be exercised when preparing a seedbed in the fall months as the soil will remain vulnerable during early crop establishment and may result in high soil erosion during heavy rain or snowmelt events

Cover crops following late summer/fall tillage

Many potato producers like to perform tillage in the fall on fields destined for potato planting the following spring. Traditionally, many of these fields were plowed late in the fall after potato harvest was completed; however, doing this significantly increases vulnerability to erosion and nutrient leaching over the winter.

In recent years, many producers have begun to use vertical tillage equipment which leaves more residue on the surface of the soil. As well, many producers are performing this tillage in August or September, allowing them to get tillage done before the busy harvest season and providing a larger window for the establishment of cover crops. In fact, some of these new models of tillage equipment have seed boxes built-in, allowing for cover crop establishment in one pass.

Cover crop species selection (after tillage)

If establishing a cover crop in mid-to late-August or early- to mid-September, cover crop species possibilities increase considerably. These are species (or mixtures) that will establish quickly and produce significant biomass before the winter and not regrow in the spring (ahead of potato planting). Examples which have been successfully used in Prince Edward Island include:

- Spring cereals (barley, oats)
- Annual ryegrass
- Brown mustard
- Oilseed radish
- Daikon (tillage) radish
- Winter canola (rapeseed)
- Kale/turnips
- Austrian winter peas

Many agronomists recommend planting a mixture of grass and brassica (e.g., mustard, radish) species to maximize ground cover and frost tolerance. Many brassica species can be seeded at low rates (8-12 lbs./acre) but require adequate time to establish. The later the seeding date, the more spring cereals like barley or oats should be used.

Benefits of cover crops ahead of potatoes

- Protects soil from water and wind erosion.
- Keeps a living crop growing in the soil much longer, thus building soil organic matter and improving soil health metrics.
- Increases marketable yields, as recent studies have shown a correlation between use of cover crops ahead of vegetable production and yields.

A barley cover crop.

(Photo: Ryan Barrett, PEI Potato Board)

Considerations for cover crops ahead of potatoes

- Choose a cover crop that does not require termination ahead of potato planting the following spring.
- Heavy rates of radish crops may result in quick breakdown and a rapid release of nutrients in the spring.
- Brown mustard has been shown to have a beneficial effect on control for fields with high wireworm pressure.
- Consider using tillage equipment that allows for seeding and tillage to be performed in one pass, reducing cost and soil compaction.

Mulching

Over the past two decades, increased use of newer, earlier-maturing varieties has reduced the acres of potatoes harvested too late for cover crop establishment. With climate change expected to lengthen the growing season, the trend toward planting winter cover crops should continue. However, a significant acreage of the potato crop is still harvested too late for cover crop establishment. For those areas, straw and hay mulching remains an option for erosion control during the winter months.

Applying round bale mulch at an angle across harvested potato field.

(Photo: PEI Department of Agriculture & Land)

Mulch controls erosion by reducing the impact of rain-drops hitting the soil surface and slowing runoff velocity, similar to the effects of increased surface residue. Farmers can apply mulch until fields become impassible due to wet field conditions or snow cover.

Mulch consists of chopped straw or hay, spread evenly over a recently harvested field with a round bale processor. Field tests have shown that erosion rates can be as much as 40 times lower on mulched versus bare fields.

It is important to note that mulch will not protect areas prone to gully erosion. Gullies should be left planted in permanent grass or grassed waterways should be constructed to provide adequate runoff control.

Mulch spreading techniques

- Mulch should be spread on potato fields as soon as possible after harvesting. If soil conditions are wet, it is better to wait until the ground freezes to avoid soil compaction.
- Mulch should be applied at a rate of 3.3-4.5 tonnes/ha (1.5-2.0 tons/acre).
- For maximum erosion control, the entire field should be mulched and the mulch should be applied at a slight angle across the potato drills, reducing the potential for erosion on bare strips between equipment passes.
- If there is insufficient time or availability of mulch materials, priority should be given to sloped or heavily trafficked areas.

For more information on mulching for erosion control on PEI, contact the PEI Department of Agriculture and Land for a copy of the factsheet: *Mulching for Erosion Control on Harvested Potato Land.*[15]

15. *Mulching for Erosion Control on Harvested Potato Land.* DeHaan, K.R., Holstrom, D. Agriculture Canada, PEI Department of Agriculture, 1996.

Increasing soil surface roughness

BMP *- Reduce runoff velocities and improve water infiltration by increasing surface roughness on row formed crops.*

Surface roughness describes the capacity of a surface to store runoff and detached sediment. A surface's roughness is either natural or determined by the shape of the surface created, termed hydraulic and created (or formed) roughness, respectively.

Furrow damming (sometimes referred to as basin tillage) is an example of created roughness on the soil surface. Furrow damming is a tillage practice in which soil between the potato rows is dragged and periodically dumped in the furrow, creating small dams with basins to collect runoff. Furrow dammers, in use in PEI for many years, have been proven to significantly reduce runoff during mid-summer thunderstorms. In field research conducted in 2007 and 2008, basin tillage had 78% and 75% less runoff than traditional hilling and one-pass hilling, respectively ($P < 0.05$). An improvement in soil moisture retention through the growing season was also noted.[16] A recent modification of the traditional furrow dammer, the micro-dammer, creates smaller but more numerous basins.

Potato rows after basin tillage.

(Photo: PEI Department of Agriculture & Land)

Basket hillers are a modification to the traditional one pass hiller. Typically mounted on the toolbar behind the planter, the basket hiller creates a roughened surface to the formed hill. Because the surface roughness has increased, flow velocities within the hill will be reduced.

A basket hiller.

(Photo: Allan Potato Equipment, PEI)

Cross slope farming

Plowing and cultivating fields up and down the slope creates channels where surface runoff can be concentrated. Channels are created regardless of the plowing direction, however when the direction is up and down the slope, the runoff is more erosive because it travels at higher velocity. When crop land is farmed across the slope, this practice by itself will reduce erosion by up to 50%.

Tilling and planting across the natural slope creates a series of dams which redirect and slow runoff, allowing water to soak into the ground or to flow gently between the rows of potatoes to grassed headlands at the edge of the field or to

16. Gordon R.J., Vanderzaag A.C., Dekker P.A., De Haan R., Madani A. (2011): Impact of modified tillage on runoff and nutrient loads from potato fields in Prince Edward Island. Agricultural Water Management, 98: 1782–1788.

grassed waterways within the field. On longer slopes, cross-slope farming should be used in combination with strip cropping and/or terraces. All areas that concentrate water into hollows or low areas must be left as permanent grass waterways to avoid rill and/or gully erosion.

Management considerations

- Many farms on Prince Edward Island are long and narrow, with the major slope running the length of the field. To efficiently farm these properties across the slope, fields may have to be consolidated.
- If slopes are very steep, some equipment modifications may be required to prevent side hill slippage, though the use of GPS autosteer feature on modern potato equipment has greatly reduced or eliminated issues with side hill slippage
- Natural depressions must be left in permanent grass. If necessary, grassed waterways should be constructed to provide adequate row drainage. Such waterways are crucial for soil conservation work to be successful.
- Using a rollover plow is recommended to turn the sod uphill if conventional tillage is being performed.

Benefits

- Greater infiltration of water into the soil means increased availability of moisture during the growing season. It also reduces the total amount of surface runoff.
- Planting potatoes in rows across the slope results in slower surface runoff and, therefore, a lower risk of erosion.
- Horsepower and fuel requirements are lower than when farming up and down the slope.

An integrated soil conservation system with cross slope and strip cropping.

(Photo: PEI Department of Agriculture & Land)

Strip cropping

Strip cropping involves planting row crops in strips across the slope, with alternate strips of grain, forage crops, etc. It combines the soil and moisture conservation properties of cross slope farming with the soil-building advantages of crop rotation and is more effective in reducing soil losses.

Strip width will depend on the steepness of the slope and the management practices used. Technical assistance for laying out a strip cropping system is available from the PEI Department of Agriculture and Land.

Strip cropping in Bedeque area.

(Photo: PEI Department of Agriculture & Land)

- When designing a strip cropping system, widths are finetuned to accommodate equipment widths; i.e., planters, sprayers and harvesters.
- An even number of passes along each strip will allow field operations to start and finish at the same end of the field.
- Grassed headlands and grassed waterways are integral to any strip cropping system.

Benefits

- If potatoes are grown using a strip cropping system in a three-year rotation with grain and hay, erosion rates can be reduced by 75% compared to farming up and down the slope with the same rotation.
- As in cross-slope farming, strip cropping has the added benefit of reduced horsepower and fuel requirements.
- Strip-cropping negates the need to haul hay or straw to the potato field for mulching.

Things to Consider

- As with cross-slope farming, fields must be wide enough so that they can be farmed efficiently; therefore, consolidation of fields may be required.
- Grassed waterways must be constructed to provide adequate row drainage in depressional areas.
- Strip cropping can result in increased travel time because the practice involves growing the various crops in the rotation every year, on any particular field.
- Increased attention is required to avoid herbicide drift between the various crops.
- Scouting reports indicate a possibility of increased populations of Colorado potato beetles and European corn borers. Alternate strips can provide winter habitat for insects. On a three-year rotation, this problem can be reduced by growing two of the three crops in the field in any particular year.

Permanent grassed headlands

BMP *- Consider permanently establishing grassed headlands to provide the best protection for end-of-row runoff in regulated crop fields.*

Grassed headland at the end of potato field.

(Photo: PEI Department of Agriculture & Land)

Maintaining headlands at the lower ends of potato fields in permanent grass cover has numerous benefits. Grassed headlands are frequently the last line of defense before runoff leaves the field. Grassed areas at the end of a potato row will reduce runoff velocity, decreasing its carrying capacity and forcing the silt to be deposited within the field boundary. Research has shown that grassed buffers reduce sediment, nutrient, and pesticide losses from agricultural lands through their filtering function.[17, 18] In addition, permanently maintaining a minimum 10-metre grassed headland within the 200-metre headland zone ensures compliance with the PEI **Environmental Protection Act**. Leaving headlands in permanent grass will allow for the development of a resilient sod, better able to withstand the pressure of vehicles turning and reduces the compaction that normally occurs on headlands.

Grassed filter strips

In-field grassed filter strips can reduce sediment loads in runoff on hillslopes. Grassed filter strips slow runoff velocities, filter out sediment and other pollutants, and allow some infiltration into the underlying soil. They are most effective in reducing sediments carried by sheet erosion. The efficacy of a grassed filter strip is largely determined by flow velocity and may be limited by the slope of the field. For areas where flow has concentrated and/or gully erosion is evident, the establishment of grassed waterways are the best option.

17. A.M. Dunn, G. Julien, W.R. Ernst, A. Cook, K.G. Doe, P.M. Jackman. *Evaluation of buffer zone effectiveness in mitigating the risks associated with agricultural runoff in Prince Edward Island.* Science of the Total Environment 409 (2011) 868–882.
18. Patty L, Réal B, Gril J. *The use of grassed buffer strips to remove pesticides, nitrate and soluble phosphorus compounds from runoff water.* Pestic Sci 1997;49:243–51.

Erosion control structures

BMP *- Utilize strategies to minimize runoff. Doing so is critical to maintaining the health of the soil and preventing sedimentation in waterways. When soil conservation measures include erosion control structures, seek the advice of a soil and water conservation engineer.*

When agronomic soil conservation practices alone will not adequately reduce the risk of erosion, soil conservation structures may be required. Diversion terraces, farmable berms, grassed waterways, surface inlets, rock chutes and energy dissipaters, are the most common structures required for soil conservation on Prince Edward Island.

Planning, design and construction of erosion control structures should be carried out by qualified professionals.

Diversion terraces

Diversion terraces are required when a combination of crop rotation, sound production practices and strip cropping cannot reduce erosion to tolerable levels on long or steep slopes. If the slope-length of a field is greater than the allowable limit for cross slope farming or strip cropping, the field should be terraced to control runoff.

Diversion terraces, consisting of a ditch and a high berm, are positioned parallel to the direction of farming and designed to intercept surface water flow. Typically, diversion terraces are 5 m (17 ft) in width and designed to be constructed within a potato planter pass. Due to the berm height (0.6 m or 2 ft) and placement,

A diversion terrace.

(Photo: PEI Department of Agriculture & Land)

terraces should not be driven over with farm equipment. Suitable outlets for the water being intercepted and diverted by the terrace are required, most often these outlets are grassed waterways.

Diversion terraces will transport substantial amounts of runoff and must be permanently vegetated. Spacing between terraces is based on equipment widths, soil erodibility, slope steepness, crop rotation and local rainfall as well as whether the field is strip cropped, residue managed or winter covered. Grade along the length of the terrace should be less than 2%. Regular maintenance including annual repairs, mowing, and fertilization is necessary.

Diversion terraces require detailed engineering design and should not be attempted before consulting a soil and water conservation engineer with the Department of Agriculture and Land.

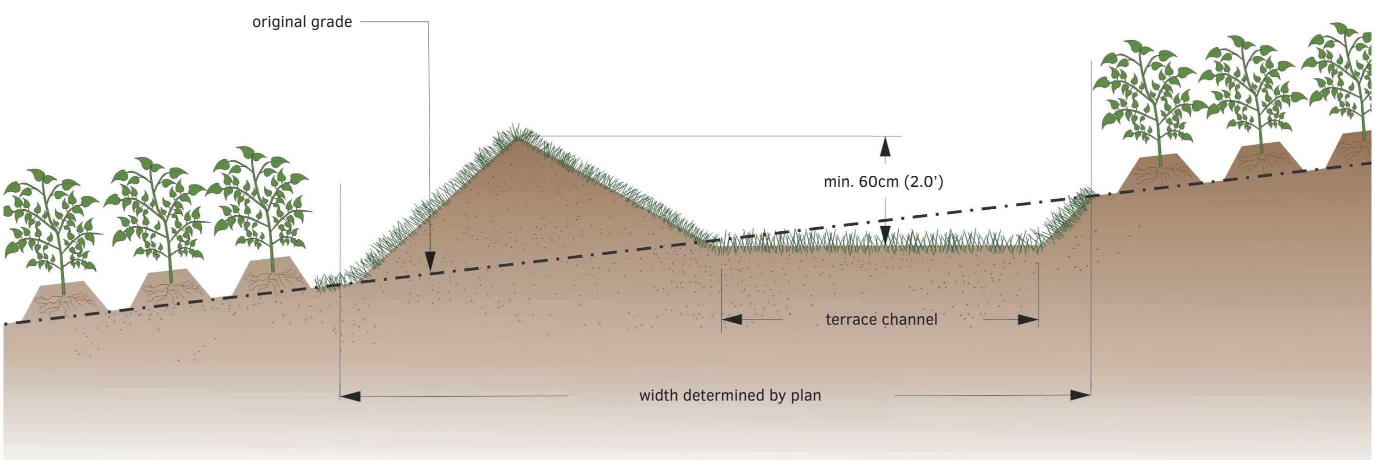
Benefits

- Can be designed to reduce erosion to acceptable levels regardless of the rotation. However, costs will be minimized by integrating terracing with complementary agronomic practices.
- Will improve drainage at lower ends of fields by diverting surface runoff to a controlled outlet location.
- Terraces will often reduce the number of grassed waterways required

Costs

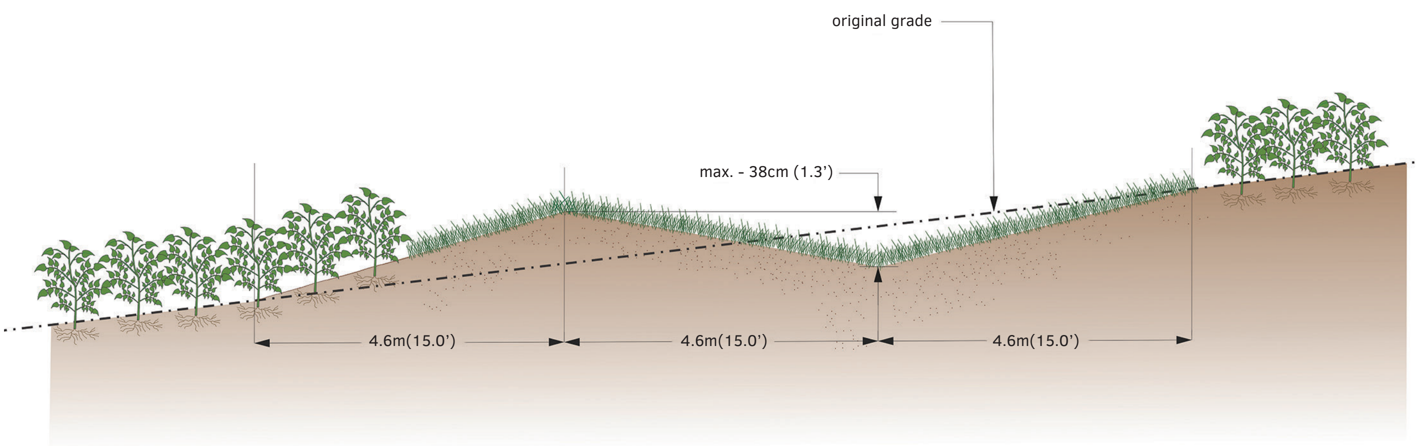
- Terracing will permanently remove land from production. The amount of land removed from production will depend on the system requirements, but will normally range from 0%-5% of the land base. Partial cost recovery is possible through the ALUS program for land lost under a soil conservation structure.
- Typical terrace costs including seeding range between $2.50-3.25/metre ($0.75-$1.25/ foot) of length. Average total costs for a terrace system with suitable outlets are $320/hectare ($130/acre).

A diversion terrace x-section. Grade on terrace channel should be kept to 2% or less.



Farmable berms

Where field consolidation for terracing or cross slope farming is not possible, slope lengths may be reduced by using farmable berms, a variation of the diversion terrace. Farmable berms are frequently used on the long, narrow properties commonly found on PEI. These low wide terraces, designed to be driven over with farm equipment, are positioned perpendicular to the direction of farming. Typically, farmable berms are 14 m (45 ft) in width and the total height from channel bottom to top of berm does not exceed 38 cm (15”).



A farmable berm x-section.

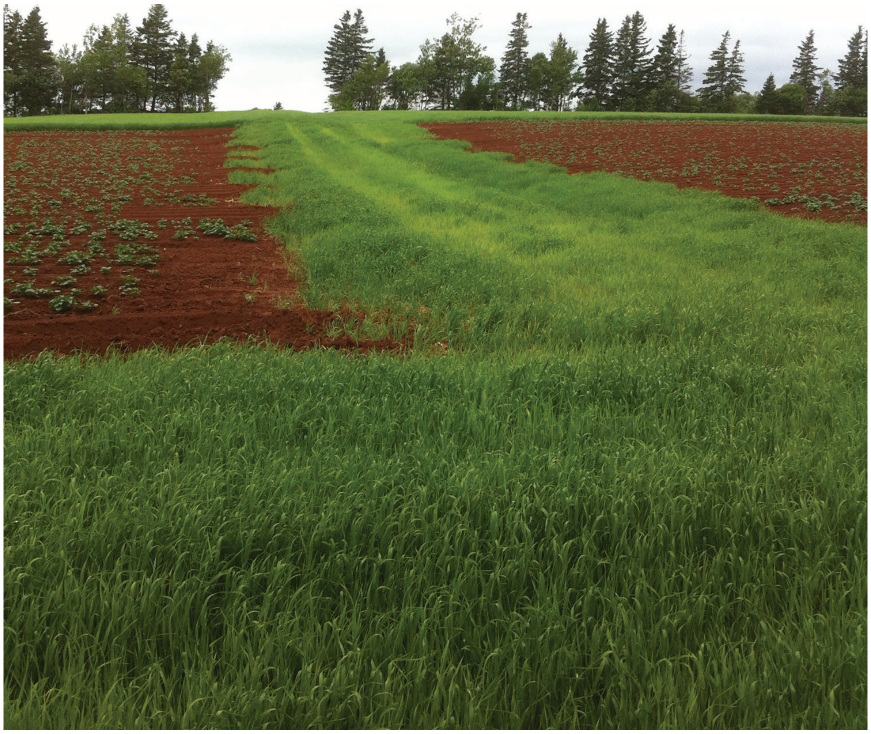
The principal limitation for using farmable berms is the natural slope of the field. It is not recommended to construct farmable berms on field slopes exceeding a 4% grade as there will be insufficient material to form the back of the berm. Farmable berms should not be used as outlets for other drainage structures. If desired, the back of the farmable berm can be farmed, but the main drainage channel must be stabilized with permanent grass cover, as with other erosion control structures.

Benefits

- Farmable berms are the ideal structure for breaking up long field slopes that run parallel to farming direction. Farmable berms divert water from the field that would otherwise continue to flow downslope, gaining velocity and forming gullies.
- As farmable berms are designed to be drivable, the impact to cropping activities and field travel is minimized.

Limitations

- Farmable berms typically have lower capacity than terraces due to the berm height restriction of 15” and there is a potential for the berm to breach if the channel depth is restricted with ice during freeze-thaw events.



A well-established farmable berm.

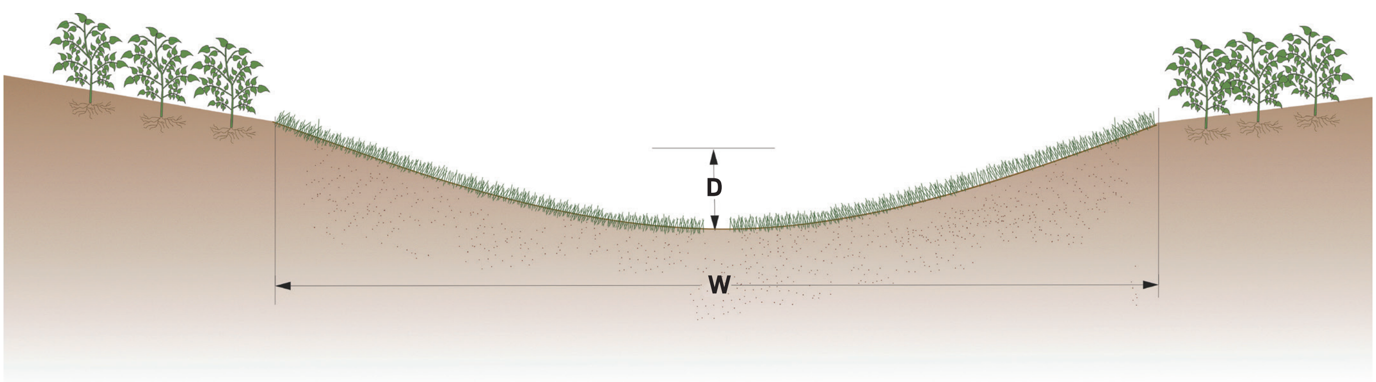
(Photo: PEI Department of Agriculture & Land)

Costs

- Farmable berms will permanently remove some land from production. The amount of land impacted will depend on whether the producer chooses to farm the backside of the berm or not. Partial sost recovery is possible through the ALUS program for land lost under a soil conservation structure.
- Typical farmable berm costs, including seeding, range between \$4.90-\$6.50/metre (\$1.50-\$2.00/foot). There will be additional construction costs if material must be moved to build up the back of the berm.

Grassed waterways

Grassed waterways are broad, shallow channels that are protected against erosion by a permanent grass cover. They are typically placed in a natural drainage path created by field topography and are used to control gully erosion where water collects and flows through these natural depressions in the field. They may also serve as outlets for diversion terraces and farmable berms.



A grassed waterway x-section. Depth D and width W are determined by the plan.

Design considerations

- The waterway must be well drained to encourage vigorous grass growth and to protect it from rutting when farm machinery crosses it.
- The dimensions of the waterway should be designed for the anticipated peak flow of a 1- in-10 year-storm (minimum).
- The waterway cross-section will depend on the peak flow, the grade along the length of the channel, and whether the channel is to be crossed by farming equipment.
- Grassed waterways which will be crossed by farm equipment should be constructed to be at least 12 m (40 ft) wide and .4 m (1.25 ft) deep to ensure drivability.
- Ideally, grassed waterways are gently sloped to control water flow speeds. Occasionally, grade control structures are required to ensure the stability of the waterway. Check dams consisting of irregular-shaped rock lining over a filter cloth is common. Rock chutes may be required where grassed waterways discharge into an open ditch, to protect against erosion.

Benefits

- Controls erosion in field gullies and provides excellent outlets for terrace and farmable berm systems.
- Generally constructed in existing drainage paths created by natural topography, grassed waterways are a more erosion-stable version of natural field drainage paths.
- Improves overall field drainage which increases field trafficability for spraying and harvesting in wet conditions.
- Reduces the possibility of potatoes going into storage with soft rot problems due to water ponding between potato rows in depressional areas.

Costs

- Grassed waterways permanently take land out of cereal and row crop production but they can be harvested for forage production.
- Typical costs of constructed grassed waterways with temporary erosion protection and seeding range between $6.50-$11.50/m ($2.00-$3.50/ft) depending upon depth and width.
- Cost recovery is possible through the ALUS program for land lost under a soil conservation structure.

Surface inlets

Grassed waterways are the least expensive method of gully erosion control but they do reduce the amount of land in production. A surface inlet and underground piping system is an option that minimizes the loss of land and avoids some of the inconveniences associated with waterways. However, construction costs increase significantly with surface inlets vs. the traditional grassed waterway.

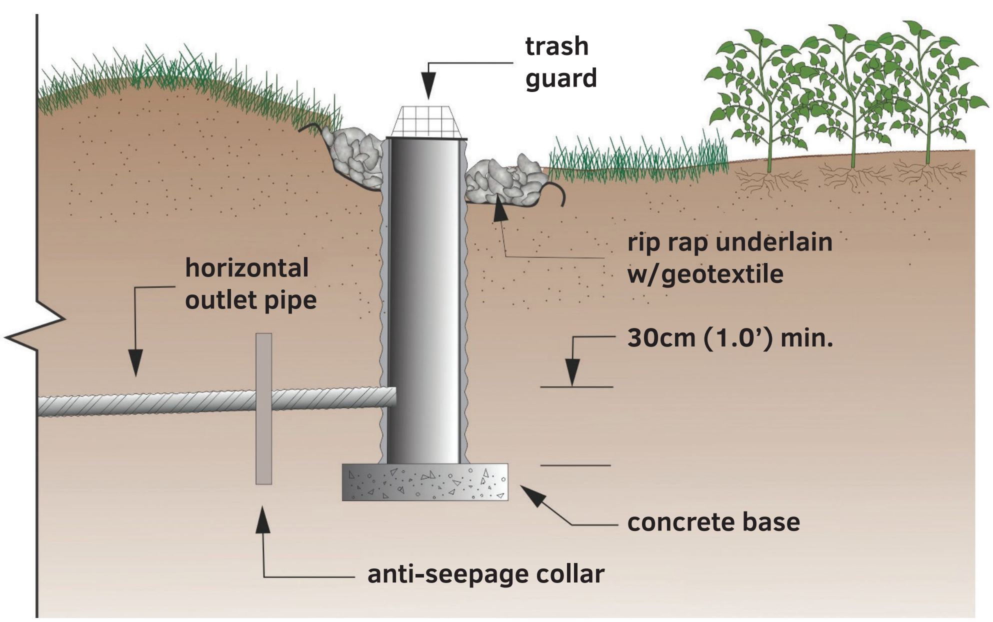
Earthen berms or dams can be constructed at strategic locations within fields to intercept heavy runoff. The water can then be discharged through a surface inlet and underground piping system to a safe and convenient outlet location. Surface inlets can also be used as outlets for terrace systems.

Surface inlets are constructed using precast or formed concrete, corrugated plastic or galvanized metal. The underground piping system can be concrete, galvanized metal, corrugated plastic or PVC. All surface inlets should also be equipped with trash racks to prevent debris from entering the drainage system.

The size of the surface inlet and underground piping system will depend on peak flow, storm frequency, and grade and distance over which runoff is to be conveyed as well as the design and materials used for the underground piping system.

Pipe size requirements and costs can be substantially reduced if the water is allowed to temporarily pond before entering the system. Temporary ponding will also improve runoff quality as sediment is allowed to settle. The length of time that water can be ponded will depend upon the sensitivity of the crop. Potatoes can usually tolerate water ponding for up to six hours.

Surface inlet systems require detailed engineering designs and should not be attempted before consulting a soil and water conservation engineer with the PEI Department of Agriculture and Land.



A surface inlet x-section.

Benefits

- Surface inlet systems keep more land in production
- More convenient in terms of in-field farm equipment operation
- If ponding is incorporated into the design, less silt will leave the property
- A good option as an outlet for part of a terrace draining a small area where discharging to a grassed waterway would require considerable re-grading.

Costs

- Costs are site-specific, depending upon the anticipated flows and the distance to a suitable outlet
- Cost can be prohibitively expensive if design requires large capacity pipes

Rock Chutes

Rock chute.

(Photo: PEI Department of Agriculture & Land)

A rock chute is a type of outlet structure that allows surface flow to drop in elevation in a controlled manner. A rock chute is used in locations where stabilization with normal vegetation could not withstand the eroding force of a sudden drop in topography. On PEI, rock chute structures are most commonly used in outlets near natural watercourses. Drop structures carry flow down an inclined surface lined with geo-textile and rock rip rap. Rock chutes must be sized according to the calculated peak flow and should be designed by a soil and water engineer. They can be costly due to the rip rap required and, depending on the elevation difference to be controlled, may extend back into the farmed portion of the field. Rock chutes are, however, the only way to effectively conduct significant discharge over steep drops in topography.

Energy dissipaters

Energy dissipaters are rock-lined structures designed to reduce discharge velocities into outlets. Commonly used at the exits of culverts and waterways, energy dissipaters are an excellent tool to ensure discharge from an erosion control system does not impact downstream areas that may not be able to withstand the overland flow velocity of a well-vegetated waterway or ditch. As with rock chutes, energy dissipaters are sized according to the calculated peak flow reporting to them and should be designed by a soil and water engineer as part of an integrated soil conservation system.

Energy dissipater at the end of a grassed waterway.

(Photo: PEI Department of Agriculture & Land)

Maintenance and stabilization considerations

***BMP** - Control runoff more effectively by maintaining soil conservation structures, natural grassed waterways, and filter strips in good working order.*

1. Over the life of the structure, immediately repair any damaged sections minimizing the disturbance on the rest of the structure.
2. Use a grass mix that spreads by rhizomes. A typical recommended grass mix for Prince Edward Island is Highway Mix – 55% creeping red fescue, 10% Kentucky blue, 10% white Dutch clover, 10% perennial rye, 10% timothy, and 5% red top.
3. When preparing for seeding, do not till up-and-down the length of a grassed waterway. Rill erosion will develop in the furrows, damaging waterway stability.
4. Protection for newly seeded grassed waterways is necessary until grass becomes established. The best protection is commercially available jute erosion mat used in the centre 25-30% of the waterway or placed along the bottom where flow is expected.
5. Grassed waterways, terraces and farmable berms must be maintained on a regular basis. Waterways should be mowed and fertilized annually. Periodically inspect grassed waterways and immediately repair any washouts or bare soil.

A compact seeder well suited for seedling soil conservation structures. The rolling basket helps reduce rills.

(Photo: GWR Farms Inc.)

6. Livestock should not be allowed to graze on grassed waterways; nor should they be used as roadways for equipment.

7. Grassed waterways, terraces and farmable berms should be seeded before **September 15** so enough grass cover will be established to resist winter and spring runoff.

8. Grassed waterways are designed to be used with other soil conservation practices in an erosion control system. If sheet and rill erosion on the upper slopes are not controlled, a build-up of silt in the waterway could eventually reduce its effectiveness.

9. Extreme care must be taken to ensure, once installed, erosion control structures are not damaged by field operations. Familiarize all employees on the location and importance of critical structures like waterways, berms and grassed filter strips to prevent their being inadvertently be worked up or sprayed with herbicide.

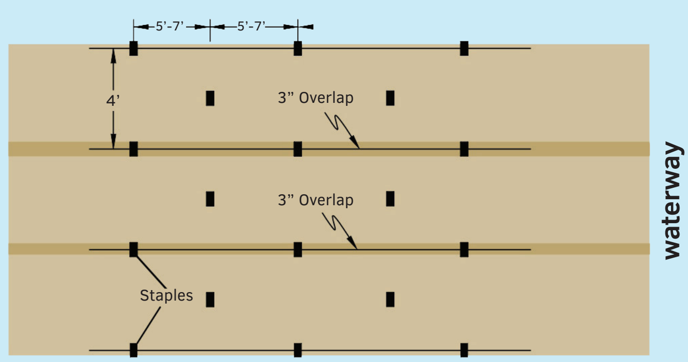
10. Minimize the amount of soil moved into grassed waterways and farmable berms as much as possible during planting, hilling and harvesting. If soil ridges are formed during these operations, excavate the ridges back into the field to eliminate issues with overland flow tracking along the ridge and not entering the structure as intended.

Erosion Jute Mat Installation Instructions

The erosion mat must be installed in the lower part of the waterway where most of the concentrated flow will be. Start laying mat in the lowest area and work outwards with the mat.

Multiple widths of erosion mat should have the edges of each 4 foot width overlapping by 3 inches.

Staples for the erosion mat should be installed in rows every 5 to 7 feet. A 900 yard by 4 foot wide bale of jute will require a minimum of 580 staples. The pattern can alternate, however staples are required at the overlapping edges and in the centre of each 4 foot width. Refer to the diagram for stapling details. This is an important step to ensure your erosion mat provides the best protection for your newly seeded grassed waterway.



Erosion jute mat stapling pattern

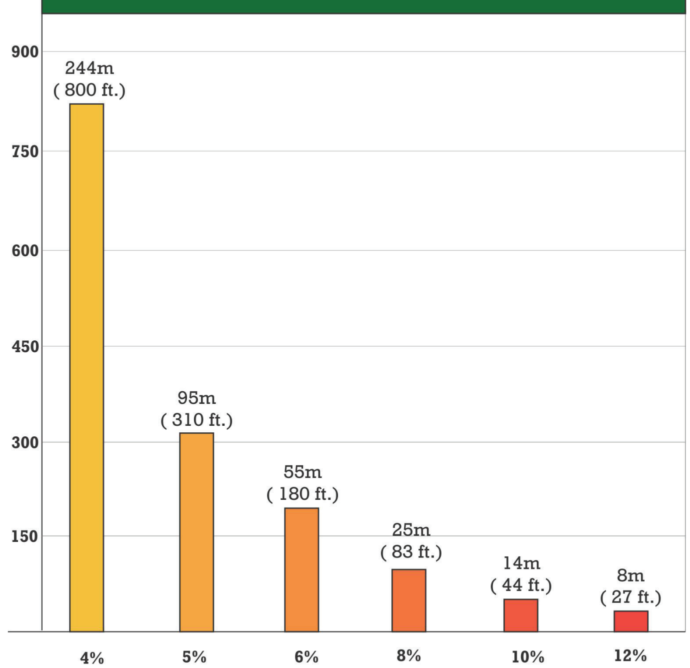
High slope land retirement

***BMP** - Consider removing from row crop production areas identified as high risk despite significant investment in soil conservation structures or other BMPs.*

In certain situations, the most effective response to controlling runoff on an area at high risk for impacting a nearby watercourse may be to retire that portion of the field from crop production. Land retirement may be considered for areas too steep for farmable berms, too narrow for cross-slope farming with terraces or simply too steep for any measures to be practical and effective. The decision to retire land must be made with careful consideration of all options and weighed against the need for risk mitigation. The ALUS program offers a per hectare, annual payment to landowners for high-risk land retirement. More information on the **Alternative Land Use Services** program can be found on the PEI Department of Agriculture and Land website.

Hedgerows

Maintaining sustainable soil loss with various slope length & steepness combinations[1]

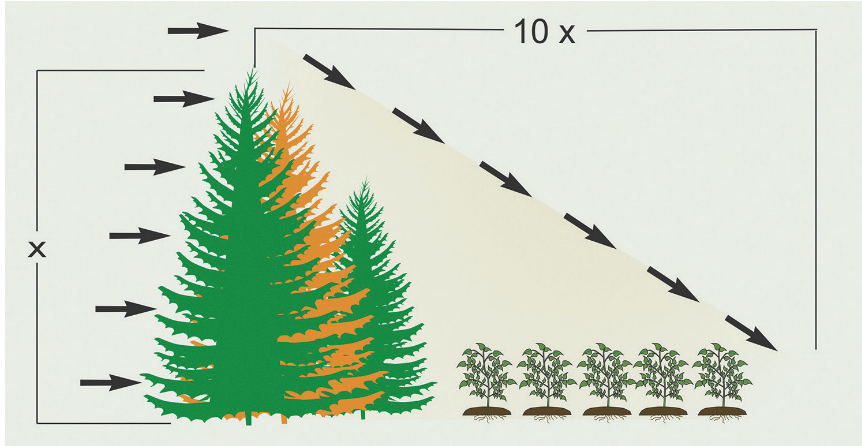


Hedgerows are treed windbreaks that protect fields from wind erosion. Hedgerows control soil erosion by reducing wind speed at ground level and by trapping snow, leaving the soil less exposed during the winter months.

Well-established windbreaks can reduce wind speed downwind for a distance equal to 20 times the height of the windbreak. Snow drifting can be controlled for a distance of 10 times the height. Hedgerows should be planted at right angles to the prevailing winter winds. Ecologically, hedgerows act as important wildlife corridors allowing birds and mammals to move between isolated habitats.

1. Same rotation and management with the effects of slops length for sustainable soil loss. (RUSLE factors are A=7 tonnes/ha./yr (3 tons/acre/year), C= 0.13, P (up and down slop)= 1, R= 89, K=0.38.

Hedgerows should not be planted up and down slopes where they may hinder cross slope farming practices. Well designed hedgerows should be planted with at least two rows of trees, although three rows are preferred. Trees should be spaced 2 m (6 ft) apart, both within and between rows. They should be staggered so that trees in the middle row alternate with those in the two outside rows. If hedgerows are incorporated into a strip cropping/terracing system, they should be located a strip boundary away from the terrace to avoid snow accumulation problems at the terrace. A variety of shrubs and trees can be incorporated into the hedgerow to strengthen it as well as to provide valuable food sources for local wildlife.



Area protected by a windbreak.

Benefits

- Reduced wind erosion
- Reduced wind damage to crops
- Creation of microclimate that results in additional heat units being available to the crop
- Conserves moisture under most conditions but may compete for moisture during a dry season
- Provides habitat for local wildlife

Information on establishing hedgerows can be obtained through the **MacPhail Woods Ecological Forestry Project** or the PEI Department of Environment, Water and Climate Change's **Hedgerow Planting Program**.

Well established hedgerow in field.

(Photo: Forests Fish & Wildlife, Government of PEI)

Conclusion

Prince Edward Island is fortunate to have many of the natural attributes necessary for producing high-quality food. Agriculture is one of the pillars of PEI's economy, and practicing sustainable agriculture has become a cornerstone of modern food production here on the Island.

Farmers on PEI have embraced many sustainable practices as evidenced by the popularity of the ALUS program, Environmental Farm Plan participation and involvement in initiatives like the 4R Fertilizer program, soil health projects and soil conservation works. The information presented in this publication is intended to assist producers build on that success and continue to protect one of the most important assets in their farming enterprise: healthy and resilient soil.

Glossary

adsorbed particles – is the adhesion of atoms, ions, or molecules to the surface of a solid, i.e. a soil particle.

agro-ecosystem – the ecological systems that exist within an agricultural enterprise.

biomass – the total living matter in a unit area or volume of soil

biota - the flora and fauna of a specified region or space

estuarine ecosystem – the community of plants and animals living in partially en-closed bodies of water and their coastal zones, that are especially adapted to the changing salinity and dynamic water circulation of an estuary.

geotextile – a thick non-woven fabric used under rip rap to prevent scouring of the substrate.

hydrological cycle - the sequence of water passing from vapor in the atmosphere to precipitation on land or water surfaces and ultimately back into the atmosphere as a result of evaporation and transpiration

microbial – relating to microbes or very small living things. In a soil health context, small organisms living in the soil that decompose organic material.

rhizosphere - the rhizosphere is the thin region of soil or substrate surrounding a plant root that is directly influenced by root secretions and associated soil micro-organisms known as the root microbiome.

riparian zone – the interface between uplands and a river or stream. Riparian zones are often characterized by the presence of vegetation that can thrive in excessively wet soil conditions.

rip rap – a layer of specifically sized stone laid down at the outlet of a surface flow structure designed to absorb the energy of the surface flow preventing damage to the substrate.

root exudates - fluids emitted through the roots of plants. These secretions influence the rhizosphere around the roots to inhibit harmful microbes and promote the growth of the plant.

watershed - the drainage areas that are upslope of any particular point. Watershed area is based on topography.

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