DESIGN FOR RISER INLET PHOSPHORUS TREATMENT SYSTEM

Submitted to:

Ontario Federation of Agriculture
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Guelph, ON N1G 5L3

Prepared by:

BluMetric Environmental Inc.
171 Victoria Street North
Kitchener, ON N2H 5C5

Project Number: 170253
25 August 2017

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ACKNOWLEDGEMENTS

I would like to thank Chad Penn of the United States Department of Agriculture, John Benson of Stelco, David Dessureault of Harsco Metals and Minerals, Kevin McKague of the Ontario Ministry of Agriculture, Food and Rural Affairs, and Don Hilborn of the Ontario Federation of Agriculture. Their consultation was invaluable to completing this project, and this report would not have been possible without them.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

The following report presents the design of a phosphorus treatment system for riser inlets used in agriculture. Riser inlets provide a direct route for agricultural surface water runoff to enter the tile drainage system, bypassing natural filtration barriers such as the soil. As a result dissolved reactive phosphorus (DRP), may be able to enter the drainage system in higher concentrations than if it were forced to pass through the soil. The riser inlets do however play an important role in draining cropland at a rate that is sufficient enough to not harm the crops themselves. For this reason a treatment system was designed in order to reduce DRP and still provide adequate cropland drainage.

The objective was to reduce DRP by 40% over a period of several years to comply with the 2015 *Western Basin of Lake Erie Collaborative Agreement* that was signed by the Premier of Ontario and the Governors of Michigan and Ohio. The specifications of a typical riser inlet were considered, namely a 6 inch diameter inlet draining approximately 10 acres of farmland at a rate of ½ inch per day.

This project was completed in consultation with the United States Department of Agriculture (USDA), Stelco, Harsco Metals and Minerals, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and the Ontario Federation of Agriculture (OFA).

2 DESIGN OVERVIEW

2.1 SELECTING A PHOSPHORUS SORBING MATERIAL (PSM)

The selection of a material to treat dissolved phosphorus can be challenging as there are numerous considerations. Ultimately the material chosen was electric arc furnace steel slag sieved to a particle size range of 1mm to 9.5mm (3/8 inch). The rationale for this decision is described in the following sections.

2.1.1 Cost and Availability

After corresponding with Stelco via e-mail, steel slag appeared to be a viable economic option for agriculture in Ontario. The material is freely available at Stelco's site in Nanticoke, Ontario which is 136km driving distance from London, Ontario. The material is a byproduct of steel production and therefore is often available for free in large quantities as producers attempt to dispose of it.

2.1.2 Safety Considerations

When utilizing a material for water filtration in agriculture it is important to ensure that no toxic byproducts are generated by the material itself. The slag that was decided upon is already approved for crop application by OMAFRA as shown by the consultation e-mail (Figure 1).

From: John Benson [mailto:JBenson@uss.com]
Sent: Friday, June 23, 2017 12:46 PM
To: Adam Wojtczak
Subject: RE: [External]-Re: Slag Inquiry for P Filtration

The slag I am offering has no use in our plant - not quite waste but I have to pay the trucking for people to use it in driveways and parking lots. The material is approve by OMFRA for crop application (non toxic).

John Benson
Environmental Manager

STELCO

2330 Haldimand Road 3
Nanticoke, ON N0A 1L0

Email: jbenson@uss.com
Office: 519-587-4541 ext 5189
Cell: 519-428-8210
Web: stelcocanada.com

Figure 1: Correspondence regarding steel slag via e-mail

2.1.3 Effectiveness

Two considerations were made in deciding upon an effective PSM. The first was that the material must allow for a sufficient flow rate to drain the farmland. The second was that the material must be able to adequately sorb DRP. Lab testing was completed for the slag material and a saturated hydraulic conductivity of 11cm/hr or 3.0×10^{-5}m/s was determined. Upon consultation with Harsco Metals and the USDA it was determined that slag can be used as an effective phosphorus sorbing material as well. Both of these pieces of information prompted further testing of steel slag.

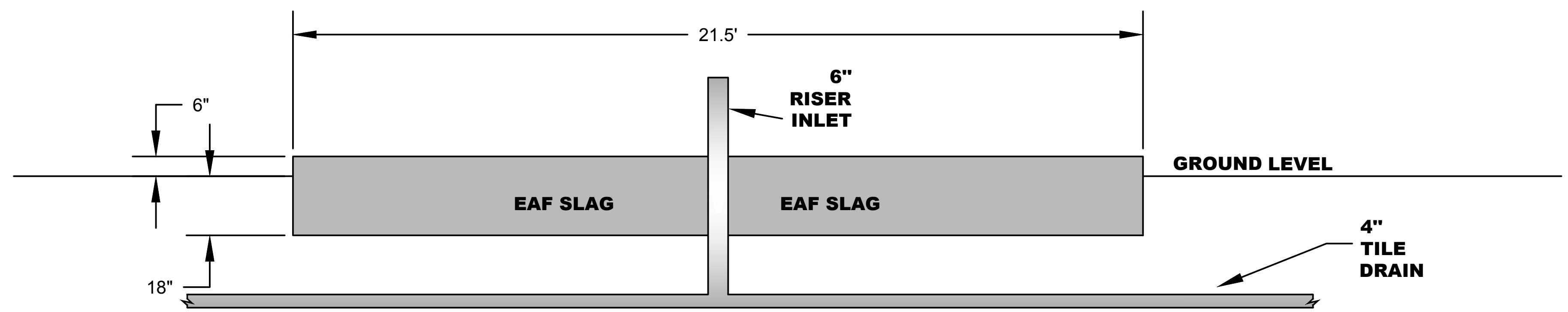
2.2 Structure

2.2.1 General Concept

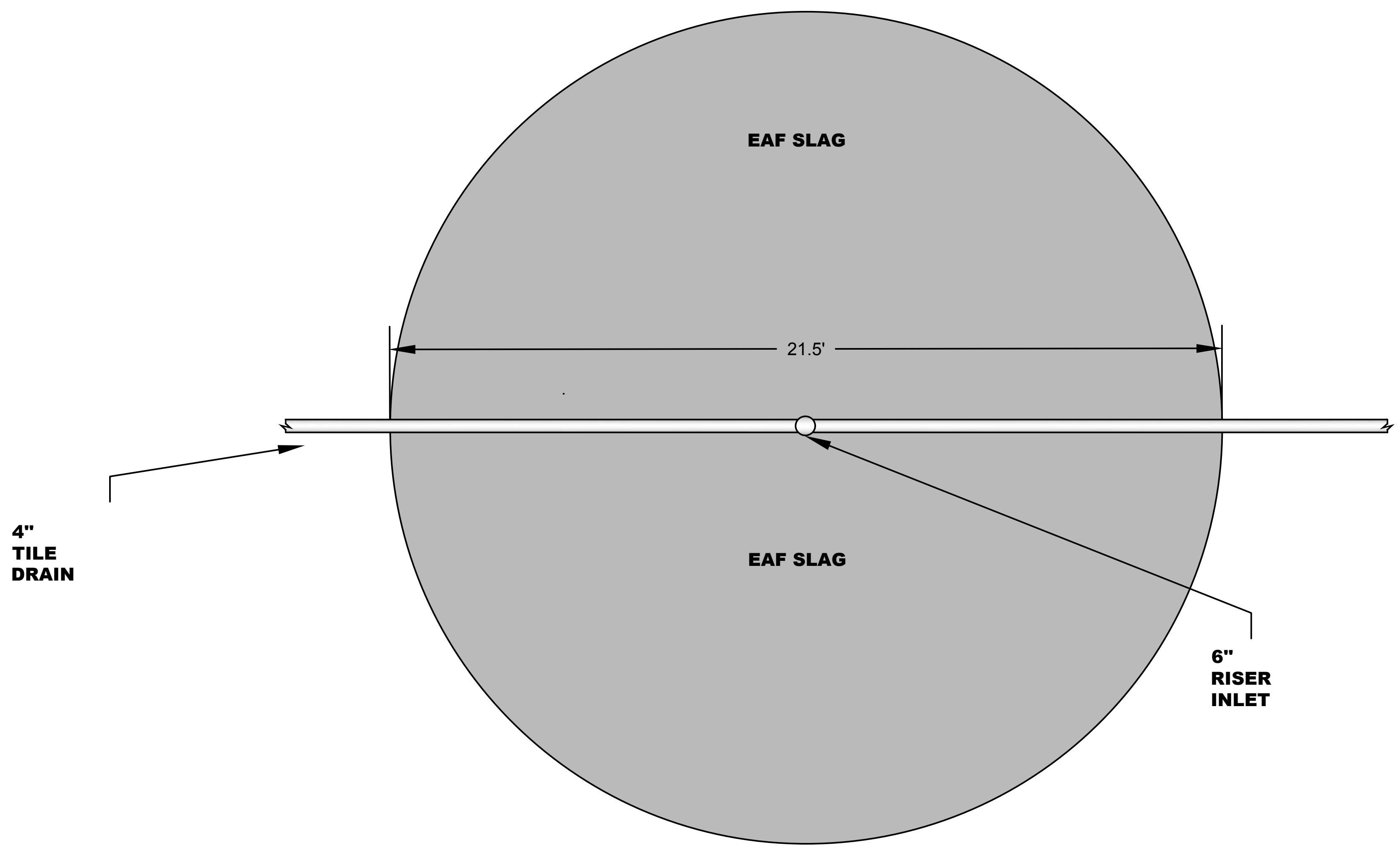
The structure designed is a cylindrical structure partially recessed into the ground surrounding the inlet as shown in Figure 2. It is 10.5ft from the edge of the inlet to the native soil, and 18 inches below ground and 6 inches above ground. The rationale behind these dimensions is described in the next section. The structure must be contained by a rigid material on the outside of the cylinder to support the 6 inch rise above ground. It would also be advisable to use the same material to surround the inlet itself, to prevent slag from washing into the inlet. It is not necessary to have a material underlying the slag.

Surface water may pond around the inlet as usual except with this design water is forced to pass through the PSM before entering the drainage system. This will reduce the amount of DRP in drainage water.

SIDEVIEW



TOPVIEW



LEGEND

REV.	DESCRIPTION	DATE	BY	CHK

REFERENCE :

1:50 0 33 66 99 132 165
SCALE (ft)
THIS SCALE TO BE USED TO OBTAIN APPROXIMATE DIMENSIONS FOR INFORMATION

CLIENT
OFA

PROJECT
OFA Collaborative Strategy

TITLE
Riser Inlet Design

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PROJECT #	DATE	REV.	FIG.
170253-01	2017-06-08	-	1

DRAWN	DESIGNED	CHECKED	CAD DRAWING
KT	AW	AW	170253-01-FIG1.DWG

2.2.2 Size and Dimensions

Extensive consultation was completed with the USDA to determine the correct dimensions for the structure. A sample of slag was sent directly to a USDA laboratory, and the software PhROG (Phosphorus Removal Online Guidance) was used to generate a feasible design.

Inputs to the software included a drainage rate of 6L/s (requirement for 6 inch riser inlet to drain 10 acres of land at ½ inch per day), a DRP concentration of 0.2ppm, an annual flow volume of 760K gallons, and an annual removal goal of 40%. The DRP concentration was based off of observed DRP concentrations in (Van Esbroeck et al., 2016).

Bed Output	
Mass Required (tons)	33.88
Depth of Material (inches)	12.
Depth of Structure (inches)	12
Length of Structure (ft)	35.
Width of Structure (ft)	18.4831
Number of Subsurface Drainage Pipes Needed	5
Actual RT (min)	15.7251
Actual Maximum Flow Rate Through the PSM (gpm)	121.461
Estimated lifetime to meet both minFR and RT	-

Years	Cumulative Dissolved P(%)	Cumulative Dissolved P(lbs)
1	70.8	0.898
2	57.53	1.459
3	47.57	1.81
4	40.	2.029
5	34.16	2.166
6	29.59	2.252
7	25.97	2.306
8	23.05	2.339
9	20.67	2.36
9.545	19.56	2.368

Figure 3: PhROG Software Output

The output of the software was a structure 35ft in length, 18.5ft in width, and 1ft in depth. The structure was capable of removing at least 40% of the DRP for a period of 4 years.

Using these numbers the quantity of PSM required for the desired removal capacity is known. The dimensions were simply altered to suit the cylindrical design while keeping the volume of PSM constant. This is how the dimensions in Section 2.2.1 were determined.

2.2.3 Containment Material

Determination of a containment material for the structure is difficult due to the requirements. The material must allow water to freely pass through, but must also be rigid to support the 6 inches of slag that must be piled above ground. A perforated hard plastic material such as that used for the tile drains themselves, is suggested.

2.2.4 Installation and Removal

Details regarding installation and removal would be best discussed with drainage contractors as they have expertise in this area. The structure would likely require excavation, and loading with heavy equipment.

As for disposal of the slag after the 4 year lifespan there are two options. The first would be to spread the slag and work it into the field. Since the slag is approved for crop application there should be no environmental issues with this. Secondly, slag is extensively used in asphalt, and this could be a second disposal option.

2.3 Cost of Implementation

2.3.1 Predicted Expenses

The two major expenses associated with implementing this structure would be transportation costs and drainage contractor costs. The material itself is free but will need to be transported to the site. Additionally drainage contractors will likely be needed for installation and removal of the structure.

3 CONCLUSIONS

In conclusion, laboratory testing has demonstrated this material to be a potentially viable option for DRP removal. According to consultation with the USDA, the material has the potential to remove 40% of DRP over a period of 4 years at an adequate flow rate. Upon consultation with Stelco the material appears to be both safe and economical.

4 RECOMMENDATIONS

Given the laboratory testing, a full scale pilot study would be recommended. An appropriate test site would need to be determined, along with appropriate monitoring equipment.

Also worthy of consideration is finding even more suitable PSMs. The USDA has suggested that a hematite type of material may be capable of having the same effect as steel slag but using 1/5 of the mass. If this is the case however, the material must meet all of the other criteria described in this report before proceeding.

5 CLOSING

The information and opinions expressed in this report are prepared for the sole benefit of Ontario Federation of Agriculture (OFA). No other party may use or rely upon this report or any portion thereof without the express written consent of BluMetric.

Sincerely yours,
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6 REFERENCES

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