Appendix A

RENEWABLE ENERGY APPROVALS

Ontario

Ministry of the Environment
Ministère de l'Environnement

RENEWABLE ENERGY APPROVAL

NUMBER 0905-8S7M96
Issue Date: May 16, 2012

Penn Energy Renewables, Ltd.
620 Righters Ferry Rd
Bala Cynwyd, Pennsylvania
USA 19004

Project Location: Hamilton_Port Hope-4 Solar Energy Facility
2700 Payne Road
Lot 3, Concession 2
Township of Hamilton, County of Northumberland

You have applied in accordance with Section 47.4 of the Environmental Protection Act *for approval to engage in a renewable energy project in respect of a Class 3 solar facility consisting of the following:*

The construction, installation, operation, use and retiring of a Class 3 solar facility with a total name plate capacity of up to approximately 10 megawatts (AC).

For the purpose of this renewable energy approval, the following definitions apply:

1. "Acoustic Assessment Report" means the report included in the Application and entitled Acoustic Assessment Report Penn Energy-Hamilton Port Hope 4 Solar Farm, Township of Hamilton, Northumberland County Ontario, dated December 7, 2011, prepared by HGC Engineering and signed by Petr Chocensky PhD;

2. "Acoustic Audit" means an investigative procedure consisting of measurements and/or acoustic modelling of all sources of noise emissions due to the operation of the Equipment/Facility, assessed to determine compliance with the Noise Performance Limits set out in this Approval;

3. "Acoustic Audit Report" means a report presenting the results of the Acoustic Audit;

4. "Acoustical Consultant" means a person currently active in the field of environmental acoustics and noise/vibration control, who is knowledgeable about Ministry noise guidelines and procedures and has a combination of formal university education, training and experience necessary to assess noise emissions from solar facilities;

5. "Act" means the *Environmental Protection Act* , R.S.O 1990, c.E.19, as amended;

6. "Adverse Effect" has the same meaning as in the Act;

7. "Application" means the application for a Renewable Energy Approval dated July 12, 2011 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the application, including amended documentation submitted up to May 9, 2012;

8. "Approval" means this Renewable Energy Approval issued in accordance with Section 47.4 of the Act, including any schedules to it;

9. "A-weighting" means the frequency weighting characteristic as specified in the International Electrotechnical Commission (IEC) Standard 61672, and intended to approximate the relative sensitivity of the normal human ear to different frequencies (pitches) of sound . It is denoted as “A”;

10. "A-weighted Sound Pressure Level" means the Sound Pressure Level modified by application of an A-weighting network. It is measured in decibels, A-weighted, and denoted “dBA”;

11. "Class 1 Area" means an area with an acoustical environment typical of a major population centre, where the background sound level is dominated by the activities of people, usually road traffic, often referred to as “urban hum";

12. "Class 2 Area" means an area with an acoustical environment that has qualities representative of both Class 1 and Class 3 Areas:

    (a) sound levels characteristic of Class 1 during daytime (07:00 to 19:00 or to 23:00 hours);
    (b) low evening and night background sound level defined by natural environment and infrequent human activity starting as early as 19:00 hours (19:00 or 23:00 to 07:00 hours);
    (c) no clearly audible sound from stationary sources other than from those under impact assessment.

13. "Class 3 Area" means a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as the following:

    (a) a small community with less than 1000 population;
    (b) agricultural area;
    (c) a rural recreational area such as a cottage or a resort area; or
    (d) a wilderness area.

14. "Company" means Penn Energy Renewables, Ltd. and includes it successors and assignees;

15. "Decibel" means a dimensionless measure of Sound Level or Sound Pressure Level, denoted as dB;

16. "Director" means a person appointed in writing by the Minister of the Environment pursuant to section 5 of the Act as a Director for the purposes of section 47.5 of the Act;

17. "District Manager" means the District Manager of the appropriate local district office of the Ministry where the Facility is geographically located;

18. "Equipment" the one (1) pad-mounted 1 Megavolt ampere (MVA) transformer and one (1) 1 megawatt or two (2) 500 kilowatt inverters within each array, and one (1) 10 MVA step up power transformer substation, identified in this Approval and as further described in the Application, to the extent approved by this Approval;

19. "Equivalent Sound Level" is the value of the constant sound level which would result in exposure to the same total A-weighted energy as would the specified time-varying sound, if the constant sound level persisted over an equal time interval. It is denoted Leq and is measured in dB A-weighting (dBA);

20. "Facility" means the renewable energy generation facility, including the Equipment, as described in this Approval and as further described in the Application, to the extent approved by this Approval;

21. "Independent Acoustical Consultant" means an Acoustical Consultant who is not representing the Company and was not involved in preparing the Acoustic Assessment Report. The Independent Acoustical Consultant shall not be retained by the Acoustical Consultant involved in the noise impact assessment;

22. "Ministry" means the ministry of the government of Ontario responsible for the Act and includes all officials, employees or other persons acting on its behalf;

23. "Noise Control Measures" means measures to reduce the noise emissions from the Facility and/or Equipment including, but not limited to, barriers, silencers, acoustical louvres, hoods and acoustical treatment, described in the Acoustic Assessment Report and in Schedule C of this Approval;

24. "Noise Receptor" has the same meaning as in O. Reg. 359/09;

25. "O. Reg. 359/09" means Ontario Regulation 359/09 “Renewable Energy Approvals under Part V.0.1 of the Act” made under the Act;

26. "Point of Reception" has the same meaning as in Publication NPC-205 or Publication NPC-232, as applicable, and is subject to the same qualifications described in those documents;

27. "Publication NPC-103" means the Ministry Publication NPC-103, "Procedures", August 1978;

28. "Publication NPC-104" means the Ministry Publication NPC-104, "Sound Level Adjustments", August 1978;

29. "Publication NPC-205" means the Ministry Publication NPC-205, “Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban)”, October, 1995;

30. "Publication NPC-232" means the Ministry Publication NPC-232, "Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)", October, 1995;

31. "Sound Level" means the A-weighted Sound Pressure Level;

32. "Sound Level Limit" is the limiting value described in terms of the one hour A-weighted Equivalent Sound Level Leq;

33. "Sound Power Level" means ten times the logarithm to the base of 10 of the ratio of the sound power (Watts) of a noise source to standard reference power of 10^{-12} Watts;

34. "Sound Pressure" means the instantaneous difference between the actual pressure and the average or barometric pressure at a given location. The unit of measurement is the micro pascal (μPa);

35. "Sound Pressure Level" means twenty times the logarithm to the base 10 of the ratio of the effective pressure (μPa) of a sound to the reference pressure of 20 μPa;

36. "UTM" means Universal Transverse Mercator coordinate system.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

<u>TERMS AND CONDITIONS</u>

A. GENERAL

1. The Company shall construct, install, operate, use and retire the Facility in accordance with the terms and conditions of this Approval and the Application and in accordance with the following Schedules attached hereto:

   Schedule A - Facility Description
   Schedule B - Coordinates of the Equipment

2. Where there is a conflict between a provision of this Approval and any document submitted by the Company, the conditions in this Approval shall take precedence. Where there is a conflict between one or more of the documents submitted by the Company, the document bearing the most recent date shall take precedence.

3. The Company shall ensure a copy of this Approval is:

   (1) accessible, at all times, by Company staff operating the Facility and;

   (2) submitted to the clerk of each local municipality and upper-tier municipality in which the Facility is situated.

4. If the Company has a publicly accessible website, the Company shall ensure that the Approval and the Application are posted on the Company's publicly accessible website within five (5) business days of receiving this Approval.

5. The Company shall, at least six (6) months prior to the anticipated retirement date of the entire Facility, or part of the Facility, review its Decommissioning Plan Report to ensure that it is still accurate. If the Company determines that the Facility cannot be decommissioned in accordance with the Decommissioning Plan Report, the Company shall provide the Director and District Manager a written description of plans for the decommissioning of the Facility.

6. The Facility shall be retired in accordance with the Decommissioning Plan Report and any directions provided by the Director or District Manager.

7. The Company shall provide the District Manager and the Director at least ten (10) days written notice of the following:

   (1) the commencement of any construction or installation activities at the project location; and

   (2) the commencement of the operation of the Facility.

B. EXPIRY OF APPROVAL

1. Construction and installation of the Facility must be completed within three (3) years of the later of:

   (1) the date this Approval is issued; or

   (2) if there is a hearing or other litigation in respect of the issuance of this Approval, the date that this hearing or litigation is disposed of, including all appeals.

2. This Approval ceases to apply in respect of any portion of the Facility not constructed or installed before the later of the dates identified in Condition B.1.

C. PERFORMANCE LIMITS

1. The Company shall ensure that:

(1) the Sound Levels from the Equipment, at the Points of Reception identified in the Acoustic Assessment Report, comply with the Sound Level Limit of 40 dBA as described in Publication NPC-232;

(2) the Equipment is constructed and installed at either of the following locations:

(a) at the locations identified in Schedule B of this Approval; or

(b) at a location that does not vary by more than 10 metres from the locations identified in Schedule B of this Approval and provided that,

i) the Equipment will comply with Condition C.1 (1), and

ii) all setback prohibitions established under O. Reg. 359/09 are complied with.

(3) the Equipment complies with the noise specifications set out in Schedule B of this Approval.

2. If the Company determines that some or all of the Equipment cannot be constructed in accordance with Condition C.1 (2), prior to the construction and installation of the Equipment in question, the Company shall apply to the Director for an amendment to the terms and conditions of the Approval.

3. Within three (3) months of the completion of the construction of the Facility, the Company shall submit to the Director a written confirmation signed by an individual who has the authority to bind the Company that the UTM coordinates of the "as constructed" Equipment comply with the requirements of Condition C.1 (2).

D. ACOUSTIC AUDIT

1. The Company shall carry out an Acoustic Audit in accordance with the procedures set out in Publication NPC-103, and shall submit to the District Manager and the Director an Acoustic Audit Report prepared by an Independent Acoustical Consultant in accordance with the requirements of Publication NPC-233, no later than six (6) months after the commencement of the operation of the Facility.

E. STORMWATER MANAGEMENT

1. The Company shall employ best management practices for stormwater management and sediment and erosion control during construction, installation, use, operation, maintenance and retiring of the Facility, as described in the reports included in the Application and entitled Construction Plan Report, dated April 2011 (revised April 5, 2012) and prepared by Penn Energy Renewables, Ltd and Stormwater Management Letter Report, dated May 15, 2012 and prepared by GENIVAR Inc.

F. SEWAGE WORKS OF THE TRANSFORMER SUBSTATION SPILL CONTAINMENT FACILITY

1. The Company shall design and construct a transformer substation spill containment facility which meets the following requirements:

   (1) the spill containment area serving the transformer substation shall have a minimum volume equal to the volume of the transformer oil and lubricants plus the volume equivalent to providing a minimum 24-hour duration, 25-year return storm capacity for the stormwater drainage area around the transformer under normal operating conditions;

   (2) The containment facility shall have an impervious concrete floor and walls sloped toward an outlet, maintaining a freeboard of 0.25 metres terminating approximately 0.30 metres above grade, with an impervious plastic liner or equivalent, and 1.0 metre layer of crushed stone within;

   (3) the containment pad shall drain to an oil control device, such as an oil/water separator, a pump-out sump, an oil absorbing material in a canister or a blind sump; and

   (4) the oil control device shall be equipped with an oil detection system and appropriate sewage appurtenances, as necessary (pumpout manhole, submersible pumps, level controllers, floating oil sensors, etc.) that allows for batch discharges or direct discharges, and for proper implementation of the monitoring program described in Condition F.4.

2. The Company shall:

   (1) prior to the construction of the transformer substation spill containment facility, provide the District Manager and Director the following:

      (a) final design drawings and specifications of the spill containment and associated sewage works, signed and stamped by an independent Professional Engineer licensed in Ontario;

      (b) an operation an maintenance procedures manual including an emergency/contingency plan; and

      (c) a monitoring program, including a groundwater monitoring program in the event of subsurface disposal system.

   (2) within six (6) months of the completion of the construction of the transformer substation spill containment facility, provide the District Manager and Director the following:

      (a) as-built drawings of the sewage works;

      (b) confirmation that the transformer substation spill containment facility has been designed and installed according to appropriate specifications; and

      (c) confirmation of the adequacy of the operating procedures and the emergency procedures manuals as it pertains to the installed sewage works.

   (3) as a minimum, check the oil detection system on a monthly basis and create a written record of the inspections;

(4) ensure that the effluent is essentially free of floating and settleable solids and does not contain oil or any other substance in amounts sufficient to create a visible film, sheen or foam on the receiving waters;

(5) immediately identify and clean-up all losses of oil from the transformer;

(6) upon identification of oil in the effluent pumpout, take immediate action to prevent the further occurrence of such loss; and

(7) ensure that equipment and material for the containment, clean-up and disposal of oil and materials contaminated with oil are kept within easy access and in good repair for immediate use in the event of:

(a) loss of oil from the transformer

(b) a spill within the meaning of Part X of the Act, or

(c) the identification of an abnormal amount of oil in the effluent.

3. The Company shall design, construct and operate the sewage works such that the concentration of the effluent parameter named in the table below does not exceed the maximum concentration objective shown for that parameter in the effluent, and shall comply with the following requirements:

Effluent Parameters	**Maximum Concentration Objective**
Oil and Grease	15 mg/L

(1) notify the District Manager as soon as reasonably possible of any exceedance of the maximum concentration objective set out in the table above;

(2) take immediate action to identify the cause of the exceedance; and

(3) take immediate action to prevent further exceedances.

4. Upon commencement of the operation of the Facility, the Company shall establish and carry out the following monitoring program for the sewage works:

(1) the Company shall collect and analyze the required set of samples at the sampling points listed in the table below in accordance with the measurement frequency and sample type specified for the effluent parameter, oil and grease, and create a written record of the monitoring:

Effluent Parameters	**Measurement Frequency and Sample Points**	**Sample Type**
Oil and Grease	B - Batch, i.e. for each discrete volume in the sump prior to pumpout; or Q - Quarterly for direct effluent discharge, i.e., four times over a year, relatively evenly spaced.	Grab

(2) in the event of an exceedance of the maximum concentration objective set out in the table in Condition F.3, the Company shall:

(a) increase the frequency of sampling to once per month, for each month that effluent discharges occurs, and

(b) provide the District Manager, on a monthly basis, with copies of the written record created for the monitoring until the District Manager provides written direction that monthly sampling and reporting is no longer required; and

(3) if over a period of twenty-four (24) months of effluent monitoring under Condition F.4 (1), there are no exceedances of the maximum concentration set out in the table in Condition F.3, the Company may reduce the measurement frequency of effluent monitoring to a frequency as the District Manager may specify in writing, provided that the new specified frequency is never less than annual.

5. The Company shall comply with the following methods and protocols for any sampling, analysis and recording undertaken in accordance with Condition F.4:

(1) Ministry of the Environment publication "Protocol for the Sampling and Analysis of Industrial/ Municipal Wastewater", January 1999, as amended from time to time by more recently published editions, and

(2) the publication "Standard Methods for the Examination of Water and Wastewater", 21st edition, 2005, as amended from time to time by more recently published editions.

G. WATER TAKING ACTIVITIES

1. The Company shall not take more than 50,000 litres of water on any day by any means during the construction, installation, use, operation, maintenance and retiring of the Facility.

H. ARCHAEOLOGICAL RESOURCES

1. The Company shall implement all of the recommendations, if any, for further archaeological fieldwork and for the protection of archaeological sites found in the consultant archaeologist's report included in the Application, and which the Company submitted to the Ministry of Tourism and Culture in order to comply with clause 22 (2) (b) of O. Reg. 359/09.

2. Should any previously undocumented archaeological resources be discovered, the Company shall:

(1) cease all alteration of the area in which the resources were discovered immediately;

(2) engage a consultant archaeologist to carry out the archaeological fieldwork necessary to further assess the area and to either protect and avoid or excavate any sites in the area in accordance with the *Ontario Heritage Act*, the regulations under that act and the Ministry of Tourism and Culture's *Standards and Guidelines for Consultant Archaeologists*; and

(3) notify the Director as soon as reasonably possible.

I. OPERATION AND MAINTENANCE

1. Prior to the commencement of the operation of the Facility, the Company shall prepare a written manual for use by Company staff outlining the operating procedures and a maintenance program for the Equipment that includes as a minimum the following:

   (1) routine operating and maintenance procedures in accordance with good engineering practices and as recommended by the Equipment suppliers;

   (2) emergency procedures;

   (3) procedures for any record keeping activities relating to operation and maintenance of the Equipment; and

   (4) all appropriate measures to minimize noise emissions from the Equipment.

2. The Company shall;

   (1) update, as required, the manual described in Condition I.1; and

   (2) make the manual described in Condition I.1 available for review by staff of the Ministry upon request.

3. The Company shall ensure that the Facility is operated and maintained in accordance with the Approval and the manual described in Condition I.1

J. RECORD CREATION AND RETENTION

1. The Company shall create written records consisting of the following:

   (1) an operations log summarizing the operation and maintenance activities of the Facility;

   (2) within the operations log, a summary of routine and Ministry staff inspections of the Facility; and

   (3) a record of any complaint alleging an Adverse Effect caused by the construction, installation, use, operation, maintenance or retirement of the Facility.

2. A record described under Condition J.1 (3) shall include:

   (1) a description of the complaint that includes as a minimum the following: a) the date and time the complaint was made; b) the name, address and contact information of the person who submitted the complaint;

   (2) a description of each incident to which the complaint relates that includes as a minimum the following: a) the date and time of each incident; b) the duration of each incident;

c) the wind speed and wind direction at the time of each incident;

d) the ID of the Equipment involved in each incident and its output at the time of each incident;

e) the location of the person who submitted the complaint at the time of each incident; and

(3) a description of the measures taken to address the cause of each incident to which the complaint relates and to prevent a similar occurrence in the future

3. The Company shall retain, for a minimum of five (5) years from the date of their creation, all records described in Condition J.1, and make these records available for review by staff of the Ministry upon request.

K. NOTIFICATION OF COMPLAINTS

1. The Company shall notify the District Manager of each complaint within two (2) business days of the receipt of the complaint.

2. The Company shall provide the District Manager with the written records created under Condition J.1 (3) within eight (8) business days of the receipt of the complaint.

3. If the Company receives a complaint related to groundwater or surface water, the Company shall contact the District Manager within one (1) business day of the receipt of the complaint, to discuss appropriate measures to manage any potential groundwater or surface water issues.

L. CHANGE OF OWNERSHIP

1. The Company shall notify the Director in writing, and forward a copy of the notification to the District Manager, within thirty (30) days of the occurrence of any of the following changes:

(1) the ownership of the Facility;

(2) the operator of the Facility;

(3) the address of the Company;

(4) the partners, where the Company is or at any time becomes a partnership and a copy of the most recent declaration filed under the *Business Names Act* , R.S.O. 1990, c.B.17, as amended, shall be included in the notification; and

(5) the name of the corporation where the Company is or at any time becomes a corporation, other than a municipal corporation, and a copy of the most current information filed under the *Corporations Information Act*, R.S.O. 1990, c. C.39, as amended, shall be included in the notification.

SCHEDULE A

Facility Description

The Class 3 solar facility, with a total name plate capacity of up to approximately 10 megawatts (AC), shall consist of the construction, installation, operation, use and retiring of the following:

(a) ten (10) ground mounted arrays of photovoltaic (PV) modules or panels, with each array consisting of approximately 4000-5000 PV modules, and one (1) 1 megawatt or two (2) 500 kilowatt inverters;

(b) one (1) 10 MVA step up power transformer substation; and

(c) associated ancillary equipment, systems and technologies including on-site access roads, switchgear, control and monitoring equipment, underground cabling and overhead distribution lines;

all in accordance with the application for a Renewable Energy Approval dated July 12, 2011 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the application, including amended documentation submitted up to May 9, 2012.

SCHEDULE B

Coordinates of the Equipment are listed below in UTM17-NAD83 projection:

Source ID	Sound Power Level (dBA) re 10^{-12}W	Easting (m)	Northing (m)	Source Description
NS-1	92	730,446	4,878,715	Array Inverter
NS-2	92	730,582	4,878,752	Array Inverter
NS-3	92	730,671	4,878,497	Array Inverter
NS-4	92	730,582	4,878,289	Array Inverter
NS-5	92	730,720	4,878,358	Array Inverter
NS-6	92	730,767	4,878,230	Array Inverter
NS-7	92	730,896	4,877,977	Array Inverter
NS-8	92	730,928	4,877,798	Array Inverter
NS-9	92	730,816	4,877,665	Array Inverter
NS-10	92	730,976	4,877,670	Array Inverter
NS-11	92	730,874	4,877,513	Array Inverter
NS-12	72	730,448	4,878,715	Array Transformer
NS-13	72	730,584	4,878,752	Array Transformer
NS-14	72	730,673	4,878,497	Array Transformer
NS-15	72	730,584	4,878,289	Array Transformer
NS-16	72	730,722	4,878,358	Array Transformer
NS-17	72	730,769	4,878,230	Array Transformer
NS-18	72	730,898	4,877,977	Array Transformer
NS-19	72	730,930	4,877,798	Array Transformer
NS-20	72	730,818	4,877,665	Array Transformer
NS-21	72	730,978	4,877,670	Array Transformer
NS-22	72	730,876	4,877,513	Array Transformer
NS-23	84	730,706	4,878,654	Transformer Substation 10 MVA
NS-24	84	730,835	4,878,313	Transformer Substation 10 MVA

Note: NS-23 and NS-24 are alternate locations for the single transformer substation.

The reasons for the imposition of these terms and conditions are as follows:

1. Conditions A.1 and A.2 are included to ensure that the Facility is constructed, installed, used, operated, maintained and retired in the manner in which it was described for review and upon which Approval was granted. These conditions are also included to emphasize the precedence of conditions in the Approval and the practice that the Approval is based on the most current document, if several conflicting documents are submitted for review.

2. Conditions A.3 and A.4 are included to require the Company to provide information to the public and the local municipality.

3. Conditions A.5 and A.6 are included to ensure that final retirement of the Facility is completed in an aesthetically pleasing manner, in accordance with Ministry standards, and to ensure long-term protection of the health and safety of the public and the environment.

4 Condition A.7 is included to require the Company to inform the Ministry of the commencement of activities related to the construction, installation and operation of the Facility.

5. Condition B is intended to limit the time period of the Approval.

6. Condition C.1 is included to provide the minimum performance requirement considered necessary to prevent an Adverse Effect resulting from the operation of the Equipment and to ensure that the noise emissions from the Equipment will be in compliance with applicable limits set in Publication NPC-205.

7. Conditions C.2 and C.3 are included to ensure that the Equipment is constructed, installed, used, operated, maintained and retired in a way that meets the regulatory setback prohibitions set out in O. Reg. 359/09.

8. Condition D is included to require the Company to gather accurate information so that the environmental noise impact and subsequent compliance with the Act, O. Reg. 359/09, Publication NPC-232 and this Approval can be verified.

9. Conditions E and G are included to ensure that the Facility is constructed, installed, used, operated, maintained and retired in a way that does not result in an Adverse Effect or hazard to the natural environment or any persons.

10. Condition F.1 is included to ensure that the sewage works of the transformer substation spill containment facility are designed to have adequate capacity to provide spill control. This condition is also included to enable compliance with this Approval, such that the environment is protected and deterioration, loss, injury or damage to any person, property or the environment is minimized and/or prevented.

11. Condition F.2 is included to ensure that the sewage works of the transformer substation spill containment facility will be designed, installed, operated and maintained in accordance with the information submitted by the Company, and to adequately manage and clean-up any oil spill from the transformer.

12. Condition F.3 is included to establish non-enforceable effluent quality objectives which the Company is required to strive towards on an ongoing basis. These objectives are to be used as a mechanism to trigger corrective action proactively and voluntarily before environmental impairment occurs.

13. Conditions F.4 and F.5 are included to require the Company to demonstrate that the performance of the sewage works of the transformer substation spill containment facility is at a level consistent with the design and effluent objectives specified in the Approval and is not causing any impairment to the environment.

14. Condition H is included to protect archaeological resources that may be found at the project location.

15. Condition I is included to emphasize that the Equipment must be maintained and operated according to a procedure that will result in compliance with the Act, O. Reg. 359/09 and this Approval.

16. Condition J is included to require the Company to keep records and provide information to staff of the Ministry so that compliance with the Act, O. Reg. 359/09 and this Approval can be verified.

17. Condition K is included to ensure that any complaints regarding the construction, installation, use, operation, maintenance or retirement of the Facility are responded to in a timely and efficient manner.

18. Condition L is included to ensure that the Facility is operated under the corporate name which appears on the application form submitted for this Approval and to ensure that the Director is informed of any changes.

NOTICE REGARDING HEARINGS

In accordance with Section 139 of the Environmental Protection Act, within 15 days after the service of this notice, you may by further written notice served upon the Director, the Environmental Review Tribunal and the Environmental Commissioner, require a hearing by the Tribunal.

In accordance with Section 47 of the Environmental Bill of Rights, 1993, the Environmental Commissioner will place notice of your request for a hearing on the Environmental Registry.

Section 142 of the Environmental Protection Act provides that the notice requiring the hearing shall state:

1. The portions of the renewable energy approval or each term or condition in the renewable energy approval in respect of which the hearing is required, and;

2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The signed and dated notice requiring the hearing should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The renewable energy approval number;
6. The date of the renewable energy approval;
7. The name of the Director;
8. The municipality or municipalities within which the project is to be engaged in;

This notice must be served upon:

The Secretary* Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto, Ontario M5G 1E5	AND	The Environmental Commissioner 1075 Bay Street, 6th Floor Suite 605 Toronto, Ontario M5S 2B1	AND	The Director Section 47.5, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

Under Section 142.1 of the Environmental Protection Act, residents of Ontario may require a hearing by the Environmental Review Tribunal within 15 days after the day on which notice of this decision is published in the Environmental Registry. By accessing the Environmental Registry at www.ebr.gov.on.ca, you can determine when this period ends.

Approval for the above noted renewable energy project is issued to you under Section 47.5 of the Environmental Protection Act subject to the terms and conditions outlined above.

DATED AT TORONTO this 16th day of May, 2012

Vic Schroter, P.Eng.
Director
Section 47.5, *Environmental Protection Act*

DM/
c: District Manager, MOE Peterborough
Glen Tomkinson, Penn Energy Renewables, Ltd.

Ontario

Ministry of the Environment
Ministère de l'Environnement

AMENDMENT TO RENEWABLE ENERGY APPROVAL

NUMBER 0905-8S7M96
Issue Date: October 15, 2012

Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc.
operating as Hamilton Solar Farm Partnership
620 Righters Ferry Rd
Bala Cynwyd, Pennsylvania
USA 19004

Site Location: Hamilton_Port Hope-4 Solar Energy Facility
2700 Payne Road
Lot 3, Concession 2
Hamilton Township, County of Northumberland

You are hereby notified that I have amended Approval No. 0905-8S7M96 issued on May 16, 2012 for a Class 3 solar facility , as follows:

A. The owner/ operator of the Facility has been deleted and replaced with:
Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc.
operating as Hamilton Solar Farm Partnership

B. The definition number 7 has been deleted and replaced with:

7. "Application" means the application for a Renewable Energy Approval dated July 12, 2011 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the application, including amended documentation submitted up to May 9, 2012 and as further amended by the Application for an amendment to a Renewable Energy Approval dated October 4, 2012 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the Application up to the date this amendment is issued;

C. The definition number 14 has been deleted and replaced with:

14. "Company" means Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc. operating as Hamilton Solar Farm Partnership, the partnership under the laws of Ontario, and any successor partnership or firm carrying on the same business to which this approval relates;

D. Schedule A is deleted and replaced with the following:

SCHEDULE A

Facility Description

The Facility shall consist of the construction, installation, operation, use and retiring of the following:

(a) ten (10) arrays of photovoltaic (PV) modules or panels with a total name plate capacity of up to approximately 10 megawatts (AC), with each array containing one (1) cluster of two (2) 500 kilowatt inverters and one (1) 27.6 kV/ 1-MVA transformer; and

(b) associated ancillary equipment, systems and technologies including, but not limited to, one (1) transformer substation, on-site access roads, below and above grade cabling, and below and above grade distribution lines,

all in accordance with the Application.

This Notice shall constitute part of the approval issued under Certificate of Approval No. 0905-8S7M96 dated May 16, 2012

NOTICE REGARDING HEARINGS

In accordance with Section 139 of the Environmental Protection Act, within 15 days after the service of this notice, you may by further written notice served upon the Director, the Environmental Review Tribunal and the Environmental Commissioner, require a hearing by the Tribunal.

In accordance with Section 47 of the Environmental Bill of Rights, 1993, the Environmental Commissioner will place notice of your request for a hearing on the Environmental Registry.

Section 142 of the Environmental Protection Act provides that the notice requiring the hearing shall state:

1. The portions of the renewable energy approval or each term or condition in the renewable energy approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The signed and dated notice requiring the hearing should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The renewable energy approval number;
6. The date of the renewable energy approval;
7. The name of the Director;
8. The municipality or municipalities within which the project is to be engaged in;

This notice must be served upon:

The Secretary* Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto, Ontario M5G 1E5	AND	The Environmental Commissioner 1075 Bay Street, 6th Floor Suite 605 Toronto, Ontario M5S 2B1	AND	The Director Section 9, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ene.gov.on.ca, you can determine when the leave to appeal period ends.

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 15th day of October, 2012

Vic Schroter, P.Eng.
Director
Section 47.5, *Environmental Protection Act*

MK/
c: District Manager, MOE Peterborough
Sean McCloskey/Glen Tomkinson, Hamilton General Partner 1 Inc./Penn Energy Renewables, Ltd.

Ministry of the Environment
Ministère de l'Environnement

AMENDMENT TO RENEWABLE ENERGY APPROVAL

NUMBER 0905-8S7M96
Issue Date: March 4, 2014

Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc.
operating as Hamilton Solar Farm Partnership
620 Righters Ferry Rd
Bala Cynwyd, Pennsylvania
USA 19004

Site Location: Hamilton_Port Hope-4 Solar Energy Facility
2700 Payne Road
Lot 3, Concession 2
Hamilton Township, County of Northumberland K0K 1C0

You are hereby notified that I have amended Approval No. 0905-8S7M96 issued on May 16, 2012 for a Class 3 solar project , as follows:

A. The definitions of "Acoustic Assessment Report" and "Application" in the Approval are deleted and replaced by the following.

1. "Acoustic Assessment Report" means the report included in the Application and entitled Acoustic Assessment Report Penn Energy-Hamilton Port Hope 4 Solar Farm, County of Northumberland, Ontario, dated August 28, 2013, prepared by HGC Engineering and signed by Petr Chocensky PhD and Ian Bosma, P.Eng.;

7. "Application" means the application for a Renewable Energy Approval dated July 12, 2011 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the application, including amended documentation submitted up to May 9, 2012; and as further amended by the application for a Renewable Energy Approval dated October 4, 2012 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, Penn Energy Renewables, Ltd., and all supporting documentation submitted with the application, including amended documentation submitted up to October 15, 2012; and as further amended by the application for a Renewable Energy Approval dated October 9, 2013 and signed by Glen Tomkinson, Project Manager/ REA Coordinator, on behalf of Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc. operating as Hamilton Solar Farm Partnership, and all supporting documentation submitted with the application, including amended documentation submitted up to February 25, 2014.

B. Schedule B of the Approval is deleted and replaced by the following:

Coordinates of the Equipment are listed below in UTM17-NAD83 projection:

Source ID	Sound Power Level [dBA re 10^{-12} W]	UTM Coordinates [m]		Source Description
		Easting	Northing	
NS-01	91	730,427	4,878,699	Array Inverter
NS-02	91	730,602	4,878,756	Array Inverter
NS-03	91	730,671	4,878,496	Array Inverter
NS-04	91	730,658	4,878,316	Array Inverter
NS-05	91	730,706	4,878,364	Array Inverter
NS-06	91	730,763	4,878,212	Array Inverter
NS-07	91	730,903	4,877,955	Array Inverter
NS-08	91	730,937	4,877,746	Array Inverter
NS-09	91	730,871	4,877,689	Array Inverter
NS-10	91	730,921	4,877,557	Array Inverter
NS-11	69	730,432	4,878,699	Array Transformer
NS-12	69	730,607	4,878,756	Array Transformer
NS-13	69	730,673	4,878,496	Array Transformer
NS-14	69	730,663	4,878,316	Array Transformer
NS-15	69	730,702	4,878,364	Array Transformer
NS-16	69	730,759	4,878,212	Array Transformer
NS-17	69	730,898	4,877,955	Array Transformer
NS-18	69	730,933	4,877,747	Array Transformer
NS-19	69	730,876	4,877,689	Array Transformer
NS-20	69	730,926	4,877,556	Array Transformer
NS-21	88	730,748	4,878,623	Transformer 10 MVA

Note: A five (5) dB tonal penalty is included in the above sound power levels.

All other Terms and Conditions of the Approval remain the same.

This Notice shall constitute part of the approval issued under Approval No. 0905-8S7M96 dated May 16, 2012

In accordance with Section 139 of the Environmental Protection Act, within 15 days after the service of this notice, you may by further written notice served upon the Director, the Environmental Review Tribunal and the Environmental Commissioner, require a hearing by the Tribunal.

In accordance with Section 47 of the Environmental Bill of Rights, 1993, the Environmental Commissioner will place notice of your request for a hearing on the Environmental Registry.

Section 142 of the Environmental Protection Act provides that the notice requiring the hearing shall state:

1. The portions of the renewable energy approval or each term or condition in the renewable energy approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The signed and dated notice requiring the hearing should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The renewable energy approval number;
6. The date of the renewable energy approval;
7. The name of the Director;
8. The municipality or municipalities within which the project is to be engaged in;

This notice must be served upon:

The Secretary***** Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto, Ontario M5G 1E5	AND	The Environmental Commissioner 1075 Bay Street, 6th Floor Suite 605 Toronto, Ontario M5S 2B1	AND	The Director Section 47.5, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

Under Section 142.1 of the Environmental Protection Act, residents of Ontario may require a hearing by the Environmental Review Tribunal within 15 days after the day on which notice of this decision is published in the Environmental Registry. By accessing the Environmental Registry at www.ebr.gov.on.ca , you can determine when this period ends.

Approval for the above noted renewable energy project is issued to you under Section 47.5 of the <u>*Environmental Protection Act*</u> *subject to the terms and conditions outlined above*.

DATED AT TORONTO this 4th day of March, 2014

Vic Schroter, P.Eng.
Director
Section 47.5, *Environmental Protection Act*

MK/

c: District Manager, MOE Peterborough
Glen Tomkinson, Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc. operating as Hamilton Solar Farm Partnership

Appendix B

PROVIINCIAL ORDERS (FOR REFERENCE)

Ministry of the Environment
Ministère de l'Environnement

Provincial Officer's Order

Environmental Protection Act, R.S.O. 1990, c. E.19 (EPA)
Ontario Water Resources Act, R.S.O. 1990, c. O.40 (OWRA)
Pesticides Act, R.S.O. 1990, c. P.11 (PA)
Safe Drinking Water Act, 2002, S.O. 2002, c.32 (SDWA)
Nutrient Management Act, 2002, S.O. 2002, c.4 (NMA)

Order Number
8280-9HTLDU

Incident Report No.
2248-9HERUW

To: Hamilton General Partner 1 Inc. and Hamilton General Partner 2 Inc. operating as Hamilton Solar Farm Partnership
620 Righters Ferry Rd
Bala Cynwyd, Pennsylvania, 19004
USA

Canadian Solar Solutions Inc.
545 Speedvale Ave W
Guelph, Ontario, N1K 1E6
Canada

Site: 2700 Payne Rd
Hamilton, County of Northumberland

Pursuant to my authority under EPA Section 157.1, I order you jointly and severally to do the following:

Work Ordered

Item No. 1 **Compliance Date** 2014/04/03 (YYYY/MM/DD)

Forthwith do everything practicable to prevent, eliminate and ameliorate the potential for adverse effects caused by the discharge of the contaminant, being soil-sediment laden run-off/drainage water to the natural environment.

Item No. 2 **Compliance Date** 2014/04/11 (YYYY/MM/DD)

By April 11, 2014, submit to the undersigned Provincial Officer, a written Action Plan outlining the mitigation measures that have been and will be undertaken at the site to control and prevent the discharge sediment laden run-off/drainage water to the natural environment. The Action Plan shall include an Implementation Schedule.

Item No. 3 **Compliance Date**

2014/04/03
(YYYY/MM/DD)

Forthwith engage the services of a contractor/consultant experienced in the management of storm water and run-off from construction and post-construction sites, who has appropriate qualifications and abilities to undertake the requirements of work order #1 and #2 of this Provincial Officer's Order.

A. While this Order is in effect, a copy or copies of this order shall be posted in a conspicuous place.

B. While this Order is in effect, report in writing, to the District or Area office, any significant changes of operation, emission, ownership, tenancy or other legal status of the facility or operation.

C. Unless otherwise specified, all requirements of this Order are effective upon service of this Order.

This Order is being issued for the reasons set out in the annexed Provincial Officers Report which forms part of this Order.

Issued at Toronto this 3 rd day of April, 2014.

Cathy Curlew

Cathy Curlew
Badge No: 777
Peterborough District Office
Tel: (705) 755-4338

APPEAL/REVIEW INFORMATION

REQUEST FOR REVIEW

You may request that this order be reviewed by the Director. Your request must be made in writing (or orally with written confirmation) within seven days of service of this order and sent by mail or fax to the Director at the address below. In the written request or written confirmation you must,

- specify the portions of this order that you wish to be reviewed;
- include any submissions to be considered by the Director with respect to issuance of the order to you or any other person and with respect to the contents of the order;
- apply for a stay of this order, if necessary; and provide an address for service by one of the following means:

1. mail 2. fax

The Director may confirm, alter or revoke this order. If this order is revoked by the Director, you will be notified in writing. If this order is confirmed or amended by order of the Director, the Director's order will be served upon you. The Director's order will include instructions for requiring a hearing before the Environmental Review Tribunal.

DEEMED CONFIRMATION OF THIS ORDER

If you do not receive oral or written notice of the Director's decision within seven days of receipt of your request, this order is deemed to be confirmed by order of the Director and deemed to be served upon you.

You may require a hearing before the Environmental Review Tribunal if, within 15 days of service of the confirming order deemed to have been made by the Director, you serve written notice of your appeal on the Environmental Review Tribunal and the Director. Your notice must state the portions of the order for which a hearing is required and the grounds on which you intend to rely at the hearing. Except by leave of the Environmental Review Tribunal , you are not entitled to appeal a portion of the order or to rely on grounds of appeal that are not stated in the notice requiring the hearing. Unless stayed by the Environmental Review Tribunal , the order is effective from the date of service.

Written notice requiring a hearing must be served personally, by mail or facsimile on the following:

The Secretary Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto ON M5G 1E5 Fax: (416) 314-4506 Email: ERTTribunalsecretary@ontario.ca	and	Director (Provincial Officer Orders) Ministry of the Environment Peterborough District Office 2nd Floor South Tower 300 Water St S Peterborough ON K9J 8M5 Fax: (705)755-4321 Tel: (705)755-4300

Where service is made by mail, it is deemed to be made on the fifth day after the date of mailing and the time for requiring a hearing is not extended by choosing service by mail.

Further information on the Environmental Review Tribunal 's requirements for an appeal can be obtained directly from the Tribunal by:

Tel: (416) 314-4600 Fax: (416) 314-4506 www.ert.gov.on.ca

FOR YOUR INFORMATION

- Unless stayed by the Director or the Environmental Review Tribunal , this order is effective from the date of service. Non-compliance with the requirements of this order constitutes an offence.
- The requirements of this order are minimum requirements only and do not relieve you from complying with the following:
  - any applicable federal legislation;
  - any applicable provincial requirements that are not addressed in the order; and
  - any applicable municipal law.
- The requirements of this order are severable. If any requirement of this order or the application of any requirement to any circumstance is held invalid, the application of such requirement to other circumstances and the remainder of the order are not affected.
- Further orders may be issued in accordance with the legislation as circumstances require.
- The procedures to request a review by the Director and other information provided above are intended as a guide. The legislation should be consulted for additional details and accurate reference.

Ministry of the Environment
Ministère de l'Environnement

Provincial Officer's Order

Environmental Protection Act, R.S.O. 1990, c. E.19 (EPA)
Ontario Water Resources Act, R.S.O. 1990, c. O.40 (OWRA)
Pesticides Act, R.S.O. 1990, c. P.11 (PA)
Safe Drinking Water Act, 2002, S.O. 2002, c.32 (SDWA)
Nutrient Management Act, 2002, S.O. 2002, c.4 (NMA)

Order Number
0261-9J7KVH

Incident Report No.
2248-9HERUW

To:

Canadian Solar Solutions Inc.
545 Speedvale Ave W
Guelph, Ontario, N1K 1E6
Canada

ABB Inc.
3450 Harvester Rd
Burlington, Ontario, L7N 3W5
Canada

Naylor Group Inc.
455 North Service Rd E
Oakville, Ontario, L6H 1A5
Canada

Hamilton General Partners 1 Inc.
1 Yonge St suite 1801
Toronto, Ontario, M5E 1W7
Canada

Hamilton General Partner 2 Inc.,
1 Yonge St suite 1801
Toronto, Ontario, M5E 1W7
Canada

Site:

2700 Payne Rd
Hamilton, County of Northumberland

Work Ordered

Pursuant to my authority under EPA Section 157.1 and OWRA Section 16, I order you jointly and severally to do the following:

Item No. 1 **Compliance Date** 2014/04/17
(YYYY/MM/DD)

By April 17, 2014, prepare and submit to the undersigned Provincial Officer a contingency plan to address and prevent the run-off of sediment laden water from the Site during and following rain and/or wet weather events. The contingency plan shall be prepared by a qualified person with experience and expertise in storm water management and shall include but not necessarily be limited to a schedule for implementation of proposed measures. Provisions for the inspection of the Site on a twenty-four (24) hour basis and availability of personnel to respond to environmental emergency situations.

A. While this Order is in effect, a copy or copies of this order shall be posted in a conspicuous place.

B. While this Order is in effect, report in writing, to the District or Area office, any significant changes of operation, emission, ownership, tenancy or other legal status of the facility or operation.

C. Unless otherwise specified, all requirements of this Order are effective upon service of this Order.

This Order is being issued for the reasons set out in the annexed Provincial Officers Report which forms part of this Order.

Issued at Toronto this 15th day of April, 2014.

Cathy Curlew

Cathy Curlew
Badge No: 777
Peterborough District Office
Tel: (705) 755-4338

APPEAL/REVIEW INFORMATION

REQUEST FOR REVIEW

You may request that this order be reviewed by the Director. Your request must be made in writing (or orally with written confirmation) within seven days of service of this order and sent by mail or fax to the Director at the address below. In the written request or written confirmation you must,

- specify the portions of this order that you wish to be reviewed;
- include any submissions to be considered by the Director with respect to issuance of the order to you or any other person and with respect to the contents of the order;
- apply for a stay of this order, if necessary; and provide an address for service by one of the following means:

1. mail 2. fax

The Director may confirm, alter or revoke this order. If this order is revoked by the Director, you will be notified in writing. If this order is confirmed or amended by order of the Director, the Director's order will be served upon you. The Director's order will include instructions for requiring a hearing before the Environmental Review Tribunal.

DEEMED CONFIRMATION OF THIS ORDER

If you do not receive oral or written notice of the Director's decision within seven days of receipt of your request, this order is deemed to be confirmed by order of the Director and deemed to be served upon you.

You may require a hearing before the Environmental Review Tribunal if, within 15 days of service of the confirming order deemed to have been made by the Director, you serve written notice of your appeal on the Environmental Review Tribunal and the Director. Your notice must state the portions of the order for which a hearing is required and the grounds on which you intend to rely at the hearing. Except by leave of the Environmental Review Tribunal , you are not entitled to appeal a portion of the order or to rely on grounds of appeal that are not stated in the notice requiring the hearing. Unless stayed by the Environmental Review Tribunal , the order is effective from the date of service.

Written notice requiring a hearing must be served personally, by mail or facsimile on the following:

The Secretary Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto ON M5G 1E5 Fax: (416) 314-4506 Email: ERTTribunalsecretary@ontario.ca	and	Director (Provincial Officer Orders) Ministry of the Environment Peterborough District Office 2nd Floor South Tower 300 Water St S Peterborough ON K9J 8M5 Fax: (705)755-4321 Tel: (705)755-4300

Where service is made by mail, it is deemed to be made on the fifth day after the date of mailing and the time for requiring a hearing is not extended by choosing service by mail.

Further information on the Environmental Review Tribunal 's requirements for an appeal can be obtained directly from the Tribunal by:

Tel: (416) 314-4600 Fax: (416) 314-4506 www.ert.gov.on.ca

FOR YOUR INFORMATION

- Unless stayed by the Director or the Environmental Review Tribunal , this order is effective from the date of service. Non-compliance with the requirements of this order constitutes an offence.
- The requirements of this order are minimum requirements only and do not relieve you from complying with the following:
  - any applicable federal legislation;
  - any applicable provincial requirements that are not addressed in the order; and
  - any applicable municipal law.
- The requirements of this order are severable. If any requirement of this order or the application of any requirement to any circumstance is held invalid, the application of such requirement to other circumstances and the remainder of the order are not affected.
- Further orders may be issued in accordance with the legislation as circumstances require.
- The procedures to request a review by the Director and other information provided above are intended as a guide. The legislation should be consulted for additional details and accurate reference.

Ontario

Ministry of the Environment
Ministère de l’Environnement

Provincial Officer's Order

Environmental Protection Act, R.S.O. 1990, c. E.19 (EPA)
Ontario Water Resources Act, R.S.O. 1990, c. O.40 (OWRA)
Pesticides Act, R.S.O. 1990, c. P.11 (PA)
Safe Drinking Water Act, 2002, S.O. 2002, c.32 (SDWA)
Nutrient Management Act, 2002, S.O. 2002, c.4 (NMA)

Order Number
0311-9MXHBK

Incident Report No.
0352-9MWDZM

To: ABB Inc.
3450 Harvester Rd
Burlington, Ontario, L7N 3W5
Canada

Canadian Solar Solutions Inc.
545 Speedvale Ave W
Guelph, Ontario, N1K 1E6
Canada

Naylor Renewable Energy
455 North Service East Rd E
Oakville, Ontario, L6H 1A5
Canada

Hamilton General Partners 1 Inc.
1 Yonge St suite 1801
Toronto, Ontario, M5E 1W7
Canada

Hamilton General Partner 2 Inc.,
1 Yonge St suite 1801
Toronto, Ontario, M5E 1W7
Canada

Site: 2720 Payne Rd
Hamilton, County of Northumberland

Pursuant to my authority under EPA Section 157.1, EPA Section 196(1) and EPA Section 157, I order you jointly and severally to do the following:

Work Ordered

Item No. 1 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

By August 26, 2014, prepare and submit to the issuing Provincial Officer an update to the contingency plan prepared by Aecom and dated July 11, 2014. The updated contingency plan shall be prepared by a qualified person with experience and expertise in storm water management and shall include but not necessarily be limited to the following:

- Schedule for implementation of proposed measures.
- Implementation of the plan in accordance with the proposed implementation schedule.
- Identification of how the comments provided by Ministry Surface Water Specialist Beth Gilbert, in a memorandum dated July 30, 2014, a copy of which is attached hereto as Appendix A, will be addressed.
- A written procedure including a list of criteria that is assessed to determine when the contingency plan is implemented.
- Identification of the name(s) of individuals responsible for implementing the contingency plan.
- A description of the steps that will be taken to implement the different stages of the contingency plan.
- A proposed method for settling sediment and achieving suitable water quality to discharge off-site.
- A proposed monitoring plan to determine if storm water is of suitable quality to discharge off-site.

Item No. 2 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

By August 26, 2014, submit a completed storm water management plan for storm water management at the Site which shall include but not necessarily be limited to the following:

- An assessment of the current storm water management measures at the Site signed and stamped by a Professional Engineer with experience and expertise in storm water management
- Recommendations for additional mitigation measures to prevent silt laden run-off from leaving the Site, which shall include but not be limited to the measures described in the ministry publication “Stormwater Management Planning and Design Manual" (March 2003);

Item No. 3 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

By August 26, 2014, prepare and submit to the issuing Provincial Officer an update to the Erosion and Sedimentation Control Plan (ESCP) dated July 2014 prepared by Aecom, that has been prepared by a qualified person with experience and expertise in storm water management and erosion control. The update shall include but not necessarily be limited to a schedule for stabilizing the soils/slopes at the site in a manner that will prevent sheeting and sedimentation of rain water/snow melt during rain and wet weather events. The implementation of the updated ESCP shall be in accordance with the proposed implementation schedule.

Item No. 4 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

By August 26, 2014, prepare and submit to the issuing Provincial Officer a performance monitoring reporting program for the Site prepared by a qualified person with experience and expertise in storm water management. The performance monitoring reporting program shall address comments by ministry Surface Water Specialist Beth Gilbert in her memorandum dated July 17, 2014 including but not limited to point 18 of the technical memorandum and her email dated August 14, 2014 (copies of these documents are appended to the Order). The proposed performance monitoring reporting program for the Site shall be implemented by August 26, 2014.

Item No. 5 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

By August 26, 2014 prepare and submit to the issuing Provincial Officer a report detailing surface water monitoring results from the Site for the time period of April - July 2014.

Item No. 6 **Compliance Date** 2014/08/26
(YYYY/MM/DD)

Commencing on the 15th day of September and on the 15th day of each month thereafter, prepare and submit to the issuing Provincial Officer a report detailing surface water monitoring results from the Site for the previous month.

A. While this Order is in effect, a copy or copies of this order shall be posted in a conspicuous place.

B. While this Order is in effect, report in writing, to the District or Area office, any significant changes of operation, emission, ownership, tenancy or other legal status of the facility or operation.

C. Unless otherwise specified, all requirements of this Order are effective upon service of this Order.

This Order is being issued for the reasons set out in the annexed Provincial Officers Report which forms part of this Order.

Issued at Peterborough this 15th day of August, 2014.

Cathy Curlew

Cathy Curlew
Badge No: 777
Peterborough District Office
Tel: (705) 755-4338

APPEAL/REVIEW INFORMATION

REQUEST FOR REVIEW

You may request that this order be reviewed by the Director. Your request must be made in writing (or orally with written confirmation) within seven days of service of this order and sent by mail or fax to the Director at the address below. In the written request or written confirmation you must,

- specify the portions of this order that you wish to be reviewed;
- include any submissions to be considered by the Director with respect to issuance of the order to you or any other person and with respect to the contents of the order;
- apply for a stay of this order, if necessary; and provide an address for service by one of the following means:

1. mail   2. fax

The Director may confirm, alter or revoke this order. If this order is revoked by the Director, you will be notified in writing. If this order is confirmed or amended by order of the Director, the Director's order will be served upon you. The Director's order will include instructions for requiring a hearing before the Environmental Review Tribunal.

DEEMED CONFIRMATION OF THIS ORDER

If you do not receive oral or written notice of the Director's decision within seven days of receipt of your request, this order is deemed to be confirmed by order of the Director and deemed to be served upon you.

You may require a hearing before the Environmental Review Tribunal if, within 15 days of service of the confirming order deemed to have been made by the Director, you serve written notice of your appeal on the Environmental Review Tribunal and the Director. Your notice must state the portions of the order for which a hearing is required and the grounds on which you intend to rely at the hearing. Except by leave of the Environmental Review Tribunal , you are not entitled to appeal a portion of the order or to rely on grounds of appeal that are not stated in the notice requiring the hearing. Unless stayed by the Environmental Review Tribunal , the order is effective from the date of service.

Written notice requiring a hearing must be served personally, by mail or facsimile on the following:

The Secretary Environmental Review Tribunal 655 Bay Street, 15th Floor Toronto ON M5G 1E5 Fax: (416) 314-4506 Email: ERTTribunalsecretary@ontario.ca	and	Director (Provincial Officer Orders) Ministry of the Environment Peterborough District Office 2nd Floor South Tower 300 Water St S Peterborough ON K9J 8M5 Fax: (705) 755-4321 Tel: (705)755-4300

Where service is made by mail, it is deemed to be made on the fifth day after the date of mailing and the time for requiring a hearing is not extended by choosing service by mail.

Further information on the Environmental Review Tribunal 's requirements for an appeal can be obtained directly from the Tribunal by:

Tel: (416) 314-4600   Fax: (416) 314-4506   www.ert.gov.on.ca

FOR YOUR INFORMATION

- Unless stayed by the Director or the Environmental Review Tribunal , this order is effective from the date of service. Non-compliance with the requirements of this order constitutes an offence.
- The requirements of this order are minimum requirements only and do not relieve you from complying with the following:
  - any applicable federal legislation;
  - any applicable provincial requirements that are not addressed in the order; and
  - any applicable municipal law.
- The requirements of this order are severable. If any requirement of this order or the application of any requirement to any circumstance is held invalid, the application of such requirement to other circumstances and the remainder of the order are not affected.
- Further orders may be issued in accordance with the legislation as circumstances require.
- The procedures to request a review by the Director and other information provided above are intended as a guide. The legislation should be consulted for additional details and accurate reference.

Appendix C

POST-CONSTRUCTION STORMWATER
MANAGEMENT REPORT

Post–Construction Stormwater Management Report

Hamilton – Port Hope 4 Solar Farm, Hamilton Township, Ontario

Prepared for:
Canadian Solar Solutions Inc.
545 Speedvale Avenue West
Guelph, Ontario
N1K 1E6

Prepared by:
McIntosh Perry Consulting Engineers Ltd.
1-1329 Gardiners Road
Kingston, Ontario
K7P 0L8

March 2017

MPCE No. PP-14-9580

Table of Contents

LIST OF APPENDICES

LIST OF DRAWINGS

Report Limitations

This report was produced for the exclusive use of Canadian Solar Solutions Inc. (CSSI). The purpose of the report is to assess the existing stormwater management system and provide post-construction recommendations and designs that are in compliance with the guidelines and standards from the Ministry of the Environment and Climate Change (MOECC). McIntosh Perry reviewed the Stormwater Management Report and addendums prepared by AECOM. While the previous data was reviewed by McIntosh Perry and site visits were performed, no field verification/measures of any information were conducted.

Any use of this review by a third party, or any reliance on decisions made based on it, without a reliance report is the responsibility of such third parties. McIntosh Perry accepts no responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this review.

McIntosh Perry's scope was concentrated on the review and revision of the outlets to the temporary construction ponds including: removing ponds, if required; improving erosion and sediment control performance by reducing concentrated flows and flow volumes; and, increasing the use of measures that promote sheet flow, wherever possible. We have not evaluated/sized the interior ditches, culverts and sediment and erosion controls other than those noted within this report. Please note that there are additional controls on site that were installed previously and that are not explicitly noted in this report, but that were installed by the Contractor during construction which are believed to have been installed following typical best management practises. The design of these best management practises was performed by others.

The findings, conclusions and/or recommendations of this report are only valid as of the date of this report. No assurance is made regarding any changes in conditions subsequent to this date. If additional information is discovered or becomes available at a future date, McIntosh Perry should be requested to re-evaluate the conclusions presented in this report, and provide amendments, if required.

Report Context

The pre-development conditions were a farmed crop field similar to the adjacent properties to the north and south. The construction practises on site included regrading, road construction and pile installation over a period from April 2013 to August 2014. During construction, the Contractor installed erosion and sediment controls throughout the site that were consistent with best management practises. However, as a result of turbid water being released offsite in April 2014, ponds were built at various locations in and around the project site on an emergency basis to prevent further discharge.

This report along with the amended REA application is being submitted to the Ministry of the Environment and Climate Change (MOECC) for their review and approval in order to update stormwater management-related aspects of the REA. The amended REA, once approved, will include changes to some project boundaries to account for stormwater management measures that were added at the site including three (3) permanent ponds. Two (2) temporary construction ponds will have been removed or regraded.

Provincial Officer's Orders were issued by the MOECC on April 3, 2014, April 15, 2014 and August 15, 2014. The Orders placed a number of requirements on the project, including implementing a water quality monitoring program and providing an updated stormwater management design. Water quality monitoring data has been collected for several months and the vegetation has taken root. The monitoring reports prepared by Dillon Consulting, AECOM and GHD indicate that the site is trending in the right direction in regards to water quality (i.e.: collected stormwater has significantly lower turbidity and TSS as the vegetation establishes) and through discussions with local MOECC officer, the number of monitoring locations have been reduced given the data indicates no further issues exist in some locations.

This stormwater management report describes the post-construction rehabilitation design in which the remaining permanent ponds have free flowing, gravity outlets. The site is expected to be able to function as a passive or remotely operated site (e.g., no mechanical or manual operating of gate valves, etc.). The report will also provide details on how the site achieves its quality and quantity control objectives through the implementation of infiltration and dry ponds respectively. The report describes additional best management practises in regards to the implementation of erosion and sediment controls and site maintenance best practices.

It should be noted that the goal of this post-construction rehabilitation design is to ensure that the site is operating efficiently and meeting the criteria set forth by the MOECC, the local conservation authority and the municipality.

1.0 PURPOSE

This report has been prepared at the request of Canadian Solar Solutions Inc. (CSSI) to assess the existing stormwater management system and describe the post-construction rehabilitation design that brings the site into compliance with the guidelines and standards from the Ministry of the Environment and Climate Change (MOECC). The original Stormwater Management Reports for the Hamilton – Port Hope 4 solar site were prepared by AECOM (dated July 2013 and August 2014).

This document focuses primarily on two major post-construction issues; the interior drainage patterns that caused erosion and the outfalls of the site (SWM ponds). In addition, the document describes the removal of the temporary stormwater management ponds that were constructed but are not necessary. For the purpose of this report, the rehabilitation design for the Block 10 area is described in a separate standalone document, Appendix F.

The goal of the rehabilitation design is to ensure that the site will function as originally intended. To implement the rehabilitation design, the Contractor will need to undertake earth excavation and placement activities. The Contractor will also be required to implement the proposed erosion and sediment control measures as described in Section 5.0 and specified on the attached engineering design drawings. The proposed earth moving activities will be limited as much as feasible on site and in areas where stormwater management ponds are to be modified. The Contractor is required to prepare and adhere to a control plan for any stockpiled material on site. This plan will address the potential for erosion and sediment migration and should ensure there are no negative impacts to any neighbouring waterbodies or downstream infrastructure. The report provides recommendations to CSSI and the Contractor regarding items such as routine monitoring of the performance of the erosion and sediment controls surrounding the stockpiles, as well as all erosion controls on site, to ensure they are operating as intended throughout construction. Items such as ongoing construction supervision during earth moving activities and until vegetation is rooted will be discussed to ensure that the construction activities minimize the potential for future erosion. Additional information pertaining to erosion and sediment control has been provided in Section 5.0.

2.0 SITE DESCRIPTION

The property is located on Payne Road, within the Township of Hamilton, north of the Town of Cobourg. The legal description of the land is Part of Lot 3, Concession 2, in the Township of Hamilton. The project area encompasses approximately 40 hectares and is bounded by rural residential agricultural lands to the east, north and south and by forested lands to the west. A location plan has been provided in Appendix A.

Drainage of the developed site is primarily via overland sheet flow and concentrated flow within interior and roadside ditches. The rolling site topography ranges in elevation from 223m at the south end of the development to 256m at the north west limits of the development. The site is located at the highpoint of several drainage areas with runoff from the site entering into the Cobourg Creek Watershed and the Brook Creek Watershed - spread over several tributaries.

As per AECOM reports (noted in section 2.1.2) the majority of pre-developed site was farmed (crop land). The exception to this land use was areas on the west of the site that are woodlands as well as a significant valleyland to the south of the site. The solar farm construction included, but was not limited to, gravel access lanes, foundations and racking equipment for solar photovoltaic panels and the necessary appurtenances. Furthermore, erosion and sediment control measures were implemented on site during construction and have been repaired and monitored during the post-construction period. The bare and areas of concern in proximity to the erosion and sediment control measures that were installed appear to be re-establishing themselves.

2.1 BACKGROUND REVIEW

2.1.1 *Geotechnical Investigation Report – January 2011*

A Geotechnical Investigation Report was prepared by Genivar (now WSP), dated January 2011. As part of the investigation, WSP completed 10 boreholes. Boreholes were terminated between 5.0m and 6.6m generally within dense silty sand material. A single borehole contained groundwater at a depth of 6.2m below existing grade.

Topsoil was found to be between 200 and 300mm in thickness. A layer of sandy silt was encountered in one of the boreholes, while the remainder were composed of glacial till extending to the termination of the boreholes. The soils generally became denser with depth, with dense to very dense soils being encountered below 3.0m.

Refer to the report prepared by WSP for further details and recommendations pertaining to the site.

A follow up investigation was prepared by WSP in the spring of 2015 where additional boreholes were taken throughout areas adjacent to the ponds on site. The boreholes illustrate the soil composition and approximate depths to groundwater (if present). Generally, the soils were consistent with those detailed in their original report. Theoretical infiltration rates were also noted for the soils, with the majority falling into the 50mm/hr range represented by silty sand with N-values > 30.

2.1.2 *Roads, Stormwater Management and Grading Report for the Hamilton Port Hope 4 1PV Solar Project – July 2013 – Updated August 2014*

The original stormwater management and grading report was prepared by AECOM, dated July 2013 and revised August 2014. As part of the investigation, AECOM reviewed the on-site drainage areas and the capacity of the on-site stormwater management facilities.

The August 2014 report reviewed specific locations on-site where runoff had been problematic or erosion was present. Additional control measures and ponds were proposed. Some of these control measures and ponds were required for the construction period only and are no longer required in the post-development, vegetated state of the project. As such, these temporary control measures and ponds have been revised.

A review of the report prepared by AECOM noted that the stormwater was modelled using the rational method. Due to the size of the drainage areas, size of ponds and number of storm events required to be reviewed by the MOECC, we have determined that it would be prudent to model the site using modeling software and increase the rainfall volumes proposed by AECOM in order to promote a more conservative design.

3.0 PROPOSED STORMWATER MANAGEMENT

3.1 DESIGN CRITERIA AND METHODOLOGY

In the absence of a sub-watershed plan for this area, the MOECC Stormwater Management Planning and Design Manual (March 2003) is used to govern the management of stormwater. This methodology promotes water management from an environmentally sustainable perspective. The intent of this rehabilitation plan is to provide adequate stormwater treatment for both quantity and quality control.

The rehabilitation plan for the project location ensures that post-development drainage is consistent with pre-development drainage patterns. Currently, sheet flow runoff over grassed slopes is providing the continued opportunity for large particle settlement. Runoff from the solar panels is directed onto grassed areas and conveyed via overland sheet flow into grass lined ditches. The site currently employs five temporary end-of-pipe controls (four discussed in the main body of this report and one discussed in Appendix F) allowing for both on-site quantity and quality control. Additional quality control measures are in place throughout the site which includes rock flow check dams, enhanced grassed swales, etc. These measures will remain in place during the rehabilitation works.

As part of the rehabilitation design, runoff calculations, hydraulic grade line (HGL) analysis, and stormwater management pond design were completed with the aid of the computer modelling program CivilStorm™ developed by Bentley Systems. CivilStorm™ is a dynamic hydraulic modelling program developed for the analysis of complex stormwater systems. It is used to analyse drainage and detention facilities for systems with hydraulically-connected elements. CivilStorm™ provides calculations for catchment runoff, gutters, inlets, junctions, pipe and prismatic channel networks, ponds and outfalls.

The procedure presented by the Soil Conservation Service (SCS) was used in the CivilStorm™ model to generate rainfall runoff hydrographs for each drainage area. The rainfall runoff generated in the SCS procedure is based upon land use and soil type criteria, which are discussed below.

The Hydrologic Soils Group (HSG) of the soils for the site and surrounding area have been classified as type 'B' soils as noted within the geotechnical report prepared by AECOM and Genivar (WSP).

The hydrologic state of the soil condition before a storm event and how it will affect runoff probability is known as the antecedent moisture condition (AMC). The state of the soils and the location of the site have classified these soils as category II "Average conditions".

Using the classification above, the function of soil cover type and condition, the percentage of impervious area in the watershed and the percent directly or indirectly connected impervious area, each soil is given a curve number (CN). In cases where there are multiple land uses in a single drainage area, a weighted number is calculated. This weighted value is called the composite curve number (CNc). The curve numbers used have been discussed further in Section 3.3 of this report.

3.1.1 *Stormwater Pond Design Parameters*

The evaluation of the stormwater management pond design is also derived using the CivilStorm™ modelling program. The CivilStorm™ modelling program uses a dynamic wave analysis, which determines the performance of the pond based upon physical size and available volume (entered in CivilStorm™ through an elevation-volume selection), inflows, the allowable outflows, and backwater effects from the downstream receiving watercourse. The allowable outflows are determined by the outlet structure.

It should be noted that the pond outlet will be a pipe extending to the existing creek downstream of the site. As the site is at the upper reach of the drainage tributary for the watercourses, it is assumed that the majority of the flow conveyed at the tie in is received from the site's stormwater management ponds. Therefore, the tailwater is considered to be the outflow of the pond and the outfall will act as a free outfall, (i.e.: no tailwater effect).

3.1.2 *CivilStorm™ Design Parameters*

Although CivilStorm™ is a complex hydraulic analysis program designed to dynamically model stormwater management systems, it has some limitations regarding data input. The limitations were reviewed and evaluated to ensure that the modelling results are meaningful and accurate. The following details the CivilStorm™ specific design parameters used for the Hamilton – Port Hope 4 Solar Farm stormwater management analysis:

- All pipe lengths are entered as a minimum of 3.05 m, which is a requirement by CivilStorm™ for computational purposes.

- The manning's values used in this model are 0.013 for concrete pipes, 0.010 for PVC pipes and 0.030 for grass lined ditches.

- The CivilStorm™ input/output data was saved as a comma delineated file (*.csv) and imported into Microsoft Excel for aesthetics, since the CivilStorm™ input/output files can be lengthy and difficult to read.

3.2 BEST MANAGEMENT PRACTICES (BMPs)

The entire Hamilton – Port Hope 4 Solar Farm utilizes multiple Best Management Practices (BMPs). The intent of implementing stormwater BMPs throughout the site is to ensure that water quality and quantity concerns are addressed during- and post-construction. BMPs were implemented at the "lot", "conveyance" and "end of pipe" levels.

Lot level BMPs include directing runoff onto grassed areas, minimizing ground slopes and maintaining as much of the development as possible in a natural state so that surface sheet flow has the maximum opportunity to infiltrate naturally. Runoff from the solar modules currently flows to grass areas, which will provide an opportunity for initial filtration of any sediment and provide an opportunity for absorption and ground water recharge.

The conveyance systems employed include grass lined swales, rock-lined ditches, road culverts and flow dissipators. All swales have been constructed at minimal gradient, where possible, thus promoting absorption and infiltration, as well as providing opportunity for particle filtration. During the implementation of the rehabilitation measures, riprap will be placed at erosion-prone areas and all disturbed areas will be re-vegetated as soon as possible.

The end of the pipe systems implemented in this rehabilitation design are dry ponds, which have free flowing outlets. It should be noted that Pond 10 has two alternatives for the outlet, an automatic pump and a gravity feed outlet pipe, this report will focus on the gravity outlet, whereas Appendix F provides additional information on the pumping alternative. The ponds have been sized to accommodate the 100year 24hour storm and they have the required freeboard above and beyond the ponding level of the 100-year storm event (0.30m). In general, stormwater impinging on the impervious areas such as interior roads on site will flow into roadside ditches and on towards the dry ponds or other water dispensing outflow structures.

3.3 RUNOFF CALCULATIONS

As previously noted, runoff calculations were completed with the aid of a computer modelling program, CivilStorm™. The overland travel time of concentration for each of the drainage areas was derived using the SCS Lag equation:

$$T_c = 60\left(L^{0.8} \frac{(S'+25.4)^{0.7}}{4238S^{0.33}} \right) \text{(min)}$$

Where:

L = Flow length (m)

S' = Potential maximum retention ($S' = \frac{25400}{CN} - 254$)

CN = Curve Number

S = Average watershed land slope (%)

Manning Equation was used to determine the stormwater velocity while travelling through channelized flow represented by:

$$V = (R^{2/3}S^{1/2})/n \ \text{(m/s)}$$

Where: R = Hydraulic Radius
S = slope of the ditch (%)
n = Manning's roughness coefficient (0.03 for grass swales)

The proposed curve numbers have been selected from the MTO Drainage Management Manual for Hydrologic Soil Group 'B'. As such, a value of 74 was used for site where crops were grown, and 65 was used for the site which was unmaintained in pre-development conditions (pasture). Based on comparable curve numbers and their corresponding descriptions within the MTO Drainage Management Manual, we consider this value to be reasonable based on the existing site conditions. A value of 82 was used for all improved areas for post-development, for all improved land, which is consistent with "grass" type vegetation. In an effort to be conservative, the improved areas were taken as soils group 'C' to increase the post-development flowrates and rendering the stormwater management ponds larger. A curve number of 85 was used for granular access road and 98 was used for all impervious surfaces. A summary of the above noted chosen values has been provided in Table 1.

A Manning's roughness coefficient of 0.03 for grass swales was selected from the MTO Drainage Management Manual (Chart 2.01) under the "Unlined Open Channels – Earthy fairly uniform" section for "Grass, some weeds". We believe this coefficient to be reasonable based on the existing site conditions. Please note that the "Channels not maintained, vegetation uncut" and the "grass channels and swales" were not used, as the depth of grass within the channels will vary throughout the life of the project and we would not want to place unwanted maintenance expectations on the Contractor to ensure that they mow the grass to a specific length. With this in mind, 0.03 was determined to be reasonable coefficient.

The initial abstraction values were calculated through the relation of the CN number and the soil moisture retention, where:

$$S = \frac{25400}{CN} - 254$$

Where CN is the curve number and S is the potential maximum soil moisture retention. The initial abstraction is then related to the soil moisture retention by $I_a = 0.2S$.

Land Use	Curve Number
Pre-Development	
Impervious	98
Cultivated (HSG 'B')	74
Pasture (HSG 'B')	65
Post-Development	
Impervious	98
Gravel	85
Grass (Improved) (HSG 'C')	82
Pasture (HSG 'B')	65
Water	100

Table 1: Curve Numbers

Relevant excerpts from the above noted sources have been included in Appendix B.

3.4 RAINFALL DEPTHS

Based on the report prepared by AECOM, they noted the use of the Ministry of Transportation's (MTO) IDF Curve lookup as the source for their rainfall data. Through discussions with the local Conservation Authority (GRCA), IDF curves exist for this area, however, a review of the total depth of rainfall in the 24hr 100-year storm event noted the CA's total to be approximately 84mm. As the MTO lookup provides a total of approximately 122mm (representing a significant increase from the CA's data), the MTO values were used for calculation purposes.

The MTO figures will aid in producing a more conservative design, which will result in the ponds possessing a larger factor of safety (in comparison to the GRCA's information).

The 2-, 5-, 10-, 25-, 50-, and 100-year storm events were reviewed for both the 12-hour and 24-hour SCS Type II distributions at the pond inlet, forebay, active storage, and outlet locations. Each storm was evaluated in the pre-development condition and compared with its results in the post-development condition to determine the worst case scenario between all storm events. It is important to note that the worst case scenario design storm event (i.e.: either the 12- or 24-hour event) may differ for the design of the above noted elements.

Storms	Return Periods (Years)	Total Rainfall Depths (mm)	Design Storm Peak Intensity (mm/hr)
12Hr SCS	2	43.2	57.0
	5	58.8	77.6
	10	68.4	90.3
	25	80.4	106.1
	50	90.0	118.8
	100	99.6	131.5
24Hr SCS	2	55.2	60.9
	5	72.0	79.5
	10	84.0	92.7
	25	100.8	111.3
	50	110.4	121.9
	100	122.4	135.1

Table 2: Design Storm Peak Intensity and Rainfall Data 5min Time Step Shown – Used in Post, for 15min used in Pre see Appendix E

3.5 PRE-DEVELOPMENT DRAINAGE

The subject property was reviewed based on the original stormwater report by AECOM. The site is located at the peak of several catchment areas. The flow from the site will split into five areas which will ultimately enter into either the Cobourg Creek Watershed flowing towards the north or the Brook Creek Tributaries flowing to the west. Further details pertaining to these drainage areas can be found below. A Pre-Development Drainage Plan, as well as the Pre-Development CivilStorm™ Model Schematic and associated calculations have been provided in Appendix C.

3.5.1 *Pre-Development Drainage Area A1 and A2 – Cobourg Creek Watershed*

Pre-development drainage area A1 encompasses the northwest corner of the site and a relatively large portion of offsite land to the north of the site. Pre-development drainage area A1 measures approximately 8.8ha and has an estimated curve number of 67.3. The area is comprised of undeveloped farmland. On-site runoff generally flows from the east and south and outlets to roadside ditches along Community Center Road. Runoff then enters culverts under the road and continues to flow north.

Pre-development drainage area A2 encompasses the northeast corner of the site and a relatively small portion of offsite land to the north of the site. The pre-development drainage area A2 measures approximately 10.7ha and has an estimated curve number of 73.0. The area is comprised of undeveloped farmland. Runoff generally flows from the west and south, outlets to roadside ditches along Payne Road and continues north.

3.5.2 *Pre-Development Drainage Area A3, A4 and A5 – Brook Creek Watershed*

Pre-development drainage area A3 encompasses an area immediately south of area A2 - in the north west section of the property - and includes a large section of offsite lands. The area measures approximately 9.7ha and has an estimated curve number of 69.3. The area is comprised of undeveloped farmland. Runoff generally flows from the east and south, and sheet flows offsite to the west and continues west to the Brook Creek Tributaries.

Pre-development drainage area A4 encompasses a relatively large area that includes a significant portion of the middle of the site as well as a large offsite area to the west. The area measures approximately 28.6ha and has an estimated curve number of 69.7. The area is comprised of undeveloped farmland. Runoff generally flows from the north, east and south, towards the west-central limits of the site, where it continues west to the Brook Creek Tributaries.

Pre-development drainage area A5 encompasses the south of the site and a portion of offsite lands south of the site. The pre-development drainage area A5 measures approximately 24.6ha and has an estimated curve number of 68.3. The area is comprised of undeveloped farmland. Runoff generally flows from the north, outlets off the south end of the site and continues south and west to the Brook Creek Tributaries. The input parameters and results have been summarized in the following tables, while the full detailed output results can be found in Appendix C.

Catchment ID	Area (ha)	CN	T_c (min)
A1	8.8	67.3	29
A2	10.7	73.0	26
A3	9.7	69.3	21
A4	28.6	69.7	53
A5	24.6	68.3	25
Total	**82.5**		

Table 3: Pre-development input parameters.

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A1	22	122	217	359	490	633
Area A2	103	317	483	716	917	1,134
Area A3	50	219	365	576	761	958
Area A4	99	362	586	927	1,233	1,562
Area A5	85	430	742	1,200	1,620	2,077
Total	359	1,450	2,394	3,778	5,020	6,363

Table 4: 12-Hour pre-development output results

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A1	64	186	298	480	595	747
Area A2	185	401	579	851	1,015	1,232
Area A3	118	297	455	701	852	1,047
Area A4	210	526	811	1,274	1,561	1,938
Area A5	229	629	984	1,548	1,899	2,367
Total	806	2,039	3,127	4,854	5,922	7,330

Table 5: 24-Hour pre-development output results

3.6 POST-DEVELOPMENT DRAINAGE

The developed property was reviewed based on the topographic survey data provided by ABB via CSSI. The flow from the site will split into nine areas, which will ultimately enter into either the Cobourg Creek Watershed flowing towards the north or the Brook Creek Tributaries flowing to the west. Further details pertaining to these drainage areas can be found below. A Post-Development Drainage Plan, as well as the Post-Development CivilStorm™ Model Schematic and associated calculations have been provided in Appendix D.

3.6.1 *Post-Development Drainage Areas B1, B2, B4, B9 and B11 – Cobourg Creek Watershed*

Post-development drainage areas B1, B2, B4 and B11 are located in the north section of the site, while B9 is located in the central eastern portion. The areas are generally comprised of a mix of undeveloped farmland and developed solar farm lands. On-site runoff from these areas generally flows into roadside ditches within the site and outlets to roadside ditches along Payne Road and Community Center Road. Runoff then enters culverts under Community Center Road and continues to flow north.

Post-development drainage area B1 is similar to pre-development drainage area A1 and encompasses the northwest corner of the site and a relatively large portion of offsite lands to the north of the site. The area measures approximately 8.2ha and has an estimated composite curve number of 67.7. On-site topography of the area ranges in elevation from approximately 256.4m at the most southern point of the catchment boundary to 241.7m at the west corner of the site. Runoff generally flows from the east and south, enters into roadside ditches within the site and outlets to roadside ditches along Community Center Road.

Post-development drainage area B2 is similar to pre-development drainage area A2 and encompasses the north corner of the site. The area measures approximately 3.6ha and has an estimated composite curve number of 84.0. On-site topography of the area ranges in elevation from approximately 249.0 at the western limit of Block 10 to 230.80m in the stormwater pond at the north corner of the site. Runoff generally flows from the west and south, enters into roadside ditches within the site and enters a stormwater pond at the north east corner. Please note that two outlet alternatives for Pond 10 have been designed, each alone can handle the required outflow from Pond 10 in a 100-year storm event. CSSI will install at least one of the outlet alternatives. Please see Appendix F for more information regarding alternative 1 – Outletting via gravity flow and Appendix G for more information regarding alternative 2 – Pumping behind the house.

Post-development drainage area B4 encompasses a relatively small area along the east border of the site, south of area B2. The area measures approximately 1.5ha and has an estimated composite curve number of 81.5. The area is comprised of a mix of constructed solar farm lands. On-site topography of the area ranges in elevation from approximately 245.2m at the most western point of the catchment boundary to 238m in the roadside where runoff enters into a ditch inlet catchbasin and ultimately flows into the pond.

Post-development drainage B9 encompasses a relatively small area along the east border of the site, south of area B4. The area measures approximately 1.1ha and has an estimated composite curve number of 71.6. The area is comprised of a mix of constructed solar farm lands and a portion of Payne Road to the east of the site. On-site topography of the area ranges in elevation from approximately 241.0m at the central portion of the catchment boundary to 245.0m at the northern portion of the catchment boundary. Runoff generally flows east, across into the Payne Road right of way where it continues north.

Post-development drainage B1 encompasses a relatively small area to the north of Pond 10, the municipal ROW and a portion of Payne Road adjacent to areas B2 and B4. The area measures approximately 3.2ha and has an estimated composite curve number of 72.6. The area is comprised of a mix of agricultural fields, vegetated ROW and a portion of Payne Road to the east of the site. Runoff ultimately reaches the crossing culvert on Payne Road where it continues north.

3.6.2 *Post-Development Drainage Areas B3, B5 to B8 & B10 - Brook Creek Watershed*

Post-development drainage areas B3, B5 to B8 and B10 are located in the south and west sections of the site and are generally comprised of a mix of undeveloped farmland and developed solar farm lands. Areas B5 and B6 together are similar to pre-development drainage area A4, while B7 and B8 together are similar to area A5. On-site runoff from these areas generally flows into roadside ditches within the site and outlets to farmland west and south of the site through flow dissipation features. In B3 and most of B6, the primary flow path off site is surface sheet-flow into the adjacent valleylands to the west. Runoff then continues west to Brook Creek Tributaries.

Post-development drainage area B3 is similar to pre-development drainage area A3, encompasses an area immediately south of area A2, in the north-west section of the property and includes a large section of offsite lands. The area measures approximately 7.1ha and has an estimated composite curve number of 71.8. On-site topography of the area ranges in elevation from approximately 254.3m on the access road in the north-west corner of the area to 235m at the south corner of the area. Runoff generally sheet flows from the north, east and south and outlets to the west of the site (the flow path to the west is further discussed in Appendix G: Flow behind the House).

Post-development drainage area B5 encompasses an area immediately to the south of area B4, in the north-east section of the property and is comprised of constructed solar farm lands. The area measures approximately 5.5ha and has an estimated composite curve number of 84.3. On-site topography of the area ranges in elevation from approximately 246.2m on the road at the north-west corner of the catchment boundary to 237.4m in the stormwater pond in the south corner of the area. Runoff generally flows from the north and east and either enters into a stormwater pond via overland flow or roadside ditches within the site. The pond outlet drains to the west of the site.

Post-development drainage area B6 encompasses a large area along the west side of the site adjacent to area B5 and is comprised of constructed solar farm lands and a relatively large area of undeveloped farmland. The area measures approximately 22.0ha and has an estimated composite curve number of 71.0. On-site topography of the area ranges in elevation from approximately 246.7m at the east corner of the area to 231.5m along the south-west edge of the area. Runoff generally flows from the north and east and drains off the site to the west via overland flow.

Post-development drainage area B7 encompasses a large area of undeveloped farmland to the south of the site as well as two small sections of the developed site that do not enter the stormwater management pond. The area measures approximately 20.6ha and has an estimated composite curve number of 67.9. Runoff generally flows from the north and east and continues west to Brook Creek Tributaries.

Post-development drainage area B8 encompasses a relatively small area across the south end of the property and is comprised of constructed solar farm lands. The area measures approximately 3.5ha and has an estimated composite curve number of 82.1. On-site topography of the area ranges in elevation from approximately 247.0m at the north corner of the area to 228.0m in the stormwater pond at the south side of the site. Runoff generally flows from the north and enters into a stormwater pond via overland flow or existing ditches within the site. The pond outlet drains to the south of the site, where runoff flows south and west to Brook Creek Tributaries.

Post-development drainage area B10 encompasses an area west of B2 and B4 in the northern section of the property and is comprised of constructed solar farm lands. The area measures approximately 6.1ha and has an estimated composite curve number of 77.6. The area is comprised of constructed solar farm lands and a small section of access road. On-site topography of the area ranges in elevation from approximately 253.0m at the western boundary of the site to 242.0m where the runoff flows off site to the south. Runoff generally flows from the north and west and drains off the site to the south to a man-made storage area (the flow path to the west is further discussed in Appendix G: Flow behind the House).

The input parameters and results have been summarized in the following tables, while the full detailed output results can be found in Appendix D.

Catchment ID	Area (ha)	CN	T_c (min)	Outlet
B1	8.2	67.7	15	Unrestricted to Community Center Road Municipal ditch and heads west to Baltimore Creek Tributary
B2	3.6	84.0	8	Restricted by Pond 10 and outlets into Payne Road Municipal ditch and heads generally east towards Baltimore Creek Tributary. Please see Appendix F for more details. Alternative 2, for B2 includes the pumping of runoff to drainage ditch between B2 and B10, please see Appendix G for more details.
B3	7.1	71.8	33	Unrestricted towards Brook Creek Tributary to west
B4	1.5	81.5	15	Restricted by Pond 10 and outlets into Payne Road Municipal ditch and heads generally east towards Baltimore Creek Tributary
B5	5.5	84.3	15	Restricted by Pond 5 towards Brook Creek Tributary to west via B6
B6	22.0	71.0	43	Unrestricted towards Brook Creek Tributary to the west
B7	20.6	67.9	25	Unrestricted towards Brook Creek Tributary to south
B8	3.5	82.1	9	Restricted by Pond 3 towards Brook Creek Tributary to South via B7
B9	1.1	71.6	20	Unrestricted to Northeast towards Baltimore Creek Tributary
B10	6.1	77.6	14	Unrestricted towards Brook Creek Tributary to west via B3
B11	3.2	72.6	21	Unrestricted to northeast towards Baltimore Creek Tributary
Total:	**82.5**			

Table 6: Post-development input parameters.

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B1	32	191	328	527	702	888
Area B2	227	411	532	688	815	944
Area B3	47	156	244	373	486	605
Area B4	63	123	165	220	266	312
Area B5	289	531	691	899	1,068	1,240
Area B6	108	370	592	912	1,194	1,494
Area B7	64	340	595	972	1,317	1,695
Area B8	186	349	462	609	730	852
Area B9	10	35	54	82	107	133
Area B10	172	388	543	752	927	1,108
Area B11	33	106	162	240	307	381
Total	1,231	3,000	4,370	6,273	7,917	9,650

Table 7: 12-Hour post-development uncontrolled output results

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B1	108	305	475	745	916	1,141
Area B2	302	479	610	799	907	1,044
Area B3	99	232	345	519	625	762
Area B4	89	150	197	265	304	354
Area B5	392	626	801	1,052	1,198	1,380
Area B6	230	554	838	1,284	1,557	1,912
Area B7	192	562	899	1,446	1,784	2,227
Area B8	253	417	540	719	824	955
Area B9	22	51	75	113	136	165
Area B10	271	497	673	936	1,091	1,288
Area B11	69	151	220	326	391	474
Total	2,028	4,023	5,673	8,204	9,732	11,703

Table 8: 24-Hour post-development uncontrolled output results

3.7 RESTRICTION

As per the MOECC's requirements and recommendations, the stormwater management BMPs on the site have been designed such that the post-development peak flow rates match pre-development peak flow rates from the site. It was determined that the 24-hour storm produced larger post-development flow rates. As a result, three permanent stormwater management ponds have been implemented on the site. Each pond was sized to ensure that the 24-hour events were contained within its banks and each maintained the required acceptable freeboard. Although most site areas do not have ponds, stormwater is restricted as necessary by utilizing rock flow check dams, grass-lined ditches and flow spreading devices.

In the case of catchment areas B3 and B10 outletting to the west, post-development flows exceed pre-development flows. However, the receiving watercourse and downstream areas have been assessed to ensure negligible impacts to downstream waterbodies and infrastructure are experienced (see Appendix G: Flow behind the House).

3.8 QUALITY CONTROL

All of the site's post-development catchment areas were reviewed to confirm they would achieve the mandated quality control for the site. The requirements were determined based on the MOECC Stormwater Management Design Guidelines Table 3.2 for "Infiltration" to achieve 80% TSS (enhanced) removal rates. The site was broken down based on each outlet and reviewed on a basis of percent imperviousness. Please note the site possesses a relatively minor percent imperviousness (max 5%), resulting primarily from the addition of gravel access roads and buildings. To avoid potential for sediment issues, the site will not be sanded and salted during winter maintenance. Interpolating within Table 3.2 of the MOECC Design Guidelines yields the required storage volumes shown in Table 9 (below) in both m^3/ha and m^3.

Outlet #1 was not reviewed in detail as part of the scope of this report, however, the requirements are illustrated within Table 9 and no concerns have been raised regarding this area. Outlet #2 is reviewed in full detail in Appendix F: Pond 10; however, the requirements are illustrated in summary within Table 9. Outlet #3 generally flows unrestricted and is located outside the project location. Infiltration trenches will be implemented within the Block 8 ditch to achieve and exceed the required volume.

In Outlets #4 and #5, given the stormwater management ponds (Ponds 1+3 and 5) and the relatively limited requirement of infiltration volume required in accordance with Table 3.2 of the MOECC Guidelines, it has been proposed that the existing ponds be over excavated and an infiltration basin be installed at the bottom of the pond, lined with non-woven geotextile and filled with riprap, clear stone or riverstone. This area is also required from an erosion control perspective, around the bottom outlet of the pond. The void space within the riprap will be utilized to gain the necessary volume. The volume of infiltration in Outlets #4 and #5 will greatly exceed the requirements noted below exceeding the infiltration requirements to achieve the necessary quality control. Please note as per the geotechnical investigation provided by WSP, the infiltration rate for the soils in proximity to the ponds ranges from 50mm/hr to 75mm/hr.

	Units	Outlet 1	Outlet 2	Outlet 3	Outlet 4	Outlet 5
Catchment Imperviousness	%	1.8%	5.6%	1.2%	2.6%	4.8%
Total Site Area	ha	8.2	9.1	13.2	9.5	3.5
Table 3.2 - Required Storage Volume	m^3/ha	1.3	4.0	0.9	1.9	3.4
Required Storage	m^3	**10**	**37**	**11**	**18**	**12**
Provided Storage	m^3	N/A	**60**	**24**	**47**	**24**

Table 9: Infiltration Requirements

Outlet #1 Comprised of B1, Outlet #2 Comprised of B2, B4, B9 and B11, Outlet #3 Comprised of B3 and B10, Outlet #4 Comprised of B5 and portions of B6, Outlet #5 Comprised of B8
Please note that Outlet #1 was included for illustration but, was not calculated given the lack of development and that there are no concerns regarding quality control of runoff from this area. This area does possess a number of permanent controls including riprap check dams, and riprap lined spillways to filter any sediment from the roadways.

3.9 ROADSIDE DITCHES, CULVERTS AND ROCK FLOW CHECK DAMS

The roadside ditches were constructed to route runoff along the road network. Upon concentrating and channelizing the flow, erosion was observed given the relatively steep slopes on site. Therefore, in an effort to reduce the velocity of runoff within the now existing ditches, rock flow check dams were implemented. Flow overtopping the rock flow check dams in ditches have been modelled using the 100-year storm flow rate of the cross-section to determine the impact to the adjacent land and roadways. The 24-hour event was determined to produce the largest flow rates and was therefore used in this modelling.

The cross-section locations can be identified by looking at the Post-Development Drainage Plan (Sheet 12). Through a review of the cross-sections it was determined that the 100-year flow would be able to pass over the rock flow check dams within the ditch cross-section, with the exception of sections A-A, B-B and C-C located in Blocks 10, 8 and 5 respectively. Through the review it was determined that these cross-sections will overtop the check dam during a 100-year storm. As the ditches are located adjacent to the roadways, and the roadways are all at a higher elevation than the adjacent top of bank of the solar farm, the overflow will be directed into the solar farm rather than overtopping the roadways. This is not foreseen to be an issue or concern as rock flow check dams are typically not sized to handle 100-year events and the ditches themselves were not noted in previous reports to be sized to handle major events. Please note that the velocity in the 100-year events over the rock flow check dams do not exceed that of the maximum permissible velocities within MTO Drainage Manual Chart 2.17. Once the rock check dams are installed, the disturbed soils will see the addition of erosion control blanket and seed. The maximum permissible velocity for the coconut blanket specified for this project is 2.7m/s which exceed the flow velocity in the areas which overtop the banks.

	Slope of Ditch (%)	Allowable Depth Elevation (m)	Velocity (m/s)	100-YR Flow (m^3/s)	Normal Depth Elevation (m)	Freeboard (m)
A1-A1 (B2)	2.7	234.20	1.31	0.76	234.22	0 – exceeded
B1-B1 (B10)	2.0	241.70	0.76	0.20	241.59	0.21
C1-C1 (B5)	6.4	243.26	1.26	0.22	243.20	0.06
D1-D1 (B6)	3.2	244.91	1.08	0.35	244.69	0.22
E1-E1 (B8)	2.9	229.13	1.55	0.98	228.85	0.28
F1-F1 (B7)	6.5	242.66	1.63	0.18	241.99	0.67

Table 10: Roadside Ditch Capacity assuming no rock flow check dams or restrictions

	Slope of Ditch (%)	Allowable Depth Elevation (m)	Velocity (m/s)	100-YR Flow (m^3/s)	Normal Depth Elevation (m)	Freeboard (m)
A1-A1 (B2)	2.7	234.20	0.75	0.76	234.27	0 – exceeded
B1-B1 (B10)	2.0	241.70	0.36	0.20	241.71	0 – exceeded
C1-C1 (B5)	6.4	243.26	0.64	0.22	243.29	0 - exceeded
D1-D1 (B6)	3.2	244.91	0.57	0.35	244.87	0.04
E1-E1 (B8)	2.9	229.13	0.86	0.98	229.06	0.07
F1-F1 (B7)	6.5	242.66	0.77	0.18	242.16	0.50

Table 11: Roadside Ditch Capacity assuming rock flow check dam is blocked and flow will overtop the spillway

3.10 STORMWATER MANAGEMENT FACILITY DESIGN – POND 1

3.10.1 *INLET DESIGN*

Concentrated flow is directed to pond 1 via an existing ditch with a proposed riprap lined spillway extending down to the bottom of the pond from the east. The proposed riprap lined spillway will have 200mm nominal sized stone to prevent erosion of the channel (see Sheet 4). Please see Appendix E for riprap applied to all ponds.

3.10.2 *SWMF QUALITY CONTROL*

Quality control will be obtained through the implementation of an infiltration basin which will utilize the void space in the riprap erosion protection at the bottom of the pond. In addition to this void space, the flow to the outlet travels through restricted swales and ditches upstream of the ponds prior to being reverted to sheet flow on route to the tributary of Brooks Creek. Please see section 3.8 for more details.

3.10.3 *DRAWDOWN TIME*

The MOECC's guidelines suggest a minimum drawdown time of 24-hours as a target for storage detention which may be reduced to 12-hours if there is a conflict with the minimum sizing of orifice. The retention time is primarily to allow for particle settling to occur. The drawdown time for the 25mm storm event for the proposed dry pond with a 75mm orifice has been calculated to be 6 hours, using equation 4.11 below which is outlined in the MOECC Design Manual. If the pond was being used in a quality function, this result would not be acceptable; however, given that we are providing a post-construction solution to the site and using the minimum orifice acceptable to the MOECC, the pond will function to provide quantity control to the proposed intent.

Refer to the *Drawdown Time (Using Linear Regression)* sheet located in Appendix E for a detailed calculation.

3.10.4 *SWMF QUANTITY CONTROL*

As per the requirements from the Conservation Authority, Municipality and MOECC, the site will be equipped with stormwater management facilities providing quantity control. A stormwater management dry pond providing quantity treatment will receive runoff from the southern portion of the solar development. The table below illustrates the stage-storage-discharge relationship for Pond 1&3 based on the outlet structure for the 2-, 5-, 10-, 25-, 50- and 100-year storm events for the 24-hour SCS design storm (worst case scenario) based on the volume of runoff.

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
25mm	228.55	73	4	1.85	2,024
2-year	228.84	325	23	1.56	1,729
5-year	229.03	506	62	1.37	1,547
10-year	229.20	663	81	1.20	1,390
25-year	229.46	908	104	0.94	1,145
50-year	229.62	1,060	116	0.78	993
100-year	229.80	1,274	128	0.60	779

Table 12: Stage-Storage-Discharge – Pond 1

A maximum required volume of 1,274 m^3 for the 100-year 24-hour SCS storm at an elevation of 229.80m was calculated when restricting the post-development flow to 128L/s based on the outlet control devices located within the pipes. The total available storage in the existing pond is 2,097 m^3 at an elevation of 230.40 m, which indicates a freeboard depth of approximately 0.60 m, which exceeds the minimum recommended freeboard depth (typically 0.30 m).

3.10.5 *OUTLET STRUCTURE AND EMERGENCY OVERFLOW SPILLWAY*

The outlet structure will consist of a 75mm orifice within a 450mm pipe located at the bottom of the pond as well as a 250mm orifice within a vertical 900mm pipe located at an elevation of 228.70m.

The emergency overflow pipe shall provide passage of the large storm event peak flows. In order to size the emergency overflow pipe, the starting water surface elevation shall be at the principal pipe elevation. The emergency overflow pipe shall have an invert elevation at the 100-year water surface elevation and the flood head water passing through the pipe shall not exceed the freeboard elevation when using the large storm event peak flows.

The emergency overflow pipe has been designed using a 900mm pipe within the pond at an invert elevation 229.80m. The total worst-case post-development unrestricted 100-year peak flow for the pond was a flow rate of 955L/s for the 24-hour SCS design storm. The overflow pipe conveys a total flow of 1,310L/s at an elevation of 230.40m through the outlet structure. Flows exceeding the combined capacity of the outlet structure and the emergency pipe will cascade over the top of the pond onto the neighbouring vacant property. Refer to the Elevation-Discharge table in Appendix E for detailed calculations pertaining to the outlet control. Refer to the drawing for a detailed cross-section of the emergency pipe. Please see Sheet 5 – Pond 1&3 Details – Section D-D'.

3.11 STORMWATER MANAGEMENT FACILITY DESIGN – POND 5

3.11.1 *INLET DESIGN*

Concentrated flow reaching pond 5 will be via one of three structures outletting into the pond. The flow from the north roadside ditches will be via existing culverts which will be directed towards the bottom of the pond by extending the pipe ultimately outletting to plunge pools. The flow from the east will be into a ditch inlet catchbasin where it will outlet at the bottom of the pond and into a plunge pool. In locations where sheet flow enters into the pond to the north through the proposed expansion of the pond it will flow over riprap lined side slopes towards the bottom of the pond. The riprap will have 200mm nominal sized stone, to prevent erosion of the sidewall and low flow channel. Please see Appendix E for riprap applied to all ponds.

3.11.2 *SWMF QUALITY CONTROL*

Quality control will be obtained through the implementation of an infiltration basin which will utilize the void space in the riprap erosion protection at the bottom of the pond. In addition to this void space, the flow to the outlet travels through restricted swales and ditches upstream of the ponds prior entering into the pond. Please see section 3.8 for more details.

3.11.3 *DRAWDOWN TIME*

The MOECC's guidelines suggest a minimum drawdown time of 24-hours as a target for storage detention which may be reduced to 12-hours if there is a conflict with the minimum sizing of orifice. The retention time is primarily to allow for particle settling to occur. The drawdown time for the 25mm storm event for the proposed dry pond with a 75mm orifice has been calculated to be 6 hours(using Equation 4.11 below which is outlined in the MOECC Design Manual). Refer to the *Drawdown Time (Using Linear Regression)* sheet located in Appendix E for a detailed calculation. If the pond was being used in a quality function this result would not be acceptable; however, given that we are providing a post-construction solution to the site and using the minimum orifice acceptable to the MOECC, the pond will function to provide quantity control to the proposed intent.

3.11.4 *SWMF QUANTITY CONTROL*

As per the requirements from the Conservation Authority, Municipality and MOECC, the site will be equipped with a stormwater management facility providing quantity control. Pond 5 will provide quantity treatment of water received from Block 5. The table below illustrates the stage-storage discharge relationship for Pond 5 based on the outlet structure for the 2-, 5-, 10-, 25-, 50- and 100-year storm events for the 24-hour SCS design storm (worst case scenario) based on the volume of runoff.

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
25mm	236.43	139	9	2.75	3,451
2-year	237.35	758	14	1.83	2,832
5-year	237.86	1,269	19	1.32	2,321
10-year	238.07	1,616	27	1.11	1,974
25-year	238.44	2,256	35	0.74	1,334
50-year	238.63	2,575	38	0.55	1,015
100-year	238.88	2,996	41	0.30	594

Table 13: Stage-Storage-Discharge – Pond 5

A maximum required volume of 2,996m^3 for the 100-year 24-hour SCS storm at an elevation of 238.88m was calculated when restricting the post-development flow to 41L/s. The total available storage in the pond is 3,590m^3 at an elevation of 239.18m, which indicates a freeboard depth of approximately 0.30m which meets the minimum recommended freeboard depth (typically 0.30 m).

It should be noted that the 2- through 100-year storms exceed the pre-development levels for the overall outlet. The exceeded flow rates are relatively minor in nature and vary from 16% in the 2-year to less than 1% in the 100-year storm. The drawdown pipe was reduced to the minimum size (75mm diameter orifice) and additional area was directed towards the pond in an effort to ensure that the outlet would match pre-development. Based on the number of controls throughout the Blocks 5 and 6 areas which have not been accounted for, including but not limited to French drains, infiltration trenches, rock flow check dams, etc., it is our belief that the outflow controls at Pond 5 including the controls noted above will adequately reduce flow rate leaving the site through Outlet 4 as a whole.

3.11.5 *OUTLET STRUCTURE AND EMERGENCY OVERFLOW SPILLWAY*

The outlet structure will consist of a 75mm orifice within a 450mm pipe at an elevation of 235.80m as well as a 130mm orifice within a vertical 450mm pipe at an elevation of 237.80m.

The emergency overflow spillway shall provide passage of the large storm event peak flows. In order to size the emergency spillway the starting water surface elevation shall be at the principal spillway elevation. The emergency spillway shall have an invert elevation at the 100-year water surface elevation and the flood head water passing through the emergency spillway weir shall not exceed the freeboard elevation when using the large storm event peak flows.

The emergency overflow spillway has been designed using a 5m wide riprap weir adjacent to the outlet structure at an invert elevation 238.88m. The total worst-case post-development unrestricted 100-year peak flow for the pond was a flow rate of 1,380L/s for the 24-hour SCS design storm. Including the overflow spillway, a total flow of 1,575L/s at an elevation of 239.18m can be conveyed through the outlet structure. Flow exceeding the combined capacity of the outlet structure and the emergency earth weir will cascade over the top of the pond onto the adjacent woodlands area. Refer to the Elevation-Discharge table in Appendix E for details calculations pertaining to the outlet control. Refer to Sheet 2 for the location and a detailed cross-section of the emergency weir.

4.0 SITE MAINTENANCE

It should be noted that no stormwater management plan can guarantee no future ponding, erosion or sedimentation will occur. Based on the topography and soil conditions at Hamilton – Port Hope 4, once the rehabilitation areas are re-graded, there is a possibility that small ruts and gullies may form on-site. The party providing operations and maintenance services should review the site regularly while the vegetation is becoming established and after large rainfall events (over 10mm) to ensure that these areas are identified and repaired. The maintenance staff should note, repair and monitor the site for erosion and long term ponding. Should a particular situation worsen, maintenance staff should contact the appropriate engineering consultant to review and recommend remediation that could include enhanced vegetation, and grading and structure improvements.

Re-vegetation of the site is a key concern as sediment deposition and erosion become increased concerns with the absence of vegetation. Every effort should be made by the Contractor to reseed all disturbed areas as soon as work has been completed. Given the soils on-site, the placement of mulch and/or topsoil may be required to allow for vegetation to take root. Similarly, aeration or scarification of the soils may be required to promote vegetation growth. Should the Contractor experience erosion concerns making it difficult to re-vegetate, it is recommended that an engineer be consulted to provide recommendations on additional measures that could be taken to promote vegetation growth.

4.1.1 *ROADSIDE DITCHES AND CULVERTS*

The roadside ditches and associated culverts are a key component to the stormwater conveyance system for the site. As such, they should be maintained to ensure they can continue to function as intended. This includes regular grass cutting and removal of debris and sediment as required. A minimum annual review of sediment accumulation within the ditches should be performed, particularly during the first 2-3 years of operation. Cleanouts and routine maintenance periods can be determined based on site conditions.

4.1.2 *RETENTION AREAS*

The existing ponds are located adjacent to existing gravel access roads which will allow access to the stormwater management facilities. Given that the ponds are dry, maintenance is expected to be completed from within the ponds if required. Given the relatively limited amount of impervious surface on the site and given that the gravel access roads will be traversed fairly infrequently, sediment or debris from road surfaces are not expected to be a concern once the initial settling has occurred.

Regular cleaning of the ponds may be required throughout the life span of the project and should be reviewed on a regular basis. It is recommended that the Contractor perform an inspection of the dry ponds at the completion of the rehabilitation works and the Contractor shall perform a clean out of the ponds, as required by the inspections.

4.1.3 *INFILTRATION TRENCHES*

The trenches are accessible in order to perform any necessary cleanout, vegetation removal or debris removal. In order to apply BMPs, it will be necessary for maintenance staff to perform routine maintenance checks which will aid in the long-term performance of the stormwater management facilities. Recommended maintenance for a typical infiltration trench, as per Table 6.1 of the MOECC Stormwater Management Planning & Design Manual, includes routine inspection, grass cutting as required, removal of accumulated sediment, and trash removal. Based on the location of the infiltration trenches, it is not anticipated that grass and weed control will be necessary, nor should trash removal be of concern. As such, the level of oversight and general maintenance required would be considered low.

It is recommended that during the first one to two years of operation (depending on vegetation growth), inspections should be made after every significant storm event (storms >10mm). After the first one to two years (depending on vegetation growth), only semi-annual inspections may be required. The MOECC also suggests stormwater measures are to be maintained once a 5% reduction to the quality storage volume is observed. Again, based on the limited sediment loading this requirement is not anticipated to be of great concern however, it should be reviewed during annual maintenance inspections. Additional details regarding the cleanout frequency is noted in Section 4.1.4.

4.1.4 CLEANOUT FREQUENCY

Estimated cleanout requirements have been provided in Appendix E and are generally summarized below. Please note that the calculations have been estimated based on a 5% decrease in the required quality control storage volume, referencing the annual sediment loading from the MOECC Design Manual – Table 6.3. Timelines provided assume the site is fully vegetated.

	Imperviousness	Annual Sediment	Catchment Area	Available Storage	Accumulation before cleanout	Cleanout Frequency
	%	m^3/ha	ha	m^3	m^3	years
Pond 1	4.8	0.08	3.5	2,241	112	388
Pond 5	6.0	0.10	5.1	2,336	117	221
Pond 10	8.1	0.70	5.1	3,390	170	239

Table 14: Cleanout Frequency

Sediment loading within the drainage areas has been estimated through extrapolation of Table 6.3 of the MOECC Design Manual. In calculating the anticipated sediment loading, all upstream contributing drainage areas were factored in when determining the imperviousness level and contributing area. Based on an estimated 5% reduction in required quality control storage, it has been estimated that a cleanout rates will vary for each type of retention method. Given the relatively small diameter gravity outlets on the retention areas, more frequent cleanouts to ensure these outlets do not become clogged with sediment buildup may be required. Please note that the purpose of this equation at a high level is to determine the cleanout frequency in urban ponds, given the rural nature of the site and the lack of sediment loading (winter sand and salt on roads) it is very likely that these frequencies will be extended. It is recommended to monitor the retention areas and outlets to ensure they are operating as intended, and perform maintenance as required to ensure their continued function.

5.0 SEDIMENT AND EROSION CONTROL

5.1 TEMPORARY MEASURES

Before work is implemented, the rehabilitation plan described herein requires that temporary silt fence, straw wattles and/or rock flow check dams are installed at all natural outlets where rehabilitation activities are taking place. This includes installing silt fence on contours around the site perimeter to prevent sediment migration offsite during cut and fill activities. Furthermore, additional protection measures should be installed downstream of the site as a secondary preventative measure during construction activities. These measures can be removed once construction is complete and vegetation has rooted. It is crucial that these controls be maintained throughout construction and inspection of sediment and erosion control measures will be facilitated by the Contractor or Contract Administration staff throughout the construction period.

The Contractor, at their discretion or at the instruction of the Municipality, Ganaraska Region Conservation Authority or the Contract Administrator shall increase the quantity of erosion and sediment controls on-site to ensure that the site is operating as intended and no additional sediment finds its way into the adjacent waterbodies, wetlands or ditches. All controls shall be inspected weekly and after rainfall events. Care shall be taken to properly remove sediment from the fences and check dams (if applicable) as required.

Work through winter months shall be closely monitored for erosion along sloped areas. Should erosion be noted, the Contractor shall be alerted and shall take all necessary steps to rectify the situation. Should the Contractor's efforts fail at remediating the eroded areas, the Contractor shall contact the Ganaraska Region Conservation Authority to review the site conditions and determine the appropriate course of action. Please refer to the sediment and erosion controls on the pond plans for additional details regarding the temporary measures to be installed and their appropriate OPSD references. Full time construction inspection is strongly recommended during the rehabilitation efforts.

5.2 PERMANENT MEASURES

Riprap has been proposed at locations that have, in our opinion a high potential for concentrated flow and erosion. In addition, Riprap and geotextile shall be placed at the inlet and outlet of all road crossing culverts. It is crucial that the Contractor ensure that the geotextile is keyed in properly to ensure runoff does not undermine the rip rapped area. Should erosion be witnessed at a location during construction identified by the Contractor / Contract Administrator / Municipality or Conservation Authority, appropriate preventative measures must be put in place, generally resulting in the addition of riprap lining, where appropriate.

It is expected that the Contractor performing this rehabilitation work will promptly ensure that all disturbed areas receive seed and that grass be established as soon as possible. The intent is to maximize the density and coverage of the natural surfaces with healthy vegetation. This rehabilitation plan calls for topsoil to be installed before seeding any exposed areas, including dry pond bottoms. Any areas where earth moving activities are proposed for the installation of roads, excavated material shall be removed or levelled as soon as possible and must be located a sufficient distance from any watercourse to ensure that no sediment is washed out into the watercourse. As vegetation growth along the roadside and stormwater ditches (as applicable) provides a key component to the control of sediment for the site, it must be properly maintained once established. This includes a minimum annual review of sediment buildup within the ditches, removal of sediment buildup and grass cutting as required, to ensure continued operation as intended.

6.0 SUMMARY

- Three stormwater management ponds that were installed temporarily as 'wet' ponds have had their outlet controls reviewed and revised to transition to permanent dry ponds (two described in the main body of this report, one described in Appendix F: Pond 10).
- Two temporary ponds have been regraded so as not to function as retention structures.
- Erosion and sediment controls have been specified and indicated within the report and the rehabilitation plans and are to be implemented by CSSI.
- BMPs and infiltration basins/trenches will provide adequate quality control.
- Two alternative outlet methods from Pond 10 are proposed. One will be implemented pending neighbour consultation and are detailed in Appendix F and G respectively.
- Full time construction inspection during rehabilitation is strongly recommended in order to ensure that the rehabilitation plan implementation is properly implemented.

7.0 RECOMMENDATIONS

Based on the information presented in this report, we recommend that CSSI implement the Post-Construction Stormwater Management rehabilitation plan described herein and that the Ministry of the Environment and Climate Change approve this *Post-Construction Stormwater Management Report* in support of the proposed rehabilitation work at the Hamilton – Port Hope 4 Solar Farm.

LICENSED PROFESSIONAL ENGINEER
Mar 9/17
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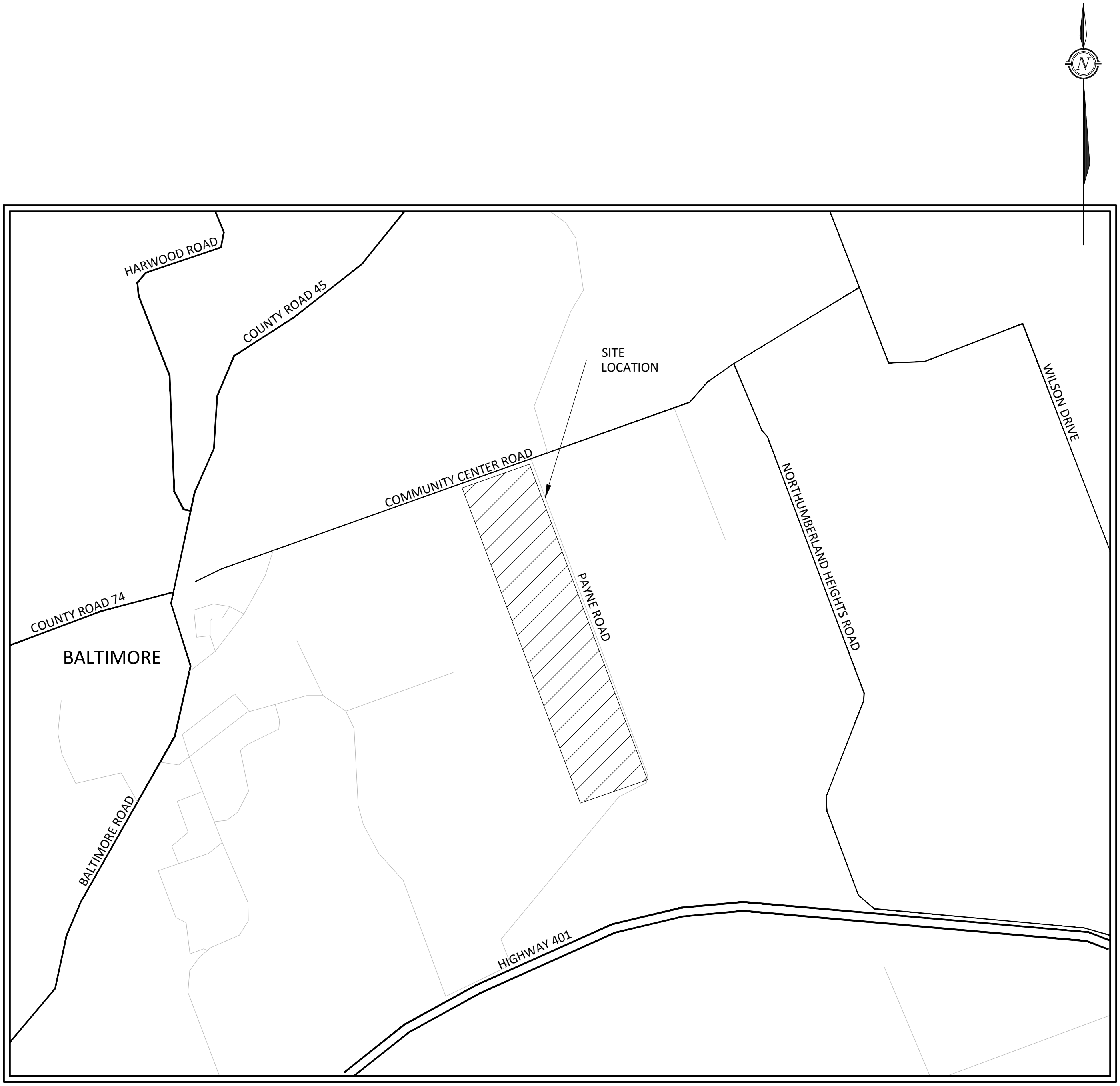
APPENDIX A
LOCATION PLAN



SCALE 1 : 35000

0 700 1400 2100 2800 3500 Metres

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Drawn by: DL	Scale: 1:35000
Checked By: JS	Date: APR/20/2015
Project Number: PP-14-9580	

Client: CANADIAN SOLAR SOLUTIONS
545 SPEEDVALE AVE. WEST GUELPH, ON N1K 1E6

Project: HAMILTON - PORT HOPE 4 SOLAR FARM
BALTIMORE, ONTARIO

Title: LOCATION PLAN

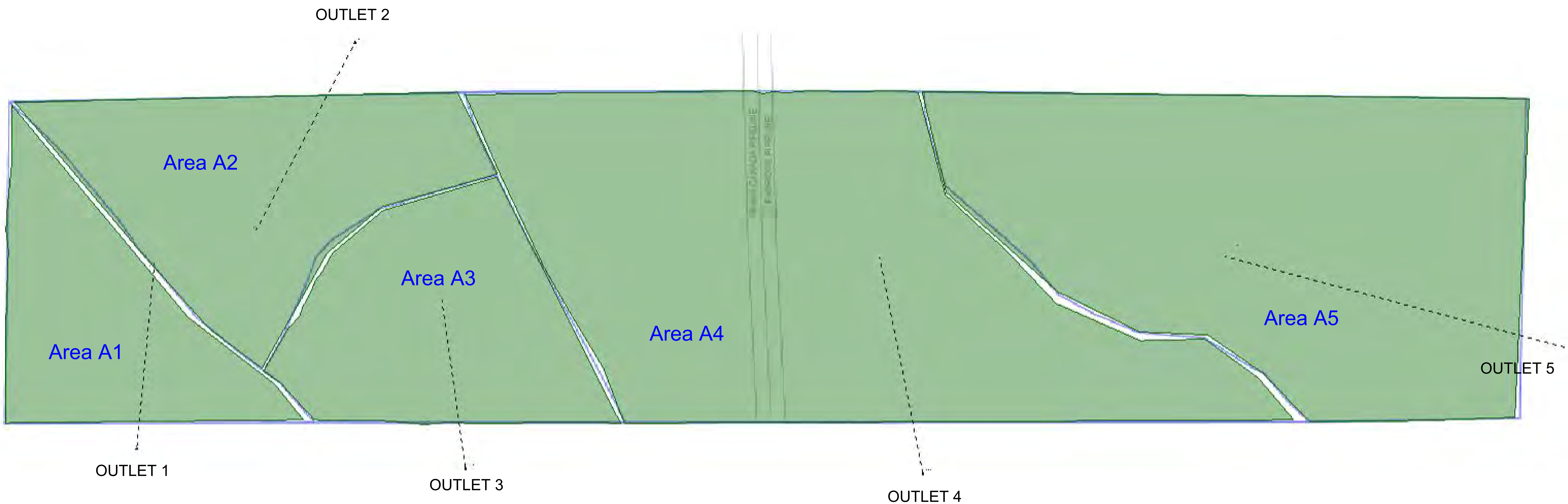
No.	Revision / Issue	Date	Drawing Number:

FILENAME: M:\02-Documents\2014\0PP-14-9580 - Canadian Solar Baltimore Solar\Drawings\PP-14-9580 Baltimore Solar Apr 16 2015.dwg
LAST SAVED: Monday, April 20, 2015 LAST SAVED BY: d.longmuir
LAST PLOTTED: Monday, April 20, 2015 CTB FILE USED: MP-DEFAULT(reduced).ctb

APPENDIX B
MODEL PARAMETER
SOURCE EXCERPTS

Hamilton - Port Hope 4 Solar Farm

Pre-Development Schematic



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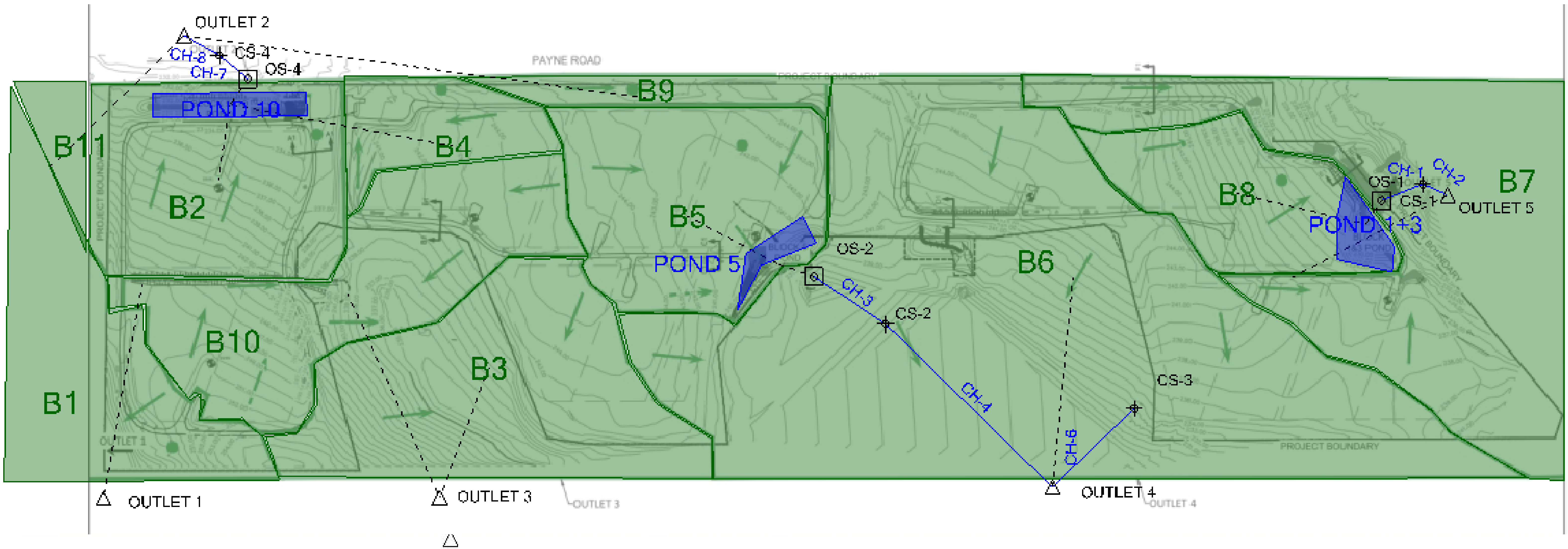
Hamilton - Port Hope 4 Solar Farm

Post-Development Schematic



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IDF CURVE LOOKUP

Coordinate Selection | Terms of Use | About

Active coordinate

44° 1' 15" N, 78° 7' 14" W (44.020833,-78.120833) Modify selection

Retrieved: Mon, 30 Mar 2015 16:51:26 GMT

Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

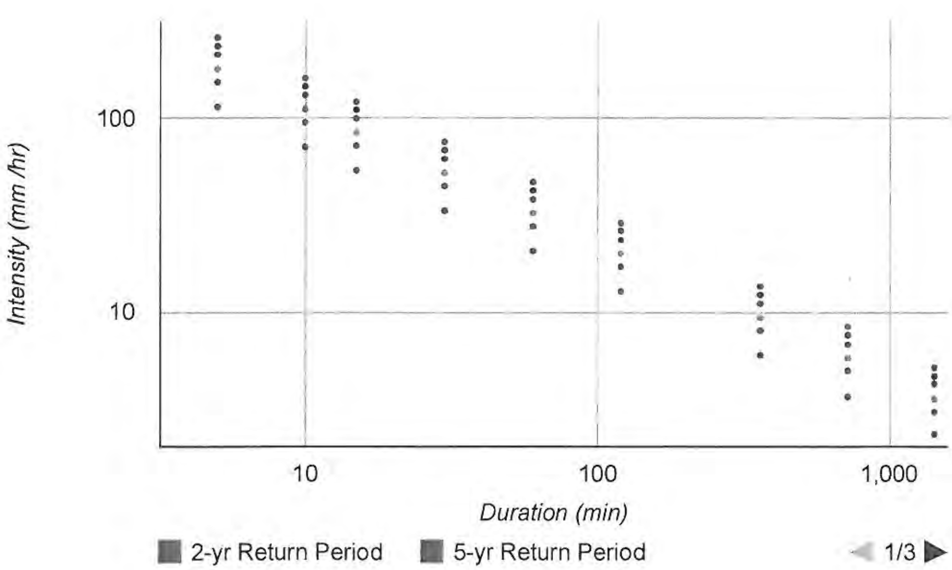
These are the coordinates in the selection.

IDF Curve: 44° 1' 15" N, 78° 7' 14" W (44.020833,-78.120833)

Results

An IDF curve was found for this set of coordinates.

Coordinate: 44.020833,-78.120833



Coefficient summary Notes

Click a return period in the table header for more detail.

Return period	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	20.4	27.4	32.0	37.8	42.0	46.3
B	-0.693	-0.693	-0.693	-0.695	-0.693	-0.694

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	114.2	70.6	53.3	33.0	20.4	12.6	5.9	3.6	2.3
5-yr	153.3	94.8	71.6	44.3	27.4	16.9	7.9	4.9	3.0
10-yr	179.1	110.8	83.6	51.7	32.0	19.8	9.2	5.7	3.5
25-yr	212.6	131.3	99.1	61.2	37.8	23.3	10.9	6.7	4.2
50-yr	235.0	145.4	109.8	67.9	42.0	26.0	12.1	7.5	4.6
100-yr	259.7	160.6	121.2	74.9	46.3	28.6	13.4	8.3	5.1

Terms of Use

You have agreed to the Terms of Use of this site by reviewing, using or otherwise interpreting this data.

Design Chart 1.09: Soil Conservation Service Curve Numbers (Continued)

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow (special cases only)	77	82	86	89	91	93	94
Crop and other improved land	66** (62)	70** (68)	74	78	82	84	86 AMC I
Pasture & other unimproved land	58* (38)	62* (51)	65	71	76	79	81
Woodlots and forest	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare bedrock draining directly to stream by surface flow							98
Bare bedrock draining indirectly to stream as groundwater (usual case)							70
Lakes and wetlands							50

Notes

(i) All values are based on AMC II except those marked by * (AMC III) or ** (mean of AMC II and AMC III).

(ii) Values in brackets are AMC II and are to be used only for special cases.

(iii) Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff.

APPENDIX C
PRE-DEVELOPMENT DRAINAGE PLAN & INPUT PARAMETERS, SCHEMATIC AND RESULTS

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT
DRAINAGE AREA INFORMATION (POST DEV - AECOM)

Land Use Breakdown

Catchment ID	Area (m^2)	Impervious (m^2)	Pasture (m^2)	Crop (m^2)	Pond (m^2)	CN
A1	87,625	381	65,892	21,352	0	67.3
A2	106,861	1554	16,185	89,122	0	73.0
A3	97,469	0	53,597	42,822	1,050	69.3
A4	286,403	0	138,303	148,100	0	69.7
A5	246,496	0	156,164	90,332	0	68.3
Total	**824,854**	**1935**	**430,141**	**391,728**	**1,050**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
A1	444	4.7	90	3.3	2.35	29
A2	444	4.7	180	2.0	1.83	26
A3	224	4.6	215	0.3	0.73	21
A4	732	2.7				53
A5	412	5.1				25

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
A1	8.8	67.3	29
A2	10.7	73.0	26
A3	9.7	69.3	21
A4	28.6	69.7	53
A5	24.6	68.3	25
Total	**82.5**		

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT HYDROLOGICAL RESULTS

12-Hr - Pre-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A1	22	122	217	359	490	633
Area A2	103	317	483	716	917	1,134
Area A3	50	219	365	576	761	958
Area A4	99	362	586	927	1,233	1,562
Area A5	85	430	742	1,200	1,620	2,077
Total	359	1,450	2,394	3,778	5,020	6,363

24-Hr - Pre-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A1	64	186	298	480	595	747
Area A2	185	401	579	851	1,015	1,232
Area A3	118	297	455	701	852	1,047
Area A4	210	526	811	1,274	1,561	1,938
Area A5	229	629	984	1,548	1,899	2,367
Total	806	2,039	3,127	4,854	5,922	7,330

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT HYDROLOGICAL RESULTS

Storms	Return Periods (Years)	Rainfall Depths (mm)		Return Periods (Years)	Rainfall Depths (mm)
12Hr SCS	2	43.2	24Hr SCS	2	55.2
	5	58.8		5	72.0
	10	68.4		10	84.0
	25	80.4		25	101.4
	50	90.0		50	110.4
	100	99.6		100	122.4

12-Hr - Pre-Development Volume and Runoff Volume Coefficient

	Area	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
	m^2	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC
Area A1	87,630	215	6%	654	13%	1,009	17%	1,528.0	22%	1,992.3	25%	2,493.2	29%
Area A2	106,860	538	12%	1,277	20%	1,831	25%	2,605.9	30%	3,279.8	34%	3,992.5	38%
Area A3	97,470	313	7%	863	15%	1,296	19%	1,916.3	24%	2,466.1	28%	3,055.0	31%
Area A4	286,400	971	8%	2,625	16%	3,919	20%	5,770.7	25%	7,407.8	29%	9,158.9	32%
Area A5	246,500	690	6%	1,997	14%	3,041	18%	4,552.3	23%	5,898.7	27%	7,346.2	30%

24-Hr - Pre-Development Volume and Runoff Volume Coefficient

	Area	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
	m^2	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC
Area A1	87,630	527	11%	1,143	18%	1,679	23%	2,532	28%	3,064	32%	3,766	35%
Area A2	106,860	1,074	18%	2,037	26%	2,830	32%	4,052	37%	4,797	41%	5,765	44%
Area A3	97,470	709	13%	1,461	21%	2,102	26%	3,110	31%	3,733	35%	4,552	38%
Area A4	286,400	2,132	13%	4,359	21%	6,250	26%	9,222	32%	11,057	35%	13,464	38%
Area A5	246,500	1,626	12%	3,439	19%	4,999	24%	7,470	30%	9,004	33%	11,024	37%

APPENDIX D
POST-DEVELOPMENT DRAINAGE PLAN & INPUT PARAMETERS, SCHEMATIC AND RESULTS

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT DRAINAGE AREA INFORMATION

Land Use Breakdown

Catchment ID	Area (m^2)	Gravel (m^2)	Impervious (m^2)	Crop (m^2)	Improved (m^2)	Pasture (m^2)	Pond (m^2)	CN
B1	82,420	1,458	381	8,955	6,000	65,626	0	67.7
B2	35,884	1,917	35	0	30,327	0	3,605	84.0
B3	70,534	326	0	5,661	24,793	39,754	0	71.8
B4	15,173	1,650	535	0	11,767	1,221	0	81.5
B5	54,633	3,805	105	0	48,685	1,202	2,038	84.3
B6	219,890	3,251	53	35,052	55,478	126,056	0	71.0
B7	206,268	2,907	53	16,334	22,826	164,148	0	67.9
B8	35,261	1,649	35	6,118	24,899	0	2,560	82.1
B9	11,395	650	0	6859	0	3,886	0	71.6
B10	61,036	1,192	70	3454	39581	15,689	1050	77.6
B11	32,360	1,009	1,278	8,619	6,223	15,231	0	72.6
Total	**824,854**	**19,814**	**2,545**	**91,052**	**270,579**	**432,813**	**9,253**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope of Land (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
B1	227	6.2	90	3.3	2.35	15
B2	203	6.7	47	1.5	1.57	8
B3	215	2.2				33
	143	4.0	215	0.3	2.36	
B4	225	2.6	82	3.4	2.36	15
B5	203	2.0	128	4.5	2.72	15
B6	160	1.8	60	3.8	2.50	43
	359	3.8				
B7	412	5.1				25
B8	197	6.9	170	3.3	2.34	9
B9	197	2.1				20
B10	155	7.0	97	1.3	1.48	14
	93	6.7				
B11	301	5.6	271	0.6	0.99	21

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT DRAINAGE AREA INFORMATION

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)	Outlet
B1	8.2	67.7	15	Neighbouring Property
B2	3.6	84.0	8	Block 10 Pond
B3	7.1	71.8	33	Creek to West Unrestricted
B4	1.5	81.5	15	Block 10 Pond
B5	5.5	84.3	15	Block 5 Pond
B6	22.0	71.0	43	Creek to West Unrestricted
B7	20.6	67.9	25	Creek to South Unrestricted
B8	3.5	82.1	9	Block 1+3 Pond
B9	1.1	71.6	20	Unrestricted to North
B10	6.1	77.6	14	Wetland West of Block 8
B11	3.2	72.6	21	Payne Road Culvert Unrestricted
	82.5			

Reference

The SCS Lag Formula

$$tc = \frac{60 * L^{0.8} (S'+25.4)^{0.7}}{4238*S^{0.33}}$$

where

tc = time of concentration, min.
L = watershed length, m.
S' = potential maximum retention (S' = (25400 / CN) - 254)
CN = curve number
S = watershed slope, %

Channel Flow

Mannings Equation

$$V = \frac{(R^{2/3}*S^{1/2})}{n}$$

where

V = velocity (m/s)
R = hydraulic radius
S = slope of ditch, %
n = manning's roughness coefficients (0.03 for grass swales)

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

Unrestricted

12-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area B1	32	191	328	527	702	888	Unrestricted to Community Center Road Municipal ditch and heads west to Baltimore Creek Tributary
Area B2	227	411	532	688	815	944	Restricted by Pond 10 and outlets into Payn Road Municipal ditch and heads generally east towards Baltimore Creek Tributary
Area B3	47	156	244	373	486	605	Unrestricted towards Brook Creek Tributary to west
Area B4	63	123	165	220	266	312	Restricted by Pond 10 and outlets into Payn Road Municipal ditch and heads generally east towards Baltimore Creek Tributary
Area B5	289	531	691	899	1,068	1,240	Restricted by Pond 5 towards Brook Creek Tributary to west via B6
Area B6	108	370	592	912	1,194	1,494	Unrestricted towards Brook Creek Tributary to the west
Area B7	64	340	595	972	1,317	1,695	Unrestricted towards Brook Creek Tributary to south
Area B8	186	349	462	609	730	852	Restricted by Pond 3 towards Brook Creek Tributary to South via B7
Area B9	10	35	54	82	107	133	Unrestricted to northeast towards Baltimore Creek Tributary
Area B10	172	388	543	752	927	1,108	Unrestricted towards Brook Creek Tributary to west via B3
Area B11	33	106	162	240	307	381	Unrestricted to northeast towards Baltimore Creek Tributary
Total	1,231	3,000	4,370	6,273	7,917	9,650	

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

24-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area B1	108	305	475	745	916	1,141	Unrestricted to Community Center Road Municipal ditch and heads west to Baltimore Creek Tributary
Area B2	302	479	610	799	907	1,044	Restricted by Pond 10 and outlets into Payn Road Municipal ditch and heads generally east towards Baltimore Creek Tributary
Area B3	99	232	345	519	625	762	Unrestricted towards Brook Creek Tributary to west
Area B4	89	150	197	265	304	354	Restricted by Pond 10 and outlets into Payn Road Municipal ditch and heads generally east towards Baltimore Creek Tributary
Area B5	392	626	801	1,052	1,198	1,380	Restricted by Pond 5 towards Brook Creek Tributary to west via B6
Area B6	230	554	838	1,284	1,557	1,912	Unrestricted towards Brook Creek Tributary to the west
Area B7	192	562	899	1,446	1,784	2,227	Unrestricted towards Brook Creek Tributary to south
Area B8	253	417	540	719	824	955	Restricted by Pond 1 towards Brook Creek Tributary to South via B7
Area B9	22	51	75	113	136	165	Unrestricted to Northeast towards Baltimore Creek Tributary
Area B10	271	497	673	936	1,091	1,288	Unrestricted towards Brook Creek Tributary to west via B3
Area B11	69	151	220	326	391	474	Unrestricted to Northeast towards Baltimore Creek Tributary
Total	2,028	4,023	5,673	8,204	9,732	11,703	

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

Storms	Return Periods (Years)	Rainfall Depths (mm)		Return Periods (Years)	Rainfall Depths (mm)
12Hr SCS	2	43.2	24Hr SCS	2	55.2
	5	58.8		5	72.0
	10	68.4		10	84.0
	25	80.4		25	101.4
	50	90.0		50	110.4
	100	99.6		100	122.4

12-Hr - Post-Development Volume and Runoff Volume Coefficient

	Area	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
	m^2	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC
Area B1	82,420	211	6%	632	13%	972	17%	1,466	22%	1,907	26%	2,383	29%
Area B2	35,880	492	32%	888	42%	1,155	47%	1,507	52%	1,799	56%	2,098	59%
Area B3	70,560	310	10%	768	19%	1,117	23%	1,609	28%	2,039	32%	2,495	36%
Area B4	15,170	170	26%	323	36%	428	41%	569	47%	686	50%	808	53%
Area B5	54,630	767	33%	1,377	43%	1,786	48%	2,325	53%	2,772	56%	3,231	59%
Area B6	219,890	878	9%	2,247	17%	3,298	22%	4,789	27%	6,098	31%	7,491	34%
Area B7	206,270	545	6%	1,611	13%	2,468	17%	3,714	22%	4,825	26%	6,022	29%
Area B8	35,260	416	27%	779	38%	1,028	43%	1,358	48%	1,635	52%	1,920	55%
Area B9	11,380	49	10%	122	18%	178	23%	257	28%	326	32%	399	35%
Area B10	61,040	488	19%	1,013	28%	1,387	33%	1,896	39%	2,331	42%	2,783	46%
Area B11	32,360	156	11%	375	20%	540	24%	772	30%	974	33%	1,187	37%

24-Hr - Post-Development Volume and Runoff Volume Coefficient

	Area	2-Year		5-Year		10-Year		25-Year		50-Year		100-Year	
	m^2	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC	RV	RC
Area B1	82,420	516	11%	1,107	19%	1,619	23%	2,434	29%	2,939	32%	3,606	36%
Area B2	35,880	791	40%	1,257	49%	1,613	54%	2,133	59%	2,438	62%	2,826	64%
Area B3	70,560	642	16%	1,246	25%	1,750	30%	2,533	35%	3,010	39%	3,633	42%
Area B4	15,170	285	34%	468	43%	610	48%	821	53%	945	56%	1,103	59%
Area B5	54,630	1,224	41%	1,939	49%	2,483	54%	3,279	59%	3,744	62%	4,336	65%
Area B6	219,890	1,858	15%	3,674	23%	5,200	28%	7,579	34%	9,037	37%	10,941	41%
Area B7	206,270	1,312	12%	2,800	19%	4,087	24%	6,134	29%	7,404	33%	9,077	36%
Area B8	35,260	688	35%	1,123	44%	1,458	49%	1,953	55%	2,244	58%	2,616	61%
Area B9	11,380	102	16%	199	24%	280	29%	406	35%	483	38%	583	42%
Area B10	61,040	877	26%	1,530	35%	2,050	40%	2,832	46%	3,299	49%	3,901	52%
Area B11	32,360	316	18%	603	26%	841	31%	1,208	37%	1,432	40%	1,723	43%

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APPENDIX E
STORMWATER MANAGEMENT FACILITY DESIGNS

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT COMPARISON HYDROLOGICAL RESULTS

Unrestricted

24-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B1	108	305	475	745	916	1,141
Area B2	302	479	610	799	907	1,044
Area B3	99	232	345	519	625	762
Area B4	89	150	197	265	304	354
Area B5	392	626	801	1,052	1,198	1,380
Area B6	230	554	838	1,284	1,557	1,912
Area B7	192	562	899	1,446	1,784	2,227
Area B8	253	417	540	719	824	955
Area B9	22	51	75	113	136	165
Area B10	271	497	673	936	1,091	1,288
Area B11	69	151	220	326	391	474
Total	2,028	4,023	5,673	8,204	9,732	11,703

Outlet #1	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area A1	64	186	298	480	595	747	Neighbouring Property
Area B1	108	305	475	745	916	1,141	Neighbouring Property
Δ	44	119	177	265	321	394	
Restricted via Herringbone check dams and RFCDs on site							

Outlet #2	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area A2	185	401	579	851	1,015	1,232	Payne Road
Area B2	302	479	610	799	907	1,044	Pond 10
Area B4	89	150	197	265	304	354	Pond 10
Area B9	22	51	75	113	136	165	Payne Road
Area B11	69	151	220	326	391	474	Payne Road
Δ	297	429	523	651	723	806	
Allowable Outflow from B2 Pond	5	49	88	147	184	238	
See Appendix F for additional details							

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT COMPARISON HYDROLOGICAL RESULTS

Outlet #3	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area A3	118	297	455	701	852	1,047	Creek to West Unrestricted
Area B3	99	232	345	519	625	762	Creek to West Unrestricted
Area B10	271	497	673	936	1,091	1,288	Creek to West Unrestricted
Δ	252	432	564	754	864	1,003	
See Appendix G for additional details							

Outlet #4	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area A4	210	526	811	1,274	1,561	1,938	Creek to West Unrestricted
Area B5	392	626	801	1,052	1,198	1,380	Block 5
Area B6	230	554	838	1,284	1,557	1,912	Creek to West Unrestricted
POST	622	1,180	1,639	2,337	2,754	3,292	
Δ	412	653	828	1,063	1,193	1,354	
Allowable Outflow from B5	-20	-27	-27	-10	4	26	
Actual Outflow from B5 Pond	14	19	27	35	38	41	
Combined Outflow	244	573	865	1,319	1,595	1,953	
% Over Pre	16%	9%	7%	4%	2%	1%	

Outlet #5	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	
	(L/s)						
Area A5	229	629	984	1,548	1,899	2,367	Creek to West Unrestricted
Area B7	192	562	899	1,446	1,784	2,227	Creek to West Unrestricted
Area B8	253	417	540	719	824	955	Blocks 1+3
POST	445	978	1,439	2,165	2,607	3,182	
Δ	216	350	455	617	708	815	
Allowable Outflow from B1 Pond	37	67	86	102	115	140	
Actual Outflow from B1 Pond	23	62	81	104	116	128	
Combined Outflow	216	624	979	1,550	1,900	2,355	

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

Restricted - 24 Hour

Pond 1+3

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	228.84	325	23	1.56	1,729
5-year	229.03	506	62	1.37	1,547
10-year	229.20	663	81	1.20	1,390
25-year	229.46	908	104	0.94	1,145
50-year	229.62	1,060	116	0.78	993
100-year	229.80	1,274	128	0.60	779

Pond #5

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	237.35	758	14	1.83	2,832
5-year	237.86	1,269	19	1.32	2,321
10-year	238.07	1,616	27	1.11	1,974
25-year	238.44	2,256	35	0.74	1,334
50-year	238.63	2,575	38	0.55	1,015
100-year	238.88	2,996	41	0.30	594

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

Restricted - 12 Hour

Pond 1+3

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	228.76	244	12	1.64	1,810
5-year	228.93	411	42	1.47	1,642
10-year	229.06	533	66	1.34	1,520
25-year	229.25	706	86	1.15	1,347
50-year	229.41	863	100	0.99	1,190
100-year	229.59	1028	114	0.81	1,025

Pond #5

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Discharge [Peak Flow] (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	237.01	530	13	2.17	3,060
5-year	237.73	1053	16	1.45	2,538
10-year	237.92	1376	22	1.26	2,214
25-year	238.16	1774	29	1.02	1,816
50-year	238.41	2190	34	0.77	1,400
100-year	238.61	2544	38	0.57	1,046

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT DRAWDOWN TIME (USING LINEAR REGRESSION)

As per the Section 4.6.2 (Wet Ponds) of the MOE Stormwater Management Planning and Design Manual, March 2003, a detention time of 24 hours should be targeted in all instances.

The detention time can be easily solved if the relationship between pond surface area and wetland depth is approximated using a linear regression equation as follows:

Drawdown Time Equation ---->

$$t = \frac{0.66\, C_2\, h^{1.5} + 2\, C_3\, h^{0.5}}{2.75\, A_o}$$

Equation 4.11 (MOE SWM Planning Design Manual, 2003)

where,
t = Drawdown time in seconds
C_2 = Slope coefficient from the area-depth linear regression
C_3 = Intercept from the area-depth linear regression
h = Maximum water elevation above the orifice (m)
A_o = Cross-sectional area of the orifice (m^2)

The relationship between A and h using Linear Regression (i.e., $A = C_2 h + C_3$)

Orifice Details:	***Blocks #1+3***		***Block #5***	
Orifice(s) Diameter =	75 mm	250 mm	75 mm	130 mm
Orifice Invert Elevation =	228.40 m	228.70 m	235.80 m	237.80 m

From Elevation - Discharge Table Sheet

Pond Details:

Storage Elevation (m)	**Max. Water Elevation Above Orifice (m)**	**Surface area of the Pond (m^2)**	**Storage Elevation (m)**	**Max. Water Elevation Above Orifice (m)**	**Surface area of the Pond (m^2)**
Blocks #1+3			***Block #5***		
228.40	0.00	172	235.80	0.00	41
228.55	0.15	650	236.43	0.63	453

Drawdown Time Results:	***Blocks #1+3***	***Block #5***
Slope (C_2) =	3,187	655
Intercept (C_3) =	172	41
Maximum Water Elevation Above Orifice (h) =	0.15 m	0.63 m
Cross-sectional area of the orifice (A_o) =	0.004 m2	0.004 m2
Drawdown time	21,023 s	23,140 s
Drawdown Time (rounded to nearest hour, exact times calculated)	**6 hrs**	**6 hrs**

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT ELEVATION - DISCHARGE TABLE POND 1+3

For Orifice Flow, C =	0.60
For Weir Flow, C =	1.84

	Drawdown Outlet	Outlet	Emergency Outlet
Invert Elevation	228.40	228.70	229.80
Orifice Width/Weir Length	75 mm	250 mm	900 mm
Orifice Area (m^2)	0.004	0.049	0.636

Elevation	Drawdown Outlet		Outlet		Emergency Spillway Outlet		Total
	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	Q [m^3/s]
228.40	x	x	x	x	x	x	x
228.70	0.30	0.006	x	x	x	x	0.006
229.12	0.72	0.010	0.42	0.085	x	x	0.095
230.40	2.00	0.017	1.70	0.170	0.60	1.310	1.496

Notes: 1. For Orifice Flow, User is to Input an Elevation Higher than Invert of Orifice.

*2. Orifice Equation: $Q = cA(2gh)^{1/2}$ (m^3/s *1000 = l/s)*

*3. Weir Equation: $Q = CLH^{3/2}$ (m^3/s *1000 = l/s)*

4. These Computations Do Not Account for Submergence Effects Within the Pond Riser.

5. H for orifice equations is depth of water above the invert of the orifice.

6. H for weir equations is depth of water above the weir crest.

Reference: Urban Hydrology, Hydraulics and Stormwater Quality: engineering application and computer modeling / A. Akan, Robert J. Houghtalen, 2003.

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT ELEVATION - DISCHARGE TABLE POND 5

For Orifice Flow, C =	0.60
For Weir Flow, C =	1.84

	Drawdown Outlet	Outlet #1	Emergency Weir
Invert Elevation	235.80	237.80	238.88
Orifice Width/Weir Length	75 mm	130 mm	5.00 m
Orifice Area (m^2)	0.004	0.013	

Elevation	Drawdown Outlet		Outlet #1		Emergency Weir		Total
	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	Q [m^3/s]
236.10	x	x	x	x	N/A		x
237.80	2.00	0.017	x	x			0.017
238.88	3.08	0.021	1.08	0.037			0.057
239.18	3.38	0.022	1.38	0.041	0.30	1.512	1.575

Notes: 1. For Orifice Flow, User is to Input an Elevation Higher than Invert of Orifice.
*2. Orifice Equation: $Q = cA(2gh)^{1/2}$ (m^3/s *1000 = l/s)*
*3. Weir Equation: $Q = CLH^{3/2}$ (m^3/s *1000 = l/s)*
4. These Computations Do Not Account for Submergence Effects Within the Pond Riser.
5. H for orifice equations is depth of water above the invert of the orifice.
6. H for weir equations is depth of water above the weir crest.

Reference: Urban Hydrology, Hydraulics and Stormwater Quality: engineering application and computer modeling / A. Akan, Robert J. Houghtalen, 2003.

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT ELEVATION - INFILTRATION

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Table 6.3: Annual Sediment Loadings (SWM Design Manual)

Requirements		Outlet 1	Outlet 2	Outlet 3	Outlet 4	Outlet 5	Units
Catchment Imperviousness	=	1.8%	5.6%	1.2%	2.6%	4.8%	
Total Area	=	8.2	9.1	13.2	9.5	3.5	ha
Storage Volume	=	1.3	4.0	0.9	1.9	3.4	m^3/ha
Required Storage Volume	**=**	**10**	**37**	**11**	**18**	**12**	**m^3**
Provided Storage Volume	**=**		**60**	**24**	**47**	**24**	**m^3**

Outlet #1 Comprised of B1

Outlet #2 Comprised of B2, B4, B9 and B11

Outlet #3 Comprised of B3 and B10

Outlet #4 Comprised of B5 and portions of B6

Outlet #5 Comprised of B8

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PP-14-9580 - HAMILTON-PORT HOPE 4 SOLAR FARM PROJECT - ANNUAL SEDIMENT LOADING AND CLEANOUT RATE - POND 9 & 10

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Table 6.3: Annual Sediment Loadings (SWM Design Manual)

Requirements		Result	Units
Catchment Imperviousness	=	8.1%	
Sediment Loading Per 1-Year	=	0.14	m^3/ha
Total Area to Pond	=	5.1	ha
Annual Sediment Accumulation in Pond	=	0.7	m^3
Available Storage Volume (Raw data 24hr Pond 10)	=	*3,390*	m^3
Storage Volume @ 5% Less Efficient	=	*3,221*	m^3
Total Sediment Accumlation Allowed Before Removal Required (Provided - Max Allowed 5% Reduction)	=	170	m^3
Total Approximate Number of Years Before Sediment Removal is Required	**=**	**239**	**years**

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PP-14-9580 - HAMILTON-PORT HOPE 4 SOLAR FARM PROJECT - ANNUAL SEDIMENT LOADING AND CLEANOUT RATE - POND 1 & 3

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Table 6.3: Annual Sediment Loadings (SWM Design Manual)

Requirements		Result	Units
Catchment Imperviousness	=	4.78%	
Sediment Loading Per 1-Year	=	0.08	m^3/ha
Total Area to Pond	=	3.5	ha
Annual Sediment Accumulation in Pond	=	0.29	m^3
Available Storage Volume	=	*2,241*	m^3
Storage Volume @ 5% Less Efficient	=	*2,129*	m^3
Total Sediment Accumlation Allowed Before Removal Required (Provided - Max Allowed 5% Reduction)	=	112	m^3
Total Approximate Number of Years Before Sediment Removal is Required	**=**	**388**	**years**

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PP-14-9580 - HAMILTON-PORT HOPE 4 SOLAR FARM PROJECT - ANNUAL SEDIMENT LOADING AND CLEANOUT RATE - POND 5

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Table 6.3: Annual Sediment Loadings (SWM Design Manual)

Requirements		Result	Units
Catchment Imperviousness	=	6.0%	
Sediment Loading Per 1-Year	=	0.10	m^3/ha
Total Area to Pond	=	5.1	ha
Annual Sediment Accumulation in Pond	=	0.53	m^3
Available Storage Volume	=	*2,336*	m^3
Storage Volume @ 5% Less Efficient	=	*2,219*	m^3
Total Sediment Accumlation Allowed Before Removal Required (Provided - Max Allowed 5% Reduction)	=	117	m^3
Total Approximate Number of Years Before Sediment Removal is Required	**=**	**221**	**years**

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Worksheet for Irregular Section - Ditch A-A

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	2.65000	%
Discharge	0.76	m³/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	234.19
0+000.99	234.11
0+001.18	234.09
0+001.36	234.08
0+001.79	234.08
0+002.10	234.08
0+002.89	234.08
0+004.42	234.08
0+004.84	234.23
0+004.92	234.25
0+005.45	234.43
0+005.71	234.51
0+005.94	234.54
0+006.79	234.65
0+007.57	234.74
0+009.06	234.91
0+010.09	235.03
0+010.71	235.11
0+012.43	235.25
0+013.18	235.30
0+014.14	235.36
0+015.68	235.43

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient

Worksheet for Irregular Section - Ditch A-A

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 234.19)	(0+015.68, 235.43)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.14	m
Elevation Range	234.08 to 235.43 m		
Flow Area		0.58	m²
Wetted Perimeter		4.88	m
Hydraulic Radius		0.12	m
Top Width		4.82	m
Normal Depth		0.14	m
Critical Depth		0.16	m
Critical Slope		0.01756	m/m
Velocity		1.31	m/s
Velocity Head		0.09	m
Specific Energy		0.23	m
Froude Number		1.21	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.14	m

Worksheet for Irregular Section - Ditch A-A

GVF Output Data

Critical Depth	0.16	m
Channel Slope	2.65000	%
Critical Slope	0.01756	m/m

Messages

Notes

Section A-A is located in post-development drainage area B2. Area B2 has a flow rate of 1.9 m3/s. This flow rate has been prorated based on the upstream area 3.28ha that flows into the ditch. This results in an estimated flow of 0.76m3/s reaching the ditch. Section A-A is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch B-B

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	2.00000	%
Discharge	0.20	m³/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	241.69
0+000.95	241.66
0+001.18	241.65
0+001.94	241.60
0+003.92	241.46
0+004.67	241.51
0+006.18	241.60
0+007.64	241.71
0+009.26	241.80
0+009.38	241.81

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 241.69)	(0+000.95, 241.66)	0.030
(0+000.95, 241.66)	(0+001.18, 241.65)	0.030
(0+001.18, 241.65)	(0+001.94, 241.60)	0.030
(0+001.94, 241.60)	(0+003.92, 241.46)	0.030
(0+003.92, 241.46)	(0+004.67, 241.51)	0.030
(0+004.67, 241.51)	(0+006.18, 241.60)	0.030
(0+006.18, 241.60)	(0+007.64, 241.71)	0.030
(0+007.64, 241.71)	(0+009.26, 241.80)	0.030
(0+009.26, 241.80)	(0+009.38, 241.81)	0.030

Worksheet for Irregular Section - Ditch B-B

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.13	m
Elevation Range	241.46 to 241.81 m		
Flow Area		0.26	m²
Wetted Perimeter		4.02	m
Hydraulic Radius		0.07	m
Top Width		4.01	m
Normal Depth		0.13	m
Critical Depth		0.13	m
Critical Slope		0.02211	m/m
Velocity		0.76	m/s
Velocity Head		0.03	m
Specific Energy		0.16	m
Froude Number		0.95	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.13	m
Critical Depth	0.13	m
Channel Slope	2.00000	%
Critical Slope	0.02211	m/m

Messages

Notes

Worksheet for Irregular Section - Ditch B-B

Messages

Section B-B is located in post-development drainage area B3. B3 has a flow rate of 1.273m3/s. This flow rate has been prorated based on the upstream area 1.7 ha that will flow into the ditch. This results in an estimated flow of 0.20 m3/s to the ditch. Section B-B is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch C-C

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.40000	%
Discharge	0.22	m^3/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	243.40
0+000.67	243.36
0+003.51	243.10
0+003.73	243.09
0+005.42	243.20
0+005.67	243.22
0+006.30	243.25
0+006.74	243.26
0+007.06	243.25

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 243.40)	(0+000.67, 243.36)	0.030
(0+000.67, 243.36)	(0+003.51, 243.10)	0.030
(0+003.51, 243.10)	(0+003.73, 243.09)	0.030
(0+003.73, 243.09)	(0+005.42, 243.20)	0.030
(0+005.42, 243.20)	(0+005.67, 243.22)	0.030
(0+005.67, 243.22)	(0+006.30, 243.25)	0.030
(0+006.30, 243.25)	(0+006.74, 243.26)	0.030
(0+006.74, 243.26)	(0+007.06, 243.25)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch C-C

Options

Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.11	m
Elevation Range	243.09 to 243.40 m		
Flow Area		0.18	m²
Wetted Perimeter		3.06	m
Hydraulic Radius		0.06	m
Top Width		3.05	m
Normal Depth		0.11	m
Critical Depth		0.14	m
Critical Slope		0.02138	m/m
Velocity		1.26	m/s
Velocity Head		0.08	m
Specific Energy		0.19	m
Froude Number		1.67	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.11	m
Critical Depth	0.14	m
Channel Slope	6.40000	%
Critical Slope	0.02138	m/m

Messages

Notes

Section C-C is located in post-development drainage area B5. B5 has a flow rate of 1.424m3/s. This flow rate has been prorated based on the upstream area 0.99ha that will flow into the ditch. This results in an estimated flow of 0.22 m3/s to the ditch. Section C-C is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch D-D

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.20000	%
Discharge	0.35	m³/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	244.90
0+001.05	244.88
0+002.51	244.68
0+002.77	244.64
0+003.21	244.60
0+006.33	244.60
0+006.38	244.61
0+007.40	244.87
0+007.94	245.00
0+009.10	245.13
0+009.76	245.19

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 244.90)	(0+001.05, 244.88)	0.030
(0+001.05, 244.88)	(0+002.51, 244.68)	0.030
(0+002.51, 244.68)	(0+003.21, 244.60)	0.030
(0+003.21, 244.60)	(0+006.33, 244.60)	0.030
(0+006.33, 244.60)	(0+006.38, 244.61)	0.030
(0+006.38, 244.61)	(0+007.40, 244.87)	0.030
(0+007.40, 244.87)	(0+007.94, 245.00)	0.030
(0+007.94, 245.00)	(0+009.10, 245.13)	0.030
(0+009.10, 245.13)	(0+009.76, 245.19)	0.030

Worksheet for Irregular Section - Ditch D-D

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.09	m
Elevation Range	244.60 to 245.19 m		
Flow Area		0.33	m²
Wetted Perimeter		4.24	m
Hydraulic Radius		0.08	m
Top Width		4.23	m
Normal Depth		0.09	m
Critical Depth		0.10	m
Critical Slope		0.02004	m/m
Velocity		1.08	m/s
Velocity Head		0.06	m
Specific Energy		0.15	m
Froude Number		1.24	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth		0.00	m
Length		0.00	m
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	m
Profile Description			
Profile Headloss		0.00	m
Downstream Velocity		Infinity	m/s
Upstream Velocity		Infinity	m/s
Normal Depth		0.09	m
Critical Depth		0.10	m
Channel Slope		3.20000	%
Critical Slope		0.02004	m/m

Messages

Notes

Worksheet for Irregular Section - Ditch D-D

Messages

Section D-D is located in post-development drainage area B6. Area B6 has a flow rate of 1.907 m3/s. This flow rate has been prorated based on the upstream area 4.1ha that flows into the ditch. This results in an estimated flow of 0.35m3/s reaching the ditch. Section D-D is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch E-E

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	2.90000	%
Discharge	0.96	m³/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	230.40
0+000.51	230.29
0+002.02	230.00
0+002.15	229.96
0+002.83	229.80
0+003.46	229.67
0+003.80	229.60
0+004.25	229.47
0+004.52	229.40
0+004.94	229.27
0+005.15	229.20
0+005.62	229.06
0+005.77	229.00
0+006.05	228.93
0+006.67	228.80
0+007.23	228.71
0+007.79	228.60
0+010.10	228.75
0+010.39	228.80
0+010.70	228.85
0+011.48	229.00
0+012.57	229.12
0+012.63	229.13

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient

Worksheet for Irregular Section - Ditch E-E

Input Data

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 230.40)	(0+000.51, 230.29)	0.030
(0+000.51, 230.29)	(0+002.02, 230.00)	0.030
(0+002.02, 230.00)	(0+002.15, 229.96)	0.030
(0+002.15, 229.96)	(0+002.83, 229.80)	0.030
(0+002.83, 229.80)	(0+003.46, 229.67)	0.030
(0+003.46, 229.67)	(0+003.80, 229.60)	0.030
(0+003.80, 229.60)	(0+004.25, 229.47)	0.030
(0+004.25, 229.47)	(0+004.52, 229.40)	0.030
(0+004.52, 229.40)	(0+004.94, 229.27)	0.030
(0+004.94, 229.27)	(0+005.15, 229.20)	0.030
(0+005.15, 229.20)	(0+005.62, 229.06)	0.030
(0+005.62, 229.06)	(0+005.77, 229.00)	0.030
(0+005.77, 229.00)	(0+006.05, 228.93)	0.030
(0+006.05, 228.93)	(0+006.67, 228.80)	0.030
(0+006.67, 228.80)	(0+007.23, 228.71)	0.030
(0+007.23, 228.71)	(0+007.79, 228.60)	0.030
(0+007.79, 228.60)	(0+010.10, 228.75)	0.030
(0+010.10, 228.75)	(0+010.39, 228.80)	0.030
(0+010.39, 228.80)	(0+010.70, 228.85)	0.030
(0+010.70, 228.85)	(0+011.48, 229.00)	0.030
(0+011.48, 229.00)	(0+012.57, 229.12)	0.030
(0+012.57, 229.12)	(0+012.63, 229.13)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.25	m
Elevation Range	228.60 to 230.40 m		
Flow Area		0.62	m²
Wetted Perimeter		4.34	m
Hydraulic Radius		0.14	m
Top Width		4.30	m
Normal Depth		0.25	m
Critical Depth		0.28	m

Worksheet for Irregular Section - Ditch E-E

Results

Critical Slope		0.01634	m/m
Velocity		1.55	m/s
Velocity Head		0.12	m
Specific Energy		0.38	m
Froude Number		1.30	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.25	m
Critical Depth	0.28	m
Channel Slope	2.90000	%
Critical Slope	0.01634	m/m

Messages

Notes

This section E-E located in post drainage area B8 is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch F-F

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.50000	%
Discharge	0.18	m^3/s

Section Definitions

Station (m)	Elevation (m)
0+000.00	244.27
0+001.00	244.24
0+007.41	241.81
0+010.59	242.51
0+011.59	242.66

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+000.00, 244.27)	(0+001.00, 244.24)	0.030
(0+001.00, 244.24)	(0+007.41, 241.81)	0.030
(0+007.41, 241.81)	(0+010.59, 242.51)	0.030
(0+010.59, 242.51)	(0+011.59, 242.66)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.18	m
Elevation Range	241.81 to 244.27 m	
Flow Area	0.11	m^2
Wetted Perimeter	1.31	m
Hydraulic Radius	0.08	m

Worksheet for Irregular Section - Ditch F-F

Results

Top Width		1.26	m
Normal Depth		0.18	m
Critical Depth		0.22	m
Critical Slope		0.01943	m/m
Velocity		1.63	m/s
Velocity Head		0.14	m
Specific Energy		0.31	m
Froude Number		1.76	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.18	m
Critical Depth	0.22	m
Channel Slope	6.50000	%
Critical Slope	0.01943	m/m

Messages

Notes

Section F-F is located in post-development drainage area B7. B7 has a flow rate of 2.216m3/s. This flow rate has been prorated based on the upstream area 1.7 ha that will flow into the ditch. This results in an estimated flow of 0.18 m3/s to the ditch. Section F-F is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch A-A (Rock Check Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02650	m/m
Discharge	0.76	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	234.19
0+03	234.13
0+03	234.12
0+05	234.12
0+05	234.11
0+06	234.11
0+06	234.11
0+06	234.12
0+07	234.13
0+08	234.20
0+09	234.40

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 234.19)	(0+03, 234.13)	0.030
(0+03, 234.13)	(0+03, 234.12)	0.030
(0+03, 234.12)	(0+05, 234.12)	0.069
(0+05, 234.12)	(0+05, 234.11)	0.069
(0+05, 234.11)	(0+06, 234.11)	0.069
(0+06, 234.11)	(0+06, 234.11)	0.069
(0+06, 234.11)	(0+06, 234.12)	0.069
(0+06, 234.12)	(0+07, 234.13)	0.069
(0+07, 234.13)	(0+08, 234.20)	0.030
(0+08, 234.20)	(0+09, 234.40)	0.030

Worksheet for Irregular Section - Ditch A-A (Rock Check Dam)

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth		0.16	m
Elevation Range	234.11 to 234.40 m		
Flow Area		1.01	m²
Wetted Perimeter		8.16	m
Hydraulic Radius		0.12	m
Top Width		8.05	m
Normal Depth		0.16	m
Critical Depth		0.13	m
Critical Slope		0.06207	m/m
Velocity		0.75	m/s
Velocity Head		0.03	m
Specific Energy		0.19	m
Froude Number		0.68	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.16	m
Critical Depth	0.13	m
Channel Slope	0.02650	m/m
Critical Slope	0.06207	m/m

Messages

Notes

Messages

Section A-A (Rock Check Dam) located in post-development drainage area B2. Area B2 has a flow rate of 0.84 m3/s. This flow rate has been prorated based on the upstream area 3.28ha that flows into the ditch. This results in an estimated flow of 0.33m3/s reaching the ditch. In the 100-year event, the runoff will bypass over the spillway and flow partially into the solar array.

Worksheet for Irregular Section - Ditch B-B Rock Check Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02000	m/m
Discharge	0.20	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	241.69
0+01	241.64
0+04	241.64
0+04	241.54
0+04	241.54
0+04	241.64
0+07	241.64
0+08	241.71

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 241.69)	(0+01, 241.64)	0.030
(0+01, 241.64)	(0+04, 241.64)	0.078
(0+04, 241.64)	(0+04, 241.54)	0.078
(0+04, 241.54)	(0+04, 241.54)	0.078
(0+04, 241.54)	(0+04, 241.64)	0.078
(0+04, 241.64)	(0+07, 241.64)	0.078
(0+07, 241.64)	(0+08, 241.71)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch B-B Rock Check Dam)

Results

Normal Depth		0.17	m
Elevation Range	241.54 to 241.71 m		
Flow Area		0.56	m²
Wetted Perimeter		7.97	m
Hydraulic Radius		0.07	m
Top Width		7.74	m
Normal Depth		0.17	m
Critical Depth		0.14	m
Critical Slope		0.13078	m/m
Velocity		0.36	m/s
Velocity Head		0.01	m
Specific Energy		0.18	m
Froude Number		0.43	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.17	m
Critical Depth	0.14	m
Channel Slope	0.02000	m/m
Critical Slope	0.13078	m/m

Messages

Notes

Section B-B (Rock Check Dam) located in post-development drainage area B3. B3 has a flow rate of 1.273m3/s. This flow rate has been prorated based on the upstream area 1.7 ha that will flow into the ditch. This results in an estimated flow of 0.20 m3/s to the ditch. In the 100-year event, the runoff will bypass over the spillway and flow partially into the solar array.

Worksheet for Irregular Section - Ditch C-C (Rock Check Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06400	m/m
Discharge	0.22	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	243.40
0+02	243.24
0+03	243.24
0+03	243.14
0+04	243.14
0+04	243.24
0+06	243.24
0+07	243.26

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 243.40)	(0+02, 243.24)	0.030
(0+02, 243.24)	(0+03, 243.24)	0.069
(0+03, 243.24)	(0+03, 243.14)	0.069
(0+03, 243.14)	(0+04, 243.14)	0.069
(0+04, 243.14)	(0+04, 243.24)	0.069
(0+04, 243.24)	(0+06, 243.24)	0.069
(0+06, 243.24)	(0+07, 243.26)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch C-C (Rock Check Dam)

Results

Normal Depth		0.15	m
Elevation Range	243.14 to 243.40 m		
Flow Area		0.34	m²
Wetted Perimeter		5.44	m
Hydraulic Radius		0.06	m
Top Width		5.20	m
Normal Depth		0.15	m
Critical Depth		0.14	m
Critical Slope		0.10576	m/m
Velocity		0.64	m/s
Velocity Head		0.02	m
Specific Energy		0.17	m
Froude Number		0.80	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.15	m
Critical Depth	0.14	m
Channel Slope	0.06400	m/m
Critical Slope	0.10576	m/m

Messages

Notes

Section C-C (Rock Check Dam) located in post-development drainage area B5. B5 has a flow rate of 1.424m3/s. This flow rate has been prorated based on the upstream area 0.99ha that will flow into the ditch. This results in an estimated flow of 0.223 m3/s to the ditch. In the 100-year event, the runoff will bypass over the spillway and flow partially into the solar array.

Worksheet for Irregular Section - Ditch D-D (Rock Check Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.03200	m/m
Discharge	0.35	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	244.91
0+02	244.77
0+04	244.77
0+04	244.67
0+05	244.67
0+05	244.77
0+07	244.78
0+08	244.99

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 244.91)	(0+02, 244.77)	0.030
(0+02, 244.77)	(0+04, 244.77)	0.069
(0+04, 244.77)	(0+04, 244.67)	0.069
(0+04, 244.67)	(0+05, 244.67)	0.069
(0+05, 244.67)	(0+05, 244.77)	0.069
(0+05, 244.77)	(0+07, 244.78)	0.069
(0+07, 244.78)	(0+08, 244.99)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch D-D (Rock Check Dam)

Results

Normal Depth		0.20	m
Elevation Range	244.67 to 244.99 m		
Flow Area		0.61	m²
Wetted Perimeter		6.99	m
Hydraulic Radius		0.09	m
Top Width		6.78	m
Normal Depth		0.20	m
Critical Depth		0.17	m
Critical Slope		0.09519	m/m
Velocity		0.57	m/s
Velocity Head		0.02	m
Specific Energy		0.21	m
Froude Number		0.61	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.20	m
Critical Depth	0.17	m
Channel Slope	0.03200	m/m
Critical Slope	0.09519	m/m

Messages

Notes

Section D-D (Rock Check Dam) located in post-development drainage area B6. Area B6 has a flow rate of 1.907 m3/s. This flow rate has been prorated based on the upstream area 4.1ha that flows into the ditch. This results in an estimated flow of 0.35m3/s reaching the ditch. Section D-D is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch E-E Rock Check Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.02900	m/m
Discharge	0.96	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	230.39
0+06	228.87
0+08	228.87
0+08	228.82
0+09	228.82
0+09	228.87
0+11	228.87
0+13	229.13

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 230.39)	(0+06, 228.87)	0.030
(0+06, 228.87)	(0+08, 228.87)	0.069
(0+08, 228.87)	(0+08, 228.82)	0.069
(0+08, 228.82)	(0+09, 228.82)	0.069
(0+09, 228.82)	(0+09, 228.87)	0.069
(0+09, 228.87)	(0+11, 228.87)	0.069
(0+11, 228.87)	(0+13, 229.13)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch E-E Rock Check Dam)

Results

Normal Depth		0.24	m
Elevation Range	228.82 to 230.39 m		
Flow Area		1.11	m²
Wetted Perimeter		6.77	m
Hydraulic Radius		0.16	m
Top Width		6.64	m
Normal Depth		0.24	m
Critical Depth		0.20	m
Critical Slope		0.06926	m/m
Velocity		0.86	m/s
Velocity Head		0.04	m
Specific Energy		0.28	m
Froude Number		0.67	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.24	m
Critical Depth	0.20	m
Channel Slope	0.02900	m/m
Critical Slope	0.06926	m/m

Messages

Notes

This section E-E (Rock Check Dam) located in post drainage area B8 is capable of handling the 100-yr storm event.

Worksheet for Irregular Section - Ditch F-F (Rock Flow Dam)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.06500	m/m
Discharge	0.18	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	242.52
0+02	242.08
0+03	242.08
0+03	241.98
0+03	241.98
0+03	242.08
0+04	242.08
0+05	242.49

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 242.52)	(0+02, 242.08)	0.030
(0+02, 242.08)	(0+03, 242.08)	0.069
(0+03, 242.08)	(0+03, 241.98)	0.069
(0+03, 241.98)	(0+03, 241.98)	0.069
(0+03, 241.98)	(0+03, 242.08)	0.069
(0+03, 242.08)	(0+04, 242.08)	0.069
(0+04, 242.08)	(0+05, 242.49)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Worksheet for Irregular Section - Ditch F-F (Rock Flow Dam)

Results

Normal Depth		0.18	m
Elevation Range	241.98 to 242.52 m		
Flow Area		0.23	m²
Wetted Perimeter		2.77	m
Hydraulic Radius		0.08	m
Top Width		2.55	m
Normal Depth		0.18	m
Critical Depth		0.16	m
Critical Slope		0.10211	m/m
Velocity		0.77	m/s
Velocity Head		0.03	m
Specific Energy		0.21	m
Froude Number		0.81	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.18	m
Critical Depth	0.16	m
Channel Slope	0.06500	m/m
Critical Slope	0.10211	m/m

Messages

Notes

This section F-F (Rock Check Dam) located in post drainage area B7 is capable of handling the 100-yr storm event.

SCS TYPE II - 12 HOUR STORM
Baltimore

Souce: MTO Drainage Manual Chart 1.05

Time Step = 15min or = 0.25 hr

TIME ENDING (hr)	PER CENT RAINFALL (%)	CUM RAINFALL	RAINFALL INTENSITY (mm/hr) 2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0.25	0.625	0.625	1.08	1.47	1.71	2.01	2.25	2.49
0.5	0.625	1.25	1.08	1.47	1.71	2.01	2.25	2.49
0.75	0.625	1.875	1.08	1.47	1.71	2.01	2.25	2.49
1	0.625	2.5	1.08	1.47	1.71	2.01	2.25	2.49
1.25	0.625	3.125	1.08	1.47	1.71	2.01	2.25	2.49
1.5	0.625	3.75	1.08	1.47	1.71	2.01	2.25	2.49
1.75	0.625	4.375	1.08	1.47	1.71	2.01	2.25	2.49
2	0.625	**5.00**	1.08	1.47	1.71	2.01	2.25	2.49
2.25	0.75	5.75	1.30	1.76	2.05	2.41	2.70	2.99
2.5	0.75	6.5	1.30	1.76	2.05	2.41	2.70	2.99
2.75	0.75	7.25	1.30	1.76	2.05	2.41	2.70	2.99
3	0.75	**8.00**	1.30	1.76	2.05	2.41	2.70	2.99
3.25	1	9	1.73	2.35	2.74	3.22	3.60	3.98
3.5	1	**10.00**	1.73	2.35	2.74	3.22	3.60	3.98
3.75	1	11	1.73	2.35	2.74	3.22	3.60	3.98
4	1	**12.00**	1.73	2.35	2.74	3.22	3.60	3.98
4.25	1.5	13.5	2.59	3.53	4.10	4.82	5.40	5.98
4.5	1.5	**15.00**	2.59	3.53	4.10	4.82	5.40	5.98
4.75	2	17	3.46	4.70	5.47	6.43	7.20	7.97
5	2	**19.00**	3.46	4.70	5.47	6.43	7.20	7.97
5.25	3	22	5.18	7.06	8.21	9.65	10.80	11.95
5.5	3	**25.00**	5.18	7.06	8.21	9.65	10.80	11.95
5.75	12	**37.00**	20.74	28.22	32.83	38.59	43.20	47.81
6	33	**70.00**	57.02	77.62	90.29	106.13	118.80	131.47
6.25	4.5	74.5	7.78	10.58	12.31	14.47	16.20	17.93
6.5	4.5	**79.00**	7.78	10.58	12.31	14.47	16.20	17.93
6.75	2	81	3.46	4.70	5.47	6.43	7.20	7.97
7	2	**83.00**	3.46	4.70	5.47	6.43	7.20	7.97
7.25	1.5	84.5	2.59	3.53	4.10	4.82	5.40	5.98
7.5	1.5	**86.00**	2.59	3.53	4.10	4.82	5.40	5.98
7.75	1.5	87.5	2.59	3.53	4.10	4.82	5.40	5.98
8	1.5	**89.00**	2.59	3.53	4.10	4.82	5.40	5.98
8.25	0.875	89.875	1.51	2.06	2.39	2.81	3.15	3.49
8.5	0.875	90.75	1.51	2.06	2.39	2.81	3.15	3.49
8.75	0.875	91.625	1.51	2.06	2.39	2.81	3.15	3.49
9	0.875	92.5	1.51	2.06	2.39	2.81	3.15	3.49
9.25	0.875	93.375	1.51	2.06	2.39	2.81	3.15	3.49
9.5	0.875	94.25	1.51	2.06	2.39	2.81	3.15	3.49
9.75	0.875	95.125	1.51	2.06	2.39	2.81	3.15	3.49
10	0.875	**96.00**	1.51	2.06	2.39	2.81	3.15	3.49
10.25	0.5	96.5	0.86	1.18	1.37	1.61	1.80	1.99
10.5	0.5	97	0.86	1.18	1.37	1.61	1.80	1.99
10.75	0.5	97.5	0.86	1.18	1.37	1.61	1.80	1.99
11	0.5	98	0.86	1.18	1.37	1.61	1.80	1.99
11.25	0.5	98.5	0.86	1.18	1.37	1.61	1.80	1.99
11.5	0.5	99	0.86	1.18	1.37	1.61	1.80	1.99
11.75	0.5	99.5	0.86	1.18	1.37	1.61	1.80	1.99
12	0.5	**100.00**	0.86	1.18	1.37	1.61	1.80	1.99
			43.20	58.80	68.40	80.40	90.00	99.60

SCS TYPE II - 12 HOUR STORM
Baltimore

Souce: MTO Drainage Manual Chart 1.05

Time Step = 5min or = 0.083 hr

TIME ENDING (hr)	PER CENT RAINFALL (%)	CUM RAINFALL	RAINFALL INTENSITY (mm/hr) 2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0.083333	0.20833333	0.20833333	1.08	1.47	1.71	2.01	2.25	2.49
0.166667	0.20833333	0.41666667	1.08	1.47	1.71	2.01	2.25	2.49
0.25	0.20833333	0.625	1.08	1.47	1.71	2.01	2.25	2.49
0.333333	0.20833333	0.83333333	1.08	1.47	1.71	2.01	2.25	2.49
0.416667	0.20833333	1.04166667	1.08	1.47	1.71	2.01	2.25	2.49
0.5	0.20833333	1.25	1.08	1.47	1.71	2.01	2.25	2.49
0.583333	0.20833333	1.45833333	1.08	1.47	1.71	2.01	2.25	2.49
0.666667	0.20833333	1.66666667	1.08	1.47	1.71	2.01	2.25	2.49
0.75	0.20833333	1.875	1.08	1.47	1.71	2.01	2.25	2.49
0.833333	0.20833333	2.08333333	1.08	1.47	1.71	2.01	2.25	2.49
0.916667	0.20833333	2.29166667	1.08	1.47	1.71	2.01	2.25	2.49
1	0.20833333	2.5	1.08	1.47	1.71	2.01	2.25	2.49
1.083333	0.20833333	2.70833333	1.08	1.47	1.71	2.01	2.25	2.49
1.166667	0.20833333	2.91666667	1.08	1.47	1.71	2.01	2.25	2.49
1.25	0.20833333	3.125	1.08	1.47	1.71	2.01	2.25	2.49
1.333333	0.20833333	3.33333333	1.08	1.47	1.71	2.01	2.25	2.49
1.416667	0.20833333	3.54166667	1.08	1.47	1.71	2.01	2.25	2.49
1.5	0.20833333	3.75	1.08	1.47	1.71	2.01	2.25	2.49
1.583333	0.20833333	3.95833333	1.08	1.47	1.71	2.01	2.25	2.49
1.666667	0.20833333	4.16666667	1.08	1.47	1.71	2.01	2.25	2.49
1.75	0.20833333	4.375	1.08	1.47	1.71	2.01	2.25	2.49
1.833333	0.20833333	4.58333333	1.08	1.47	1.71	2.01	2.25	2.49
1.916667	0.20833333	4.79166667	1.08	1.47	1.71	2.01	2.25	2.49
2	0.20833333	**5.00**	1.08	1.47	1.71	2.01	2.25	2.49
2.083333	0.25	5.25	1.30	1.76	2.05	2.41	2.70	2.99
2.166667	0.25	5.5	1.30	1.76	2.05	2.41	2.70	2.99
2.25	0.25	5.75	1.30	1.76	2.05	2.41	2.70	2.99
2.333333	0.25	6	1.30	1.76	2.05	2.41	2.70	2.99
2.416667	0.25	6.25	1.30	1.76	2.05	2.41	2.70	2.99
2.5	0.25	6.5	1.30	1.76	2.05	2.41	2.70	2.99
2.583333	0.25	6.75	1.30	1.76	2.05	2.41	2.70	2.99
2.666667	0.25	7	1.30	1.76	2.05	2.41	2.70	2.99
2.75	0.25	7.25	1.30	1.76	2.05	2.41	2.70	2.99
2.833333	0.25	7.5	1.30	1.76	2.05	2.41	2.70	2.99
2.916667	0.25	7.75	1.30	1.76	2.05	2.41	2.70	2.99
3	0.25	**8.00**	1.30	1.76	2.05	2.41	2.70	2.99
3.083333	0.33333333	8.33333333	1.73	2.35	2.74	3.22	3.60	3.98
3.166667	0.33333333	8.66666667	1.73	2.35	2.74	3.22	3.60	3.98
3.25	0.33333333	9	1.73	2.35	2.74	3.22	3.60	3.98
3.333333	0.33333333	9.33333333	1.73	2.35	2.74	3.22	3.60	3.98
3.416667	0.33333333	9.66666667	1.73	2.35	2.74	3.22	3.60	3.98
3.5	0.33333333	**10.00**	1.73	2.35	2.74	3.22	3.60	3.98
3.583333	0.33333333	10.3333333	1.73	2.35	2.74	3.22	3.60	3.98
3.666667	0.33333333	10.6666667	1.73	2.35	2.74	3.22	3.60	3.98
3.75	0.33333333	11	1.73	2.35	2.74	3.22	3.60	3.98

3.833333	0.33333333	11.3333333	1.73	2.35	2.74	3.22	3.60	3.98
3.916667	0.33333333	11.6666667	1.73	2.35	2.74	3.22	3.60	3.98
4	0.33333333	**12.00**	1.73	2.35	2.74	3.22	3.60	3.98
4.083333	0.5	12.5	2.59	3.53	4.10	4.82	5.40	5.98
4.166667	0.5	13	2.59	3.53	4.10	4.82	5.40	5.98
4.25	0.5	13.5	2.59	3.53	4.10	4.82	5.40	5.98
4.333333	0.5	14	2.59	3.53	4.10	4.82	5.40	5.98
4.416667	0.5	14.5	2.59	3.53	4.10	4.82	5.40	5.98
4.5	0.5	**15.00**	2.59	3.53	4.10	4.82	5.40	5.98
4.583333	0.66666667	15.6666667	3.46	4.70	5.47	6.43	7.20	7.97
4.666667	0.66666667	16.3333333	3.46	4.70	5.47	6.43	7.20	7.97
4.75	0.66666667	17	3.46	4.70	5.47	6.43	7.20	7.97
4.833333	0.66666667	17.6666667	3.46	4.70	5.47	6.43	7.20	7.97
4.916667	0.66666667	18.3333333	3.46	4.70	5.47	6.43	7.20	7.97
5	0.66666667	**19.00**	3.46	4.70	5.47	6.43	7.20	7.97
5.083333	1	20	5.18	7.06	8.21	9.65	10.80	11.95
5.166667	1	21	5.18	7.06	8.21	9.65	10.80	11.95
5.25	1	22	5.18	7.06	8.21	9.65	10.80	11.95
5.333333	1	23	5.18	7.06	8.21	9.65	10.80	11.95
5.416667	1	24	5.18	7.06	8.21	9.65	10.80	11.95
5.5	1	**25.00**	5.18	7.06	8.21	9.65	10.80	11.95
5.583333	4	29	20.74	28.22	32.83	38.59	43.20	47.81
5.666667	4	33	20.74	28.22	32.83	38.59	43.20	47.81
5.75	4	**37.00**	20.74	28.22	32.83	38.59	43.20	47.81
5.833333	11	48	57.02	77.62	90.29	106.13	118.80	131.47
5.916667	11	59	57.02	77.62	90.29	106.13	118.80	131.47
6	11	**70.00**	57.02	77.62	90.29	106.13	118.80	131.47
6.083333	1.5	71.5	7.78	10.58	12.31	14.47	16.20	17.93
6.166667	1.5	73	7.78	10.58	12.31	14.47	16.20	17.93
6.25	1.5	74.5	7.78	10.58	12.31	14.47	16.20	17.93
6.333333	1.5	76	7.78	10.58	12.31	14.47	16.20	17.93
6.416667	1.5	77.5	7.78	10.58	12.31	14.47	16.20	17.93
6.5	1.5	**79.00**	7.78	10.58	12.31	14.47	16.20	17.93
6.583333	0.66666667	79.6666667	3.46	4.70	5.47	6.43	7.20	7.97
6.666667	0.66666667	80.3333333	3.46	4.70	5.47	6.43	7.20	7.97
6.75	0.66666667	81	3.46	4.70	5.47	6.43	7.20	7.97
6.833333	0.66666667	81.6666667	3.46	4.70	5.47	6.43	7.20	7.97
6.916667	0.66666667	82.3333333	3.46	4.70	5.47	6.43	7.20	7.97
7	0.66666667	**83.00**	3.46	4.70	5.47	6.43	7.20	7.97
7.083333	0.5	83.5	2.59	3.53	4.10	4.82	5.40	5.98
7.166667	0.5	84	2.59	3.53	4.10	4.82	5.40	5.98
7.25	0.5	84.5	2.59	3.53	4.10	4.82	5.40	5.98
7.333333	0.5	85	2.59	3.53	4.10	4.82	5.40	5.98
7.416667	0.5	85.5	2.59	3.53	4.10	4.82	5.40	5.98
7.5	0.5	**86.00**	2.59	3.53	4.10	4.82	5.40	5.98
7.583333	0.5	86.5	2.59	3.53	4.10	4.82	5.40	5.98
7.666667	0.5	87	2.59	3.53	4.10	4.82	5.40	5.98
7.75	0.5	87.5	2.59	3.53	4.10	4.82	5.40	5.98
7.833333	0.5	88	2.59	3.53	4.10	4.82	5.40	5.98
7.916667	0.5	88.5	2.59	3.53	4.10	4.82	5.40	5.98
8	0.5	**89.00**	2.59	3.53	4.10	4.82	5.40	5.98
8.083333	0.29166667	89.2916667	1.51	2.06	2.39	2.81	3.15	3.49
8.166667	0.29166667	89.5833333	1.51	2.06	2.39	2.81	3.15	3.49
8.25	0.29166667	89.875	1.51	2.06	2.39	2.81	3.15	3.49
8.333333	0.29166667	90.1666667	1.51	2.06	2.39	2.81	3.15	3.49

8.416667	0.29166667	90.4583333	1.51	2.06	2.39	2.81	3.15	3.49
8.5	0.29166667	90.75	1.51	2.06	2.39	2.81	3.15	3.49
8.583333	0.29166667	91.0416667	1.51	2.06	2.39	2.81	3.15	3.49
8.666667	0.29166667	91.3333333	1.51	2.06	2.39	2.81	3.15	3.49
8.75	0.29166667	91.625	1.51	2.06	2.39	2.81	3.15	3.49
8.833333	0.29166667	91.9166667	1.51	2.06	2.39	2.81	3.15	3.49
8.916667	0.29166667	92.2083333	1.51	2.06	2.39	2.81	3.15	3.49
9	0.29166667	92.5	1.51	2.06	2.39	2.81	3.15	3.49
9.083333	0.29166667	92.7916667	1.51	2.06	2.39	2.81	3.15	3.49
9.166667	0.29166667	93.0833333	1.51	2.06	2.39	2.81	3.15	3.49
9.25	0.29166667	93.375	1.51	2.06	2.39	2.81	3.15	3.49
9.333333	0.29166667	93.6666667	1.51	2.06	2.39	2.81	3.15	3.49
9.416667	0.29166667	93.9583333	1.51	2.06	2.39	2.81	3.15	3.49
9.5	0.29166667	94.25	1.51	2.06	2.39	2.81	3.15	3.49
9.583333	0.29166667	94.5416667	1.51	2.06	2.39	2.81	3.15	3.49
9.666667	0.29166667	94.8333333	1.51	2.06	2.39	2.81	3.15	3.49
9.75	0.29166667	95.125	1.51	2.06	2.39	2.81	3.15	3.49
9.833333	0.29166667	95.4166667	1.51	2.06	2.39	2.81	3.15	3.49
9.916667	0.29166667	95.7083333	1.51	2.06	2.39	2.81	3.15	3.49
10	0.29166667	**96.00**	1.51	2.06	2.39	2.81	3.15	3.49
10.08333	0.16666667	96.1666667	0.86	1.18	1.37	1.61	1.80	1.99
10.16667	0.16666667	96.3333333	0.86	1.18	1.37	1.61	1.80	1.99
10.25	0.16666667	96.5	0.86	1.18	1.37	1.61	1.80	1.99
10.33333	0.16666667	96.6666667	0.86	1.18	1.37	1.61	1.80	1.99
10.41667	0.16666667	96.8333333	0.86	1.18	1.37	1.61	1.80	1.99
10.5	0.16666667	97	0.86	1.18	1.37	1.61	1.80	1.99
10.58333	0.16666667	97.1666667	0.86	1.18	1.37	1.61	1.80	1.99
10.66667	0.16666667	97.3333333	0.86	1.18	1.37	1.61	1.80	1.99
10.75	0.16666667	97.5	0.86	1.18	1.37	1.61	1.80	1.99
10.83333	0.16666667	97.6666667	0.86	1.18	1.37	1.61	1.80	1.99
10.91667	0.16666667	97.8333333	0.86	1.18	1.37	1.61	1.80	1.99
11	0.16666667	98	0.86	1.18	1.37	1.61	1.80	1.99
11.08333	0.16666667	98.1666667	0.86	1.18	1.37	1.61	1.80	1.99
11.16667	0.16666667	98.3333333	0.86	1.18	1.37	1.61	1.80	1.99
11.25	0.16666667	98.5	0.86	1.18	1.37	1.61	1.80	1.99
11.33333	0.16666667	98.6666667	0.86	1.18	1.37	1.61	1.80	1.99
11.41667	0.16666667	98.8333333	0.86	1.18	1.37	1.61	1.80	1.99
11.5	0.16666667	99	0.86	1.18	1.37	1.61	1.80	1.99
11.58333	0.16666667	99.1666667	0.86	1.18	1.37	1.61	1.80	1.99
11.66667	0.16666667	99.3333333	0.86	1.18	1.37	1.61	1.80	1.99
11.75	0.16666667	99.5	0.86	1.18	1.37	1.61	1.80	1.99
11.83333	0.16666667	99.6666667	0.86	1.18	1.37	1.61	1.80	1.99
11.91667	0.16666667	99.8333333	0.86	1.18	1.37	1.61	1.80	1.99
12	0.16666667	**100.00**	0.86	1.18	1.37	1.61	1.80	1.99
			43.20	58.80	68.40	80.40	90.00	99.60

SCS TYPE II - 24 HOUR STORM
Baltimore

Time Step
= 5min
or
= 0.083 hr

Souce: MTO Drainage Manual Chart 1.05

TIME ENDING (hr)	PER CENT RAINFALL (%)	CUM RAINFALL	RAINFALL INTENSITY (mm/hr)					
			2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0.083333	0.09166667	0.09166667	0.61	0.79	0.92	1.11	1.21	1.35
0.166667	0.09166667	0.18333333	0.61	0.79	0.92	1.11	1.21	1.35
0.25	0.09166667	0.275	0.61	0.79	0.92	1.11	1.21	1.35
0.333333	0.09166667	0.36666667	0.61	0.79	0.92	1.11	1.21	1.35
0.416667	0.09166667	0.45833333	0.61	0.79	0.92	1.11	1.21	1.35
0.5	0.09166667	0.55	0.61	0.79	0.92	1.11	1.21	1.35
0.583333	0.09166667	0.64166667	0.61	0.79	0.92	1.11	1.21	1.35
0.666667	0.09166667	0.73333333	0.61	0.79	0.92	1.11	1.21	1.35
0.75	0.09166667	0.825	0.61	0.79	0.92	1.11	1.21	1.35
0.833333	0.09166667	0.91666667	0.61	0.79	0.92	1.11	1.21	1.35
0.916667	0.09166667	1.00833333	0.61	0.79	0.92	1.11	1.21	1.35
1	0.09166667	1.1	0.61	0.79	0.92	1.11	1.21	1.35
1.083333	0.09166667	1.19166667	0.61	0.79	0.92	1.11	1.21	1.35
1.166667	0.09166667	1.28333333	0.61	0.79	0.92	1.11	1.21	1.35
1.25	0.09166667	1.375	0.61	0.79	0.92	1.11	1.21	1.35
1.333333	0.09166667	1.46666667	0.61	0.79	0.92	1.11	1.21	1.35
1.416667	0.09166667	1.55833333	0.61	0.79	0.92	1.11	1.21	1.35
1.5	0.09166667	1.65	0.61	0.79	0.92	1.11	1.21	1.35
1.583333	0.09166667	1.74166667	0.61	0.79	0.92	1.11	1.21	1.35
1.666667	0.09166667	1.83333333	0.61	0.79	0.92	1.11	1.21	1.35
1.75	0.09166667	1.925	0.61	0.79	0.92	1.11	1.21	1.35
1.833333	0.09166667	2.01666667	0.61	0.79	0.92	1.11	1.21	1.35
1.916667	0.09166667	2.10833333	0.61	0.79	0.92	1.11	1.21	1.35
2	0.09166667	**2.200**	0.61	0.79	0.92	1.11	1.21	1.35
2.083333	0.10833333	2.308	0.72	0.94	1.09	1.31	1.44	1.59
2.166667	0.10833333	2.417	0.72	0.94	1.09	1.31	1.44	1.59
2.25	0.10833333	2.525	0.72	0.94	1.09	1.31	1.44	1.59
2.333333	0.10833333	2.633	0.72	0.94	1.09	1.31	1.44	1.59
2.416667	0.10833333	2.742	0.72	0.94	1.09	1.31	1.44	1.59
2.5	0.10833333	2.850	0.72	0.94	1.09	1.31	1.44	1.59
2.583333	0.10833333	2.958	0.72	0.94	1.09	1.31	1.44	1.59
2.666667	0.10833333	3.067	0.72	0.94	1.09	1.31	1.44	1.59
2.75	0.10833333	3.175	0.72	0.94	1.09	1.31	1.44	1.59
2.833333	0.10833333	3.283	0.72	0.94	1.09	1.31	1.44	1.59
2.916667	0.10833333	3.392	0.72	0.94	1.09	1.31	1.44	1.59
3	0.10833333	3.500	0.72	0.94	1.09	1.31	1.44	1.59
3.083333	0.10833333	3.608	0.72	0.94	1.09	1.31	1.44	1.59
3.166667	0.10833333	3.717	0.72	0.94	1.09	1.31	1.44	1.59
3.25	0.10833333	3.825	0.72	0.94	1.09	1.31	1.44	1.59
3.333333	0.10833333	3.933	0.72	0.94	1.09	1.31	1.44	1.59
3.416667	0.10833333	4.042	0.72	0.94	1.09	1.31	1.44	1.59
3.5	0.10833333	4.150	0.72	0.94	1.09	1.31	1.44	1.59
3.583333	0.10833333	4.258	0.72	0.94	1.09	1.31	1.44	1.59
3.666667	0.10833333	4.367	0.72	0.94	1.09	1.31	1.44	1.59
3.75	0.10833333	4.475	0.72	0.94	1.09	1.31	1.44	1.59
3.833333	0.10833333	4.583	0.72	0.94	1.09	1.31	1.44	1.59
3.916667	0.10833333	4.692	0.72	0.94	1.09	1.31	1.44	1.59
4	0.10833333	**4.800**	0.72	0.94	1.09	1.31	1.44	1.59
4.083333	0.13333333	4.933	0.88	1.15	1.34	1.61	1.77	1.96
4.166667	0.13333333	5.067	0.88	1.15	1.34	1.61	1.77	1.96
4.25	0.13333333	5.200	0.88	1.15	1.34	1.61	1.77	1.96
4.333333	0.13333333	5.333	0.88	1.15	1.34	1.61	1.77	1.96
4.416667	0.13333333	5.467	0.88	1.15	1.34	1.61	1.77	1.96
4.5	0.13333333	5.600	0.88	1.15	1.34	1.61	1.77	1.96
4.583333	0.13333333	5.733	0.88	1.15	1.34	1.61	1.77	1.96
4.666667	0.13333333	5.867	0.88	1.15	1.34	1.61	1.77	1.96
4.75	0.13333333	6.000	0.88	1.15	1.34	1.61	1.77	1.96
4.833333	0.13333333	6.133	0.88	1.15	1.34	1.61	1.77	1.96
4.916667	0.13333333	6.267	0.88	1.15	1.34	1.61	1.77	1.96

5	0.13333333	6.400	0.88	1.15	1.34	1.61	1.77	1.96
5.083333	0.13333333	6.533	0.88	1.15	1.34	1.61	1.77	1.96
5.166667	0.13333333	6.667	0.88	1.15	1.34	1.61	1.77	1.96
5.25	0.13333333	6.800	0.88	1.15	1.34	1.61	1.77	1.96
5.333333	0.13333333	6.933	0.88	1.15	1.34	1.61	1.77	1.96
5.416667	0.13333333	7.067	0.88	1.15	1.34	1.61	1.77	1.96
5.5	0.13333333	7.200	0.88	1.15	1.34	1.61	1.77	1.96
5.583333	0.13333333	7.333	0.88	1.15	1.34	1.61	1.77	1.96
5.666667	0.13333333	7.467	0.88	1.15	1.34	1.61	1.77	1.96
5.75	0.13333333	7.600	0.88	1.15	1.34	1.61	1.77	1.96
5.833333	0.13333333	7.733	0.88	1.15	1.34	1.61	1.77	1.96
5.916667	0.13333333	7.867	0.88	1.15	1.34	1.61	1.77	1.96
6	0.13333333	**8.000**	0.88	1.15	1.34	1.61	1.77	1.96
6.083333	0.16666667	8.167	1.10	1.44	1.68	2.02	2.21	2.45
6.166667	0.16666667	8.333	1.10	1.44	1.68	2.02	2.21	2.45
6.25	0.16666667	8.500	1.10	1.44	1.68	2.02	2.21	2.45
6.333333	0.16666667	8.667	1.10	1.44	1.68	2.02	2.21	2.45
6.416667	0.16666667	8.833	1.10	1.44	1.68	2.02	2.21	2.45
6.5	0.16666667	9.000	1.10	1.44	1.68	2.02	2.21	2.45
6.583333	0.16666667	9.167	1.10	1.44	1.68	2.02	2.21	2.45
6.666667	0.16666667	9.333	1.10	1.44	1.68	2.02	2.21	2.45
6.75	0.16666667	9.500	1.10	1.44	1.68	2.02	2.21	2.45
6.833333	0.16666667	9.667	1.10	1.44	1.68	2.02	2.21	2.45
6.916667	0.16666667	9.833	1.10	1.44	1.68	2.02	2.21	2.45
7	0.16666667	10.000	1.10	1.44	1.68	2.02	2.21	2.45
7.083333	0.16666667	10.167	1.10	1.44	1.68	2.02	2.21	2.45
7.166667	0.16666667	10.333	1.10	1.44	1.68	2.02	2.21	2.45
7.25	0.16666667	10.500	1.10	1.44	1.68	2.02	2.21	2.45
7.333333	0.16666667	10.667	1.10	1.44	1.68	2.02	2.21	2.45
7.416667	0.16666667	10.833	1.10	1.44	1.68	2.02	2.21	2.45
7.5	0.16666667	11.000	1.10	1.44	1.68	2.02	2.21	2.45
7.583333	0.16666667	11.167	1.10	1.44	1.68	2.02	2.21	2.45
7.666667	0.16666667	11.333	1.10	1.44	1.68	2.02	2.21	2.45
7.75	0.16666667	11.500	1.10	1.44	1.68	2.02	2.21	2.45
7.833333	0.16666667	11.667	1.10	1.44	1.68	2.02	2.21	2.45
7.916667	0.16666667	11.833	1.10	1.44	1.68	2.02	2.21	2.45
8	0.16666667	**12.000**	1.10	1.44	1.68	2.02	2.21	2.45
8.083333	0.225	12.225	1.49	1.94	2.27	2.72	2.98	3.30
8.166667	0.225	12.450	1.49	1.94	2.27	2.72	2.98	3.30
8.25	0.225	12.675	1.49	1.94	2.27	2.72	2.98	3.30
8.333333	0.225	12.900	1.49	1.94	2.27	2.72	2.98	3.30
8.416667	0.225	13.125	1.49	1.94	2.27	2.72	2.98	3.30
8.5	0.225	13.350	1.49	1.94	2.27	2.72	2.98	3.30
8.583333	0.225	13.575	1.49	1.94	2.27	2.72	2.98	3.30
8.666667	0.225	13.800	1.49	1.94	2.27	2.72	2.98	3.30
8.75	0.225	14.025	1.49	1.94	2.27	2.72	2.98	3.30
8.833333	0.225	14.250	1.49	1.94	2.27	2.72	2.98	3.30
8.916667	0.225	14.475	1.49	1.94	2.27	2.72	2.98	3.30
9	0.225	**14.700**	1.49	1.94	2.27	2.72	2.98	3.30
9.083333	0.26666667	14.967	1.77	2.30	2.69	3.23	3.53	3.92
9.166667	0.26666667	15.233	1.77	2.30	2.69	3.23	3.53	3.92
9.25	0.26666667	15.500	1.77	2.30	2.69	3.23	3.53	3.92
9.333333	0.26666667	15.767	1.77	2.30	2.69	3.23	3.53	3.92
9.416667	0.26666667	16.033	1.77	2.30	2.69	3.23	3.53	3.92
9.5	0.26666667	**16.300**	1.77	2.30	2.69	3.23	3.53	3.92
9.583333	0.3	16.600	1.99	2.59	3.02	3.63	3.97	4.41
9.666667	0.3	16.900	1.99	2.59	3.02	3.63	3.97	4.41
9.75	0.3	17.200	1.99	2.59	3.02	3.63	3.97	4.41
9.833333	0.3	17.500	1.99	2.59	3.02	3.63	3.97	4.41
9.916667	0.3	17.800	1.99	2.59	3.02	3.63	3.97	4.41
10	0.3	**18.100**	1.99	2.59	3.02	3.63	3.97	4.41
10.08333	0.38333333	18.483	2.54	3.31	3.86	4.64	5.08	5.63
10.16667	0.38333333	18.867	2.54	3.31	3.86	4.64	5.08	5.63
10.25	0.38333333	19.250	2.54	3.31	3.86	4.64	5.08	5.63
10.33333	0.38333333	19.633	2.54	3.31	3.86	4.64	5.08	5.63
10.41667	0.38333333	20.017	2.54	3.31	3.86	4.64	5.08	5.63
10.5	0.38333333	**20.400**	2.54	3.31	3.86	4.64	5.08	5.63
10.58333	0.51666667	20.917	3.42	4.46	5.21	6.25	6.84	7.59
10.66667	0.51666667	21.433	3.42	4.46	5.21	6.25	6.84	7.59

10.75	0.51666667	21.950	3.42	4.46	5.21	6.25	6.84	7.59
10.83333	0.51666667	22.467	3.42	4.46	5.21	6.25	6.84	7.59
10.91667	0.51666667	22.983	3.42	4.46	5.21	6.25	6.84	7.59
11	0.51666667	**23.500**	3.42	4.46	5.21	6.25	6.84	7.59
11.08333	0.8	24.300	5.30	6.91	8.06	9.68	10.60	11.75
11.16667	0.8	25.100	5.30	6.91	8.06	9.68	10.60	11.75
11.25	0.8	25.900	5.30	6.91	8.06	9.68	10.60	11.75
11.33333	0.8	26.700	5.30	6.91	8.06	9.68	10.60	11.75
11.41667	0.8	27.500	5.30	6.91	8.06	9.68	10.60	11.75
11.5	0.8	**28.300**	5.30	6.91	8.06	9.68	10.60	11.75
11.58333	3.46666667	31.767	22.96	29.95	34.94	41.93	45.93	50.92
11.66667	3.46666667	35.233	22.96	29.95	34.94	41.93	45.93	50.92
11.75	3.46666667	**38.700**	22.96	29.95	34.94	41.93	45.93	50.92
11.83333	9.2	47.900	60.94	79.49	92.74	111.28	121.88	135.13
11.91667	9.2	57.100	60.94	79.49	92.74	111.28	121.88	135.13
12	9.2	**66.300**	60.94	79.49	92.74	111.28	121.88	135.13
12.08333	1.2	67.500	7.95	10.37	12.10	14.52	15.90	17.63
12.16667	1.2	68.700	7.95	10.37	12.10	14.52	15.90	17.63
12.25	1.2	69.900	7.95	10.37	12.10	14.52	15.90	17.63
12.33333	1.2	71.100	7.95	10.37	12.10	14.52	15.90	17.63
12.41667	1.2	72.300	7.95	10.37	12.10	14.52	15.90	17.63
12.5	1.2	**73.500**	7.95	10.37	12.10	14.52	15.90	17.63
12.58333	0.61666667	74.117	4.08	5.33	6.22	7.46	8.17	9.06
12.66667	0.61666667	74.733	4.08	5.33	6.22	7.46	8.17	9.06
12.75	0.61666667	75.350	4.08	5.33	6.22	7.46	8.17	9.06
12.83333	0.61666667	75.967	4.08	5.33	6.22	7.46	8.17	9.06
12.91667	0.61666667	76.583	4.08	5.33	6.22	7.46	8.17	9.06
13	0.61666667	**77.200**	4.08	5.33	6.22	7.46	8.17	9.06
13.08333	0.11666667	77.317	0.77	1.01	1.18	1.41	1.55	1.71
13.16667	0.11666667	77.433	0.77	1.01	1.18	1.41	1.55	1.71
13.25	0.11666667	77.550	0.77	1.01	1.18	1.41	1.55	1.71
13.33333	0.11666667	77.667	0.77	1.01	1.18	1.41	1.55	1.71
13.41667	0.11666667	77.783	0.77	1.01	1.18	1.41	1.55	1.71
13.5	0.11666667	**77.900**	0.77	1.01	1.18	1.41	1.55	1.71
13.58333	0.68333333	78.583	4.53	5.90	6.89	8.27	9.05	10.04
13.66667	0.68333333	79.267	4.53	5.90	6.89	8.27	9.05	10.04
13.75	0.68333333	79.950	4.53	5.90	6.89	8.27	9.05	10.04
13.83333	0.68333333	80.633	4.53	5.90	6.89	8.27	9.05	10.04
13.91667	0.68333333	81.317	4.53	5.90	6.89	8.27	9.05	10.04
14	0.68333333	**82.000**	4.53	5.90	6.89	8.27	9.05	10.04
14.08333	0.25	82.250	1.66	2.16	2.52	3.02	3.31	3.67
14.16667	0.25	82.500	1.66	2.16	2.52	3.02	3.31	3.67
14.25	0.25	82.750	1.66	2.16	2.52	3.02	3.31	3.67
14.33333	0.25	83.000	1.66	2.16	2.52	3.02	3.31	3.67
14.41667	0.25	83.250	1.66	2.16	2.52	3.02	3.31	3.67
14.5	0.25	83.500	1.66	2.16	2.52	3.02	3.31	3.67
14.58333	0.25	83.750	1.66	2.16	2.52	3.02	3.31	3.67
14.66667	0.25	84.000	1.66	2.16	2.52	3.02	3.31	3.67
14.75	0.25	84.250	1.66	2.16	2.52	3.02	3.31	3.67
14.83333	0.25	84.500	1.66	2.16	2.52	3.02	3.31	3.67
14.91667	0.25	84.750	1.66	2.16	2.52	3.02	3.31	3.67
15	0.25	85.000	1.66	2.16	2.52	3.02	3.31	3.67
15.08333	0.25	85.250	1.66	2.16	2.52	3.02	3.31	3.67
15.16667	0.25	85.500	1.66	2.16	2.52	3.02	3.31	3.67
15.25	0.25	85.750	1.66	2.16	2.52	3.02	3.31	3.67
15.33333	0.25	86.000	1.66	2.16	2.52	3.02	3.31	3.67
15.41667	0.25	86.250	1.66	2.16	2.52	3.02	3.31	3.67
15.5	0.25	86.500	1.66	2.16	2.52	3.02	3.31	3.67
15.58333	0.25	86.750	1.66	2.16	2.52	3.02	3.31	3.67
15.66667	0.25	87.000	1.66	2.16	2.52	3.02	3.31	3.67
15.75	0.25	87.250	1.66	2.16	2.52	3.02	3.31	3.67
15.83333	0.25	87.500	1.66	2.16	2.52	3.02	3.31	3.67
15.91667	0.25	87.750	1.66	2.16	2.52	3.02	3.31	3.67
16	0.25	**88.000**	1.66	2.16	2.52	3.02	3.31	3.67
16.08333	0.1875	88.188	1.24	1.62	1.89	2.27	2.48	2.75
16.16667	0.1875	88.375	1.24	1.62	1.89	2.27	2.48	2.75
16.25	0.1875	88.563	1.24	1.62	1.89	2.27	2.48	2.75
16.33333	0.1875	88.750	1.24	1.62	1.89	2.27	2.48	2.75
16.41667	0.1875	88.938	1.24	1.62	1.89	2.27	2.48	2.75

16.5	0.1875	89.125	1.24	1.62	1.89	2.27	2.48	2.75
16.58333	0.1875	89.313	1.24	1.62	1.89	2.27	2.48	2.75
16.66667	0.1875	89.500	1.24	1.62	1.89	2.27	2.48	2.75
16.75	0.1875	89.688	1.24	1.62	1.89	2.27	2.48	2.75
16.83333	0.1875	89.875	1.24	1.62	1.89	2.27	2.48	2.75
16.91667	0.1875	90.063	1.24	1.62	1.89	2.27	2.48	2.75
17	0.1875	90.250	1.24	1.62	1.89	2.27	2.48	2.75
17.08333	0.1875	90.438	1.24	1.62	1.89	2.27	2.48	2.75
17.16667	0.1875	90.625	1.24	1.62	1.89	2.27	2.48	2.75
17.25	0.1875	90.813	1.24	1.62	1.89	2.27	2.48	2.75
17.33333	0.1875	91.000	1.24	1.62	1.89	2.27	2.48	2.75
17.41667	0.1875	91.188	1.24	1.62	1.89	2.27	2.48	2.75
17.5	0.1875	91.375	1.24	1.62	1.89	2.27	2.48	2.75
17.58333	0.1875	91.563	1.24	1.62	1.89	2.27	2.48	2.75
17.66667	0.1875	91.750	1.24	1.62	1.89	2.27	2.48	2.75
17.75	0.1875	91.938	1.24	1.62	1.89	2.27	2.48	2.75
17.83333	0.1875	92.125	1.24	1.62	1.89	2.27	2.48	2.75
17.91667	0.1875	92.313	1.24	1.62	1.89	2.27	2.48	2.75
18	0.1875	**92.500**	1.24	1.62	1.89	2.27	2.48	2.75
18.08333	0.1125	92.613	0.75	0.97	1.13	1.36	1.49	1.65
18.16667	0.1125	92.725	0.75	0.97	1.13	1.36	1.49	1.65
18.25	0.1125	92.838	0.75	0.97	1.13	1.36	1.49	1.65
18.33333	0.1125	92.950	0.75	0.97	1.13	1.36	1.49	1.65
18.41667	0.1125	93.063	0.75	0.97	1.13	1.36	1.49	1.65
18.5	0.1125	93.175	0.75	0.97	1.13	1.36	1.49	1.65
18.58333	0.1125	93.288	0.75	0.97	1.13	1.36	1.49	1.65
18.66667	0.1125	93.400	0.75	0.97	1.13	1.36	1.49	1.65
18.75	0.1125	93.513	0.75	0.97	1.13	1.36	1.49	1.65
18.83333	0.1125	93.625	0.75	0.97	1.13	1.36	1.49	1.65
18.91667	0.1125	93.738	0.75	0.97	1.13	1.36	1.49	1.65
19	0.1125	93.850	0.75	0.97	1.13	1.36	1.49	1.65
19.08333	0.1125	93.963	0.75	0.97	1.13	1.36	1.49	1.65
19.16667	0.1125	94.075	0.75	0.97	1.13	1.36	1.49	1.65
19.25	0.1125	94.188	0.75	0.97	1.13	1.36	1.49	1.65
19.33333	0.1125	94.300	0.75	0.97	1.13	1.36	1.49	1.65
19.41667	0.1125	94.413	0.75	0.97	1.13	1.36	1.49	1.65
19.5	0.1125	94.525	0.75	0.97	1.13	1.36	1.49	1.65
19.58333	0.1125	94.637	0.75	0.97	1.13	1.36	1.49	1.65
19.66667	0.1125	94.750	0.75	0.97	1.13	1.36	1.49	1.65
19.75	0.1125	94.862	0.75	0.97	1.13	1.36	1.49	1.65
19.83333	0.1125	94.975	0.75	0.97	1.13	1.36	1.49	1.65
19.91667	0.1125	95.087	0.75	0.97	1.13	1.36	1.49	1.65
20	0.1125	**95.200**	0.75	0.97	1.13	1.36	1.49	1.65
20.08333	0.11666667	95.317	0.77	1.01	1.18	1.41	1.55	1.71
20.16667	0.11666667	95.433	0.77	1.01	1.18	1.41	1.55	1.71
20.25	0.11666667	95.550	0.77	1.01	1.18	1.41	1.55	1.71
20.33333	0.11666667	95.667	0.77	1.01	1.18	1.41	1.55	1.71
20.41667	0.11666667	95.783	0.77	1.01	1.18	1.41	1.55	1.71
20.5	0.11666667	95.900	0.77	1.01	1.18	1.41	1.55	1.71
20.58333	0.11666667	96.017	0.77	1.01	1.18	1.41	1.55	1.71
20.66667	0.11666667	96.133	0.77	1.01	1.18	1.41	1.55	1.71
20.75	0.11666667	96.250	0.77	1.01	1.18	1.41	1.55	1.71
20.83333	0.11666667	96.367	0.77	1.01	1.18	1.41	1.55	1.71
20.91667	0.11666667	96.483	0.77	1.01	1.18	1.41	1.55	1.71
21	0.11666667	96.600	0.77	1.01	1.18	1.41	1.55	1.71
21.08333	0.11666667	96.717	0.77	1.01	1.18	1.41	1.55	1.71
21.16667	0.11666667	96.833	0.77	1.01	1.18	1.41	1.55	1.71
21.25	0.11666667	96.950	0.77	1.01	1.18	1.41	1.55	1.71
21.33333	0.11666667	97.067	0.77	1.01	1.18	1.41	1.55	1.71
21.41667	0.11666667	97.183	0.77	1.01	1.18	1.41	1.55	1.71
21.5	0.11666667	97.300	0.77	1.01	1.18	1.41	1.55	1.71
21.58333	0.11666667	97.417	0.77	1.01	1.18	1.41	1.55	1.71
21.66667	0.11666667	97.533	0.77	1.01	1.18	1.41	1.55	1.71
21.75	0.11666667	97.650	0.77	1.01	1.18	1.41	1.55	1.71
21.83333	0.11666667	97.767	0.77	1.01	1.18	1.41	1.55	1.71
21.91667	0.11666667	97.883	0.77	1.01	1.18	1.41	1.55	1.71
22	0.11666667	**98.000**	0.77	1.01	1.18	1.41	1.55	1.71
22.08333	0.08333333	98.083	0.55	0.72	0.84	1.01	1.10	1.22
22.16667	0.08333333	98.167	0.55	0.72	0.84	1.01	1.10	1.22

22.25	0.08333333	98.250	0.55	0.72	0.84	1.01	1.10	1.22
22.33333	0.08333333	98.333	0.55	0.72	0.84	1.01	1.10	1.22
22.41667	0.08333333	98.417	0.55	0.72	0.84	1.01	1.10	1.22
22.5	0.08333333	98.500	0.55	0.72	0.84	1.01	1.10	1.22
22.58333	0.08333333	98.583	0.55	0.72	0.84	1.01	1.10	1.22
22.66667	0.08333333	98.667	0.55	0.72	0.84	1.01	1.10	1.22
22.75	0.08333333	98.750	0.55	0.72	0.84	1.01	1.10	1.22
22.83333	0.08333333	98.833	0.55	0.72	0.84	1.01	1.10	1.22
22.91667	0.08333333	98.917	0.55	0.72	0.84	1.01	1.10	1.22
23	0.08333333	99.000	0.55	0.72	0.84	1.01	1.10	1.22
23.08333	0.08333333	99.083	0.55	0.72	0.84	1.01	1.10	1.22
23.16667	0.08333333	99.167	0.55	0.72	0.84	1.01	1.10	1.22
23.25	0.08333333	99.250	0.55	0.72	0.84	1.01	1.10	1.22
23.33333	0.08333333	99.333	0.55	0.72	0.84	1.01	1.10	1.22
23.41667	0.08333333	99.417	0.55	0.72	0.84	1.01	1.10	1.22
23.5	0.08333333	99.500	0.55	0.72	0.84	1.01	1.10	1.22
23.58333	0.08333333	99.583	0.55	0.72	0.84	1.01	1.10	1.22
23.66667	0.08333333	99.667	0.55	0.72	0.84	1.01	1.10	1.22
23.75	0.08333333	99.750	0.55	0.72	0.84	1.01	1.10	1.22
23.83333	0.08333333	99.833	0.55	0.72	0.84	1.01	1.10	1.22
23.91667	0.08333333	99.917	0.55	0.72	0.84	1.01	1.10	1.22
24	0.08333333	**100.000**	0.55	0.72	0.84	1.01	1.10	1.22
			55.20	72.00	84.00	100.80	110.40	122.40

SCS TYPE II - 24 HOUR STORM
Baltimore

Time Step
= 15min
or
= 0.25 hr

Souce: MTO Drainage Manual Chart 1.05

TIME ENDING (hr)	PER CENT RAINFALL (%)	CUM RAINFALL	RAINFALL INTENSITY (mm/hr)					
			2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
0.25	0.275	0.275	0.61	0.79	0.92	1.11	1.21	1.35
0.5	0.275	0.55	0.61	0.79	0.92	1.11	1.21	1.35
0.75	0.275	0.825	0.61	0.79	0.92	1.11	1.21	1.35
1	0.275	1.1	0.61	0.79	0.92	1.11	1.21	1.35
1.25	0.275	1.375	0.61	0.79	0.92	1.11	1.21	1.35
1.5	0.275	1.65	0.61	0.79	0.92	1.11	1.21	1.35
1.75	0.275	1.925	0.61	0.79	0.92	1.11	1.21	1.35
2	0.275	**2.2**	0.61	0.79	0.92	1.11	1.21	1.35
2.25	0.325	2.525	0.72	0.94	1.09	1.31	1.44	1.59
2.5	0.325	2.85	0.72	0.94	1.09	1.31	1.44	1.59
2.75	0.325	3.175	0.72	0.94	1.09	1.31	1.44	1.59
3	0.325	3.5	0.72	0.94	1.09	1.31	1.44	1.59
3.25	0.325	3.825	0.72	0.94	1.09	1.31	1.44	1.59
3.5	0.325	4.15	0.72	0.94	1.09	1.31	1.44	1.59
3.75	0.325	4.475	0.72	0.94	1.09	1.31	1.44	1.59
4	0.325	**4.8**	0.72	0.94	1.09	1.31	1.44	1.59
4.25	0.4	5.2	0.88	1.15	1.34	1.61	1.77	1.96
4.5	0.4	5.6	0.88	1.15	1.34	1.61	1.77	1.96
4.75	0.4	6	0.88	1.15	1.34	1.61	1.77	1.96
5	0.4	6.4	0.88	1.15	1.34	1.61	1.77	1.96
5.25	0.4	6.8	0.88	1.15	1.34	1.61	1.77	1.96
5.5	0.4	7.2	0.88	1.15	1.34	1.61	1.77	1.96
5.75	0.4	7.6	0.88	1.15	1.34	1.61	1.77	1.96
6	0.4	**8**	0.88	1.15	1.34	1.61	1.77	1.96
6.25	0.5	8.5	1.10	1.44	1.68	2.02	2.21	2.45
6.5	0.5	9	1.10	1.44	1.68	2.02	2.21	2.45
6.75	0.5	9.5	1.10	1.44	1.68	2.02	2.21	2.45
7	0.5	10	1.10	1.44	1.68	2.02	2.21	2.45
7.25	0.5	10.5	1.10	1.44	1.68	2.02	2.21	2.45
7.5	0.5	11	1.10	1.44	1.68	2.02	2.21	2.45
7.75	0.5	11.5	1.10	1.44	1.68	2.02	2.21	2.45
8	0.5	**12**	1.10	1.44	1.68	2.02	2.21	2.45
8.25	0.675	12.675	1.49	1.94	2.27	2.72	2.98	3.30
8.5	0.675	13.35	1.49	1.94	2.27	2.72	2.98	3.30
8.75	0.675	14.025	1.49	1.94	2.27	2.72	2.98	3.30
9	0.675	**14.7**	1.49	1.94	2.27	2.72	2.98	3.30
9.25	0.8	15.5	1.77	2.30	2.69	3.23	3.53	3.92
9.5	0.8	**16.3**	1.77	2.30	2.69	3.23	3.53	3.92
9.75	0.9	17.2	1.99	2.59	3.02	3.63	3.97	4.41
10	0.9	**18.1**	1.99	2.59	3.02	3.63	3.97	4.41
10.25	1.15	19.25	2.54	3.31	3.86	4.64	5.08	5.63
10.5	1.15	**20.4**	2.54	3.31	3.86	4.64	5.08	5.63
10.75	1.55	21.95	3.42	4.46	5.21	6.25	6.84	7.59
11	1.55	**23.5**	3.42	4.46	5.21	6.25	6.84	7.59
11.25	2.4	25.9	5.30	6.91	8.06	9.68	10.60	11.75
11.5	2.4	**28.3**	5.30	6.91	8.06	9.68	10.60	11.75
11.75	19	47.3	41.95	54.72	63.84	76.61	83.90	93.02
12	19	**66.3**	41.95	54.72	63.84	76.61	83.90	93.02
12.25	3.6	69.9	7.95	10.37	12.10	14.52	15.90	17.63
12.5	3.6	**73.5**	7.95	10.37	12.10	14.52	15.90	17.63
12.75	1.85	75.35	4.08	5.33	6.22	7.46	8.17	9.06
13	1.85	**77.2**	4.08	5.33	6.22	7.46	8.17	9.06
13.25	0.35	77.55	0.77	1.01	1.18	1.41	1.55	1.71
13.5	0.35	**77.9**	0.77	1.01	1.18	1.41	1.55	1.71
13.75	2.05	79.95	4.53	5.90	6.89	8.27	9.05	10.04
14	2.05	**82**	4.53	5.90	6.89	8.27	9.05	10.04
14.25	0.75	82.75	1.66	2.16	2.52	3.02	3.31	3.67
14.5	0.75	83.5	1.66	2.16	2.52	3.02	3.31	3.67
14.75	0.75	84.25	1.66	2.16	2.52	3.02	3.31	3.67

15	0.75	85	1.66	2.16	2.52	3.02	3.31	3.67
15.25	0.75	85.75	1.66	2.16	2.52	3.02	3.31	3.67
15.5	0.75	86.5	1.66	2.16	2.52	3.02	3.31	3.67
15.75	0.75	87.25	1.66	2.16	2.52	3.02	3.31	3.67
16	0.75	**88**	1.66	2.16	2.52	3.02	3.31	3.67
16.25	0.45	88.45	0.99	1.30	1.51	1.81	1.99	2.20
16.5	0.45	88.9	0.99	1.30	1.51	1.81	1.99	2.20
16.75	0.45	89.35	0.99	1.30	1.51	1.81	1.99	2.20
17	0.45	89.8	0.99	1.30	1.51	1.81	1.99	2.20
17.25	0.45	90.25	0.99	1.30	1.51	1.81	1.99	2.20
17.5	0.45	90.7	0.99	1.30	1.51	1.81	1.99	2.20
17.75	0.45	91.15	0.99	1.30	1.51	1.81	1.99	2.20
18	0.45	91.6	0.99	1.30	1.51	1.81	1.99	2.20
18.25	0.45	92.05	0.99	1.30	1.51	1.81	1.99	2.20
18.5	0.45	92.5	0.99	1.30	1.51	1.81	1.99	2.20
18.75	0.45	92.95	0.99	1.30	1.51	1.81	1.99	2.20
19	0.45	93.4	0.99	1.30	1.51	1.81	1.99	2.20
19.25	0.45	93.85	0.99	1.30	1.51	1.81	1.99	2.20
19.5	0.45	94.3	0.99	1.30	1.51	1.81	1.99	2.20
19.75	0.45	94.75	0.99	1.30	1.51	1.81	1.99	2.20
20	0.45	**95.2**	0.99	1.30	1.51	1.81	1.99	2.20
20.25	0.3	95.5	0.66	0.86	1.01	1.21	1.32	1.47
20.5	0.3	95.8	0.66	0.86	1.01	1.21	1.32	1.47
20.75	0.3	96.1	0.66	0.86	1.01	1.21	1.32	1.47
21	0.3	96.4	0.66	0.86	1.01	1.21	1.32	1.47
21.25	0.3	96.7	0.66	0.86	1.01	1.21	1.32	1.47
21.5	0.3	97	0.66	0.86	1.01	1.21	1.32	1.47
21.75	0.3	97.3	0.66	0.86	1.01	1.21	1.32	1.47
22	0.3	97.6	0.66	0.86	1.01	1.21	1.32	1.47
22.25	0.3	97.9	0.66	0.86	1.01	1.21	1.32	1.47
22.5	0.3	98.2	0.66	0.86	1.01	1.21	1.32	1.47
22.75	0.3	98.5	0.66	0.86	1.01	1.21	1.32	1.47
23	0.3	98.8	0.66	0.86	1.01	1.21	1.32	1.47
23.25	0.3	99.1	0.66	0.86	1.01	1.21	1.32	1.47
23.5	0.3	99.4	0.66	0.86	1.01	1.21	1.32	1.47
23.75	0.3	99.7	0.66	0.86	1.01	1.21	1.32	1.47
24	0.3	**100**	0.66	0.86	1.01	1.21	1.32	1.47
			55.20	72.00	84.00	100.80	110.40	122.40

Permissible Tractive Forces (1997 MTO, Chapter 5)

Tractive Forces by Permissible Shear Stress				
Worst Case Scenerio - Ditches within Catchment B10, bottom lined with riprap, side slopes inc. for information				
Input Parameters:				
Bottom Width	b_w=	2	m	
Flow Depth	y=	0.29	m	
Side Slope	z=	3	H:V	
Side Slope	ϴ=	18	degrees	
Wetted Perimeter	P_w=	3.84	m	
Wetted Area	A_w=	0.84	m^2	
Hydraulic Radius	R=	0.22	m	
Water Density	γ_w	9810	N/m^3	
Channel Slope	S=	0.03	m/m	
Step 1	**Estimate Forces acting on Channel Bed and Sides**			
Mean Boundary shear, T	T_o =	64.75	N/m^2	$T_o = \gamma_w * R * S$ (Eqn 5.33)
Channel Bottom Force, Tb				
Bed coefficient	K_b=	1.36		Design Chart 2.11
Max, bed force	T_b=	87.93	N/m^2	$T_b = K_b * T_o$ (Eqn 5.27)
Channel Side Force, Ts				
Bank coefficient	K_{bk}=	1.17		Design Chart 2.11
Max. side force	T_s=	75.70	N/m^2	$Ts = K_{bk} * \gamma_w * R * S$ (Eqn 5.28)

Step 2	Estimate Shear Resistance for Channel Lining

Channel Bottom Shear Resistance, T_{cb}

Input Lining material size	d_{50}=	200	mm	
Input Lining angle of rep.	θ=	41.5	degrees	Design Chart 2.13
Bed shear resistance	T_{cb}=	12.84	kg/m^2	T_{cb}= 0.0642 * d_{50}
	T_{cb}=	125.96	N/m^2	(Eqn 5.31)

Channel Side Shear Resistance, T_{cs}

Critical shear coeff.	K_{CS} =	0.885	$K_{CS} = (1-\sin^2\theta/\sin^2\phi))^{0.5}$ (Eqn 5.36)	
	T_{CS} =	11.36	kg/m^2	T_{cs}= K_{cs} * T_{cb}
Side Shear resistance	T_{CS} =	111.42	N/m^2	(Eqn.5.36)

Step 3	Check Forces with available Shear Resistance	
Channel Bed	Check for $T_{cb} > T_b$	Bed Material Acceptable
Channel Side Slopes	Check for $T_{cs} > T_s$	Side Material Acceptable

Source: Pages 111 to 114, Chapter 5, MTO Drainage Management Manual, 1997

Permissible Tractive Forces (1997 MTO, Chapter 5)

Tractive Forces by Permissible Shear Stress				
Worst Case Scenerio - Ditches within Catchment B10, bottom lined with riprap, side slopes inc. for information				
Input Parameters:				
Bottom Width	b_w=	2.5	m	
Flow Depth	y=	0.19	m	
Side Slope	z=	3	H:V	
Side Slope	ϴ=	18	degrees	
Wetted Perimeter	P_w=	7.15	m	
Wetted Area	A_w=	0.6435	m^2	
Hydraulic Radius	R=	0.09	m	
Water Density	γ_w	9810	N/m^3	
Channel Slope	S=	0.0265	m/m	
Step 1	**Estimate Forces acting on Channel Bed and Sides**			
Mean Boundary shear, T	T_o =	23.40	N/m^2	$T_o = \gamma_w * R * S$ (Eqn 5.33)
Channel Bottom Force, Tb				
Bed coefficient	K_b=	1.16		Design Chart 2.11
Max, bed force	T_b=	27.11	N/m^2	$T_b = K_b * T_o$ (Eqn 5.27)
Channel Side Force, Ts				
Bank coefficient	K_{bk}=	1.06		Design Chart 2.11
Max. side force	T_s=	24.73	N/m^2	$Ts = K_{bk} * \gamma_w * R * S$ (Eqn 5.28)

Step 2	Estimate Shear Resistance for Channel Lining			
Channel Bottom Shear Resistance, T_{cb}				
Input Lining material size	d_{50}=	150	mm	
Input Lining angle of rep.	ɵ=	41.5	degrees	Design Chart 2.13
Bed shear resistance	T_{cb}=	9.63	kg/m^2	T_{cb}= 0.0642 * d_{50}
	T_{cb}=	94.47	N/m^2	(Eqn 5.31)
Channel Side Shear Resistance, T_{cs}				
Critical shear coeff.	K_{CS} =	0.885	$K_{CS} = (1-\sin^2ɵ/\sin^2ϕ))^{0.5}$	
			(Eqn 5.36)	
	T_{CS} =	8.52	kg/m^2	T_{cs}= K_{cs} * T_{cb}
Side Shear resistance	T_{CS} =	83.57	N/m^2	(Eqn.5.36)

Step 3	Check Forces with available Shear Resistance	
Channel Bed	Check for $T_{cb} > T_b$	Bed Material Acceptable
Channel Side Slopes	Check for $T_{cs} > T_s$	Side Material Acceptable

Source: Pages 111 to 114, Chapter 5, MTO Drainage Management Manual, 1997

Plunge Pool Calculations

Standard and Specification for Plunge Pools (D-4-2)

Design Criteria for Plunge Pool in Pond 1/3 (900mm Pipe)

1. Select type of plunge pool (Type 1 requires larger stone)

Type 1: Plunge pool is depressed 1/2 the size of the culvert
Type 2: Plunge pool is depressed full height of the culvert

2. Determine stone sizing

$$D_{50} = (0.0125d^2/Tw) \times (Q/d^{2.5})^{4/3}$$

Stone Size	D_{50}=		ft		
Design Flow Rate	Q=	33.73	cfs	0.955	m^3/s
Culvert Diameter	d=	2.95	ft	0.9	m
Tailwater	TW=	1.18	ft	0.36	m
	D_{50}=	0.272	ft		
		0.083	m		

Use 200mm At Apron

2. Determine plunge pool dimensions

$$C = (3 \times d) + (6 \times F)$$
$$B = (2 \times d) + (6 \times F)$$

Plunge Pool Depth	F=	1.476	ft	(0.5d for Type 1)	
Culvert Diameter	d=	3.0	ft		
				Converted to Metric	
Length of Plunge Pool	C =	18	ft	5.40	m
Width of Plunge Pool	B =	15	ft	4.50	m
Culvert Diameter	E =	3.0	ft	0.90	m
Plunge Pool Bottom Length	3E =	8.9	ft	2.70	m
Plunge Pool Bottom Width	2E =	5.9	ft	1.80	m

*Rounded to nearest foot for presentation, actual values carried through

State of Maryland - Erosion and Sediment Control Guidelines

Plunge Pool Calculations

Standard and Specification for Plunge Pools (D-4-2)

Design Criteria for Plunge Pool in Pond 5 (300mm Culvert)

1. Select type of plunge pool (Type 1 requires larger stone)

Type 1: Plunge pool is depressed 1/2 the size of the culvert

Type 2: Plunge pool is depressed full height of the culvert

2. Determine stone sizing

$$D_{50} = (0.0125d^2/Tw) \times (Q/d^{2.5})^{4/3}$$

Stone Size	D_{50}=		ft		
Design Flow Rate	Q=	8.83	cfs	0.25	m^3/s
Culvert Diameter	d=	0.98	ft	0.3	m
Tailwater	TW=	0.39	ft	0.12	m
	D_{50}=	0.592	ft		
		0.180	m		

Use 200mm At Apron

2. Determine plunge pool dimensions

C = (3 x d) + (6 x F)

B = (2 x d) + (6 x F)

Plunge Pool Depth	F=	0.492	ft	(0.5d for Type 1)	
Culvert Diameter	d=	1.0	ft		
				Converted to Metric	
Length of Plunge Pool	C =	6	ft	1.80	m
Width of Plunge Pool	B =	5	ft	1.50	m
Culvert Diameter	E =	1.0	ft	0.30	m
Plunge Pool Bottom Length	3E =	3.0	ft	0.90	m
Plunge Pool Bottom Width	2E =	2.0	ft	0.60	m

*Rounded to nearest foot for presentation, actual values carried through

State of Maryland - Erosion and Sediment Control Guidelines

Plunge Pool Calculations

Standard and Specification for Plunge Pools (D-4-2)

Design Criteria for Plunge Pool in Pond 10 (600mm Pipe)

1. Select type of plunge pool (Type 1 requires larger stone)

Type 1: Plunge pool is depressed 1/2 the size of the culvert

Type 2: Plunge pool is depressed full height of the culvert

2. Determine stone sizing

$$D_{50} = (0.0125d^2/Tw) \times (Q/d^{2.5})^{4/3}$$

Stone Size	D_{50}=		ft		
Design Flow Rate	Q=	30.37	cfs	0.86	m^3/s
Culvert Diameter	d=	1.97	ft	0.6	m
Tailwater	TW=	0.79	ft	0.24	m
	D_{50}=	0.610	ft		
		0.186	m		

Use 200mm At Apron

3. Determine plunge pool dimensions

C = (3 x d) + (6 x F)

B = (2 x d) + (6 x F)

Plunge Pool Depth	F=	0.984	ft	(0.5d for Type 1)	
Culvert Diameter	d=	2.0	ft		
				Converted to Metric	
Length of Plunge Pool	C =	12	ft	3.60	m
Width of Plunge Pool	B =	10	ft	3.00	m
Culvert Diameter	E =	2.0	ft	0.60	m
Plunge Pool Bottom Length	3E =	5.9	ft	1.80	m
Plunge Pool Bottom Width	2E =	3.9	ft	1.20	m

*Rounded to nearest foot for presentation, actual values carried through

State of Maryland - Erosion and Sediment Control Guidelines

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Pond 1/3 - 900mm Pipe - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	33.73	cfs	0.955	m^3/s
Culvert Diameter	d=	31	in	0.8	m
Tailwater	TW=	1.0	ft	0.32	m

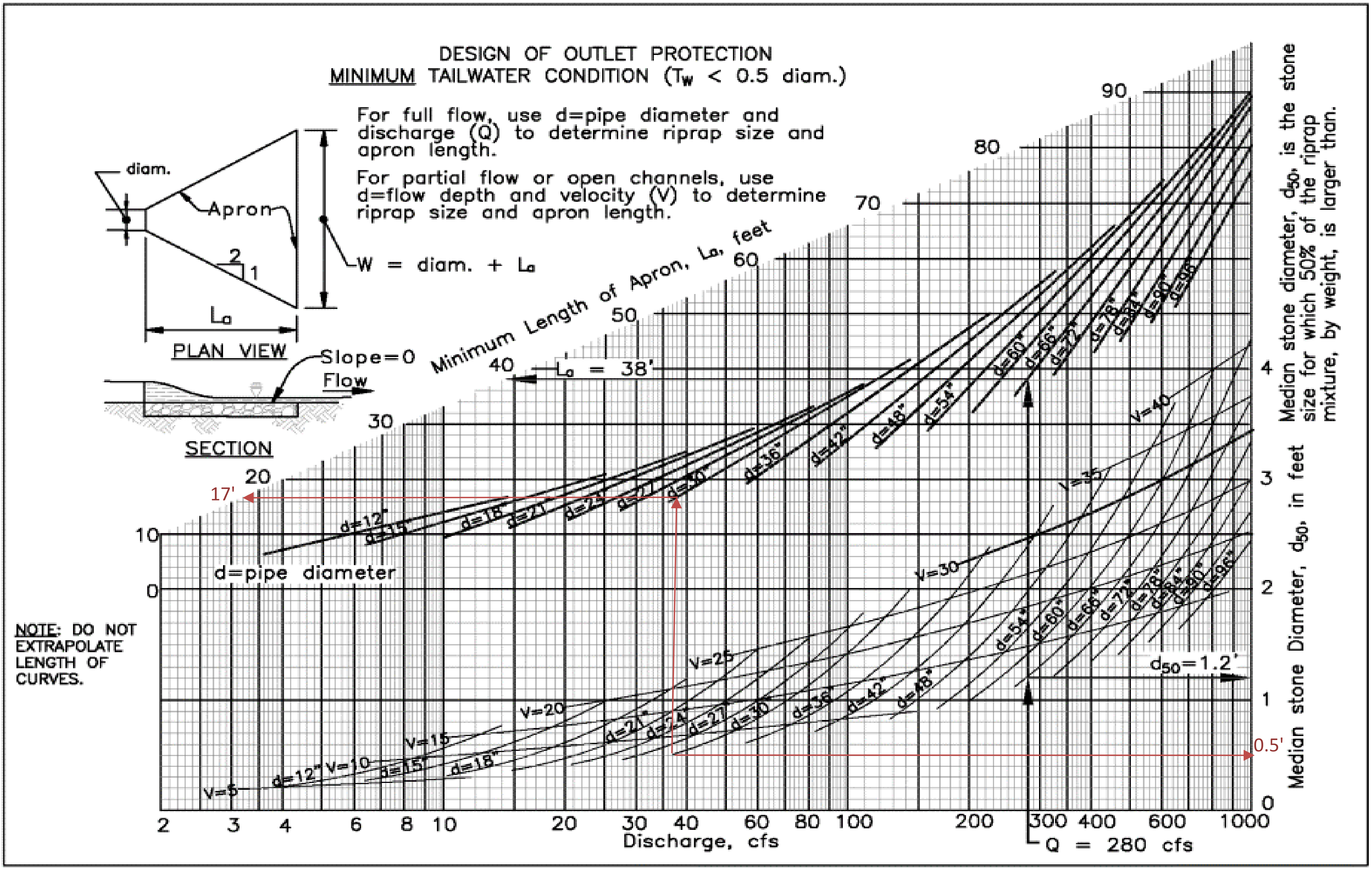

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.5 ft	
		0.15 m	Use 0.15m
Minimum Length of Apron	La =	17 ft	
		5.18 m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection 400mm Culverts in Block 1 - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	6.50	cfs	0.184	m^3/s
Culvert Diameter	d=	16	in	0.4	m
Tailwater	TW=	0.5	ft	0.16	m

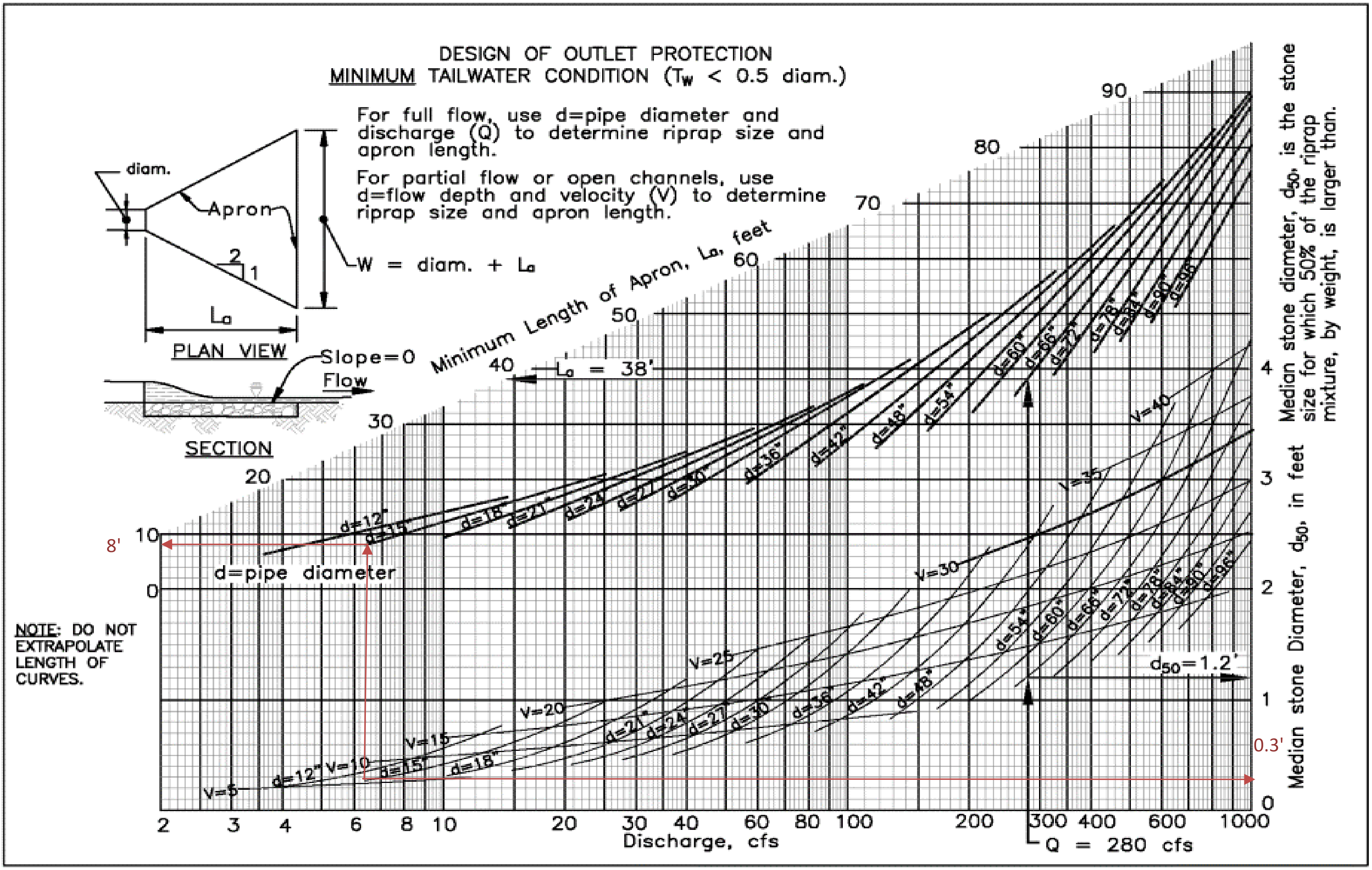

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.3 ft	
		0.09 m	Use 0.15m
Minimum Length of Apron	La =	8 ft	
		2.44 m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection 400mm Culverts in Block 4 - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	8.12	cfs	0.23	m^3/s
Culvert Diameter	d=	16	in	0.4	m
Tailwater	TW=	0.5	ft	0.16	m

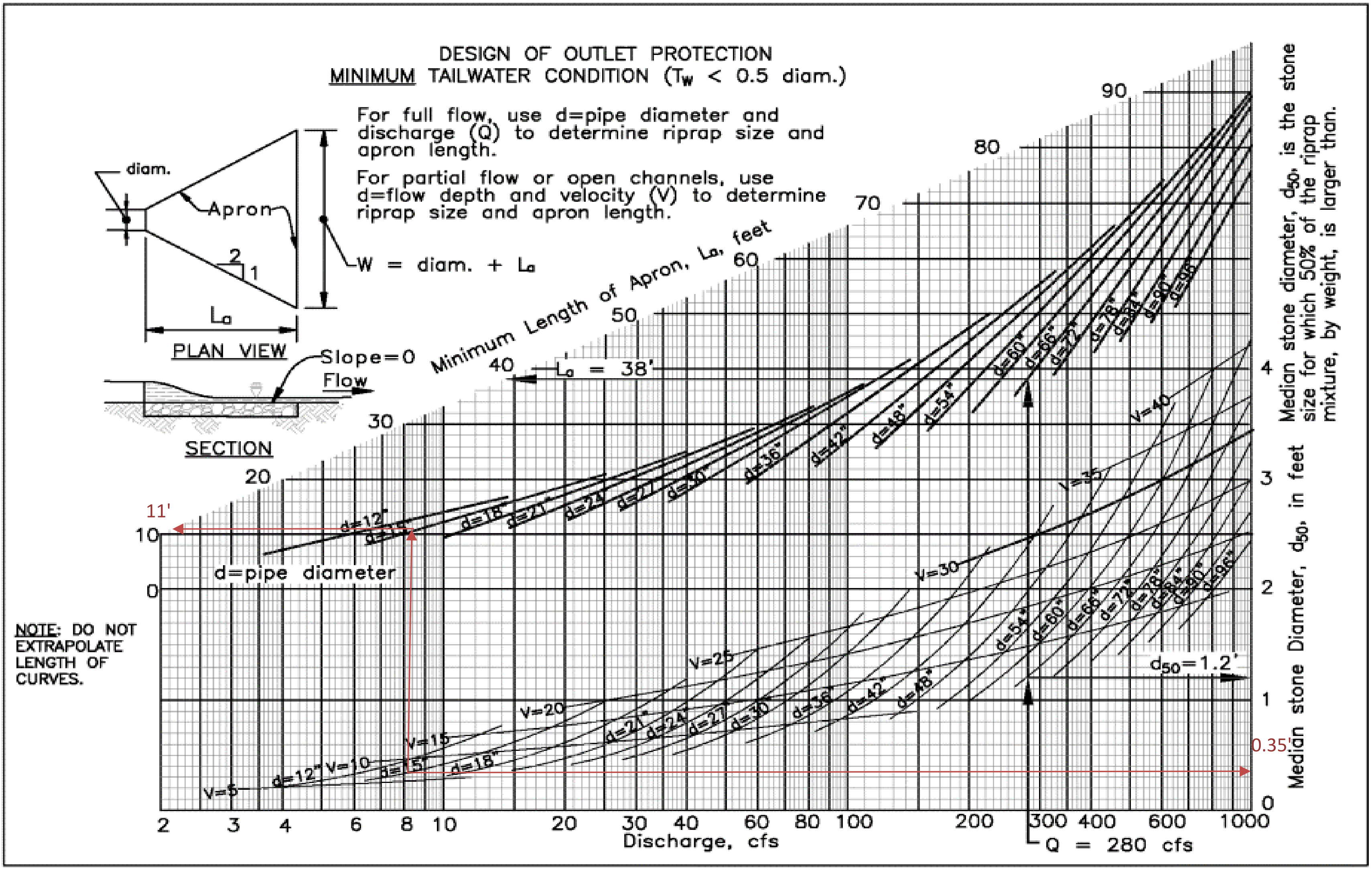

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.35	ft	
		0.11	m	Use 0.15m
Minimum Length of Apron	La =	11	ft	
		3.35	m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Pond 10 Outlet - 100year Storm

1. Determine Tailwater

Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter

Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section

b. Rock Outlet Protection 2 - to well-defined channel

c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	1.38	cfs	0.039	m^3/s	
Culvert Diameter	d=	10	in	0.25	m	*Use 12"
Tailwater	TW=	0.3	ft	0.1	m	

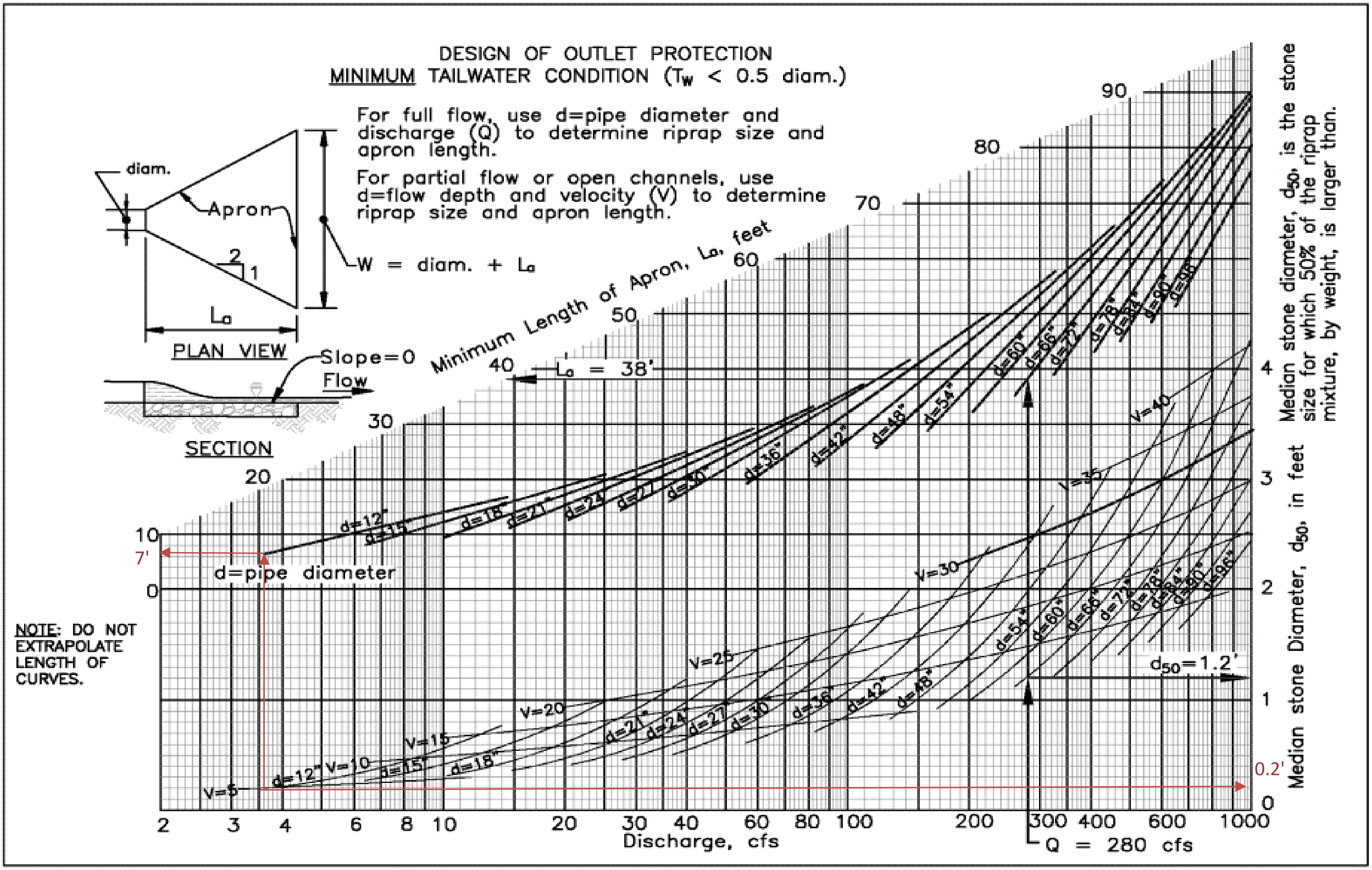

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.2	ft	
		0.06	m	Use 0.15m
Minimum Length of Apron	La =	7	ft	
		2.13	m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Culverts in Block 9 Outlet - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	9.18	cfs	0.26	m^3/s
Culvert Diameter	d=	18	in	0.45	m
Tailwater	TW=	0.6	ft	0.18	m

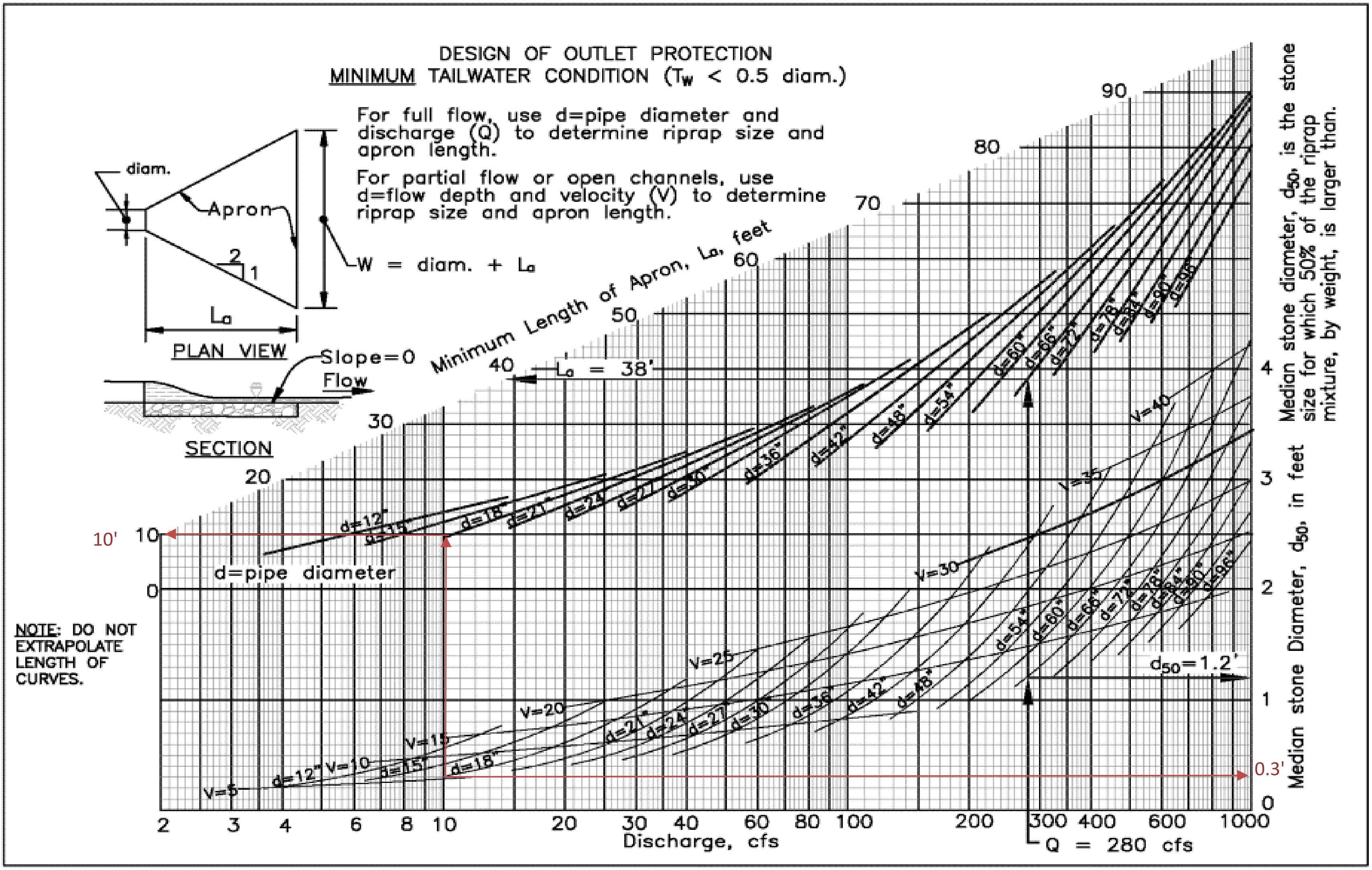

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.3	ft	
		0.09	m	Use 0.15m
Minimum Length of Apron	La =	10	ft	
		3.05	m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Pond 5 Outlet - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	1.98	cfs	0.056	m^3/s
Culvert Diameter	d=	18	in	0.45	m
Tailwater	TW=	0.6	ft	0.18	m

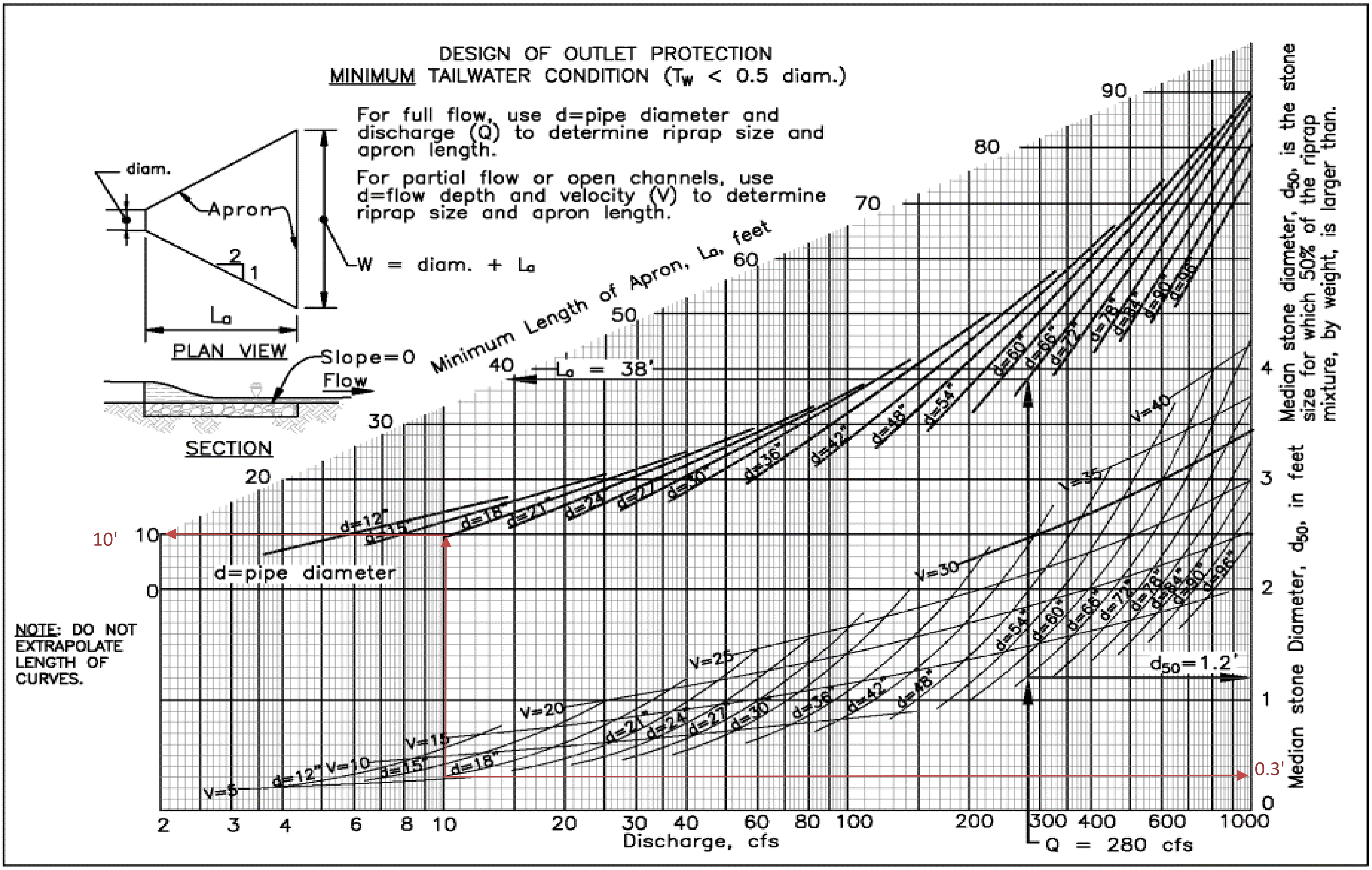

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.3 ft	
		0.09 m	Use 0.15m
Minimum Length of Apron	La =	10 ft	
		3.05 m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection 400mm Culverts in Block 8 - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	7.06	cfs	0.2	m^3/s
Culvert Diameter	d=	16	in	0.4	m
Tailwater	TW=	0.5	ft	0.16	m

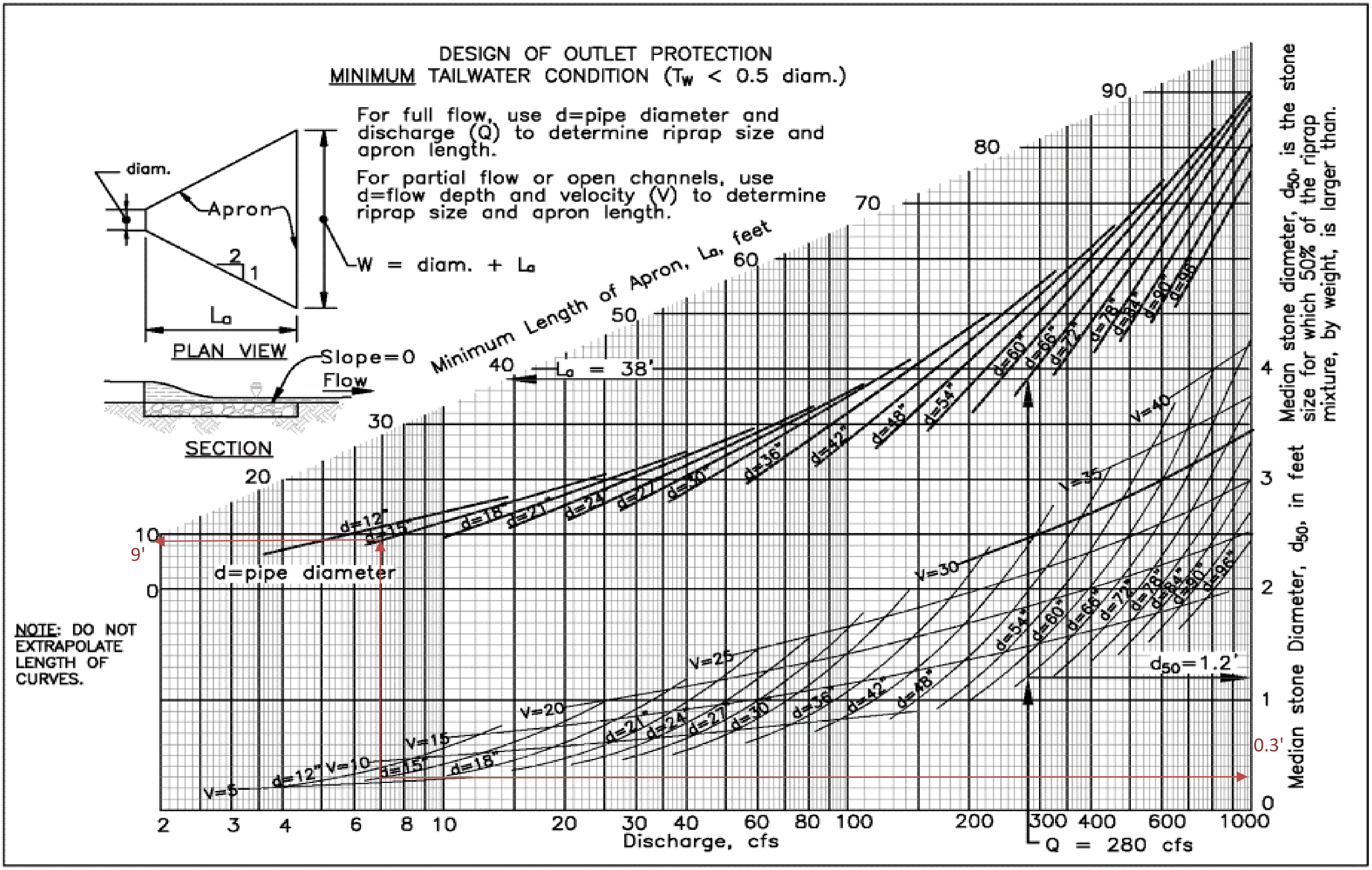

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.3	ft	
		0.09	m	Use 0.15m
Minimum Length of Apron	La =	9	ft	
		2.74	m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Payn Outlet - 100year Storm

1. Determine Tailwater
   Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter
   Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section
b. Rock Outlet Protection 2 - to well-defined channel
c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	3.53	cfs	0.1	m^3/s
Culvert Diameter	d=	16	in	0.4	m
Tailwater	TW=	0.5	ft	0.16	m

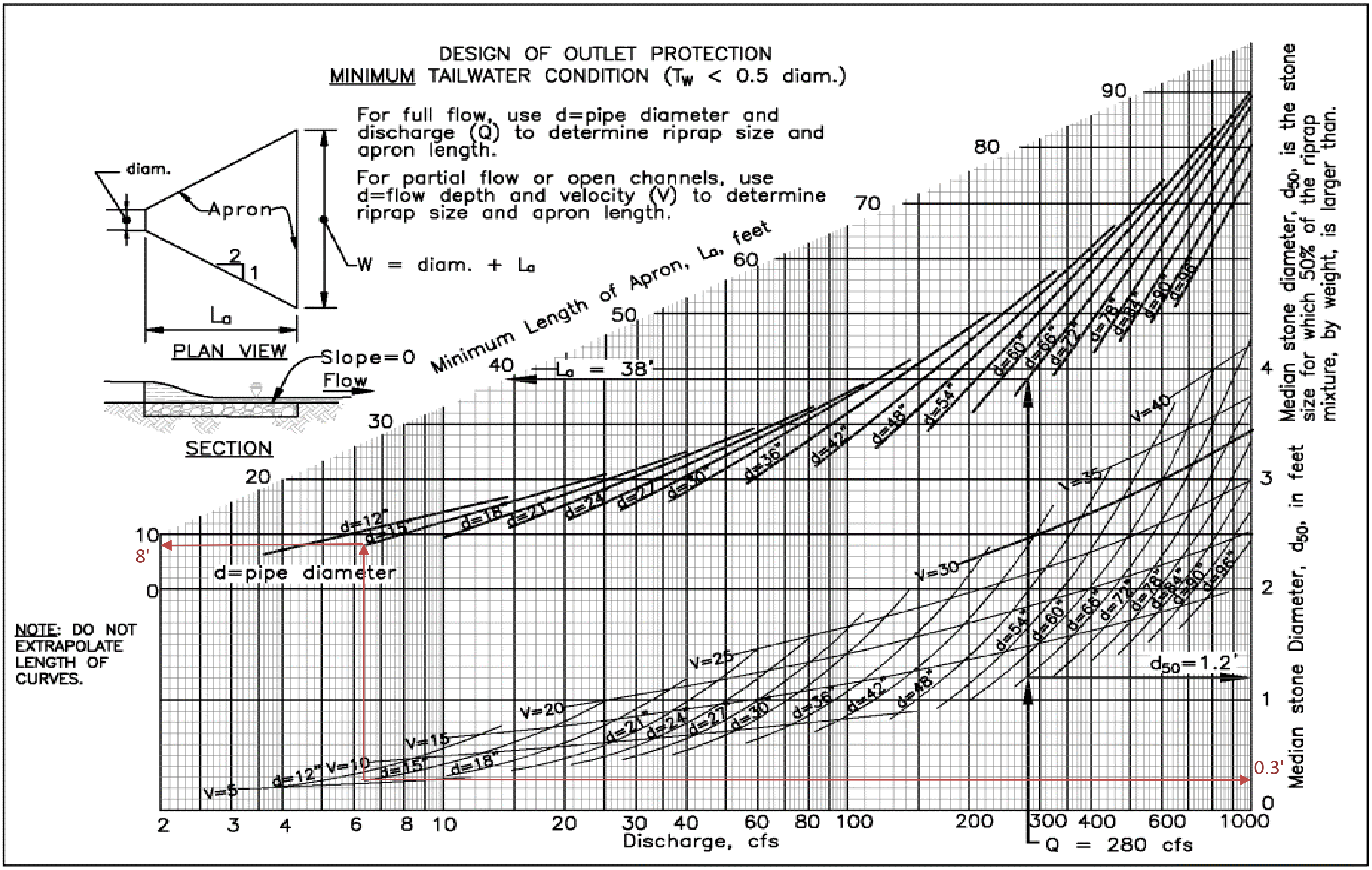

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.3 ft	
		0.09 m	Use 0.15m
Minimum Length of Apron	La =	8 ft	
		2.44 m	

Outlet Protection Calculations

Standard and Specification for Rock Outlet Projection (D-4-1)

Design Criteria for Outlet Protection Culverts in Between Block 9 and 10 Outlet - 100year Storm

1. Determine Tailwater

Minimum Tailwater Conditions: Less than 1/2 the Culvert Diameter

Maximum Tailwater Conditions: More than 1/2 the Culvert Diameter

* Pipes that outlet to flat areas can be assumed to have minimum tailwater conditions.

2. Apron Type

a. Rock Outlet Protection 1 - to semi-confined section

b. Rock Outlet Protection 2 - to well-defined channel

c. Rock Outlet Protection 3 - to flat area

3. Apron Size

Determine using Figures Below:

Design Flow Rate	Q=	26.84	cfs	0.76	m^3/s
Culvert Diameter	d=	24	in	0.6	m
Tailwater	TW=	0.8	ft	0.24	m

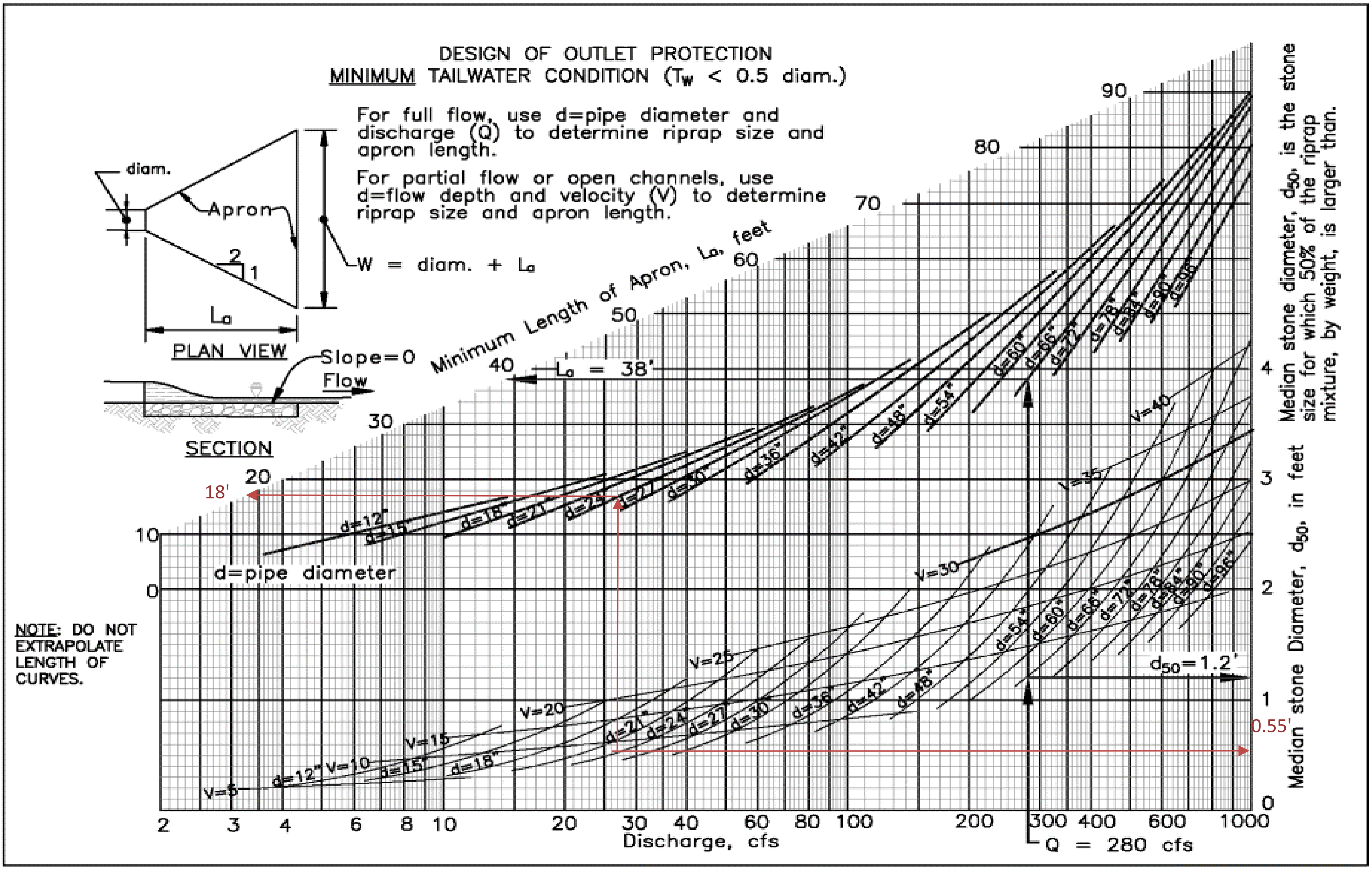

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

4. Results

Stone Size	d_{50}=	0.55	ft	
		0.17	m	Use 0.20m
Minimum Length of Apron	La =	18	ft	
		5.49	m	

APPENDIX F
POND 10

Revised March 9th, 2016

Canadian Solar Solutions Inc.
545 Speedvale Avenue West
Guelph, Ontario
N1K 1E6

Re: PP-14-9580
[Revised] Appendix F to the Post-Construction Stormwater Management Report - Pond 10

1.0 APPENDIX LIMITATIONS

This appendix has been prepared at the request of Canadian Solar Solutions Inc. (CSSI) to assess the existing stormwater management system and provide recommendations and designs for the post-construction scenario that are in compliance with the guidelines and standards from the Ministry of the Environment and Climate Change (MOECC) and local approval agencies. The original Stormwater Management Reports for the project were prepared by AECOM, dated July 2013 as well as the follow up report prepared in August 2014 for the Hamilton – Port Hope 4 solar site. This document will form part of the submission to the MOECC for a Renewable Energy Approval (REA) amendment.

Any use of this review by a third party, or any reliance on decisions made based on it, without a reliance report is the responsibility of such third parties. McIntosh Perry accepts no responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this review.

McIntosh Perry's scope was concentrated on the review and revision of the outlets to the temporary construction ponds including: removing ponds, if required; improving erosion and sediment control performance by reducing concentrated flows and flow volumes; and, increasing the use of measures that promote sheet flow, wherever possible. We have not evaluated/sized the interior ditches, culverts and sediment and erosion controls other than those noted within this report. Please note that there are additional controls on site in excess of what is noted in the report, installed by the Contractor during construction following typical best management practises. The design of these best management practises was performed by others. The findings, conclusions and/or recommendations of this report are only valid as of the date of this report. No assurance is made regarding any changes in conditions subsequent to this date. If additional information is discovered or becomes available at a future date, McIntosh Perry should be requested to re-evaluate the conclusions presented in this report, and provide amendments, if required.

2.0 PURPOSE AND OBJECTIVE

This Appendix F has been prepared at the request of CSSI, as a supplementary document and work objective to that described in the Post-Construction Stormwater Management Report, revised June 2016, prepared by McIntosh Perry. This Appendix provides a post-construction rehabilitation plan for the areas discharging into Pond 10 and Pond 10 itself in accordance with recommendations from, and in consultation with, the MOECC and Ministry of Natural Resources and Forestry (MNRF). The objective of the Pond 10 and nearby area rehabilitation is to ensure that stormwater is managed in accordance with the original intent of the approved REA for the project.

This document focuses primarily on the design and sizing of Pond 10 as a means to control runoff to less than pre-development flow rates. This Appendix provides a rehabilitation management plan with regards to Pond 10 discharges and the associated erosion and sedimentation issues. The objective of this report is to provide design details to manage stormwater currently discharging into Pond 10 from portions of Blocks 8 and 10. Stormwater management will be achieved using a combination of on-site infiltration and other controlled discharge routes.

Pond 10 requires an active outlet so it can drain in an efficient manner and have capacity for successive stormwater runoff events. Two outlet alternatives have been designed each alone can handle the required outflow from pond 10 in a 100-year storm event. CSSI will install at least one of the outlet alternatives. The first alternative is to install an outlet control device that would discharge runoff into the Municipal Right of Way, through Payne Road and ultimately into the Baltimore Creek tributary. The second alternative is to install a pump with a float system that would activate during stormwater events to drain Pond 10. The pump has been sized such that in a 100-year event, the ponding elevation in Pond 10 would continue to possess the necessary freeboard (0.3m) and it is expected to outlet to the relatively significant ditch between drainage areas B2 and B10 where it will then gravity flow behind the house. Please see Appendix G for more information regarding the proposed pumping of Pond 10, if installed.

3.0 STORMWATER MANAGEMENT REHABILITATION

The MOECC has requested that the post-development flow from the Pond 10 outlet be reduced as much as possible. Based on site conditions and the history regarding the outlet from Pond 10 through the neighbouring property to the east, the post-construction state was reviewed with the goal of substantially reducing the peak flow rate reaching the Pond 10 outlet. This goal is achieved by ensuring that the majority of the peak runoff volume remains on the site in Pond 10 as it discharges continuously at the reduced rate. In addition, the volume of water reaching Pond 10 is limited to the extent possible (please see discussion in the main body of the report and Appendix G).

Analysis was performed to estimate peak flow rates that reached this outlet (Outlet 2, cross culvert at Payne Road) pre-construction. In 100-year events, it was determined that the flow rate reaching this crossing culvert was 1,134 L/s and 1,232 L/s in the 12- and 24hr events, respectively (please see Pre-Development Hydrological Results, within this appendix for all other storm events).

The pond will rely on a gravity outlet and/or pump system as its means of discharging. Appendix F will focus on the gravity outlet whereas Appendix G includes the flow from the pumped system. The existing capacity within the pond was reviewed and alterations to the top of bank and outlet are required to provide sufficient storage to substantially reduce the post-development flow rate in the 100-year 24hr storm (worst case). The maximum pond elevation was determined to occur during the 24hr storm up to an elevation of 232.55m. With a top of bank of 232.85m, an additional 0.3m of freeboard (which is typically required in stormwater ponds) is provided.

In addition to the measures above, Pond 10 will be dry. The pond will be regraded to ensure that runoff flows towards the outlet. Runoff from the site will filter through existing and proposed upstream rock flow check dams and infiltration trenches prior to entering into the pond before it drains to the municipal right of way or is pumped behind the farmhouse (see Sheet 7).

If the gravity outlet from Pond 10 is installed, the roadside ditch along the municipal right of way will be regraded and the culvert along Payne Road lowered to accommodate the elevation of the pond. The culvert is being lowered in an attempt to reduce the potential for erosion downstream and reduce the cascading effects through the neighbouring property to the north. Please see Appendix H for more information regarding the flow through the neighbouring property.

With the objective of minimizing the total volume reaching Pond 10, post-construction flows from Block 9 that previously reached Pond 10 have been diverted south towards the west of the existing farm house on the solar farm property by implementing a diversion swale (see Sheet 8). In addition, flows from the roadside ditch that conveys runoff from Block 8 that previously drained into Pond 10 have now been directed to the west by implementing four road culverts with flow dissipators (see Sheet 1). There is a man-made water storage area that was previously used for watering livestock behind the house which is being restricted through the use of a man-made dam and outlet culvert (250mm CSP). Through discussions with the MOECC, it was noted that these diversions were acceptable given neighbouring landowner’s issues. MOECC requested confirmation that the flows which are diverted behind the house will not have any adverse effects on the downstream channel or infrastructure. Please see Appendix G: Flow behind the House for more details.

4.0 STORMWATER MANAGEMENT FACILITY DESIGN – BLOCK 10

4.1 INLET DESIGN

Pond 10 will received runoff via several ditch inlets located within the adjacent ditch as well as from a manhole which receives runoff from the south portions of Block 8. The bottom of the pond will be graded to ensure a slope of approximately 1% to the invert of the outlet pipe.

4.2 QUALITY CONTROL

As per the MOECC's guidelines, infiltration trenches located in the roadside ditch adjacent and upstream of Pond 10 will, in effect, act as the quality control mechanism for this drainage area. As per the MOECC stormwater management guidelines, an enhanced level of treatment requires 25m^3/ha, based on 35% imperviousness, which exceeds the current site imperviousness. The current drainage area possesses approximately 5.6% imperviousness, which results in approximately 3.8m^3/ha (determined through interpolation of Table 3.2 of the MOECC's Stormwater Management Planning and Design Guidelines). Given that the drainage area for Pond 10 is 5.1ha, however, the entire outlet #2 has a combined area of 9.5ha, which was used in calculating total infiltration storage volume required. This was found to be approximately 38m^3 to meet the quality objectives. There are 60m of 2.5m wide by 1.0m deep infiltration trenches upstream of Pond 10 resulting in 60m^3 of available storage (assuming a void space of 0.4). As the available volume exceeds the minimum MOECC requirements, it is believed that this outlet will achieve the enhanced quality control objective.

4.3 DRAWDOWN TIME

The MOECC's guidelines suggest a minimum drawdown time of 24-hours as a target for storage detention which may be reduced to 12-hours if there is a conflict with the minimum sizing of orifice. The retention time is primarily to allow for particle settling to occur. The drawdown time has been calculated for the 25mm storm event for a dry pond with a fixed 120mm orifice has been calculated to be 1 hours, using equation 4.11 in the MOECC Design Manual. It is understood that this is much less than the expected target, however, the upstream infiltration trenches provide the quality control for this area, therefore, we are not concerned with the lower than typically acceptable timing.

4.4 QUANTITY CONTROL

As per the requirements from the MOECC, the site will be equipped with stormwater management facilities providing quantity control. Pond 10 will receive runoff from the northern portion of the solar development represented by drainage areas B2 and B4 (Block 10 and a portion of Block 8). The table below illustrates the stage-storage-discharge relationship for Pond 10 based on the design outlet structure for the 2-, 5-, 10-, 25-, 50- and 100-year storm events for the 24-hour SCS design storm (worst case scenario) based on the volume of runoff.

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Outflow (L/s)	Freeboard (m)	Freeboard (m^3)
25mm	231.10	70	15	1.80	3320
2-year	231.61	535	26	1.24	2,855
5-year	231.83	922	30	1.02	2,468
10-year	232.02	1,292	32	0.83	2,098
25-year	232.25	1,817	35	0.60	1,573
50-year	232.39	2,137	37	0.46	1,253
100-year	232.55	2,534	39	0.30	856

Table 1: Stage-Storage-Discharge – Pond 10

A maximum required volume of 2,534m^3 for the 100-year 24-hour SCS storm at an elevation of 232.55m was calculated. The total available storage in the pond is 3,390m^3 at an elevation of 232.85m, which indicates a freeboard depth of 0.30 m, which meets the minimum recommended freeboard depth.

4.5 EMERGENCY OVERFLOW SPILLWAY

The emergency overflow spillway shall provide passage of the large storm event peak flows. In order to size the emergency spillway the starting water surface elevation shall be at the principal spillway elevation. The emergency spillway shall have an invert elevation at the 100-year water surface elevation and the flood head water passing through the emergency spillway weir shall not exceed the freeboard elevation when using the large storm event peak flows.

The emergency overflow spillway has been designed using a 5.0m wide riprap weir adjacent to the outlet structure at an invert elevation 232.55m. The total worst-case post-development unrestricted 100-year peak flow for the pond was a flow rate of 1,044 L/s and 354 L/s totalling 1,394 L/s for the 24-hour SCS design storm. The overflow spillway has a capacity of 1,512 L/s at an elevation of 232.85m. Flows exceeding the combined capacity of the outlet structure and the emergency earth weir will cascade over the top of the pond into the municipal right of way.

5.0 STORMWATER MANAGEMENT FACILITY MAINTENANCE

Please refer to the original Post-Construction Stormwater Management Report prepared by McIntosh Perry for complete stormwater management facility maintenance requirements.

6.0 SEDIMENT AND EROSION CONTROL

Please see the original Post-Construction Stormwater Management Report prepared by McIntosh Perry for complete temporary and permanent measures. Please refer to the erosion and sediment controls illustrated on the Pond 10 Rehabilitation Plan for the locations of said controls.

7.0 RECOMMENDATIONS

Based on the information presented in this report, we recommend that CSSI implement the recommendations outlined in this Post-Construction Stormwater Management Plan Addendum and that the Ministry of the Environment and Climate Change approve this *Post-Construction Stormwater Management* Addendum in support of the proposed rehabilitation work at the Hamilton – Port Hope 4 Solar Farm.

We trust that the preceding information is acceptable for your present purposes. Should you require additional information or have questions about anything contained herein please feel free to contact the undersigned.

Regards,

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT

DRAINAGE AREA INFORMATION (POST DEV - AECOM)

Land Use Breakdown

Catchment ID	Area (m^2)	Impervious (m^2)	Pasture (m^2)	Crop (m^2)	CN
A2	106,861	1554	16,185	89,122	73.0
Total	**106,861**	**1554**	**16,185**	**89,122**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
A2	444	4.7	180	2.0	1.83	26

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
A2	10.7	73.0	26
Total	**10.7**		

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT HYDROLOGICAL RESULTS

12-Hr - Pre-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A2	103	317	483	716	917	1,134
Total	103	317	483	716	917	1,134

24-Hr - Pre-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A2	185	401	579	851	1,015	1,232
Total	185	401	579	851	1,015	1,232

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT DRAINAGE AREA INFORMATION

Land Use Breakdown

Catchment ID	Area (m^2)	Gravel (m^2)	Impervious (m^2)	Crop (m^2)	Improved (m^2)	Pasture (m^2)	Pond (m^2)	CN
B2	35,884	1,917	35	0	30,327	0	3,605	84.0
B4	15,173	1,650	535	0	11,767	1,221	0	81.5
B9	11,395	650	0	6859	0	3,886	0	71.6
B11	32,360	1,009	1,278	8,619	6,223	15,231	0	72.6
Total	**94,812**	**5,226**	**1,848**	**15,478**	**48,317**	**20,338**	**3,605**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope of Land (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min)
B2	203	6.7	47	1.5	1.57	8
B4	225	2.6	82	3.4	2.36	15
B9	197	2.1				20
B11	301	5.6	271	0.6	0.99	21

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
B2	3.6	84.0	8
B4	1.5	81.5	15
B9	1.1	71.6	20
B11	3.2	72.6	21
	9.5		

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
POST-DEVELOPMENT HYDROLOGICAL RESULTS

Unrestricted

12-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B2	227	411	532	688	815	944
Area B4	63	123	165	220	266	312
Area B9	10	35	54	82	107	133
Area B11	33	106	162	240	307	381
Total	333	675	913	1,230	1,495	1,769

24-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B2	302	479	610	799	907	1,044
Area B4	89	150	197	265	304	354
Area B9	22	51	75	113	136	165
Area B11	69	151	220	326	391	474
Total	483	831	1,102	1,503	1,738	2,038

Restricted 24Hour Pond 10

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Outflow (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	231.61	535	26	1.24	2,855
5-year	231.83	922	30	1.02	2,468
10-year	232.02	1,292	32	0.83	2,098
25-year	232.25	1,817	35	0.60	1,573
50-year	232.39	2,137	37	0.46	1,253
100-year	232.55	2,534	39	0.30	856

Restricted 12Hour Pond 10

Storm Event	Stage [Elevation] (m)	Storage (m^3)	Outflow (L/s)	Freeboard (m)	Freeboard (m^3)
2-year	231.51	342	24	1.34	3,048
5-year	231.75	775	28	1.10	2,616
10-year	231.92	1,097	31	0.93	2,293
25-year	232.07	1,409	33	0.78	1,981
50-year	232.25	1,819	35	0.60	1,571
100-year	232.39	2,143	37	0.46	1,247

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT COMPARISON HYDROLOGICAL RESULTS

Unrestricted

12-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B2	227	411	532	688	815	944
Area B4	63	123	165	220	266	312
Area B9	10	35	54	82	107	133
Area B11	33	106	162	240	307	381
Total	333	675	913	1,230	1,495	1,769

24-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area B2	302	479	610	799	907	1,044
Area B4	89	150	197	265	304	354
Area B9	22	51	75	113	136	165
Area B11	69	151	220	326	391	474
Total	483	831	1,102	1,503	1,738	2,038

Outlet #2	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A2	103	317	483	716	917	1,134
Area B2	227	411	532	688	815	944
Area B4	63	123	165	220	266	312
Area B9	10	35	54	82	107	133
Area B11	33	106	162	240	307	381
POST	333	675	913	1,230	1,495	1,769
Δ	230	358	430	514	578	635
Allowable Outflow from Pond	60	176	267	393	503	620
Actual Outflow from Pond 10 - 12hr	24	28	31	33	35	37

Outlet #2	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Area A2	185	401	579	851	1,015	1,232
Area B2	302	479	610	799	907	1,044
Area B4	89	150	197	265	304	354
Area B9	22	51	75	113	136	165
Area B11	69	151	220	326	391	474
POST	483	831	1,102	1,503	1,738	2,038
Δ	297	429	523	651	723	806
Allowable Outflow from B1 Pond	211	277	315	359	381	404
Actual Outflow from Pond 10 - 24hr	26	30	32	35	37	39

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT ELEVATION - DISCHARGE TABLE POND 10

For Orifice Flow, C =	0.60
For Weir Flow, C =	1.84

	Drawdown Outlet	Outlet	Emergency Weir
Invert Elevation	230.80		232.55
Orifice Width/Weir Length	120 mm		5.00 m
Orifice Area (m^2)	0.011	0.000	

Elevation	Drawdown Outlet		Outlet		Emergency Weir		Total
	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	H [m]	Q [m^3/s]	Q [m^3/s]
230.80	x	x			x	x	0.000
232.55	1.75	0.040			x	x	0.040
232.85	2.05	0.043			0.30	1.512	1.555

Notes: 1. For Orifice Flow, User is to Input an Elevation Higher than Invert of Orifice.

*2. Orifice Equation: $Q = cA(2gh)^{1/2}$ (m^3/s *1000 = l/s)*

*3. Weir Equation: $Q = CLH^{3/2}$ (m^3/s *1000 = l/s)*

4. These Computations Do Not Account for Submergence Effects Within the Pond Riser.

5. H for orifice equations is depth of water above the invert of the orifice.

6. H for weir equations is depth of water above the weir crest.

Reference: Urban Hydrology, Hydraulics and Stormwater Quality: engineering application and computer modeling / A. Akan, Robert J. Houghtalen, 2003.

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT DRAWDOWN TIME (USING LINEAR REGRESSION)

As per the Section 4.6.2 (Wet Ponds) of the MOE Stormwater Management Planning and Design Manual, March 2003, a detention time of 24 hours should be targeted in all instances.

The detention time can be easily solved if the relationship between pond surface area and wetland depth is approximated using a linear regression equation as follows:

Drawdown Time Equation ---->

$$t = \frac{0.66\, C_2\, h^{1.5} + 2\, C_3\, h^{0.5}}{2.75\, A_o}$$

Equation 4.11 (MOE SWM Planning Design Manual, 2003)

where,
- t = Drawdown time in seconds
- C_2 = Slope coefficient from the area-depth linear regression
- C_3 = Intercept from the area-depth linear regression
- h = Maximum water elevation above the orifice (m)
- A_o = Cross-sectional area of the orifice (m^2)

The relationship between A and h using Linear Regression (i.e., $A = C_2 h + C_3$)

Orifice Details:	***Pond 10***
Orifice(s) Diameter =	120 mm
Orifice Invert Elevation =	230.80 m

From Elevation - Discharge Table Sheet

Pond Details:

Storage Elevation (m)	Max. Water Elevation Above Orifice (m)	Surface area of the Pond (m^2)
Block #10		
230.80	0.00	0
231.10	0.30	257

Drawdown Time Results:	***Blocks #10***
Slope (C_2) =	855
Intercept (C_3) =	0
Maximum Water Elevation Above Orifice (h) =	0.30 m
Cross-sectional area of the orifice (A_o) =	0.011 m2
Drawdown time	2,982 s
Drawdown Time (rounded to nearest hour, exact times calculated)	**1 hrs**

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Worksheet for 450mm PVC Pipe @3.3% - Full Flow Capacity

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.30000	%
Normal Depth	0.45	m
Diameter	0.45	m
Discharge	517.92	L/s

Results

Discharge	517.92	L/s
Normal Depth	0.45	m
Flow Area	0.16	m²
Wetted Perimeter	1.41	m
Hydraulic Radius	0.11	m
Top Width	0.00	m
Critical Depth	0.44	m
Percent Full	100.0	%
Critical Slope	0.02921	m/m
Velocity	3.26	m/s
Velocity Head	0.54	m
Specific Energy	0.99	m
Froude Number	0.00	
Maximum Discharge	0.56	m³/s
Discharge Full	0.52	m³/s
Slope Full	0.03300	m/m
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Average End Depth Over Rise	0.00	%

Worksheet for 450mm PVC Pipe @3.3% - Full Flow Capacity

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.45	m
Critical Depth	0.44	m
Channel Slope	3.30000	%
Critical Slope	0.02921	m/m

Worksheet for 450mm PVC Pipe @3.3% - 100-Year Flow

Project Description

Friction Method	Manning Formula	
Solve For	Normal Depth	

Input Data

Roughness Coefficient	0.013	
Channel Slope	3.30000	%
Diameter	0.45	m
Discharge	397.00	L/s

Results

Normal Depth	0.30	m
Flow Area	0.11	m^2
Wetted Perimeter	0.85	m
Hydraulic Radius	0.13	m
Top Width	0.43	m
Critical Depth	0.42	m
Percent Full	65.6	%
Critical Slope	0.01677	m/m
Velocity	3.59	m/s
Velocity Head	0.66	m
Specific Energy	0.95	m
Froude Number	2.25	
Maximum Discharge	0.56	m^3/s
Discharge Full	0.52	m^3/s
Slope Full	0.01939	m/m
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	65.61	%
Downstream Velocity	Infinity	m/s

Worksheet for 450mm PVC Pipe @3.3% - 100-Year Flow

GVF Output Data

Upstream Velocity	Infinity	m/s
Normal Depth	0.30	m
Critical Depth	0.42	m
Channel Slope	3.30000	%
Critical Slope	0.01677	m/m

APPENDIX G
FLOW BEHIND THE HOUSE

March 9th, 2017

Canadian Solar Solutions Inc.
545 Speedvale Avenue West
Guelph, Ontario
N1K 1E6

Re: PP-14-9580
Appendix G to the Post-Construction Stormwater Management Report – Flow behind House

1.0 APPENDIX LIMITATIONS

This appendix has been prepared at the request of Canadian Solar Solutions Inc. (CSSI) to assess the existing stormwater management system and provide recommendations and designs for the post-construction scenario that are in compliance with the guidelines and standards from the Ministry of the Environment and Climate Change (MOECC). The original Stormwater Management Reports for the project were prepared by AECOM, dated July 2013 as well as the follow up report prepared in August 2014 for the Hamilton – Port Hope 4 solar site. This document will form part of the submission to the MOECC for a Renewable Energy Approval (REA) amendment.

Any use of this review by a third party, or any reliance on decisions made based on it, without a reliance report is the responsibility of such third parties. McIntosh Perry accepts no responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this review.

McIntosh Perry's scope was concentrated on the review of the flow rates and volumes leaving the site and contributing to the watershed of Brook Creek. Through extensive consultation with the MOECC, as well as the project owner, Contractor and Client, the redirection of flow to the west was reviewed in an attempt to alleviate downstream concerns to the adjacent landowners to the east. Please note that the areas downstream of the site were reviewed at a high level and detailed topographic, geotechnical and soils data were not obtained nor available. The evaluation of the cross-sections, vegetation and stormwater management systems were reviewed through a desktop review with a site visit to confirm general conformance of the provided information.

The findings, conclusions and/or recommendations of this report are only valid as of the date of this report. No assurance is made regarding any changes in conditions subsequent to this date. If additional information is discovered or becomes available at a future date, McIntosh Perry should be requested to re-evaluate the conclusions presented in this report and provide amendments, if required.

2.0 PURPOSE AND OBJECTIVE

This Appendix G has been prepared at the request of CSSI, as a supplementary document to the information provided in the Post-Construction Stormwater Management Report revised September 2016, prepared by McIntosh Perry. This document provides a standalone review of the downstream impacts as a result of the increase in runoff directed from drainage areas B2, B3, B4 and B10 directed to the south of the house. Since, the increase of pumping runoff from Pond 10 has been included to represent the worst case scenario of runoff behind the house. For the purpose of this report, please note the "house" is the dwelling that was retained during construction and is centrally located on site. In an effort to alleviate neighbor concerns, some runoff that would otherwise flow to the east is being redirected behind the house and to the west where it will have ample opportunity to infiltrate, absorb and filter prior to continuing downstream. This appendix has been prepared to address the MOECC's requests to confirm that the increase in flow to the catchment downstream (behind the house), will not have any detrimental effects on the environment or neighbouring landowners downstream. Through consultation with the MOECC they have requested the following:

- Review and confirm impacts to the capacity of the culvert at Van Luven Road;
- Review impacts to the nearby subdivision (Hutsell Road) stormwater system;
- Confirm that the receiving watercourse has the capacity to accept the increased flows;
- Confirm that the ponds downstream of the site do not accept runoff from the watercourse;
- Infiltration data for the areas downstream of the site.

It should be noted that the acceptance of this increase in flow from the MOECC does not necessarily permit the additional flow from being directed onto this land. The local conservation authority and municipality should be contacted and satisfied with this approach prior to initiating any of the proposed work described herein. Please note this work may have impacts to the existing watershed reports prepared by others which may require updating as a result of this additional flow.

Finally, the work set out in this Appendix G and the most recent construction drawings is believed to be in the best interest of the public and environment to reduce the volumes and flow rates of runoff leaving the site to the northeast. Through discussions with the MOECC they have noted that they would permit increased runoff to the Brook Creek watershed assuming they were satisfied with the information provided to address their five noted concerns above. In this special instance, the MOECC is willing to accept an increase to a watershed which they understand has the ability to take the increased flow due to the issues to the east and waive its typical post- to pre-development restriction requirement.

3.0 DRAINAGE PATH, WATERCOURSE AND POND 10

The northwestern limits of the site (drainage areas B2, B3, B4 and B10) drain into a watercourse which contributes to the Brook Creek Tributary (see enclosed Drainage Plan which illustrates the location of the watercourse in proximity to the site). This tributary begins at the solar farm and flows to the south through a number of road crossings including Highway 401, ultimately reaching its outlet at Lake Ontario. The watercourse stretches approximately 7.2km from the site to Lake Ontario, with varying cross-sections throughout dependent on topography and local development.

The watershed reviewed as part of this Appendix commences at the solar farm and terminates at Van Luven Road. This watercourse extends approximately 1.8km, from the site to Van Luven Road. This watershed is approximately 155ha, which includes portions of the existing solar farm. Through the proposed changes, the watershed boundary will be increased by approximately 3ha.

The watercourse was reviewed in both the minor (5-year) and major (100-year) storm events. The tables below illustrate the estimated pre- and post-development peak flow rates reaching Van Luven Road in the scenario where gravity fed swales and ditches reach Van Luven Road and where pumping of Pond 10 is initiated adding to the post-development peak flow rate.

Pond 10 is located in the north east of the site and receives runoff from drainage area B2 and B4. Pond 10 requires an active outlet so it can drain in an efficient manner and have capacity for successive stormwater runoff events. Two outlet alternatives have been designed that individually handle the required outflow from Pond 10 in a 100-year storm event. The first alternative is described in Appendix F.

The second alternative is to install a pump with a float system that would activate during rain events to drain Pond 10. The pump has been sized such that in a 100-year event, the ponding elevation in Pond 10 would continue to possess the necessary freeboard (0.3m) and would pump at a maximum flow rate of 50L/s (0.05m^3/s). Runoff is pumped from Pond 10 to the ditch between drainage areas B2 and B10 where it will then gravity flow as noted above behind the house. Given the further increase in flow to this outlet, additional calculations have been provided to ensure that the increased flow from Pond 10 to the outlet will not possess any negative impacts downstream.

Table 1 - Pre- and Post-development flow rates reaching Van Luven Road with no pumping of Pond 10

	5-Year	100-Year
	m^3/s	
PRE	1.34	7.75
POST	1.41	7.81
Δ	0.07	0.06

Table 2 - Pre- and Post-development flow rates reaching Van Luven Road including pumping from Pond 10

	5-Year	100-Year
	m^3/s	
PRE	1.34	7.75
POST	1.46	7.86
Δ	0.12	0.11

Per Table 1, (in the event of no pumping from Pond 10), it is estimated that peak flow rates will increase by approximately 0.07 and 0.06 m^3/s for the 5- and 100-year storm events respectively. This represents a percent change of approximately 5% in the 5-year, and less than 1% in the 100-year storm event in comparison to pre-development estimated peak flow rates. Per Table 2, (in the event of pumping from Pond 10), it is estimated that peak flow rates will increase by approximately 0.12 and 0.11m^3/s for the 5- and 100-year storm events respectively. This represents a percent change of approximately 9% in the 5-year, and 1.4% in the 100-year storm event in comparison to pre-development estimated peak flow rates. It is our belief that as you progress further downstream the difference between the two areas will decrease as the impact of the farm is reduced given the increase in total area.

Downstream of the site, the runoff travels through a channel where ponding is promoted by way of a number of restriction devices - prior to reaching the Van Luven culvert. The following photos represent key locations throughout the downstream channel which provide a representation of the downstream conditions.

Figure 1 - Channel at Baltimore Solar's Property Limit

Figure 2 - 1.2m Wide x ~1.5m Tall Weir Structure - Inline

Figure 3 - Channel becomes much wider as it continues downstream prior to and after the private driveway culvert

Figure 4 - One of the three relatively large man-made ponds in-line with the channel

Please see the Drainage Plan (PP-14-9580 – Drain) attached which illustrates the overall watershed as well as the major crossings between the farm and the ultimate outlet (Lake Ontario).

4.0 IMPACTS TO THE EXISTING WATERCOURSE

The existing watercourse was reviewed as part of this analysis. Watercourse cross-sections were taken at three separate locations: at the property limit, within the Hutsell Road subdivision and approaching the culvert at Van Luven Road. The cross-sections were reviewed for the 5- and 100-year, 24-Hour SCS distribution to confirm capacity and impacts as a result of the increase in flow in the existing watercourse.

The following illustrates the pre-development 5- and 100-year peak flow through the cross-sections of the ditch.

Table 3 - Pre-Development 5- and 100-year Through Ditch Cross-Sections

	Slope of Ditch (%)	Velocity (m/s)	Flow (m^3/s)	Elevation (depth in m)	Flow Type
5 - Year					
A-A'	5.3	0.81	0.30	222.09 (0.20m)	Subcritical
B-B'	6.9	0.81	0.73	178.06 (0.16m)	Subcritical
C-C'	1.0	0.54	1.32	160.22 (0.22m)	Subcritical
100 - Year					
A-A'	5.3	1.26	1.50	222.27 (0.38m)	Subcritical
B-B'	6.9	1.25	4.20	178.21 (0.31m)	Supercritical
C-C'	1.0	0.91	7.64	160.57(0.57m)	Subcritical

Table 4 - Post-Development 5- and 100-year Through Ditch Cross-Sections

	Slope of Ditch (%)	Velocity (m/s)	Flow (m^3/s)	Elevation (depth in m)	Flow Type
5 - Year					
A-A'	5.3	0.84	0.30	222.10 (0.21m)	Subcritical
B-B'	6.9	0.82	0.78	178.06 (0.16m)	Subcritical
C-C'	1.0	0.55	1.40	160.23 (0.23m)	Subcritical
100 – Year					
A-A'	5.3	1.29	1.64	222.28 (0.39m)	Subcritical
B-B'	6.9	1.26	4.30	178.21 (0.31m)	Supercritical
C-C'	1.0	0.91	7.73	160.58 (0.58m)	Subcritical

Table 5 - Post-Development 5- and 100-year including pumping of Pond 10 (50L/s) Through Ditch Cross-Sections

	Slope of Ditch (%)	Velocity (m/s)	Flow (m^3/s)	Elevation (depth in m)	Flow Type
5 - Year					
A-A'	5.3	0.88	0.35	222.11 (0.22m)	Subcritical
B-B'	6.9	0.83	0.83	178.07 (0.17m)	Subcritical
C-C'	1.0	0.55	1.45	160.24 (0.24)	Subcritical
100 – Year					
A-A'	5.3	1.30	1.69	222.29 (0.40m)	Subcritical
B-B'	6.9	1.26	4.35	178.21 (0.31m)	Supercritical
C-C'	1.0	0.91	7.78	160.58 (0.58m)	Subcritical

Based on the review of the cross-sections, the increase in flow resulting from the increased drainage area does not appear to result in a significant variance in velocity or depth of runoff. Based on this analysis, it would be expected that the existing watercourse can accommodate the relatively minor change in flows and if the pump is installed in Pond 10 the change from the pumping of runoff does not appear to have a significant effect on the velocity or depth of flow.

5.0 CULVERTS AT VAN LUVEN ROAD AND PRIVATE DRIVEWAY

The culvert at Van Luven Road is the first municipal structure downstream of the solar farm, however, there are a number of other structures and low lying areas downstream which retain runoff (for examples refer to Figures 2 and 4). The Van Luven Road concrete box culvert has an opening of approximately 2.5m x 1.2m with an assumed slope of 0.1%. The size of the culvert as well as upstream and downstream conditions were field verified on June 3rd, 2016 by McIntosh Perry staff.

The culvert was analyzed under both the minor and major storm events in both pre- and post-development conditions, results for which can be found in the table below:

Table 6 - Culvert Analysis (Pre, Post and Post including flow from Pond 10) Assume Invert is 100.02m upstream and 100.00m downstream

	Flow (m^3/s)	Velocity (m/s)	Headwater Elevation (m)	Full %	Overtops Roadway?
5 – Year					
Culvert PRE	1.34	1.75	100.56	44%	No
Culvert POST	1.41	1.78	100.58	46%	No
Culvert POST – Inc. Pond 10 Flow	1.46	1.80	100.59	48%	No
100 - Year					
Culvert PRE	7.75	3.15	101.76	100%	No
Culvert POST	7.81	3.15	101.76	100%	No
Culvert POST – Inc. Pond 10 Flow	7.86	3.16	101.77	100%	No

Based on the analysis of the culvert, the increase in flow rate does not appear to significantly impact the culvert's capacity in the minor and major events. The increase in flow on account of the estimated 50L/s pumped from Pond 10, if installed, does not appear to have a significant increase to the previously noted Post-development velocity or headwater elevation.

Figure 5 - Existing Concrete Culvert at Van Luven Road

A 1.2m diameter CSP culvert, through which the tributary flows, is located under a driveway in the Hutsell road subdivision. See Figure 6. The culvert was reviewed in both the 5- and 100-year storms and the results can be seen below in Table 5.

Table 7 - Culvert Analysis (Pre, Post and Post including flow from Pond 10) Assume Invert is 100.03m upstream and 100.00m downstream

	Flow (m^3/s)	Velocity (m/s)	Headwater Elevation (m)	Full %	Overtops Roadway?
5 – Year					
Culvert PRE	0.83	1.79	100.83	67%	No
Culvert POST	0.89	1.94	100.86	70%	No
Culvert POST – Inc. Pond 10 Flow	0.94	1.97	100.89	72%	No
100 - Year					
Culvert PRE	4.81	2.91	101.70	100%	Yes by 0.17m
Culvert POST	4.92	2.92	101.71	100%	Yes by 0.18m
Culvert POST – Inc. Pond 10 Flow	4.97	2.92	101.71	100%	Yes by 0.18m

Figure 6 – 1.2m Driveway Culvert off of Hutsell Road

Based on the analysis of the driveway culvert, the increase in flow rate does not appear to significantly impact the culvert's capacity in the minor and major events. This remains consistent when one reviews the flows including the additional 50L/s from Pond 10, if the pump is installed. However, it should be noted that the culvert has not been designed such that it would permit the 100-year flow through the culvert without overtopping the driveway.

6.0 IMPACTS TO THE SUBDIVISION (HUTSELL ROAD) AND THE SWM SYSTEM

The Hutsell road is located parallel and in some cases in relatively close horizontal proximity to the drainage ditch of Brook Creek. The change in elevation from the creek to the neighbouring homes is relatively significant as shown in Figure 7, where the ditch is actually located below the pond shown to the rear of the property. Please note in this photo the pond is not in-line with the creek and is a private man-made pond.

Figure 7 - Photo from the Municipal ROW to illustrate the grade differential – There is a pond located in the middle of the image to the left of the house shown.

7.0 INFILTRATION DATA OF AREAS DOWNSTREAM OF THE STIE

As part of our analysis of the downstream area of the solar farm, the MOECC has requested further information regarding the infiltration potential of the downstream watercourse, ponds and low lying areas. A detailed geotechnical report was not completed for this work, however, we have reviewed the Brook Creek Impact Assessment prepared by SNC Lavalin (2014). The report details the area downstream of the site which is comprised of predominately diamicton with concentrated locations of clay, silt along Hutsell Road and sand, gravel in proximity to Van Luven Road. Refer to Figure 3 in the SNC report for an aerial image of surficial geology – primary materials, the farm and surrounding areas. This Figure has been extracted and included within this report for convenience.

Based on the SNC Report, it was noted that *“porous surficial material comprise the recharge areas within the northern part of the watershed. Rainfall and snowmelt percolates through these sediments and replenishes the aquifers that feed the watercourse through groundwater discharge during the summer low flow critical periods”.* For additional information regarding the geological information and impacts to the tributaries, please refer to the Brook Creek Impact Assessment prepared by SNC Lavalin (2014).

8.0 RECOMMENDATIONS

We recommend providing this Appendix to the Ministry of the Environment and Climate Change, local conservation authority and municipality for their review and approval. The analysis of the additional flow behind the house provides an indication that the effect from the increased discharge area to the overall watershed will be diminished by the time it reaches the downstream driveway culvert as well as the crossing culvert at Van Luven Road and from an overall watershed perspective, the impacts appear to be relatively minor in nature. This appears to remain consistent when the additional flow from Pond 10 is pumped as well, should the pump be installed. Prior to constructing the work, we recommend that the approval agencies provide confirmation that this *Post-Construction Stormwater Management* Appendix G in support of the proposed rehabilitation work at the Hamilton – Port Hope 4 Solar Farm is to their satisfaction.

We trust that the preceding information is acceptable for your present purposes. Should you require additional information or have questions about anything contained herein please feel free to contact the undersigned.

Regards,

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j.sharp@mcintoshperry.com

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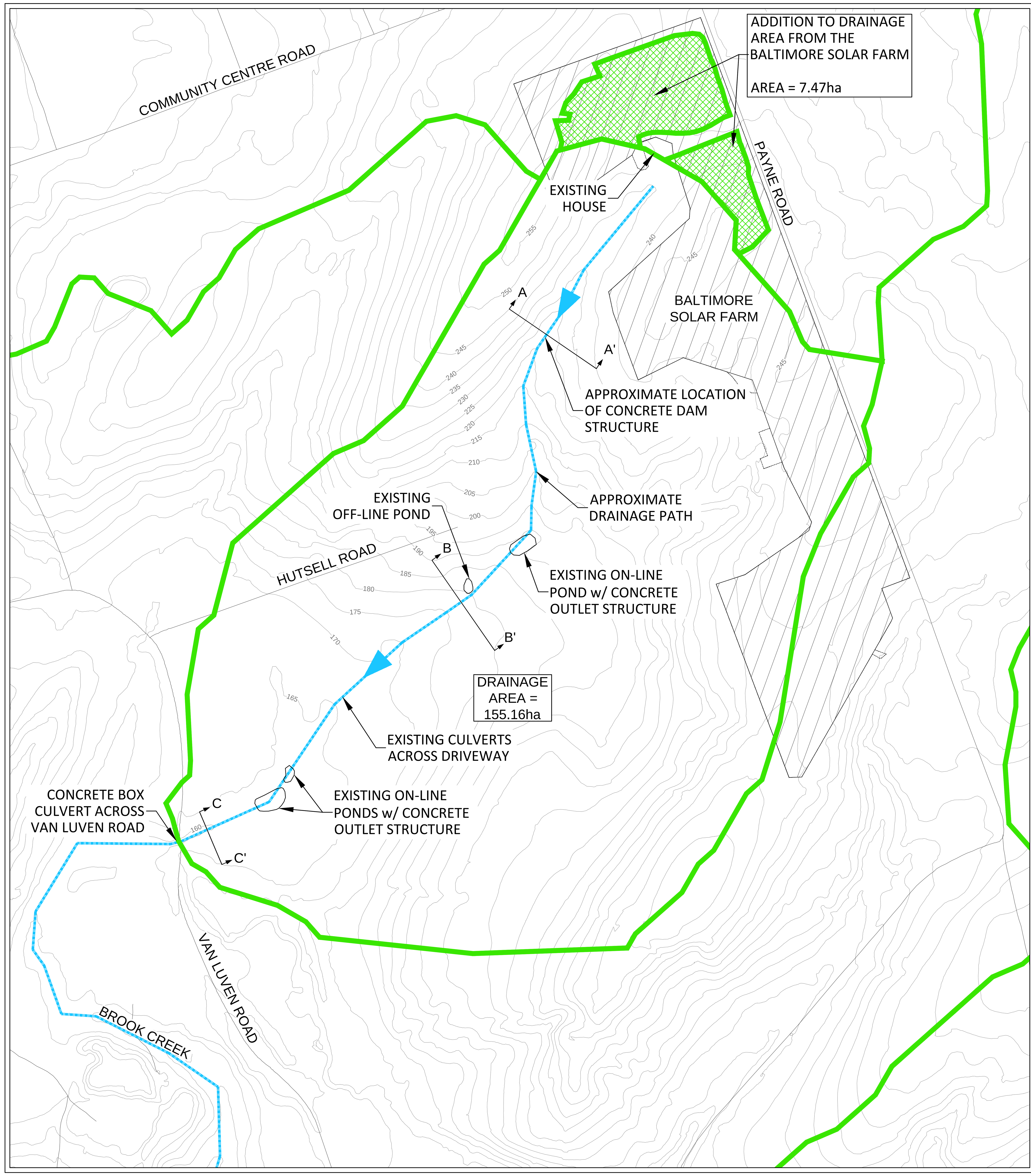

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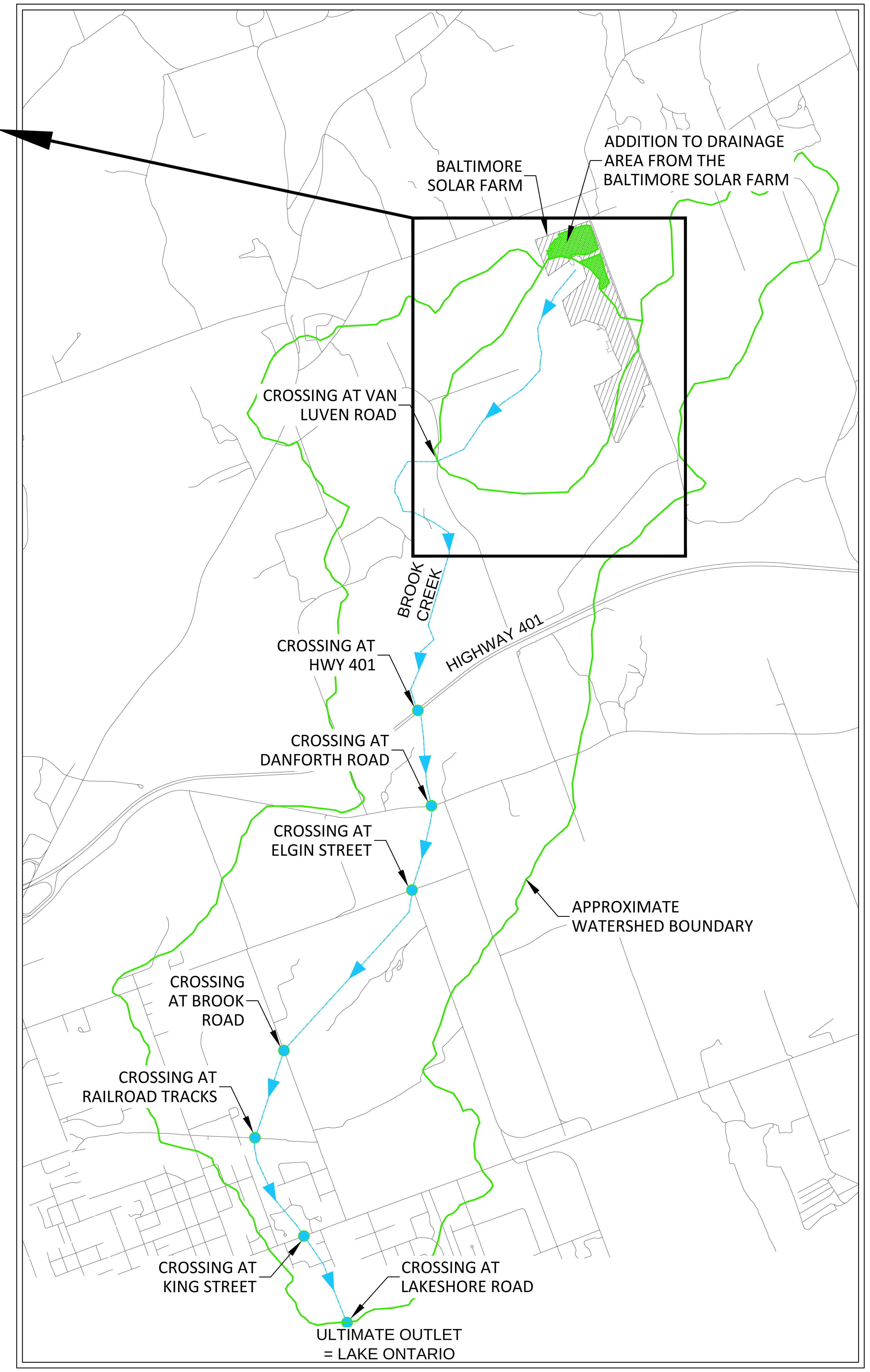

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NOTES:
1. CONTOURS FROM ONTARIO BASE MAPPING BY ESRI CANADA BASED ON ONTARIO MINISTRY OF NATURAL RESOURCES DATA. APPROXIMATE WATERSHEDS FROM ONTARIO MINISTRY OF NATURAL RESOURCES DATA. ALL ROAD CROSSINGS ARE ASSUMED.
2. PLEASE NOTE ADDITIONAL CROSSINGS, INCLUDING FARM CROSSINGS, ARE ASSUMED TO BE PRESENT IN ADDITION TO THE CROSSINGS SHOWN. THE ENTIRE WATERSHED HAS ONLY BEEN REVIEWED AT A VERY HIGH LEVEL.

LEGEND
ASSUMED WATERCOURSE AS PER OBM MAPPING
EXISTING WATERSHED (SEE NOTE 1)
ADDITIONAL AREA DIRECTED TO WATERSHED

No.	Revision/Issue	Date
1	REVISED AS PER COMMENTS	OCT/21/2016
0	ISSUED FOR REVIEW	JUNE/01/2016

Check and verify all dimensions before proceeding with the work
Do not scale drawings

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1-1329 Gardiners Road, Kingston, ON K7P 0L8
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Stamp:
FOR REVIEW ONLY
NOT FOR CONSTRUCTION

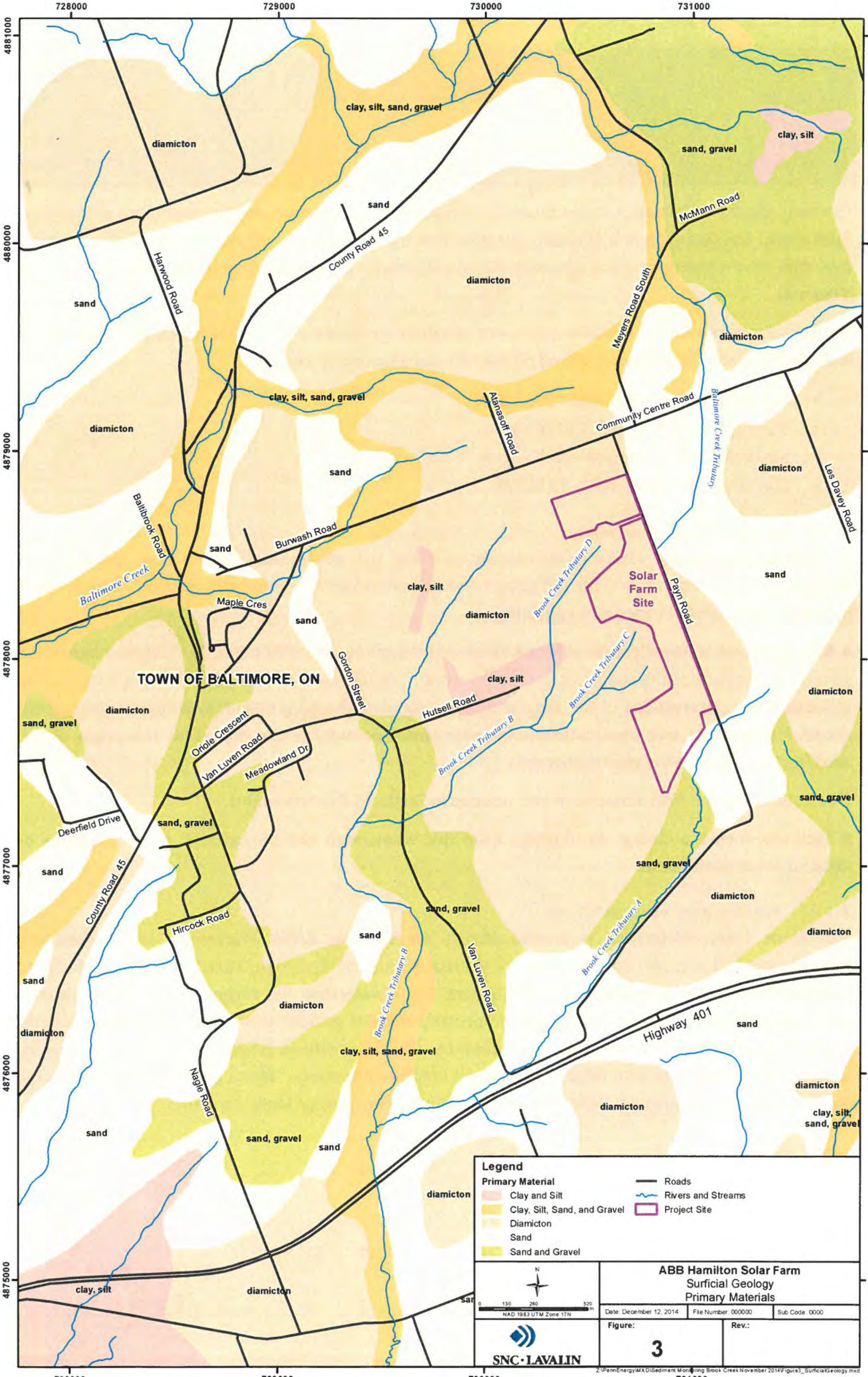
Client:
CANADIAN SOLAR SOLUTIONS INC.
545 SPEEDVALE AVE. WEST GUELPH, ON N1K1E6

Project:
HAMILTON - PORT HOPE 4 SOLAR FARM
BALTIMORE ONTARIO

Drawing Title:
DRAINAGE PLAN

Scale: AS SHOWN
Drawn by: D. LONGMUIR
Checked By: J. SHARP
Designed By:
Date: MAY/17/2016
Project Number: PP-14-9580
Drawing Number: DRAIN
SHEET 1 of 1

FILENAME: M:\02-Documents\2014\0PP-14-9580 - Canadian Solar Baltimore Solar\Drawings\PP-14-9580 Baltimore Solar May 31 2016 Watershed.dwg
LAST SAVED: Wednesday, June 22, 2016 LAST SAVED BY: d.longmuir
LAST PLOTTED: Thursday, October 20, 2016 CTB FILE USED: ----



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TOWN OF BALTIMORE, ON
Solar Farm Site
County Road 45
Harwood Road
McMann Road
Meyers Road South
Community Centre Road
Atanasoff Road
Burwash Road
Baltibrook Road
Baltimore Creek
Baltimore Creek Tributary
Les Davey Road
Payn Road
Maple Cres
Gordon Street
Hutsell Road
Oriole Crescent
Van Luven Road
Meadowland Dr
Deerfield Drive
Hircock Road
Nagle Road
Highway 401
Brook Creek Tributary A
Brook Creek Tributary B
Brook Creek Tributary C
Brook Creek Tributary D
clay, silt, sand, gravel
diamicton
sand
clay, silt
sand, gravel
Legend
Primary Material
Clay and Silt
Clay, Silt, Sand, and Gravel
Diamicton
Sand
Sand and Gravel
Roads
Rivers and Streams
Project Site
N
0 130 260 520 m
NAD 1983 UTM Zone 17N
SNC·LAVALIN
ABB Hamilton Solar Farm
Surficial Geology
Primary Materials
Date: December 12, 2014
File Number: 000000
Sub Code: 0000
Figure:
3
Rev.:
Z:\PennEnergy\MXD\Sediment Monitoring Brook Creek November 2014\Figure3_SurficialGeology.mxd

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT
DRAINAGE AREA INFORMATION TO VAN LUVEN ROAD

Land Use Breakdown

Catchment ID	Area (m^2)	Impervious (m^2)	Wooded (m^2)	Pasture (m^2)	Crop (m^2)	Wetland (m^2)	CN
A1 - To Van Luven Rd	1,551,600	21,550	704,940	809,132	10,428	5,550	62.5
Total	**1,551,600**	**21,550**	**704,940**	**809,132**	**10,428**	**5,550**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
A1	188	4.64	790	5.7	1.09	49
			980	3.1	0.81	

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
A1	155.2	62.5	49
Total	**155.2**		

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
PRE AND POST-DEVELOPMENT HYDROLOGICAL RESULTS

12-Hr - Pre-Development

	5-Year	100-Year
	(L/s)	
Area A1	715	5,410
Total	715	5,410

24-Hr - Pre-Development

	5-Year	100-Year
	(L/s)	
Area A1	1,342	7,756
Total	1,342	7,756

12-Hr - Post-Development

	5-Year	100-Year
	(L/s)	
Area A1	767	5,502
Total	767	5,502

24-Hr - Post-Development

	5-Year	100-Year
	(L/s)	
Area A1	1,413	7,808
Total	1,413	7,808

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT DRAINAGE AREA INFORMATION TO VAN LUVEN ROAD

Land Use Breakdown

Catchment ID	Area (m^2)	Impervious (m^2)	Wooded (m^2)	Pasture (m^2)	Wetland (m^2)	Solar Farm (Composite) (m^2)	CN
B1 - To Van Luven Rd	1,587,102	21,550	704,940	795,076	4,500	61,036	62.9
Total	**1,587,102**	**21,550**	**704,940**	**795,076**	**4,500**	**61,036**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope of Land (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
B1	155	7.0	97	1.3	1.48	52
	93	6.7	790	5.7	1.09	
			980	3.1	0.81	

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
B1	158.7	62.9	52
	158.7		

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - FLOW THROUGH HAMBLY PROPERTY

24-Hr - Post-Development

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(L/s)					
Hambly's Property	428	904	1,298	1,937	2,339	2,848

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
	(m/s)					
Unvegetated Velocity	1.08	1.31	1.43	1.58	1.65	1.74
Revegetated Velocity	0.80	0.96	1.05	1.16	1.22	1.28

Culvert Designer/Analyzer Report
Driveway - Pre

Analysis Component			
Storm Event	Design	Discharge	0.8300 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.8300 m³/s	Check Discharge	4.8100 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	100.51 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	0.8300 m³/s	100.83 m	1.79 m/s
Weir	Roadway (Constant Elevation)	0.0000 m³/s	100.83 m	N/A
Total	----------------	0.8300 m³/s	100.83 m	N/A

Culvert Designer/Analyzer Report
Driveway - Pre

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	100.83	m	Discharge	0.8300	m³/s
Inlet Control HW Elev.	100.75	m	Tailwater Elevation	100.51	m
Outlet Control HW Elev.	100.83	m	Control Type	Outlet Control	
Headwater Depth/Height	0.66				

Grades					
Upstream Invert	100.03	m	Downstream Invert	100.00	m
Length	6.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.51	m
Slope Type	Mild		Normal Depth	0.63	m
Flow Regime	Subcritical		Critical Depth	0.49	m
Velocity Downstream	1.79	m/s	Critical Slope	1.2358	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.83	m	Upstream Velocity Head	0.12	m
Ke	0.90		Entrance Loss	0.11	m

Inlet Control Properties					
Inlet Control HW Elev.	100.75	m	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	1.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Driveway - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.0000	m³/s	Allowable HW Elevation	100.83	m
Roadway Width	4.50	m	Overtopping Coefficient	1.38	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	N/A	m	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Driveway - Pre

Analysis Component			
Storm Event	Check	Discharge	4.8100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.8300 m³/s	Check Discharge	4.8100 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	100.51 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	2.6989 m³/s	101.70 m	2.91 m/s
Weir	Roadway (Constant Elevation)	2.1135 m³/s	101.70 m	N/A
Total	----------------	4.8124 m³/s	101.70 m	N/A

Culvert Designer/Analyzer Report
Driveway - Pre

Component:Culvert-1

Culvert Summary			
Computed Headwater Elev	101.70 m	Discharge	2.6989 m^3/s
Inlet Control HW Elev.	101.68 m	Tailwater Elevation	100.51 m
Outlet Control HW Elev.	101.70 m	Control Type	Outlet Control
Headwater Depth/Height	1.37		

Grades			
Upstream Invert	100.03 m	Downstream Invert	100.00 m
Length	6.00 m	Constructed Slope	0.5000 %

Hydraulic Profile			
Profile	M2	Depth, Downstream	0.90 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.90 m
Velocity Downstream	2.91 m/s	Critical Slope	1.8631 %

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	1.22 m
Section Size	1200 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	101.70 m	Upstream Velocity Head	0.31 m
Ke	0.90	Entrance Loss	0.28 m

Inlet Control Properties			
Inlet Control HW Elev.	101.68 m	Flow Control	Transition
Inlet Type	Projecting	Area Full	1.2 m^2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Driveway - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	2.1135	m^3/s	Allowable HW Elevation	101.70	m
Roadway Width	4.50	m	Overtopping Coefficient	1.50	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	101.70	m	Discharge Coefficient (Cr)	2.71	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Driveway - Post

Analysis Component			
Storm Event	Design	Discharge	0.8900 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.8900 m³/s	Check Discharge	4.9200 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	0.8900 m³/s	100.86 m	1.94 m/s
Weir	Roadway (Constant Elevation)	0.0000 m³/s	100.86 m	N/A
Total	----------------	0.8900 m³/s	100.86 m	N/A

Culvert Designer/Analyzer Report
Driveway - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Ele\	100.86	m	Discharge	0.8900	m^3/s
Inlet Control HW Elev.	100.78	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	100.86	m	Control Type	Outlet Control	
Headwater Depth/Height	0.68				

Grades					
Upstream Invert	100.03	m	Downstream Invert	100.00	m
Length	6.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.51	m
Slope Type	Mild		Normal Depth	0.66	m
Flow Regime	Subcritical		Critical Depth	0.51	m
Velocity Downstream	1.94	m/s	Critical Slope	1.2449	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.86	m	Upstream Velocity Head	0.13	m
Ke	0.90		Entrance Loss	0.11	m

Inlet Control Properties					
Inlet Control HW Elev.	100.78	m	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	1.2	m^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Driveway - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.0000	m^3/s	Allowable HW Elevation	100.86	m
Roadway Width	4.50	m	Overtopping Coefficient	1.38	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	N/A	m	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Driveway - Post

Analysis Component			
Storm Event	Check	Discharge	4.9200 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.8900 m³/s	Check Discharge	4.9200 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	2.7096 m³/s	101.71 m	2.92 m/s
Weir	Roadway (Constant Elevation)	2.2130 m³/s	101.71 m	N/A
Total	----------------	4.9226 m³/s	101.71 m	N/A

Culvert Designer/Analyzer Report
Driveway - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	101.71	m	Discharge	2.7096	m³/s
Inlet Control HW Elev.	101.69	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	101.71	m	Control Type	Outlet Control	
Headwater Depth/Height	1.37				

Grades					
Upstream Invert	100.03	m	Downstream Invert	100.00	m
Length	6.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.90	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.90	m
Velocity Downstream	2.92	m/s	Critical Slope	1.8692	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	101.71	m	Upstream Velocity Head	0.31	m
Ke	0.90		Entrance Loss	0.28	m

Inlet Control Properties					
Inlet Control HW Elev.	101.69	m	Flow Control	Transition	
Inlet Type	Projecting		Area Full	1.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Driveway - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	2.2130	m^3/s	Allowable HW Elevation	101.71	m
Roadway Width	4.50	m	Overtopping Coefficient	1.50	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	101.71	m	Discharge Coefficient (Cr)	2.72	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Van Luven - Pre

Analysis Component			
Storm Event	Design	Discharge	1.3400 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.3400 m³/s	Check Discharge	7.7500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.			
Discharge	1.3400 m³/s	Bottom Elevation	100.00 m
Depth	0.22 m	Velocity	2.36 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	1.3400 m³/s	100.56 m	1.75 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Pre

Component:Culvert-1

Culvert Summary					
Computed Headwater Elevation	100.56	m	Discharge	1.3400	m^3/s
Inlet Control HW Elev.	100.53	m	Tailwater Elevation	100.22	m
Outlet Control HW Elev.	100.56	m	Control Type	Outlet Control	
Headwater Depth/Height	0.44				

Grades					
Upstream Invert	100.02	m	Downstream Invert	100.00	m
Length	20.00	m	Constructed Slope	0.1000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.31	m
Slope Type	Mild		Normal Depth	0.47	m
Flow Regime	Subcritical		Critical Depth	0.31	m
Velocity Downstream	1.75	m/s	Critical Slope	0.3310	%

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.56	m	Upstream Velocity Head	0.10	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	100.53	m	Flow Control	N/A	
Inlet Type	45° wingwall flare, d=0.0430		Area Full	3.0	m^2
K	0.51000		HDS 5 Chart	9	
M	0.66700		HDS 5 Scale	1	
C	0.03090		Equation Form	2	
Y	0.80000				

Culvert Designer/Analyzer Report
Van Luven - Pre

Analysis Component			
Storm Event	Check	Discharge	7.7500 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.3400 m³/s	Check Discharge	7.7500 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	7.7500 m³/s	Bottom Elevation	100.00 m
Depth	0.54 m	Velocity	3.92 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	7.7500 m³/s	101.75 m	3.15 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Pre

Component:Culvert-1

Culvert Summary					
Computed Headwater Elevation	101.75	m	Discharge	7.7500	m^3/s
Inlet Control HW Elev.	101.68	m	Tailwater Elevation	100.54	m
Outlet Control HW Elev.	101.75	m	Control Type	Outlet Control	
Headwater Depth/Height	1.42				

Grades					
Upstream Invert	100.02	m	Downstream Invert	100.00	m
Length	20.00	m	Constructed Slope	0.1000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.01	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.01	m
Velocity Downstream	3.15	m/s	Critical Slope	0.3693	%

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	101.75	m	Upstream Velocity Head	0.37	m
Ke	0.50		Entrance Loss	0.18	m

Inlet Control Properties					
Inlet Control HW Elev.	101.68	m	Flow Control	Submerged	
Inlet Type	45° wingwall flare, d=0.0430		Area Full	3.0	m^2
K	0.51000		HDS 5 Chart	9	
M	0.66700		HDS 5 Scale	1	
C	0.03090		Equation Form	2	
Y	0.80000				

Culvert Designer/Analyzer Report
Van Luven - Post

Analysis Component			
Storm Event	Design	Discharge	1.4100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.4100 m³/s	Check Discharge	7.8100 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.			
Discharge	1.4100 m³/s	Bottom Elevation	100.00 m
Depth	0.22 m	Velocity	2.39 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	1.4100 m³/s	100.58 m	1.78 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Elevation	100.58	m	Discharge	1.4100	m^3/s
Inlet Control HW Elev.	100.55	m	Tailwater Elevation	100.22	m
Outlet Control HW Elev.	100.58	m	Control Type	Outlet Control	
Headwater Depth/Height	0.46				

Grades					
Upstream Invert	100.02	m	Downstream Invert	100.00	m
Length	20.00	m	Constructed Slope	0.1000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.32	m
Slope Type	Mild		Normal Depth	0.48	m
Flow Regime	Subcritical		Critical Depth	0.32	m
Velocity Downstream	1.78	m/s	Critical Slope	0.3304	%

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.58	m	Upstream Velocity Head	0.10	m
Ke	0.50		Entrance Loss	0.05	m

Inlet Control Properties					
Inlet Control HW Elev.	100.55	m	Flow Control	Unsubmerged	
Inlet Type	45° wingwall flare, d=0.0430		Area Full	3.0	m^2
K	0.51000		HDS 5 Chart	9	
M	0.66700		HDS 5 Scale	1	
C	0.03090		Equation Form	2	
Y	0.80000				

Culvert Designer/Analyzer Report
Van Luven - Post

Analysis Component			
Storm Event	Check	Discharge	7.8100 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	1.4100 m^3/s	Check Discharge	7.8100 m^3/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	7.8100 m^3/s	Bottom Elevation	100.00 m
Depth	0.55 m	Velocity	3.93 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	7.8100 m^3/s	101.76 m	3.16 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Elevation	101.76	m	Discharge	7.8100	m^3/s
Inlet Control HW Elev.	101.69	m	Tailwater Elevation	100.55	m
Outlet Control HW Elev.	101.76	m	Control Type	Outlet Control	
Headwater Depth/Height	1.43				

Grades					
Upstream Invert	100.02	m	Downstream Invert	100.00	m
Length	20.00	m	Constructed Slope	0.1000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.02	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.02	m
Velocity Downstream	3.16	m/s	Critical Slope	0.3698	%

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	101.76	m	Upstream Velocity Head	0.37	m
Ke	0.50		Entrance Loss	0.19	m

Inlet Control Properties					
Inlet Control HW Elev.	101.69	m	Flow Control	N/A	
Inlet Type	45° wingwall flare, d=0.0430		Area Full	3.0	m^2
K	0.51000		HDS 5 Chart	9	
M	0.66700		HDS 5 Scale	1	
C	0.03090		Equation Form	2	
Y	0.80000				

Culvert Designer/Analyzer Report
Driveway - Post w P10

Analysis Component			
Storm Event	Design	Discharge	0.9400 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.9400 m³/s	Check Discharge	4.9700 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	0.9400 m³/s	100.89 m	1.97 m/s
Weir	Roadway (Constant Elevation)	0.0000 m³/s	100.89 m	N/A
Total	----------------	0.9400 m³/s	100.89 m	N/A

Culvert Designer/Analyzer Report
Driveway - Post w P10

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	100.89	m	Discharge	0.9400	m^3/s
Inlet Control HW Elev.	100.81	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	100.89	m	Control Type	Outlet Control	
Headwater Depth/Height	0.71				

Grades					
Upstream Invert	100.03	m	Downstream Invert	100.00	m
Length	6.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.52	m
Slope Type	Mild		Normal Depth	0.68	m
Flow Regime	Subcritical		Critical Depth	0.52	m
Velocity Downstream	1.97	m/s	Critical Slope	1.2531	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	100.89	m	Upstream Velocity Head	0.13	m
Ke	0.90		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	100.81	m	Flow Control	N/A	
Inlet Type	Projecting		Area Full	1.2	m^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Driveway - Post w P10

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.0000	m^3/s	Allowable HW Elevation	100.89	m
Roadway Width	4.50	m	Overtopping Coefficient	1.38	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	N/A	m	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Driveway - Post w P10

Analysis Component			
Storm Event	Check	Discharge	4.9700 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.9400 m³/s	Check Discharge	4.9700 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-1200 mm Circular	2.7144 m³/s	101.71 m	2.92 m/s
Weir	Roadway (Constant Elevation)	2.2582 m³/s	101.71 m	N/A
Total	----------------	4.9726 m³/s	101.71 m	N/A

Culvert Designer/Analyzer Report
Driveway - Post w P10

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	101.71	m	Discharge	2.7144	m^3/s
Inlet Control HW Elev.	101.69	m	Tailwater Elevation	N/A	m
Outlet Control HW Elev.	101.71	m	Control Type	Outlet Control	
Headwater Depth/Height	1.38				

Grades					
Upstream Invert	100.03	m	Downstream Invert	100.00	m
Length	6.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.90	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.90	m
Velocity Downstream	2.92	m/s	Critical Slope	1.8719	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	1.22	m
Section Size	1200 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	101.71	m	Upstream Velocity Head	0.31	m
Ke	0.90		Entrance Loss	0.28	m

Inlet Control Properties					
Inlet Control HW Elev.	101.69	m	Flow Control	Transition	
Inlet Type	Projecting		Area Full	1.2	m^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Driveway - Post w P10

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	2.2582	m^3/s	Allowable HW Elevation	101.71	m
Roadway Width	4.50	m	Overtopping Coefficient	1.50	SI
Length	20.00	m	Crest Elevation	101.53	m
Headwater Elevation	101.71	m	Discharge Coefficient (Cr)	2.72	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	101.53
20.00	101.53

Culvert Designer/Analyzer Report
Van Luven - Post w P10

Analysis Component			
Storm Event	Design	Discharge	1.4600 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.4600 m³/s	Check Discharge	7.8600 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Design Storm.			
Discharge	1.4600 m³/s	Bottom Elevation	100.00 m
Depth	0.23 m	Velocity	2.42 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	1.4600 m³/s	100.59 m	1.80 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Post w P10

Component:Culvert-1

Culvert Summary

Computed Headwater Elev	100.59 m	Discharge	1.4600 m³/s
Inlet Control HW Elev.	100.56 m	Tailwater Elevation	100.23 m
Outlet Control HW Elev.	100.59 m	Control Type	Outlet Control
Headwater Depth/Height	0.47		

Grades

Upstream Invert	100.02 m	Downstream Invert	100.00 m
Length	20.00 m	Constructed Slope	0.1000 %

Hydraulic Profile

Profile	M2	Depth, Downstream	0.33 m
Slope Type	Mild	Normal Depth	0.49 m
Flow Regime	Subcritical	Critical Depth	0.33 m
Velocity Downstream	1.80 m/s	Critical Slope	0.3300 %

Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	2.44 m
Section Size	2440 x 1220 mm	Rise	1.22 m
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	100.59 m	Upstream Velocity Head	0.11 m
Ke	0.50	Entrance Loss	0.05 m

Inlet Control Properties

Inlet Control HW Elev.	100.56 m	Flow Control	N/A
Inlet Type	45° wingwall flare, d=0.0430	Area Full	3.0 m²
K	0.51000	HDS 5 Chart	9
M	0.66700	HDS 5 Scale	1
C	0.03090	Equation Form	2
Y	0.80000		

Culvert Designer/Analyzer Report
Van Luven - Post w P10

Analysis Component			
Storm Event	Check	Discharge	7.8600 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.4600 m³/s	Check Discharge	7.8600 m³/s

Tailwater properties: Trapezoidal Channel

Tailwater conditions for Check Storm.			
Discharge	7.8600 m³/s	Bottom Elevation	100.00 m
Depth	0.55 m	Velocity	3.93 m/s

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-2440 x 1220 mm Box	7.8600 m³/s	101.77 m	3.16 m/s
Weir	Not Considered	N/A	N/A	N/A

Culvert Designer/Analyzer Report
Van Luven - Post w P10

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	101.77	m	Discharge	7.8600	m^3/s
Inlet Control HW Elev.	101.70	m	Tailwater Elevation	100.55	m
Outlet Control HW Elev.	101.77	m	Control Type	Outlet Control	
Headwater Depth/Height	1.44				

Grades					
Upstream Invert	100.02	m	Downstream Invert	100.00	m
Length	20.00	m	Constructed Slope	0.1000	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.02	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	1.02	m
Velocity Downstream	3.16	m/s	Critical Slope	0.3703	%

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.44	m
Section Size	2440 x 1220 mm		Rise	1.22	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	101.77	m	Upstream Velocity Head	0.37	m
Ke	0.50		Entrance Loss	0.19	m

Inlet Control Properties					
Inlet Control HW Elev.	101.70	m	Flow Control	Submerged	
Inlet Type	45° wingwall flare, d=0.0430		Area Full	3.0	m^2
K	0.51000		HDS 5 Chart	9	
M	0.66700		HDS 5 Scale	1	
C	0.03090		Equation Form	2	
Y	0.80000				

Worksheet for Cross-Section A-A' - PRE - 5-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	0.26	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.20	m
Elevation Range	221.89 to 245.00 m	
Flow Area	0.32	m^2
Wetted Perimeter	3.26	m

Worksheet for Cross-Section A-A' - PRE - 5-yr

Results

Hydraulic Radius		0.10	m
Top Width		3.24	m
Normal Depth		0.20	m
Critical Depth		0.18	m
Critical Slope		0.07919	m/m
Velocity		0.81	m/s
Velocity Head		0.03	m
Specific Energy		0.23	m
Froude Number		0.83	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.20	m
Critical Depth	0.18	m
Channel Slope	5.30000	%
Critical Slope	0.07919	m/m

Worksheet for Cross-Section B-B' - PRE - 5-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	0.73	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.16	m
Elevation Range	177.90 to 190.00 m	
Flow Area	0.90	m^2
Wetted Perimeter	11.38	m
Hydraulic Radius	0.08	m
Top Width	11.37	m
Normal Depth	0.16	m
Critical Depth	0.15	m

Worksheet for Cross-Section B-B' - PRE - 5-yr

Results

Critical Slope		0.08317	m/m
Velocity		0.81	m/s
Velocity Head		0.03	m
Specific Energy		0.19	m
Froude Number		0.92	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.16	m
Critical Depth	0.15	m
Channel Slope	6.90000	%
Critical Slope	0.08317	m/m

Worksheet for Cross-Section C-C' - PRE - 5-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	1.32	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.22	m
Elevation Range	160.00 to 165.00 m	
Flow Area	2.45	m^2
Wetted Perimeter	13.40	m
Hydraulic Radius	0.18	m
Top Width	13.37	m
Normal Depth	0.22	m
Critical Depth	0.13	m
Critical Slope	0.07339	m/m

Worksheet for Cross-Section C-C' - PRE - 5-yr

Results

Velocity		0.54	m/s
Velocity Head		0.01	m
Specific Energy		0.24	m
Froude Number		0.40	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth		0.00	m
Length		0.00	m
Number Of Steps		0	

GVF Output Data

Upstream Depth		0.00	m
Profile Description			
Profile Headloss		0.00	m
Downstream Velocity		Infinity	m/s
Upstream Velocity		Infinity	m/s
Normal Depth		0.22	m
Critical Depth		0.13	m
Channel Slope		1.00000	%
Critical Slope		0.07339	m/m

Worksheet for Cross-Section A-A' - PRE - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	1.50	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.38	m
Elevation Range	221.89 to 245.00 m	
Flow Area	1.19	m²
Wetted Perimeter	6.30	m

Worksheet for Cross-Section A-A' - PRE - 100-yr

Results

Hydraulic Radius		0.19	m
Top Width		6.25	m
Normal Depth		0.38	m
Critical Depth		0.37	m
Critical Slope		0.06268	m/m
Velocity		1.26	m/s
Velocity Head		0.08	m
Specific Energy		0.46	m
Froude Number		0.92	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.38	m
Critical Depth	0.37	m
Channel Slope	5.30000	%
Critical Slope	0.06268	m/m

Worksheet for Cross-Section B-B' - PRE - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	4.20	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.31	m
Elevation Range	177.90 to 190.00 m	
Flow Area	3.35	m^2
Wetted Perimeter	21.93	m
Hydraulic Radius	0.15	m
Top Width	21.92	m
Normal Depth	0.31	m
Critical Depth	0.31	m

Worksheet for Cross-Section B-B' - PRE - 100-yr

Results

Critical Slope		0.06586	m/m
Velocity		1.25	m/s
Velocity Head		0.08	m
Specific Energy		0.39	m
Froude Number		1.02	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.31	m
Critical Depth	0.31	m
Channel Slope	6.90000	%
Critical Slope	0.06586	m/m

Worksheet for Cross-Section C-C' - PRE - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	7.64	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.57	m
Elevation Range	160.00 to 165.00 m	
Flow Area	8.42	m²
Wetted Perimeter	21.00	m
Hydraulic Radius	0.40	m
Top Width	20.93	m
Normal Depth	0.57	m
Critical Depth	0.37	m
Critical Slope	0.05418	m/m

Worksheet for Cross-Section C-C' - PRE - 100-yr

Results

Velocity		0.91	m/s
Velocity Head		0.04	m
Specific Energy		0.61	m
Froude Number		0.46	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.57	m
Critical Depth	0.37	m
Channel Slope	1.00000	%
Critical Slope	0.05418	m/m

Worksheet for Cross-Section A-A' - 5-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	0.30	m³/s
Section Definitions		

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.21	m
Elevation Range	221.89 to 245.00 m	
Flow Area	0.36	m²
Wetted Perimeter	3.44	m

Worksheet for Cross-Section A-A' - 5-yr

Results

Hydraulic Radius	0.10	m
Top Width	3.42	m
Normal Depth	0.21	m
Critical Depth	0.19	m
Critical Slope	0.07769	m/m
Velocity	0.84	m/s
Velocity Head	0.04	m
Specific Energy	0.24	m
Froude Number	0.84	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.21	m
Critical Depth	0.19	m
Channel Slope	5.30000	%
Critical Slope	0.07769	m/m

Worksheet for Cross-Section B-B' - 5-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	0.78	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.16	m
Elevation Range	177.90 to 190.00 m	
Flow Area	0.95	m^2
Wetted Perimeter	11.67	m
Hydraulic Radius	0.08	m
Top Width	11.66	m
Normal Depth	0.16	m
Critical Depth	0.16	m

Worksheet for Cross-Section B-B' - 5-yr

Results

Critical Slope		0.08244	m/m
Velocity		0.82	m/s
Velocity Head		0.03	m
Specific Energy		0.20	m
Froude Number		0.92	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.16	m
Critical Depth	0.16	m
Channel Slope	6.90000	%
Critical Slope	0.08244	m/m

Worksheet for Cross-Section C-C' - 5yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	1.40	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.23	m
Elevation Range	160.00 to 165.00 m	
Flow Area	2.56	m^2
Wetted Perimeter	13.56	m
Hydraulic Radius	0.19	m
Top Width	13.54	m
Normal Depth	0.23	m
Critical Depth	0.13	m
Critical Slope	0.07259	m/m

Worksheet for Cross-Section C-C' - 5yr

Results

Velocity		0.55	m/s
Velocity Head		0.02	m
Specific Energy		0.25	m
Froude Number		0.40	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.23	m
Critical Depth	0.13	m
Channel Slope	1.00000	%
Critical Slope	0.07259	m/m

Worksheet for Cross-Section A-A' - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	1.64	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.39	m
Elevation Range	221.89 to 245.00 m	
Flow Area	1.27	m^2
Wetted Perimeter	6.51	m

Worksheet for Cross-Section A-A' - 100-yr

Results

Hydraulic Radius		0.20	m
Top Width		6.46	m
Normal Depth		0.39	m
Critical Depth		0.38	m
Critical Slope		0.06195	m/m
Velocity		1.29	m/s
Velocity Head		0.08	m
Specific Energy		0.48	m
Froude Number		0.93	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.39	m
Critical Depth	0.38	m
Channel Slope	5.30000	%
Critical Slope	0.06195	m/m

Worksheet for Cross-Section B-B' - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	4.30	m³/s

Section Definitions

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.31	m
Elevation Range	177.90 to 190.00 m	
Flow Area	3.41	m²
Wetted Perimeter	22.13	m
Hydraulic Radius	0.15	m
Top Width	22.12	m
Normal Depth	0.31	m
Critical Depth	0.31	m

Worksheet for Cross-Section B-B' - 100-yr

Results

Critical Slope		0.06566	m/m
Velocity		1.26	m/s
Velocity Head		0.08	m
Specific Energy		0.39	m
Froude Number		1.02	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.31	m
Critical Depth	0.31	m
Channel Slope	6.90000	%
Critical Slope	0.06566	m/m

Worksheet for Cross-Section C-C' - 100-yr

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	7.73	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.58	m
Elevation Range	160.00 to 165.00 m	
Flow Area	8.50	m^2
Wetted Perimeter	21.07	m
Hydraulic Radius	0.40	m
Top Width	21.01	m
Normal Depth	0.58	m
Critical Depth	0.37	m
Critical Slope	0.05408	m/m

Worksheet for Cross-Section C-C' - 100-yr

Results

Velocity		0.91	m/s
Velocity Head		0.04	m
Specific Energy		0.62	m
Froude Number		0.46	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.58	m
Critical Depth	0.37	m
Channel Slope	1.00000	%
Critical Slope	0.05408	m/m

Worksheet for Cross-Section A-A' - 5-yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	0.35	m^3/s

Section Definitions

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.22	m
Elevation Range	221.89 to 245.00 m	
Flow Area	0.40	m^2
Wetted Perimeter	3.65	m

Worksheet for Cross-Section A-A' - 5-yr - Pond 10

Results

Hydraulic Radius	0.11	m
Top Width	3.62	m
Normal Depth	0.22	m
Critical Depth	0.21	m
Critical Slope	0.07611	m/m
Velocity	0.88	m/s
Velocity Head	0.04	m
Specific Energy	0.26	m
Froude Number	0.84	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.22	m
Critical Depth	0.21	m
Channel Slope	5.30000	%
Critical Slope	0.07611	m/m

Worksheet for Cross-Section B-B' - 5-yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	0.83	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.17	m
Elevation Range	177.90 to 190.00 m	
Flow Area	0.99	m^2
Wetted Perimeter	11.94	m
Hydraulic Radius	0.08	m
Top Width	11.93	m
Normal Depth	0.17	m
Critical Depth	0.16	m

Worksheet for Cross-Section B-B' - 5-yr - Pond 10

Results

Critical Slope		0.08175	m/m
Velocity		0.83	m/s
Velocity Head		0.04	m
Specific Energy		0.20	m
Froude Number		0.92	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.17	m
Critical Depth	0.16	m
Channel Slope	6.90000	%
Critical Slope	0.08175	m/m

Worksheet for Cross-Section C-C' - 5yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	1.45	m^3/s

Section Definitions

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.24	m
Elevation Range	160.00 to 165.00 m	
Flow Area	2.62	m^2
Wetted Perimeter	13.66	m
Hydraulic Radius	0.19	m
Top Width	13.64	m
Normal Depth	0.24	m
Critical Depth	0.14	m
Critical Slope	0.07214	m/m

Worksheet for Cross-Section C-C' - 5yr - Pond 10

Results

Velocity		0.55	m/s
Velocity Head		0.02	m
Specific Energy		0.25	m
Froude Number		0.40	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.24	m
Critical Depth	0.14	m
Channel Slope	1.00000	%
Critical Slope	0.07214	m/m

Worksheet for Cross-Section A-A' - 100-yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	5.30000	%
Discharge	1.69	m³/s
Section Definitions		

Station (m)	Elevation (m)
0+00	245.00
0+22	240.00
0+41	235.00
0+57	230.00
0+73	225.00
0+93	221.89
1+24	225.00
1+67	230.00
2+16	235.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 245.00)	(2+16, 235.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.40	m
Elevation Range	221.89 to 245.00 m	
Flow Area	1.30	m²
Wetted Perimeter	6.59	m

Worksheet for Cross-Section A-A' - 100-yr - Pond 10

Results

Hydraulic Radius		0.20	m
Top Width		6.53	m
Normal Depth		0.40	m
Critical Depth		0.39	m
Critical Slope		0.06170	m/m
Velocity		1.30	m/s
Velocity Head		0.09	m
Specific Energy		0.48	m
Froude Number		0.93	
Flow Type	Subcritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.40	m
Critical Depth	0.39	m
Channel Slope	5.30000	%
Critical Slope	0.06170	m/m

Worksheet for Cross-Section B-B' - 100-yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	6.90000	%
Discharge	4.35	m³/s
Section Definitions		

Station (m)	Elevation (m)
0+00	190.00
0+39	185.00
0+75	180.00
1+04	177.90
2+25	180.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 190.00)	(2+25, 180.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.31	m
Elevation Range	177.90 to 190.00 m	
Flow Area	3.44	m²
Wetted Perimeter	22.23	m
Hydraulic Radius	0.15	m
Top Width	22.21	m
Normal Depth	0.31	m
Critical Depth	0.31	m

Worksheet for Cross-Section B-B' - 100-yr - Pond 10

Results

Critical Slope		0.06556	m/m
Velocity		1.26	m/s
Velocity Head		0.08	m
Specific Energy		0.39	m
Froude Number		1.02	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.31	m
Critical Depth	0.31	m
Channel Slope	6.90000	%
Critical Slope	0.06556	m/m

Worksheet for Cross-Section C-C' - 100-yr - Pond 10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	1.00000	%
Discharge	7.78	m^3/s
Section Definitions		

Station (m)	Elevation (m)
0+00	165.00
0+31	160.00
0+40	160.00
1+17	165.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 165.00)	(1+17, 165.00)	0.060

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.58	m
Elevation Range	160.00 to 165.00 m	
Flow Area	8.54	m^2
Wetted Perimeter	21.11	m
Hydraulic Radius	0.40	m
Top Width	21.05	m
Normal Depth	0.58	m
Critical Depth	0.37	m
Critical Slope	0.05402	m/m

Worksheet for Cross-Section C-C' - 100-yr - Pond 10

Results

Velocity		0.91	m/s
Velocity Head		0.04	m
Specific Energy		0.62	m
Froude Number		0.46	
Flow Type	Subcritical		

GVF Input Data

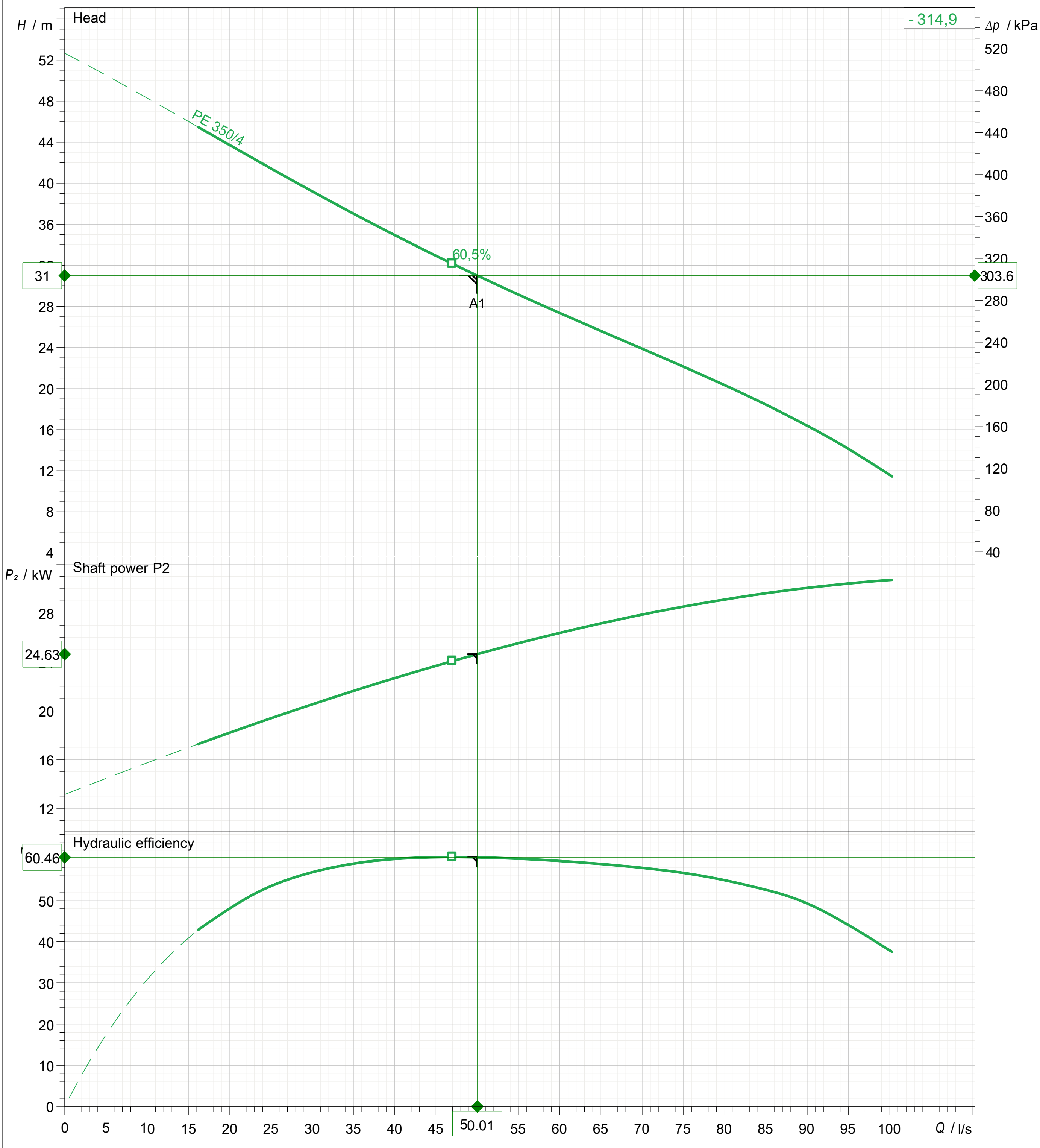
Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.58	m
Critical Depth	0.37	m
Channel Slope	1.00000	%
Critical Slope	0.05402	m/m

Curve number	Pump performance curves	
Reference curve XFP 100J-CH1 60 HZ	XFP 100J-CH1 60 HZ	SULZER

			Discharge DN100	Frequency 60 Hz
Density 998,2 kg/m³	Viscosity 1 mm²/s	Testnorm ISO 9906: 2012, HI 11.6/14.6 Gr 1U	Rated speed 1788 1/min	Date 2016-07-27
Flow 50 l/s	Head 31 m	Rated power 24,6 kW	Hydraulic efficiency 60,5 %	NPSH 3,33 m

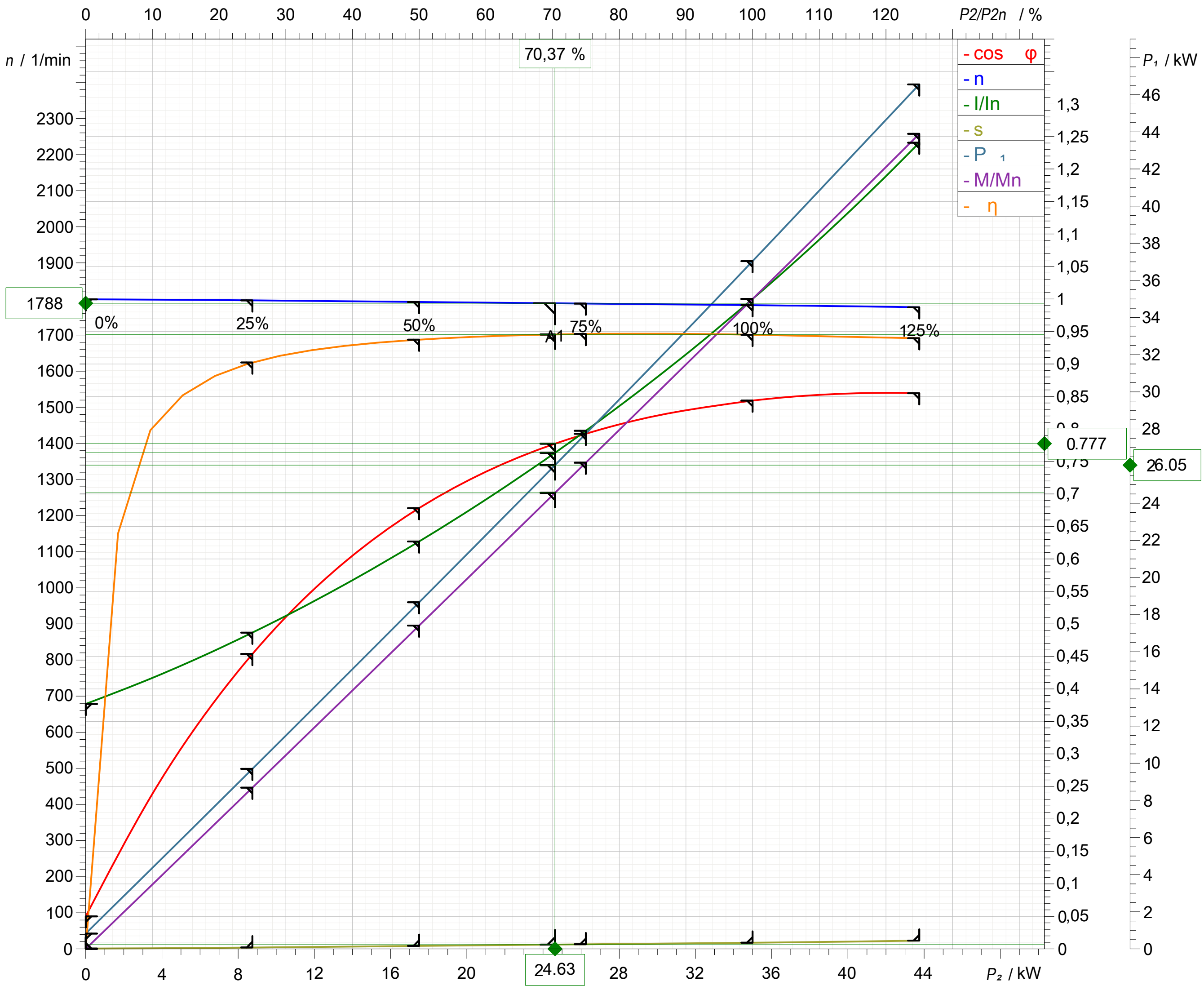


Impeller size	N° of vanes	Impeller	Solid size	Revision
315 mm	1	1-vane channel impeller	80 mm	

Version 2016/06/16
Data version Jun-2016

Frequency 60 Hz	**Motor performance curve** PE 350/4	SULZER

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
35 kW	1,3	1780 1/min	4	600 V	2016-07-27



Symbol	No loac	25 %	50 %	75 %	100 %	125 %
P_2 / kW	0	8,75	17,5	26,25	35	43,75
P_1 / kW	0,8277	9,697	18,67	27,74	37,04	46,56
η / %	0	90,24	93,75	94,62	94,49	93,97
n / 1/min	1799	1796	1792	1787	1783	1777
cos φ	0,05003	0,4539	0,6783	0,7927	0,8437	0,855
I / A	15,92	20,56	26,48	33,68	42,24	52,4
s / %	0,0571	0,2145	0,4599	0,7068	0,9522	1,276
M / Nm	0	46,52	93,27	140,3	187,5	235,1

Tolerance according to VDE 0530 T1 12.84 for rated power

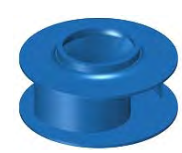
Starting current	Starting torque	Moment of inertia	No. starts per hour
346 A	525 Nm	0,359 kg m²	10

Submersible Motor Specifications, PE4 Frame

Motor Design			NEMA design B, squirrel cage induction
Motor Type			Fully enclosed Premium Efficiency submersible, IP68 protection rating
Motor Efficiency Standard and Rating			IEC 60034-30, IE3 rating
Motor Efficiency Test Protocol			IEC 60034-2-1
Insulation Material			Class H, 180ºC (356ºF), copper windings
Motor Filling Medium			Air
Temperature Rise			Class A
Maximum Fluid Temperature			40ºC (104ºF) continuous, 50ºC (122ºF) intermittent
Optional Cooling System			Closed-loop, non-toxic glycol/water mixture (⅓ / ⅔)
Motor Protection	**Thermal**	**STD**	Normally closed bimetallic switch in each phase, connected in series, 140ºC (284ºF), +/- 5 ºC opening temperature
		OPT	STD plus: upper and lower bearing bimetallic switches or 100Ω RTDs (PT100)
	Leakage	**STD**	ABS Sealminder moisture detection probe in seal sensing chamber
		OPT	STD plus: probes in motor housing and junction chamber
Sensing Chamber Filling Medium			Air
Bearing Type	**Upper**		Cylindrical roller permanently lubricated
	Lower		Dual angular contact ball bearings plus single cylindrical roller bearing, permanently lubricated
Motor Starter Types			Suitable for use with across the line, electronic soft starters, and PWM type Variable Frequency Drives*
Maximum Starts per Hour			15, evenly spaced
Inverter Duty Rating			Motors meet NEMA MG1, part 31 requirements
Maximum Submergence			20 meters (65 feet)
Available Voltages			230, 460, 600 (consult factory for other voltages)
Voltage Tolerance from Rated			+/-10%
Agency Approvals			Factory Mutual, CSA
Explosion Proof Rating			NEC 500 Class 1, Division 1, Group C & D, Class T3C max surface temp

*Output filters may be required on VFDs. See document **DS-E00-001** for details.

ABS submersible sewage pump XFP
Part of the ABS EffeX range



Premium Efficiency
without Compromise

Motor Ratings, PE4 Frame

Motor Model	Input Power (P1)	Rated Power Output (P2)	Nominal RPM	Rated Voltage	Full Load Amps	Locked Rotor Amps	NEMA Code Letter	NEMA Service Factor	Motor Efficiency at % Load			Power Factor at % Load		
									100	75	50	100	75	50
PE 250/4	26.7 kW	25 kW 33.5 HP	1785	230 460 600	79.9 40 30.6	647 324 248	J	1.3	93.6	93.1	91.6	.839	.789	.676
PE 350/4	37.1 kW	35 kW 47 HP	1785	230 460 600	110 55.1 42.2	904 452 347	J	1.3	94.5	94.6	93.8	.844	.793	.678
PE 430/4	45.3 kW	43 kW 58 HP	1780	230 460 600	137 68.7 52.7	1224 612 469	K	1.3	95.0	94.8	94.0	.827	.765	.640
PE 520/4	54.7 kW	52kW 70 HP	1780	230 460 600	163 81.4 62.4	1400 700 537	J	1.3	95.1	95.2	94.6	.844	.788	.668

Cable Data, PE4 Frame

	Motor	Motor Voltage	Cable Qty	Cable Type	Cable Nominal Dia. +/- .5mm (.02")
Power Cable	PE 250/4	230 volt	1	G-GC 4-3	30.2mm (1.19") diameter
		460 volt	1	G-GC 8-3	24.6mm (0.97") diameter
		600 volt	1	G-GC 8-3	24.6mm (0.97") diameter
	PE 350/4	230 volt	1	G-GC 2-3	34.1mm (1.3") diameter
		460 volt	1	G-GC 6-3	26.6mm (1.05") diameter
		600 volt	1	G-GC 8-3	24.6mm (0.97") diameter
	PE 430/4	230 volt	1	G-GC 1/0-3	41.9mm (1.65") diameter
		460 volt	1	G-GC 4-3	30.2mm (1.19") diameter
		600 volt	1	G-GC 6-3	26.6mm (1.05") diameter
	PE 520/4	230 volt	1	G-GC 2/0-3	43.9mm (1.73") diameter
		460 volt	1	G-GC 4-3	30.2mm (1.19") diameter
		600 volt	1	G-GC 6-3	26.6mm (1.05") diameter
Control Cable	All	Standard*	1	SOOW 16/4	10.67mm (0.42") diameter
		Full monitoring*	1	SOOW 16/8	14.6mm (0.575") diameter
		Full monitoring w/ RTDs*	1	SOOW 16/12	17.3mm (0.68") diameter
Cable Length	Standard: 15m (49 feet)		Optional: 5m (16 feet) increments up to 30m (98 feet) - Consult Factory for Longer Lengths		

* See motor protection on page 1.

Pump Data

Discharge Size	4" flanged, compatible with 4" class 125 ANSI flanges					
Suction Size	4" flanged, compatible with 4" class 125 ANSI flanges, threaded for 8x5/8-11 UNC bolts, 27mm (1.06") deep					
Volute pressure rating	10 bar (145 psi)					
Impeller Type	Closed channel, 1-vane, w/ Seal Protection System					
Impeller Size	305	315	335	353		
Solids Passage Size	80mm (3.1")	80mm (3.1")	80mm (3.1")	80mm (3.1")		
Impeller DIA	305mm (12.0")	315mm (12.4")	335mm (13.19")	353mm (13.9")		
Impeller Weight						
Min Recommended Flow, GPM	250	300	325	350		

Materials of Construction

		Standard	Optional
Motor and Intermediate Housing		Cast Iron EN-GJL-250 (ASTM A-48, Class 35B)	
Optional Cooling Jacket		Steel 1.0036 (ASTM A-570, Grade D)	
Seal Plate		Cast Iron EN-GJL-250 (ASTM A-48, Class 35B)	
Impeller		Cast Iron EN-GJL-250 (ASTM A-48, Class 35B)	Duplex Stainless Steel 1.4460 (AISI 329)
Volute		Cast Iron EN-GJL-250 (ASTM A-48, Class 35B)	
Impeller Wear Ring			Stainless Steel 1.4571 (AISI 316Ti)
Volute Wear Ring		Cast Iron EN-GJL-300 (ASTM A-48, Class 40B)	Stainless Steel 1.4581 (AISI 318)
Cable Entry Casting		Cast Iron EN-GJL-250 (ASTM A-48, Class 35B)	
Pump and Motor Shaft		Stainless Steel 1.4021 (AISI 420)	Duplex Stainless Steel 1.4462 (UNS S31803)
External Hardware		Stainless Steel 1.4401 (AISI 316)	
Lifting Hoop		Ductile Iron EN-GJS-400-18 (ASTM A-536; 60-40-18)	Duplex Stainless Steel 1.4460 (AISI 329)
O-Rings and Cable Glands		Nitrile (Buna-N)	Viton®
Tandem Mechanical Seal	**Lower**	Silicon Carbide / Silicon Carbide, Nitrile, 316 SS	Silicon Carbide / Silicon Carbide, Viton®, 316 SS
	Upper	Silicon Carbide / Silicon Carbide, Nitrile, 316 SS	
Lower Bearing Lip Seal		Nitrile (Buna-N) covered steel	
Coating		Two part epoxy, black, 100µm (3.9 mil) DFT	Two part epoxy, black, 200µm (7.9 mil) or 360 µm (14.2 mil); Coal tar epoxy, black, 200 µm (7.9 mil); Non-toxic epoxy, 200 µm (7.9 mil)

General Data

	PE 250/4	PE 350/4	PE 430/4	PE 520/4
Overall Height	1461mm (57.5")	1461mm (57.7")	1521mm (59.9")	1521mm (59.9")
Pump Weight	483 kg (1089 lb)	508 kg (1120 lb)	537 kg (1184 lb)	557 kg (1228 lb)

No: M-02.3020 - 01	**XFP 100J-CH1**
Dat/Nam.: 13.05.2014 / K. Srb	Dimension sheet PE4 WET WELL
Cad Code: M_023020	Maßblatt PE4 Nassinstallation
Technical changes reserved Änderungen vorbehalten Sous réserve de modifications	Plan d'encombrement PE4 installation submersible

SULZER

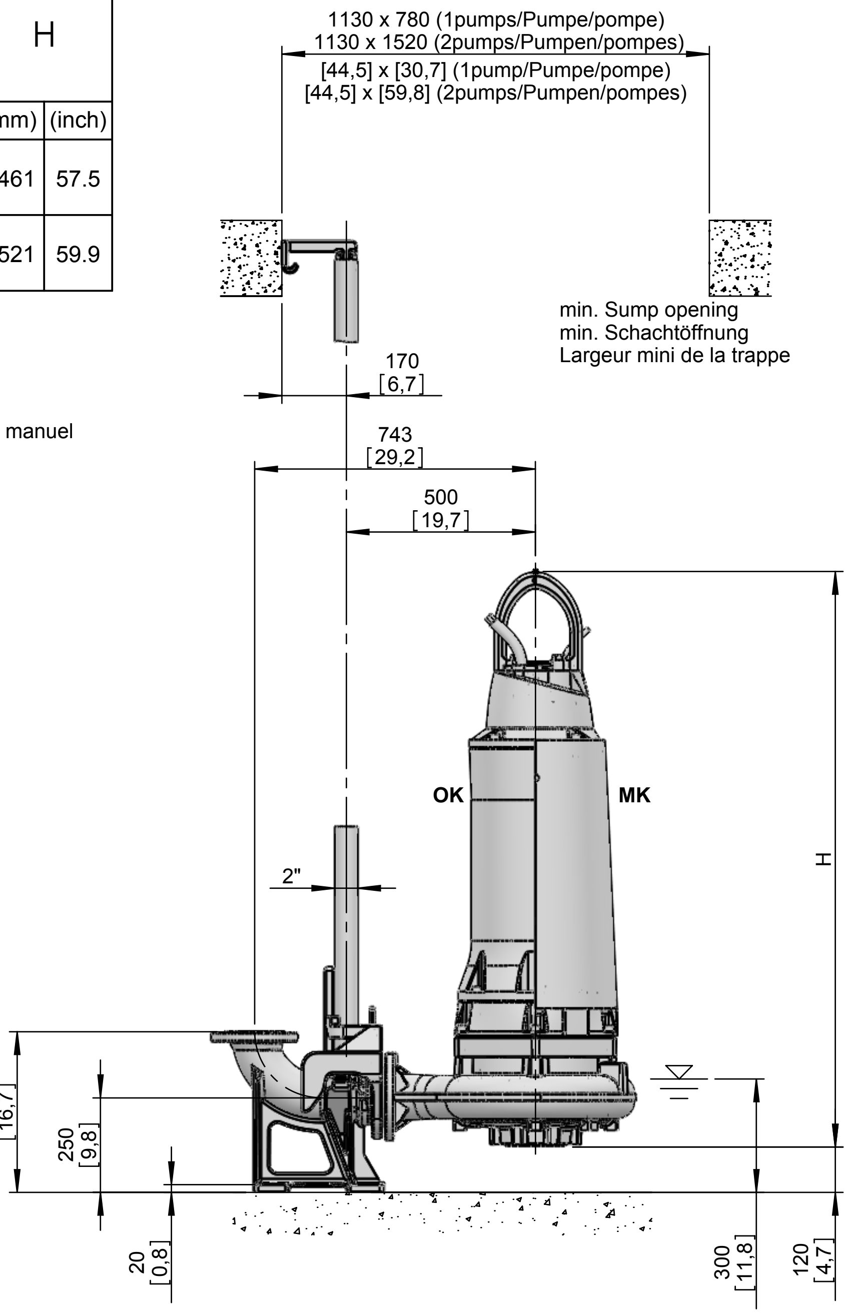
Type Typ Type 60Hz	Weight Gewicht Poids OK		Weight Gewicht Poids MK		H	
	(~kg)	(~lb)	(~kg)	(~lb)	(mm)	(inch)
PE 250/4-J-60	485	1069	545	1202	1461	57.5
PE 350/4-J-60	510	1125	570	1257		
PE 430/4-J-60	540	1191	605	1334	1521	59.9
PE 520/4-J-60	560	1235	625	1378		

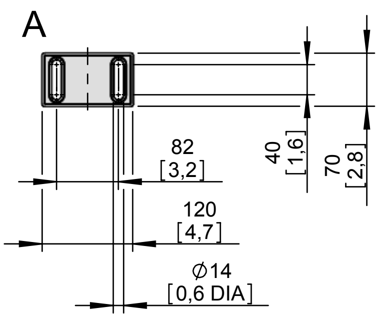
Weight: Includes pump, slider bracket and 10m cable
Gewicht: Beinhaltet Pumpe, Halterung und 10m Kabel
Poids: Pompe, coulisseau et 10m de câble

For different cable length see IOM, chapter 1.5
Für abweichende Kabellänge siehe EBA, Kapitel 1.5
Pour des longueurs supérieures, voir la section 1.5 du manuel

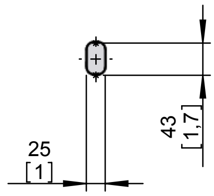
For hex.-woodscrew 0,4*2,8 plug 0,5 DIA
Für Skt.-Holzschr.10*70 Dübel Ø12mm
Pour vis à bois hexagonale 10*70 trou de 12mm

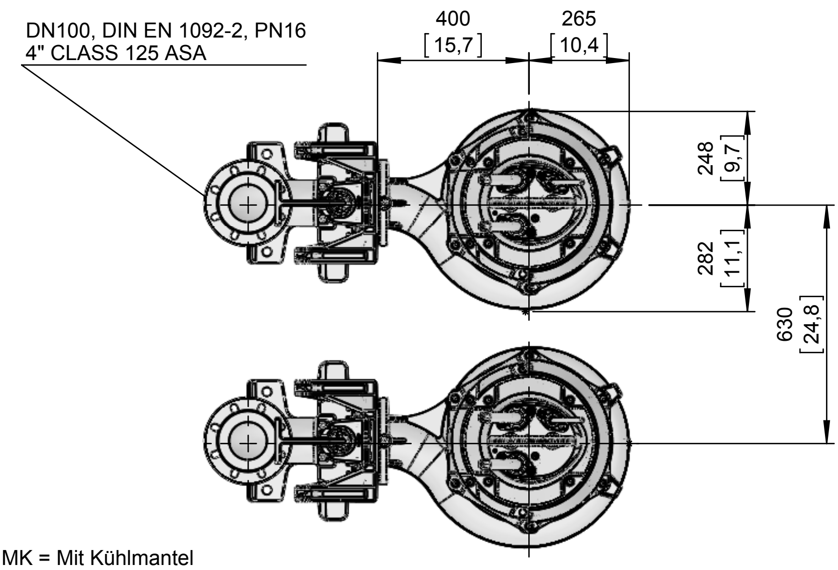
Installation instructions "pedestal" 1 597 2507
Installationsanweisung "Fußstück" 1 597 2507
Instruction d'installation du "pied d'assise" 1 597 2507

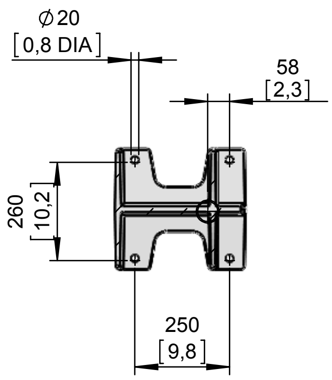




Lifting hoop cross section
Fangbügel-Querschnitt
Section de l'anse de levage







OK = Ohne Kühlmantel
Without cooling jacket
Sans enveloppe de refroidissement

MK = Mit Kühlmantel
With cooling jacket
Avec enveloppe de refroidissement

[mm / inch]

APPENDIX H
NE TRIBUTARY OF BALTIMORE CREEK AND NEIGHBOURING PROPERTY IMPACT ASSESSMENT

March 9th, 2017

Canadian Solar Solutions Inc.
545 Speedvale Avenue West
Guelph, Ontario
N1K 1E6

Re: PP-14-9580 - Appendix H to the Post-Construction Stormwater Management Report –NE Tributary of Baltimore Creek and Neighbouring Property Impact Assessment.

1.0 APPENDIX LIMITATIONS

This appendix has been prepared at the request of Canadian Solar Solutions Inc. (CSSI) to assess the existing stormwater management system and provide recommendations and designs for the post-construction scenario that are in compliance with the guidelines and standards from the Ministry of the Environment and Climate Change (MOECC).

Any use of this review by a third party, or any reliance on decisions made based on it, without a reliance report is the responsibility of such third parties. McIntosh Perry accepts no responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this review.

McIntosh Perry's scope was concentrated on the review of the flow rates and volumes leaving the site through Outlet 1 (Pond 10) and contributing to the watershed of Baltimore Creek. Through extensive consultation with the MOECC, as well as the project owner, CSSI and its contractor, the reduction of flow through to this outlet from the site was reviewed in an attempt to alleviate concerns of downstream landowners to the northeast. Please note that the areas downstream of the site were reviewed at a high level and detailed topographic, geotechnical and soils data were not obtained nor available. The evaluation of the downstream cross-sections, vegetation and stormwater management systems were reviewed through a desktop review with a site visit to confirm general conformance of the provided information.

The findings, conclusions and/or recommendations of this report are only valid as of the date of this report. No assurance is made regarding any changes in conditions subsequent to this date. If additional information is discovered or becomes available at a future date, McIntosh Perry should be requested to re-evaluate the conclusions presented in this report and provide amendments, if required.

2.0 PURPOSE AND OBJECTIVE

This appendix H has been prepared as a supplementary document to the information provided in the Post-Construction Stormwater Management Report revised June 2016, prepared by McIntosh Perry. The MOECC have requested an evaluation of the following:

- Review potential impacts, if any, to the neighbouring properties;
- Review potential impacts, if any, to the Community Centre Road crossing culvert;
- Review potential impacts, if any, to Baltimore Creek tributary flow path to the north of Community Centre Road.

This document provides a standalone review of the downstream effects as a result of flow from Outlet 1 (Pond 10) combined with the flow from the applicable watershed lands on the existing infrastructure. For the purpose of this report, please note the "neighbouring property" is located immediately downstream to the east of the Payne Road crossing culvert (please see key map as Figure 1). The Baltimore Creek tributary impacts have been assessed up to the Meyers Road crossing approximately 1km north of the project.

In its current state at the time of this report, Pond 10 is not permitted to discharge to the northeast given previous runoff quality and quantity concerns. With the vegetation established on site, water quality concerns have subsided and the remaining concerns are related to quantity control. This appendix will illustrate the anticipated impacts to the neighbouring property from flows travelling overland which exceed the capacity of the installed tile system. With regards to the flow rates illustrated, it has been assumed that during major rain events, the tile system is at full capacity and water from Outlet 1 does not enter the tile system. As detailed in the main body of the report and in Appendix F and Appendix G, substantial flow has been directed from Block 9 to behind the house to the west and other measures have been implemented to reduce the runoff entering Pond 10. Finally, the stormwater management plan described in this report, its appendices and drawings is believed to be in the best interest of the public and environment to reduce the volumes and flow rates of runoff leaving the site to the northeast.

Figure 1 – Key Map of Neighbouring property

3.0 DRAINAGE PATH AND WATERCOURSE

The stormwater flow path from the site to the northeast is as follows: Water from northeastern areas of the site drain into Pond 10; Pond 10 outlets water to a roadside ditch on the west side of Payne Road and through a road crossing culvert; water then flows over (as assumed in the worst case scenario described above) the neighbouring farm field in a north east direction before entering a defined channel at the south side of a crossing culvert at community center road. This creek channel then flows to the north and crosses Myers Road approximately 0.7km from Community Center Road and then County Road 45 1.2km later. The flow finally reaches Baltimore Creek 0.5 km further to the northwest of the County Road 45 crossing. The established watercourse stretches approximately 2.4km from Community Center Road to Baltimore Creek, with varying cross-sections throughout dependent on topography and local development.

Due to the fact that the vast majority of water entering the tributary watercourse described above comes from surrounding lands that are considered to be in the same post-development condition as in pre-development, this analysis stops at the Meyers Road crossing. Comparing the pre- and post- flow conditions, the waterway downstream (to the north) of this point is negligibly impacted by changes to the outflow characteristics from Outlet 1 (Pond 10).

4.0 WATERSHED UPSTREAM OF PAYNE ROAD

The watershed upstream of Payne Road includes portions of the existing solar farm, lands to the north and the municipal right of way, flows towards and cross through the 400mm diameter CSP culvert located on Payne Road. The pre-construction flow patterns / drainage area was approximately 11ha, all undeveloped lands. In post-development, the drainage area from the solar farm and area west of Payne Road is 4.4ha (B9 & B11) primarily undeveloped and unrestricted and 5.1ha (B2 & B4) developed and restricted for a total of 8.8ha. See Post-Development Drainage Plan which illustrates the watersheds that drains to the Payne Road crossing culvert. In the post- scenario, this watershed area is decreased by approximately 1.5ha.

The watershed was reviewed in both the minor (5-year) and major (100-year) storm events with the proposed stormwater management pond (Pond 10) acting with the areas flowing unrestricted. The table below illustrates the estimated pre- and post-development peak flow rates reaching the Payne Road culvert.

Table 1 - Pre- and Post-development flow rates reaching Payne Road

	5-Year	100-Year
	m^3/s	
PRE	0.40	1.23
POST	0.18	0.51
Δ	-0.22	-0.72

Per Table 1, it is estimated that peak flow rates will decrease by approximately 0.22 and 0.72 m^3/s for the 5- and 100-year storm events respectively. This represents an 55% and 59% reduction of estimated peak flow rates for the 5-and 100-year storm event in comparison to pre-development. This is due to the lower flow rate exiting Pond 10 and discharging through Outlet 1 in the post- condition compared to pre- as described in section 4.4 of Appendix F.

Table 2 – Payne Road Culvert Analysis (Pre and Post Conditions)

	Flow (m^3/s)	Velocity (m/s)	Headwater Elevation (m)	Full %	Overtops Roadway?
5 – Year					
Culvert PRE	0.40	1.87	232.03	100%	Yes (by 0.03m)
Culvert POST	0.18	1.59	231.03	100%	No
100 - Year					
Culvert PRE	1.23	1.94	232.10	100%	Yes (by 0.10m)
Culvert POST	0.51	2.31	232.03	100%	Yes (by 0.03m)

5.0 WATERSHED SOUTH OF COMMUNITY CENTER ROAD

The watershed, which includes portions of the existing solar farm and lands to the east of Payne Road, that culminates at the crossing culvert under Community Centre Road is approximately 45.8ha in area. See the Drainage Plan #2 (PP-14-9580 – East Drain) which illustrates the watershed that drains to the Community Center Road crossing culvert.

A watercourse is historically evident and extends approximately 0.4km from the Payne Road culvert to the Community Centre Road culvert through the neighbouring property. In the post- scenario, this watershed area is decreased by approximately 1.5ha.

The watershed was reviewed in both the minor (5-year) and major (100-year) storm events. The table below illustrates the estimated pre- and post-development peak flow rates reaching Community Centre Road.

Table 3 - Pre- and Post-development flow rates reaching Community Centre Road

	5-Year	100-Year
	m^3/s	
PRE	1.23	3.80
POST	1.01	3.08
Δ	-0.22	-0.72

Per Table 2, it is estimated that peak flow rates will decrease by approximately 0.22 and 0.82 m^3/s for the 5- and 100-year storm events respectively. This represents an 18% reduction of estimated peak flow rates for the 5-and 100-year storm event in comparison to pre-development. As you progress further downstream from the solar farm, the outflow directly from the solar farm decreases as a percentage of the overall flowrate. Impacts to the downstream infrastructure as a result of outflow from the farm are anticipated to be less than, the pre-construction impacts. This is due to the lower flow rate exiting Pond 10 and discharging through Outlet 1 in the post- condition compared to pre- as described in section 4.4 of Appendix F.

6.0 IMPACTS TO THE NEIGHBOURING PROPERTY

Based on our review of historical aerial images, it appears that runoff has always formed and been routed a path through the neighbouring property (see Figure 2). The property owner has also indicated that before construction began in 2013, surface water was evident along this path during spring melts and occasionally following serious storm events.

The existing surface drainage path was reviewed and a watercourse cross-section through the low point of the surface drainage path was taken where erosion is seen (see Drainage Plan #2 for exact location). The cross-section was reviewed for the 5- and 100-year, 24-Hour SCS distribution to confirm capacity and impacts as a result of flow along the path during storm events.

Based on the MTO Drainage Manual Design Chart 2.17 Maximum Permissive Flow Velocities – Native Materials/Linings, the maximum velocity on exposed silt loam is 0.6m/s. In the 5-year storm pre-development condition, analysis shows that the stormwater velocity exceeds the MTO maximum and therefore had the potential to erode the surface prior to construction given the relatively steep slopes, and at times, unvegetated soils through the property. This impact is expected to be slightly reduced in the post- scenario when water will discharge from the restricted pipe that outlets Pond 10.

The same MTO table gives a maximum velocity of 1.5m/s for grass mixtures for slopes less than 5%. One option to consider to reduce future erosion would be to permanently vegetate the low point path through the neighbouring property. As a further improvement measure, the site rehabilitation plan incorporates lowering the Payne Road crossing culvert thus eliminating erosive effects of falling water at the border of the neighbouring property. See the existing Payne Road culvert outfall condition in Figure 3.

Figure 2 – Surface water flow path (temporal watercourse) through Neighbouring property (generally from the Payne road culvert in a northwest direction)

The following illustrates the pre- and post-development 5- and 100-year peak flow through the cross-section.

Table 4 – Un-vegetated State: 5- and 100-year Through Ditch Cross-Section

	Slope of Ditch (%)	Velocity (m/s)	Flow (m^3/s)	Elevation (depth in m)	Flow Type
5 - Year					
A-A' (PRE)	3.5	1.01	0.45	224.07 (0.07m)	Supercritical
A-A' (POST)	3.5	0.85	0.23	224.05 (0.05m)	Supercritical
100 – Year					
A-A' (PRE)	3.5	1.33	1.38	224.11 (0.11m)	Supercritical
A-A' (POST)	3.5	1.11	0.66	224.08 (0.08m)	Supercritical

Table 5 - Vegetated 5- and 100-year Through Ditch Cross-Sections

	Slope of Ditch (%)	Velocity (m/s)	Flow (m^3/s)	Elevation (depth in m)	Flow Type
5 - Year					
A-A' (PRE)	3.5	0.74	0.45	224.08 (0.08m)	Supercritical
A-A' (POST)	3.5	0.63	0.23	224.06 (0.06m)	Supercritical
100 – Year					
A-A' (PRE)	3.5	0.98	1.38	224.12 (0.12m)	Supercritical
A-A' (POST)	3.5	0.82	0.66	224.09 (0.09m)	Supercritical

Figure 3 – Culvert proposed to be lowered at Payn Road to aid in dissipating energy (proposed to be constructed with additional outlet protection and energy dissipating riprap spillway).

7.0 CULVERT AT COMMUNITY CENTRE ROAD

The culvert at Community Centre Road is the second municipal structure downstream of the solar farm. It is an 18.8m long, 700mm diameter CSP with a slope of 3.2%. The upstream and downstream conditions were field verified by McIntosh Perry staff and the size, length and inverts of the culvert were also provided by topographic survey. The culvert was analyzed under both the minor and major storm events in both pre- and post-development conditions, results for which can be found in the table below:

Table 6 – Community Center Road Culvert Analysis (Pre and Post Conditions)

	Flow (m^3/s)	Velocity (m/s)	Headwater Elevation (m)	Full %	Overtops Roadway?
5 – Year					
Culvert PRE	1.23	2.90	220.85	100%	No
Culvert POST	1.01	2.81	220.42	100%	No
100 - Year					
Culvert PRE	3.80	3.55	221.71	100%	Yes (by 0.16m)
Culvert POST	3.08	3.52	221.68	100%	Yes (by 0.13m)

Based on the analysis, the existing culvert does not appear to have sufficient capacity to permit the minor event to flow unrestricted. Stormwater would be anticipated to pond within the municipal right of way and within the low lying area south of the roadway (on the neighbouring property) while continuing to discharge. Based on the reduction in peak flow rates, we do not anticipate any negative effects from the culvert in comparison to existing conditions.

Figure 4 – Existing watercourse reaching the culvert along Community Centre Road (looking south into the Neighbouring Property)

The Community Centre Road culvert was reviewed in terms of its capacity should the solar farm land area not contribute anything to the Neighbouring Property (a hypothetical condition). The culvert was found to restrict runoff in the minor events and overtop similarly in the major event.

8.0 WATERSHED DISCHARGING THROUGH MYERS ROAD CULVERT

The existing culvert and watercourse that crosses Myers Road is shown in Figure 5. At Myers Road, the watercourse was continually flowing during the site inspection (June 10, 2016), where upstream at the Community Centre Road culvert, was found to be dry.

Figure 5 - Existing Concrete Culvert at Myers Road

This watercourse, which is a tributary of the Baltimore Creek, has a relatively large watershed of approximately 200ha (MNR, OFAT III – flow assessment tool). See Figure 6. For comparison, the drainage area from the solar farm and area west of Payne Road is 4.4ha (B9 & B11) primarily undeveloped and unrestricted and 5.1ha (B2 & B4) developed and restricted for a total of 9.5ha. The pre-construction flow patterns / drainage area was approximately 11ha, all undeveloped. The percentage area of the farm to the Myers Road watershed is 5.5% in pre- and 4.8% in post-development.

The land area east of Payne Road and south of Community Center Road that discharges through the Community Center Road culvert is 34.8ha. This accounts for 17.4% of the total watershed. It should be noted that some of the runoff from this drainage area flows into an existing pond within the agricultural field. The pond retains some of the flow on site (pond location indicated in Drainage Plan #2). Based on the fact that the solar farm has reduced its total peak flow and that it is a very small portion of the overall drainage area to Myers Road, it is unlikely that there would be an impact attributable to the solar farm discharge only. As one progresses further downstream the impact of the solar farm on the watercourse will be even more negligible.

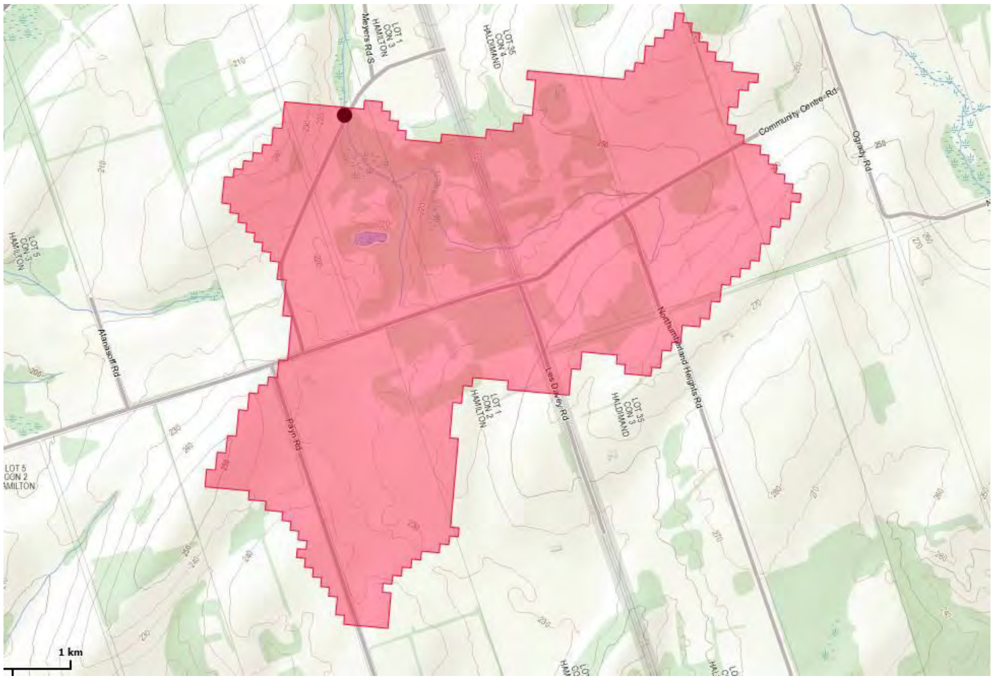


Figure 6 - OFAT Flow Assessment Tool Output – Approximate Myers Road Crossing Drainage Area

Figure 7 - Existing Concrete Culvert at Myers Road

9.0 RECOMMENDATIONS

The analysis of the neighbouring property indicates that decreasing the discharge area on the site, in combination with the Pond 10 volume and outlet diameter design, will result in less potential for erosion compared to the pre-development condition. However, without vegetative cover, periodic minor surface erosion, similar to that which existed pre-construction, is likely to persist.

From a watershed perspective, the solar farm makes up a small fraction of the total watershed area that reaches the Myers Road crossing culvert. Since the watercourse is negligibly impacted in terms of flow rate, and is already an established flow path, downstream lands are not expected to be impacted any differently in the post- condition compared to the pre-condition. There are no adverse impacts to the existing performance of municipal culverts studied across Payne Road and Community Center Road.

We trust that the preceding information is acceptable for your present purposes. Should you require additional information or have questions about anything contained herein please feel free to contact the undersigned.

Regards,

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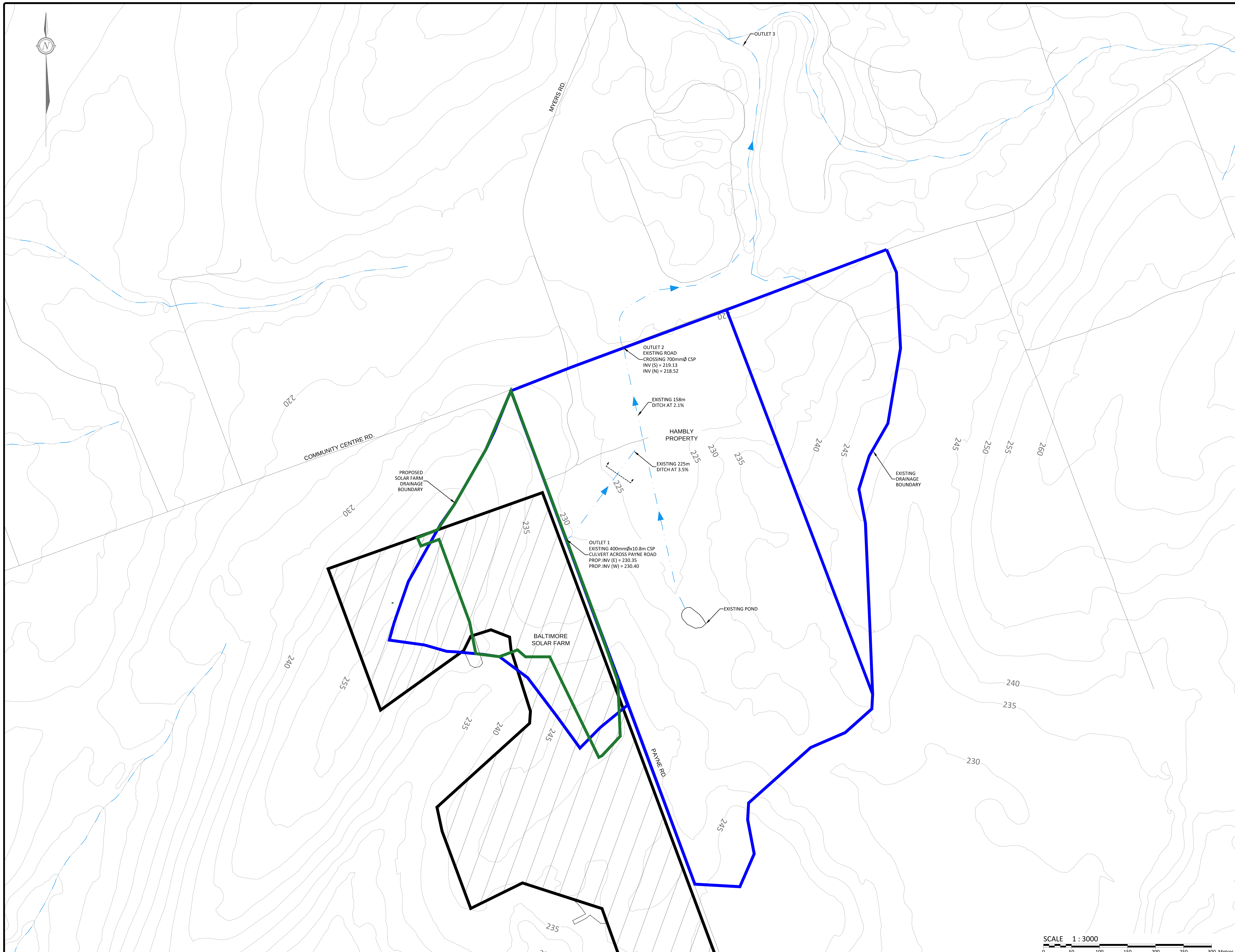

No.	Revision/Issue	Date
0	ISSUED FOR REVIEW	JULY 24/16

Check and verify all dimensions before proceeding with the work

Do not scale drawings

McINTOSH PERRY

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Client:
CANADIAN SOLAR SOLUTIONS INC.
545 SPEEDVALE AVE. WEST GUELPH, ON N1K1E6

Project:
HAMILTON - PORT HOPE 4 SOLAR FARM

BALTIMORE ONTARIO

Drawing Title:
DRAINAGE PLAN #2 - HAMBLY

Scale: 1:3000
Drawn by: D. LONGMUIR
Checked By: A. O'CONNOR
Designed By: J. SHARP
Date: JAN/19/2015

Project Number: PP-14-9580

Drawing Number:
SHEET 1 of 1
EAST DRAIN

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - PRE-DEVELOPMENT
DRAINAGE AREA INFORMATION

Land Use Breakdown

Catchment ID	Area (m^2)	Wooded (m^2)	Pasture (m^2)	Crop (m^2)	Wetland (m^2)	CN
Hambly Property	348,447	8367	0	340,080	0	73.6
Total	**348,447**	**8367**	**0**	**340,080**	**0**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
A2	1015	2.46	0	0.0	0.00	64

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
A2	34.8	73.6	64
Total	**34.8**		

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PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT -
PRE-DEVELOPMENT HYDROLOGICAL RESULTS

24-Hr - Pre-Development

	5-Year	100-Year
	(L/s)	
Baltimore Solar Farm - A2 From Report	401	1,232
Hambly Property	828	2,562
X-Section A-A	449	1,380
At Community Centre Road Culvert	1,229	3,794

X-Section A-A	5-Year	100-Year
	(m/s)	
Unvegetated Velocity	1.01	1.33
Revegetated Velocity	0.74	0.98

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - POST-DEVELOPMENT DRAINAGE AREA INFORMATION

Land Use Breakdown

Catchment ID	Area (m^2)	Wooded (m^2)	Pasture (m^2)	Crop (m^2)	Wetland (m^2)	Gravel (m^2)	Impervious (m^2)	Improved (m^2)	Pond (m^2)	CN
Hambly Property	348,447	8367	0	340,080	0	0	0	0	0	73.6
Total	**348,447**					**0**	**0**	**0**	**0**	

Time of Concentration

Catchment ID	Sheet Flow Distance (m)	Slope of Land (%)	Ditch Length (m)	Ditch Slope (%)	Ditch Velocity (m/s)	Tc (min) - SCS Lag
Hambly Property	1015	2.46	0	0.0	0.00	64

Hydrologic Model Parameters

Catchment ID	Area (ha)	CN	Tc (min)
Hambly Property	34.8	73.6	64
	34.8		

Reference

The SCS Lag Formula

$$tc = \frac{60 * L^{0.8} (S'+25.4)^{0.7}}{4238*S^{0.33}}$$

where
- tc = time of concentration, min.
- L = watershed length, m.
- S' = potential maximum retention (S' = (25400 / CN) - 254)
- CN = curve number
- S = watershed slope, %

Channel Flow

Mannings Equation

$$V = \frac{(R^{2/3}*S^{1/2})}{n}$$

where
- V = velocity (m/s)
- R = hydraulic radius
- S = slope of ditch, %
- n = manning's roughness coefficients (0.03 for grass swales)

PP-14-9580 - HAMILTON - PORT HOPE 4 SOLAR PROJECT - FLOW THROUGH HAMBLY PROPERTY

24-Hr - Post-Development

	5-Year	100-Year
	(L/s)	
Solar Farm Output (Pond 10 Output)	30	39
Hambly's Property	828	2,562
B11 - Field to North & Municipal ROW	151	474
X-Section A-A	228	661
At Community Centre Road Culvert	1,009	3,075

X-Section A-A	5-Year	100-Year
	(m/s)	
Unvegetated Velocity	0.85	1.11
Revegetated Velocity	0.63	0.82

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Analysis Component			
Storm Event	Design	Discharge	1.2300 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	1.2300 m^3/s	Check Discharge	3.8000 m^3/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	218.88 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	1.2299 m^3/s	220.85 m	2.90 m/s
Weir	Roadway (Constant Elevation)	0.0000 m^3/s	220.85 m	N/A
Total	----------------	1.2299 m^3/s	220.85 m	N/A

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Component:Culvert-1

Culvert Summary

Computed Headwater Elev:	220.85 m	Discharge	1.2299 m^3/s
Inlet Control HW Elev.	220.85 m	Tailwater Elevation	218.88 m
Outlet Control HW Elev.	220.59 m	Control Type	Inlet Control
Headwater Depth/Height	2.26		

Grades

Upstream Invert	219.13 m	Downstream Invert	218.52 m
Length	18.80 m	Constructed Slope	3.2447 %

Hydraulic Profile

Profile	M2	Depth, Downstream	0.67 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.67 m
Velocity Downstream	2.90 m/s	Critical Slope	3.4432 %

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	220.59 m	Upstream Velocity Head	0.38 m
Ke	0.90	Entrance Loss	0.34 m

Inlet Control Properties

Inlet Control HW Elev.	220.85 m	Flow Control	Submerged
Inlet Type	Projecting	Area Full	0.5 m^2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)			
Discharge	0.0000 m^3/s	Allowable HW Elevation	220.85 m
Roadway Width	7.50 m	Overtopping Coefficient	1.60 SI
Length	20.00 m	Crest Elevation	221.55 m
Headwater Elevation	N/A m	Discharge Coefficient (Cr)	2.90
Submergence Factor (Kt)	1.00		

Sta (m)	Elev. (m)
0.00	221.55
20.00	221.55

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Analysis Component			
Storm Event	Check	Discharge	3.8000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.2300 m³/s	Check Discharge	3.8000 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	218.88 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	1.5828 m³/s	221.71 m	3.55 m/s
Weir	Roadway (Constant Elevation)	2.2203 m³/s	221.71 m	N/A
Total	----------------	3.8030 m³/s	221.71 m	N/A

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Component:Culvert-1

Culvert Summary

Computed Headwater Eleva	221.71 m	Discharge	1.5828 m³/s
Inlet Control HW Elev.	221.71 m	Tailwater Elevation	218.88 m
Outlet Control HW Elev.	221.62 m	Control Type	Inlet Control
Headwater Depth/Height	3.39		

Grades

Upstream Invert	219.13 m	Downstream Invert	218.52 m
Length	18.80 m	Constructed Slope	3.2447 %

Hydraulic Profile

Profile	CompositeM2PressureProfile	Depth, Downstream	0.72 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.72 m
Velocity Downstream	3.55 m/s	Critical Slope	5.4740 %

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	221.62 m	Upstream Velocity Head	0.61 m
Ke	0.90	Entrance Loss	0.55 m

Inlet Control Properties

Inlet Control HW Elev.	221.71 m	Flow Control	Submerged
Inlet Type	Projecting	Area Full	0.5 m²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Community Centre Road - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	2.2203	m^3/s	Allowable HW Elevation	221.71	m
Roadway Width	7.50	m	Overtopping Coefficient	1.66	SI
Length	20.00	m	Crest Elevation	221.55	m
Headwater Elevation	221.71	m	Discharge Coefficient (Cr)	3.01	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	221.55
20.00	221.55

Culvert Designer/Analyzer Report
Community Centre Road - Post

Analysis Component			
Storm Event	Design	Discharge	1.0100 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	1.0100 m^3/s	Check Discharge	3.0800 m^3/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	218.88 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	1.0099 m^3/s	220.42 m	2.81 m/s
Weir	Roadway (Constant Elev0t0000 m^3/s		220.42 m	N/A
Total	----------------	1.0099 m^3/s	220.42 m	N/A

Culvert Designer/Analyzer Report
Community Centre Road - Post

Component:Culvert-1

Culvert Summary			
Computed Headwater Elev:	220.42 m	Discharge	1.0099 m^3/s
Inlet Control HW Elev.	220.42 m	Tailwater Elevation	218.88 m
Outlet Control HW Elev.	220.38 m	Control Type	Inlet Control
Headwater Depth/Height	1.69		

Grades			
Upstream Invert	219.13 m	Downstream Invert	218.52 m
Length	18.80 m	Constructed Slope	3.2447 %

Hydraulic Profile			
Profile	S2	Depth, Downstream	0.56 m
Slope Type	Steep	Normal Depth	0.56 m
Flow Regime	Supercritical	Critical Depth	0.62 m
Velocity Downstream	2.81 m/s	Critical Slope	2.6296 %

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	220.38 m	Upstream Velocity Head	0.33 m
Ke	0.90	Entrance Loss	0.30 m

Inlet Control Properties			
Inlet Control HW Elev.	220.42 m	Flow Control	N/A
Inlet Type	Projecting	Area Full	0.5 m^2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Community Centre Road - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)			
Discharge	0.0000 m^3/s	Allowable HW Elevation	220.42 m
Roadway Width	7.50 m	Overtopping Coefficient	1.60 SI
Length	20.00 m	Crest Elevation	221.55 m
Headwater Elevation	N/A m	Discharge Coefficient (Cr)	2.90
Submergence Factor (Kt)	1.00		

Sta (m)	Elev. (m)
0.00	221.55
20.00	221.55

Culvert Designer/Analyzer Report
Community Centre Road - Post

Analysis Component			
Storm Event	Check	Discharge	3.0800 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	1.0100 m³/s	Check Discharge	3.0800 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	218.88 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-750 mm Circular	1.5694 m³/s	221.68 m	3.52 m/s
Weir	Roadway (Constant Elevation)	1.5133 m³/s	221.68 m	N/A
Total	----------------	3.0827 m³/s	221.68 m	N/A

Culvert Designer/Analyzer Report
Community Centre Road - Post

Component:Culvert-1

Culvert Summary			
Computed Headwater Elev:	221.68 m	Discharge	1.5694 m^3/s
Inlet Control HW Elev.	221.68 m	Tailwater Elevation	218.88 m
Outlet Control HW Elev.	221.58 m	Control Type	Inlet Control
Headwater Depth/Height	3.34		

Grades			
Upstream Invert	219.13 m	Downstream Invert	218.52 m
Length	18.80 m	Constructed Slope	3.2447 %

Hydraulic Profile			
Profile	CompositeM2PressureProfile	Depth, Downstream	0.72 m
Slope Type	Mild	Normal Depth	N/A m
Flow Regime	Subcritical	Critical Depth	0.72 m
Velocity Downstream	3.52 m/s	Critical Slope	5.3805 %

Section			
Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	0.76 m
Section Size	750 mm	Rise	0.76 m
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	221.58 m	Upstream Velocity Head	0.60 m
Ke	0.90	Entrance Loss	0.54 m

Inlet Control Properties			
Inlet Control HW Elev.	221.68 m	Flow Control	Submerged
Inlet Type	Projecting	Area Full	0.5 m^2
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Community Centre Road - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)			
Discharge	1.5133 m^3/s	Allowable HW Elevation	221.68 m
Roadway Width	7.50 m	Overtopping Coefficient	1.65 SI
Length	20.00 m	Crest Elevation	221.55 m
Headwater Elevation	221.68 m	Discharge Coefficient (Cr)	3.00
Submergence Factor (Kt)	1.00		

Sta (m)	Elev. (m)
0.00	221.55
20.00	221.55

Culvert Designer/Analyzer Report
Payne Road - Pre

Analysis Component			
Storm Event	Design	Discharge	0.4000 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.4000 m³/s	Check Discharge	1.2300 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	0.00 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-450 mm Circular	0.2550 m³/s	232.03 m	1.87 m/s
Weir	Roadway (Constant Elevation)	0.1461 m³/s	232.03 m	N/A
Total	----------------	0.4012 m³/s	232.03 m	N/A

Culvert Designer/Analyzer Report
Payne Road - Pre

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	232.03	m	Discharge	0.2550	m³/s
Inlet Control HW Elev.	232.03	m	Tailwater Elevation	0.00	m
Outlet Control HW Elev.	232.02	m	Control Type	Inlet Control	
Headwater Depth/Height	1.49				

Grades					
Upstream Invert	231.35	m	Downstream Invert	231.13	m
Length	10.80	m	Constructed Slope	2.0370	%

Hydraulic Profile					
Profile	M2		Depth, Downstream	0.35	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.35	m
Velocity Downstream	1.87	m/s	Critical Slope	2.8066	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.46	m
Section Size	450 mm		Rise	0.46	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	232.02	m	Upstream Velocity Head	0.13	m
Ke	0.90		Entrance Loss	0.12	m

Inlet Control Properties					
Inlet Control HW Elev.	232.03	m	Flow Control	Submerged	
Inlet Type	Projecting		Area Full	0.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Payne Road - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.1461	m^3/s	Allowable HW Elevation	232.03	m
Roadway Width	6.00	m	Overtopping Coefficient	1.40	SI
Length	20.00	m	Crest Elevation	232.00	m
Headwater Elevation	232.03	m	Discharge Coefficient (Cr)	2.54	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	232.00
20.00	232.00

Culvert Designer/Analyzer Report
Payne Road - Pre

Analysis Component			
Storm Event	Check	Discharge	1.2300 m^3/s

Peak Discharge Method: User-Specified			
Design Discharge	0.4000 m^3/s	Check Discharge	1.2300 m^3/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	0.00 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-450 mm Circular	0.2727 m^3/s	232.10 m	1.94 m/s
Weir	Roadway (Constant Elevation)	0.9572 m^3/s	232.10 m	N/A
Total	----------------	1.2299 m^3/s	232.10 m	N/A

Culvert Designer/Analyzer Report
Payne Road - Pre

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	232.10	m	Discharge	0.2727	m^3/s
Inlet Control HW Elev.	232.09	m	Tailwater Elevation	0.00	m
Outlet Control HW Elev.	232.10	m	Control Type	Outlet Control	
Headwater Depth/Height	1.65				

Grades					
Upstream Invert	231.35	m	Downstream Invert	231.13	m
Length	10.80	m	Constructed Slope	2.0370	%

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	0.37	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.37	m
Velocity Downstream	1.94	m/s	Critical Slope	3.0067	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.46	m
Section Size	450 mm		Rise	0.46	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	232.10	m	Upstream Velocity Head	0.14	m
Ke	0.90		Entrance Loss	0.13	m

Inlet Control Properties					
Inlet Control HW Elev.	232.09	m	Flow Control	Submerged	
Inlet Type	Projecting		Area Full	0.2	m^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Payne Road - Pre

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.9572	m^3/s	Allowable HW Elevation	232.10	m
Roadway Width	6.00	m	Overtopping Coefficient	1.46	SI
Length	20.00	m	Crest Elevation	232.00	m
Headwater Elevation	232.10	m	Discharge Coefficient (Cr)	2.64	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	232.00
20.00	232.00

Culvert Designer/Analyzer Report
Payne Road - Post

Analysis Component			
Storm Event	Design	Discharge	0.1800 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.1800 m³/s	Check Discharge	0.5100 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	230.51 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-450 mm Circular	0.1800 m³/s	231.03 m	1.59 m/s
Weir	Roadway (Constant Elevation)	0.0000 m³/s	231.03 m	N/A
Total	----------------	0.1800 m³/s	231.03 m	N/A

Culvert Designer/Analyzer Report
Payne Road - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Elev	231.03	m	Discharge	0.1800	m³/s
Inlet Control HW Elev.	230.93	m	Tailwater Elevation	230.51	m
Outlet Control HW Elev.	231.03	m	Control Type	Outlet Control	
Headwater Depth/Height	1.31				

Grades					
Upstream Invert	230.43	m	Downstream Invert	230.35	m
Length	16.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	0.30	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.30	m
Velocity Downstream	1.59	m/s	Critical Slope	2.1834	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.46	m
Section Size	450 mm		Rise	0.46	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	231.03	m	Upstream Velocity Head	0.06	m
Ke	0.90		Entrance Loss	0.06	m

Inlet Control Properties					
Inlet Control HW Elev.	230.93	m	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	0.2	m²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Payne Road - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.0000	m^3/s	Allowable HW Elevation	231.03	m
Roadway Width	6.00	m	Overtopping Coefficient	1.38	SI
Length	20.00	m	Crest Elevation	232.00	m
Headwater Elevation	N/A	m	Discharge Coefficient (Cr)	2.50	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	232.00
20.00	232.00

Culvert Designer/Analyzer Report
Payne Road - Post

Analysis Component			
Storm Event	Check	Discharge	0.5100 m³/s

Peak Discharge Method: User-Specified			
Design Discharge	0.1800 m³/s	Check Discharge	0.5100 m³/s

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	230.51 m

Name	Description	Discharge	HW Elev.	Velocity
Culvert-1	1-450 mm Circular	0.3572 m³/s	232.03 m	2.31 m/s
Weir	Roadway (Constant Elevation)	0.1539 m³/s	232.03 m	N/A
Total	----------------	0.5110 m³/s	232.03 m	N/A

Culvert Designer/Analyzer Report
Payne Road - Post

Component:Culvert-1

Culvert Summary					
Computed Headwater Ele\	232.03	m	Discharge	0.3572	m^3/s
Inlet Control HW Elev.	231.53	m	Tailwater Elevation	230.51	m
Outlet Control HW Elev.	232.03	m	Control Type	Outlet Control	
Headwater Depth/Height	3.50				

Grades					
Upstream Invert	230.43	m	Downstream Invert	230.35	m
Length	16.00	m	Constructed Slope	0.5000	%

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	0.41	m
Slope Type	Mild		Normal Depth	N/A	m
Flow Regime	Subcritical		Critical Depth	0.41	m
Velocity Downstream	2.31	m/s	Critical Slope	4.3616	%

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	0.46	m
Section Size	450 mm		Rise	0.46	m
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	232.03	m	Upstream Velocity Head	0.24	m
Ke	0.90		Entrance Loss	0.22	m

Inlet Control Properties					
Inlet Control HW Elev.	231.53	m	Flow Control	Submerged	
Inlet Type	Projecting		Area Full	0.2	m^2
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Culvert Designer/Analyzer Report
Payne Road - Post

Component:Weir

Hydraulic Component(s): Roadway (Constant Elevation)					
Discharge	0.1539	m^3/s	Allowable HW Elevation	232.03	m
Roadway Width	6.00	m	Overtopping Coefficient	1.41	SI
Length	20.00	m	Crest Elevation	232.00	m
Headwater Elevation	232.03	m	Discharge Coefficient (Cr)	2.55	
Submergence Factor (Kt)	1.00				

Sta (m)	Elev. (m)
0.00	232.00
20.00	232.00

Worksheet for Ditch through Hambly's - 5yr - PRE

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	449.00	L/s
Section Definitions		

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.020

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.07	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.45	m²
Wetted Perimeter	12.69	m
Hydraulic Radius	0.04	m
Top Width	12.69	m
Normal Depth	0.07	m
Critical Depth	0.09	m

Worksheet for Ditch through Hambly's - 5yr - PRE

Results

Critical Slope		0.01114	m/m
Velocity		1.01	m/s
Velocity Head		0.05	m
Specific Energy		0.12	m
Froude Number		1.71	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.07	m
Critical Depth	0.09	m
Channel Slope	3.50000	%
Critical Slope	0.01114	m/m

Worksheet for Ditch through Hambly's - 100yr PRE

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	1380.00	L/s

Section Definitions

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.020

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.11	m
Elevation Range	224.00 to 225.98 m	
Flow Area	1.04	m²
Wetted Perimeter	19.35	m
Hydraulic Radius	0.05	m
Top Width	19.35	m
Normal Depth	0.11	m
Critical Depth	0.14	m

Worksheet for Ditch through Hambly's - 100yr PRE

Results

Critical Slope		0.00960	m/m
Velocity		1.33	m/s
Velocity Head		0.09	m
Specific Energy		0.20	m
Froude Number		1.83	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.11	m
Critical Depth	0.14	m
Channel Slope	3.50000	%
Critical Slope	0.00960	m/m

Worksheet for Ditch through Hambly's - 5yr POST

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	228.00	L/s

Section Definitions

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.020

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.05	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.27	m²
Wetted Perimeter	9.85	m
Hydraulic Radius	0.03	m
Top Width	9.85	m
Normal Depth	0.05	m
Critical Depth	0.07	m

Worksheet for Ditch through Hambly's - 5yr POST

Results

Critical Slope		0.01220	m/m
Velocity		0.85	m/s
Velocity Head		0.04	m
Specific Energy		0.09	m
Froude Number		1.64	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.05	m
Critical Depth	0.07	m
Channel Slope	3.50000	%
Critical Slope	0.01220	m/m

Worksheet for Ditch through Hambly's - 100yr POST

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	661.00	L/s
Section Definitions		

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.020

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.08	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.60	m²
Wetted Perimeter	14.67	m
Hydraulic Radius	0.04	m
Top Width	14.67	m
Normal Depth	0.08	m
Critical Depth	0.10	m

Worksheet for Ditch through Hambly's - 100yr POST

Results

Critical Slope		0.01059	m/m
Velocity		1.11	m/s
Velocity Head		0.06	m
Specific Energy		0.14	m
Froude Number		1.75	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.08	m
Critical Depth	0.10	m
Channel Slope	3.50000	%
Critical Slope	0.01059	m/m

Worksheet for Revegetated Ditch through Hambly's - 5yr PRE

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	449.00	L/s

Section Definitions

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.08	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.61	m²
Wetted Perimeter	14.78	m
Hydraulic Radius	0.04	m
Top Width	14.78	m
Normal Depth	0.08	m
Critical Depth	0.09	m

Worksheet for Revegetated Ditch through Hambly's - 5yr PRE

Results

Critical Slope		0.02507	m/m
Velocity		0.74	m/s
Velocity Head		0.03	m
Specific Energy		0.11	m
Froude Number		1.17	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.08	m
Critical Depth	0.09	m
Channel Slope	3.50000	%
Critical Slope	0.02507	m/m

Worksheet for Revegetated Ditch through Hambly's - 100yr PRE

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	1380.00	L/s

Section Definitions

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.12	m
Elevation Range	224.00 to 225.98 m	
Flow Area	1.41	m²
Wetted Perimeter	22.53	m
Hydraulic Radius	0.06	m
Top Width	22.53	m
Normal Depth	0.12	m
Critical Depth	0.14	m

Worksheet for Revegetated Ditch through Hambly's - 100yr PRE

Results

Critical Slope		0.02159	m/m
Velocity		0.98	m/s
Velocity Head		0.05	m
Specific Energy		0.17	m
Froude Number		1.25	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.12	m
Critical Depth	0.14	m
Channel Slope	3.50000	%
Critical Slope	0.02159	m/m

Worksheet for Revegetated Ditch through Hambly's - 5yr POST

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	228.00	L/s
Section Definitions		

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.06	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.36	m²
Wetted Perimeter	11.47	m
Hydraulic Radius	0.03	m
Top Width	11.47	m
Normal Depth	0.06	m
Critical Depth	0.07	m

Worksheet for Revegetated Ditch through Hambly's - 5yr POST

Results

Critical Slope		0.02744	m/m
Velocity		0.63	m/s
Velocity Head		0.02	m
Specific Energy		0.08	m
Froude Number		1.12	
Flow Type	Supercritical		

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.06	m
Critical Depth	0.07	m
Channel Slope	3.50000	%
Critical Slope	0.02744	m/m

Worksheet for Revegetated Ditch through Hambly's - 100yr POST

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.50000	%
Discharge	661.00	L/s
Section Definitions		

Station (m)	Elevation (m)
0+00	225.98
0+12	225.00
0+45	224.00
1+92	225.00
2+00	225.80

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 225.98)	(2+00, 225.80)	0.030

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.09	m
Elevation Range	224.00 to 225.98 m	
Flow Area	0.81	m²
Wetted Perimeter	17.09	m
Hydraulic Radius	0.05	m
Top Width	17.09	m
Normal Depth	0.09	m
Critical Depth	0.10	m

Worksheet for Revegetated Ditch through Hambly's - 100yr POST

Results

Critical Slope	0.02381	m/m
Velocity	0.82	m/s
Velocity Head	0.03	m
Specific Energy	0.13	m
Froude Number	1.20	
Flow Type	Supercritical	

GVF Input Data

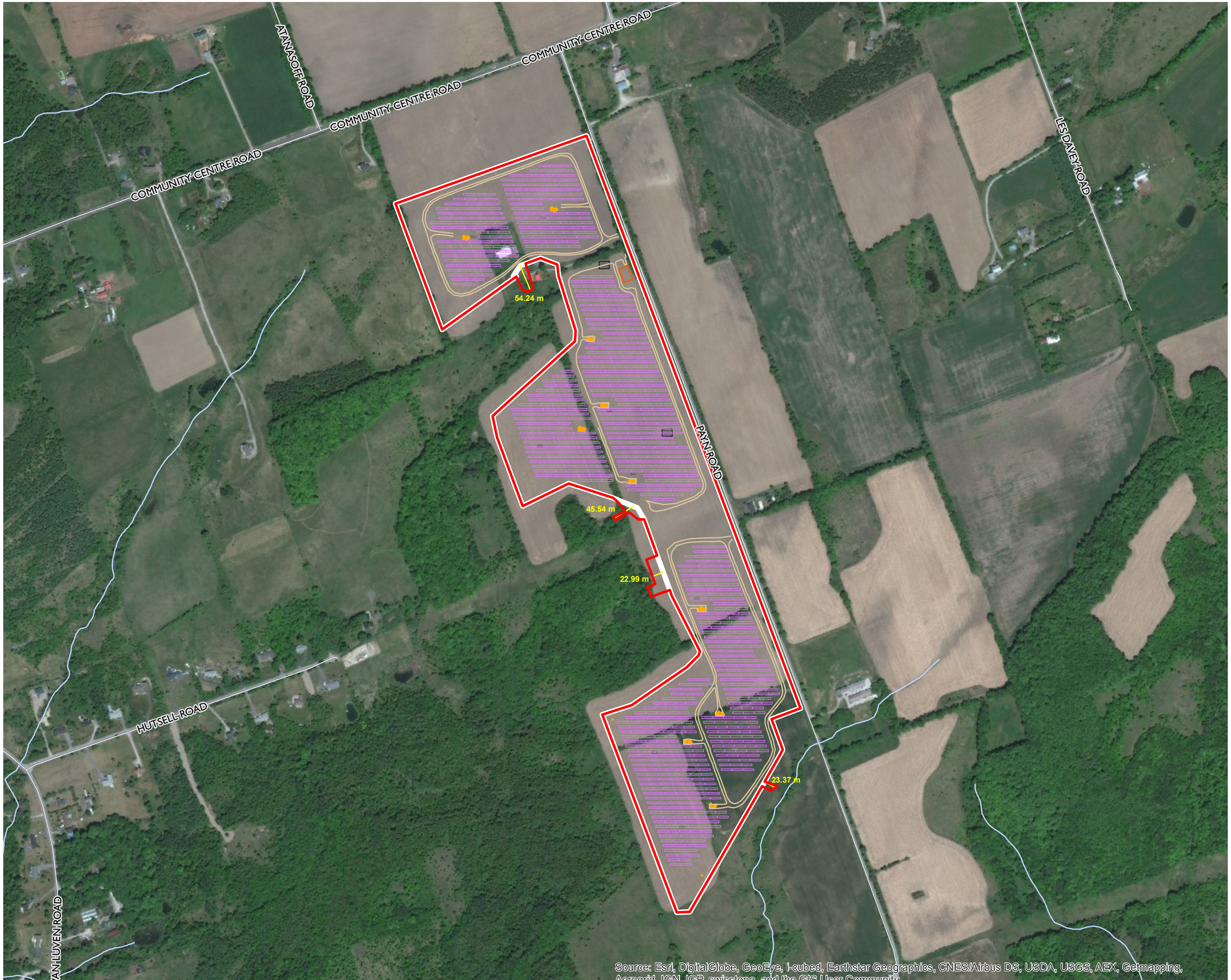
Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.09	m
Critical Depth	0.10	m
Channel Slope	3.50000	%
Critical Slope	0.02381	m/m

Appendix D

PROJECT LOCATION BOUNDARY
SHOWING MODIFICATIONS



HAMILTON SOLAR PROJECT

PROJECT LOCATION BOUNDARY MODIFICATIONS

Final Project Components

- Measure
- Revised Project Location Boundary
- Inverter
- Substation
- Access Road
- PV Panel

Preliminary Project Components

- REA Project Boundary
- Interconnection
- Collection House

1:7,500

0 50 100 200 m

N W E S

MAP CREATED BY: GM
MAP CHECKED BY: MB
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 152725
STATUS: FINAL
DATE: 11/3/2016

FILE LOCATION: I:\GIS\152725 - CSSI Penn Hamilton\mxd\Penn Hamilton Comparison of Project Components.mxd

Appendix E

MNRF AND MTCS CORRESPONDENCE

DILLON CONSULTING

Bellamy, Megan <mbellamy@dillon.ca>

Fwd: FW: NHA Modification for Penn Hamilton Solar Project

1 message

Petruniak, Jennifer <jpetruniak@dillon.ca> 18 May 2016 at 16:08
To: Megan Bellamy <mbellamy@dillon.ca>, Mark Feenstra <Mark.Feenstra@canadiansolar.com>, Permitting <Permitting@canadiansolar.com>

Pls see below from the MNRF for inclusion in the REA amendment

DILLON CONSULTING
70 years

Jennifer Petruniak
Associate
Dillon Consulting Limited
235 Yorkland Blvd Suite 800
Toronto, Ontario, M2J 4Y8
T - 416.229.4647 ext. 2432
F - 416.229.4692
M - 416.671.6825
JPetruniak@dillon.ca
www.dillon.ca

---------- Forwarded message ----------
From: **Beal, Jim (MNRF)** <jim.beal@ontario.ca>
Date: Wed, May 18, 2016 at 4:04 PM
Subject: RE: FW: NHA Modification for Penn Hamilton Solar Project
To: "Petruniak, Jennifer" <jpetruniak@dillon.ca>

MNRF has no objections to the amendment and a re-confirmation letter is not required.

Jim Beal

705-755-1362

Ministry of Natural Resources

Peterborough District Office
P.O Box 7000, 300 Water Street
1st Floor, South Tower
Peterborough, Ontario K9J 8M5
Telephone: (705) 755-2001
Facsimile: (705) 755-3125

Ministère des Richesses naturelles

Le bureau du district de Peterborough
C.P. 7000, 300 rue Water
Peterborough, Ontario K9J 8M5
Telephone: (705) 755-2001
Facsimile: (705) 755-3125

Ontario

April 20, 2011

Penn Energy Trust, LLC
620 Righters Ferry Road
Bala Cynwyd, PA 19004
United States of America

Attention: Mr. Max A. Frable, AIA

Dear Mr. Frable,

In accordance with the Ministry of the Environment's (MOE's) Renewable Energy Approvals regulation (O.Reg.359/09), applicants are required to prepare a natural heritage assessment and environmental impact study using evaluation criteria or procedures established or accepted by the Ministry of Natural Resources (MNR). The regulation requires MNR to confirm that the natural heritage assessment and environmental impact study, including mitigation measures, were prepared using established procedures acceptable to MNR. The MNR's confirmation letter, along with other required project documentation, must be submitted to MOE as part of an application for a Renewable Energy Approval for consideration by MOE in making their Renewable Energy Approval decision.

The Ministry of Natural Resources (MNR) has reviewed the natural heritage assessment and environmental impact study for the Penn Energy – Hamilton_Port Hope-4 Solar Energy Facility for Lot 3 Concession 2 of the geographic Township o Hamilton, in the County of Northumberland, submitted by Bowfin Environmental Consulting in April 2011.

In accordance with sections 28(2) and 38(2) (b) of the Renewable Energy Approvals regulation, MNR provides the following confirmations following review of the natural heritage assessment reports:

1. The MNR confirms that the determination of the existence of natural features and the boundaries of natural features was made using applicable evaluation criteria or procedures established or accepted by MNR.
2. The MNR confirms that the site investigation and records review were conducted using applicable evaluation criteria or procedures established or accepted by MNR, if no natural features were identified.
3. The MNR confirms that the evaluation of the significance or provincial significance of the natural features was conducted using applicable evaluation criteria or procedures established or accepted by MNR (if required).
4. The MNR confirms that the project location is not in a provincial park or conservation reserve.
5. The MNR confirms that the environmental impact study report has been prepared in accordance with procedures established by the MNR.

In accordance with Section 28(3)(c) and 38(2)(c) of the Renewable Energy Approvals regulation, MNR offers the following comments in respect of the project:

MNR is providing this confirmation letter based on the review of the information provided in your natural heritage assessment reports. Applicants should be aware of the transition provisions under section 62 of the amended Renewable Energy Approvals regulation and fulfill natural heritage assessment requirements accordingly.

Where specific commitments have been made by the applicant in the natural heritage assessment with respect to project design, construction, rehabilitation, operation, mitigation, or monitoring, MNR expects that these commitments will be considered in MOE's Renewable Energy Approval decision and, if approved, be implemented by the applicant.

This confirmation letter is valid for the project as proposed in the natural heritage assessment and environmental impact study, including those sections describing the environmental effects monitoring plan and construction plan report. Should any changes be made to the proposed project that would alter the natural heritage assessment, MNR may need to undertake additional review of the natural heritage assessment.

In accordance with section 12(1) of the Renewable Energy Approvals Regulation, this letter must be included as part of your application submitted to the MOE for a Renewable Energy Approval.

If you wish to discuss any part of the confirmation or additional comments provided, please contact Eric R. Prevost, Renewable Energy Planning Ecologist, at (705) 755-3134.

Sincerely,

K Bellamy

Karen Bellamy
District Manager
Peterborough District, MNR

cc. Jim Beal, Renewable Energy Provincial Field Program Coordinator, Regional Operations Division, MNR

Narren Santos, Environmental Assessment and Approvals Branch, MOE

Ministry of Tourism, Culture and Sport

Archaeology Programs Unit
Programs and Services Branch
Culture Division
401 Bay Street, Suite 1700
Toronto ON M7A 0A7
Tel.: (807) 475-1628
Email: Paige.Campbell@ontario.ca

Ministère du Tourisme, de la Culture et du Sport

Unité des programmes d'archéologie
Direction des programmes et des services
Division de culture
401, rue Bay, bureau 1700
Toronto ON M7A 0A7
Tél. : (807) 475-1628
Email: Paige.Campbell@ontario.ca

Ontario

Jul 22, 2016

T. Keith Powers (P052)
The Archaeologists Inc.
790 Exceller Newmarket ON L3X 1P6

RE: Review and Entry into the Ontario Public Register of Archaeological Reports: Archaeological Assessment Report Entitled, "Stage 2 Archaeological Assessment of the Penn Energy - Hamilton_Port Hope4 Solar Project - Additional Lands, Part of Lot 3, Concession 2, Hamilton Township, Northumberland County, Ontario ", Dated May 24, 2016, Filed with MTCS Toronto Office on Jun 20, 2016, MTCS Project Information Form Number P052-0691-2016, MTCS File Number HD00575

Dear Mr. Powers:

This office has reviewed the above-mentioned report, which has been submitted to this ministry as a condition of licensing in accordance with Part VI of the Ontario Heritage Act, R.S.O. 1990, c 0.18.[1] This review has been carried out in order to determine whether the licensed professional consultant archaeologist has met the terms and conditions of their licence, that the licensee assessed the property and documented archaeological resources using a process that accords with the 2011 Standards and Guidelines for Consultant Archaeologists set by the ministry, and that the archaeological fieldwork and report recommendations are consistent with the conservation, protection and preservation of the cultural heritage of Ontario.

The report documents the assessment of the study area as depicted in Map 5 of the above titled report and recommends the following:

The stage 2 survey did not identify any archaeological sites requiring further assessment or mitigation of impacts and it is recommended that no further archaeological assessment of the property be required.

Based on the information contained in the report, the ministry is satisfied that the fieldwork and reporting for the archaeological assessment are consistent with the ministry's 2011 Standards and Guidelines for Consultant Archaeologists and the terms and conditions for archaeological licences. This report has been entered into the Ontario Public Register of Archaeological Reports. Please note that the ministry makes no representation or warranty as to the completeness, accuracy or quality of reports in the register.

Should you require any further information regarding this matter, please feel free to contact me.

Sincerely,

Paige Campbell
Archaeology Review Officer

cc. Archaeology Licensing Officer
Don Ling,Canadian Solar Inc.
Wendy McQueen,Cobourg Heritage Committee

[1]In no way will the ministry be liable for any harm, damages, costs, expenses, losses, claims or actions that may result: (a) if the Report(s) or its recommendations are discovered to be inaccurate, incomplete, misleading or fraudulent; or (b) from the issuance of this letter. Further measures may need to be taken in the event that additional artifacts or archaeological sites are identified or the Report(s) is otherwise found to be inaccurate, incomplete, misleading or fraudulent.

Appendix F

STAGE 2 ARCHAEOLOGICAL ASSESSMENT

Stage 2 Archaeological Assessment of the Penn Energy - Hamilton_Port Hope4 Solar Project - Additional Lands, Part of Lot 3, Concession 2, Hamilton Township, Northumberland County, Ontario

PROJECT DESIGNATION: FIT #: F-000687-SPV-130-505

Prepared by

Licensee: Mr. T. Keith Powers
Archaeological Consulting Licence P052
Project Information Number P052-0691-2016

THE ARCHAEOLOGISTS INC.

Original Report
Report Dated: May 24, 2016

EXECUTIVE SUMMARY

The Archaeologists Inc. was contracted to conduct a Stage 2 Archaeological Assessment of the Penn Energy - Hamilton_Port Hope4 Solar Project - Additional Lands, Part of Lot 3, Concession 2, Hamilton Township, Northumberland County, Ontario. The proponent is seeking a Renewable energy Approval according to Ontario Regulation 359/09 issued under the Environmental Protection act, Sections 20, 21 and 22 (FIT# F-000687-SPV-130-505).

A Stage 1 to 3 archaeological assessment of the subject property was undertaken by Northeastern Archaeological Associates Ltd. (PIF #: P025-197-2010), to provide information about the property's geography, history, previous archaeological fieldwork and current land condition in order to evaluate and document in detail the property's archaeological potential and to recommend appropriate strategies for Stage 2 survey. The Stage 1 background study determined that the subject property exhibits archaeological potential and should be subject to a Stage 2 archaeological assessment.

A Stage 2 property assessment was conducted by Northeastern Archaeological Associates Ltd. (PIF #: P025-197-2010) to document all archaeological resources on the property, to determine whether the property contains archaeological resources requiring further assessment, and to recommend next steps. The characteristics of the property dictated that the Stage 2 survey be conducted by pedestrian and test pit survey. The Stage 2 property assessment resulted in the identification of two archaeological sites (BaGm-11 and BaGm-12).

The Archaeologists Inc. was contracted to conducted a Stage 2 archaeological assessment of additional lands that fell outside the previously surveyed areas. The Stage 2 property assessment of the additional lands, which consisted of a systematic test pit survey, did not identify any archaeological resources within the additional lands of the subject property. The report recommends that no further archaeological assessment of the additional lands is required.

TABLE OF CONTENTS

PROJECT PERSONNEL

Project Director:	Mr. T. Keith Powers (P052)
Field Director:	Mr. T. Keith Powers
Field Archaeologists	Mr. T. Keith Powers Mr. Barclay Powers Mr. Sam Felipe
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Graphics	Mrs. Karen Powers

INTRODUCTION

The *Ontario Heritage Act*, R.S.O. 1990 c. O.18, requires anyone wishing to carry out archaeological fieldwork in Ontario to have a license from the Ministry of Tourism, Culture & Sport (MTCS). All licensees are to file a report with the MTCS containing details of the fieldwork that has been done for each project. Following standards and guidelines set out by the MTC is a condition of a licence to conduct archaeological fieldwork in Ontario. *The Archaeologists Inc.* confirms that this report meets ministry report requirements as set out in the *2011 Standards and Guidelines for Consultant Archaeologists*, and is filed in fulfillment of the terms and conditions an archaeological license.

1.0 PROJECT CONTEXT (Section 7.5.5)

This section of the report will provide the context for the archaeological fieldwork, including the development context, the historical context, and the archaeological context.

1.1 Development Context (Section 7.5.6, Standards 1-3)

Section 7.5.6, Standard 1
The Archaeologists Inc. was contracted to conducted a Stage 2 Archaeological Assessment of the Penn Energy - Hamilton_Port Hope4 Solar Project - Additional Lands, Part of Lot 3, Concession 2, Hamilton Township, Northumberland County, Ontario. The additional lands surveyed by The Archaeologists Inc. is part of a property that is 100 acres of agricultural land about 1 km north of highway 401, and east of the city of Cobourg, Ontario. The proponent is seeking a Renewable energy Approval according to Ontario Regulation 359/09 issued under the Environmental Protection act, Sections 20, 21 and 22 (FIT# F-000687-SPV-130-505).

Section 7.5.6, Standard 2
There is no additional development-related information relevant to understanding the choice of fieldwork strategy or recommendations made in the report.

Section 7.5.6, Standard 3
Permission to access the study area to conduct all required archaeological fieldwork activities, including the recovery of artifacts was given by the landowner and their representative.

1.2 Historical Context (Section 7.5.7, Standards 1-2)

Section 7.5.7, Standard 1
In advance of the Stage 2 assessment, a Stage 1 background study of the subject property was conducted by Northeastern Archaeological Associates Limited (PIF#: P025-197-2010), in order to document the property's archaeological and land use history and present condition. Several sources were referenced to determine if features or

characteristics indicating archaeological potential for pre-contact and post-contact resources exist.

Characteristics indicating archaeological potential include the near-by presence of previously identified archaeological sites, primary and secondary water sources, features indicating past water sources, accessible or inaccessible shoreline, pockets of well-drained sandy soil, distinctive land formations that might have been special or spiritual places, such as waterfalls, rock outcrops, caverns, mounds, and promontories and their bases, resource areas, (including food or medicinal plants, scarce raw materials, early Euro-Canadian industry), areas of early Euro-Canadian settlement, early historical transportation routes, property listed on a municipal register or designated under the *Ontario Heritage Act* or that is a federal, provincial or municipal historic landmark or site, and property that local histories or informants have identified with possible archaeological sites, historical events, activities, or occupations.

Archaeological potential can be determined not to be present for either the entire property or a part of it when the area under consideration has been subject to extensive and deep land alterations that have severely damaged the integrity of any archaeological resources. This is commonly referred to as ‘disturbed’ or ‘disturbance’, and may include: quarrying, major landscaping involving grading below topsoil, building footprints, and sewage and infrastructure development. Archaeological potential is not removed where there is documented potential for deeply buried intact archaeological resources beneath land alterations, or where it cannot be clearly demonstrated through background research and property inspection that there has been complete and intensive disturbance of an area. Where complete disturbance cannot be demonstrated in Stage 1, it will be necessary to undertake Stage 2 assessment.

The background study, conducted by Northeaster Archaeological Associates Limited, determined that the following features or characteristics indicate archaeological potential for a portion of the subject property:

> *“The subject property in the Township of Hamilton, and just southeast of the Town of Baltimore, is within the broad settlement area associated with the City of Cobourg to its southwest. Cobourg, settled originally by United Empire Loyalists, was first known as Amherst and then as Hamilton, before finally adopting its present name. It was settled early on, the first settler being Elias Nicholson, who built a small cabin in 1798. Elias Jones opened the first store on King Street in 1802. Cobourg was incorporated as a village in 1837 and as a town in 1850. Construction of Victoria Hall in downtown Cobourg began in 1856 and was completed in 1860. The Cobourg and Peterborough railway opened to Rice Lake in 1854.*
>
> *Locally, a search of the land registry records for Lot 3, Concession 2 shows the patent for the property as going to Kings College in 1828. The assessment rolls and census records for the lot however, indicate that the first individual recorded here was Adolphus Hellenborld in 1823. The first recorded land cultivation was in 1827, and the first recorded house on the property was in 1837 under the name*

> *Pat Buirk. This house was recorded as being frame and brick and is therefore not thought to be associated with the still standing stone house in the north end of the property.*
>
> *Land registry records show that in 1851 and 1852, the property was sold in parts to David Haig and John Lidgate. Census records however indicate that it was being used by several people at this time. In total, there were 31 land transactions in regards to the property between 1855 and 1958. Primary names involved in these transactions include: Jayne, Weir, Mann, Hydro Electric, and later Parker. The name Buirk does not show up in the land registry forms.*
>
> *The 1878 Historic Atlas Map for Hamilton Township indicates that the area was well populated. The property at the time is shown as owned in parts by D. Haig and A. Lundgate – a slightly different spelling from the previous Lidgate. A house is shown on the end of the property owned by Haig. This map also shows several other houses within the surrounding properties. The house shown on the property at this time corresponds with a still standing stone house in the north end. (H. Belden & Co. 1878). Figure 3 below shows the area of the Historic Atlas map in which the property is located."*

In summary, the Stage 1 background study indicates, that there is potential for the recovery of pre-contact and post-contact Euro-Canadian archaeological resources within the subject property. As it cannot be clearly demonstrated through the background study that there has been complete and intensive disturbance of the area, archaeological potential is not removed. There are areas within the subject property that have the potential for the recovery of archaeological resources.

Section 7.5.7, Standard 2

The Stage 2 property assessment of the additional lands of the subject property will employ the strategy of test pit survey, following the standards listed in Sections 2.1.1 and 2.1.2 of the *2011 Standards and Guidelines for Consultant Archaeologists*. This is the appropriate strategy based on the field conditions and the Stage 1 background study. To our knowledge there are no other reports containing relevant background information related to this development project other than that described above.

1.3 Archaeological Context (Section 7.5.8, Standards 1-7)

Section 7.5.8, Standard 1

In Ontario, information concerning archaeological sites is stored in the Ontario Archaeological Sites Database (O.A.S.D.), an inventory of the documented archaeological record in Ontario.

Summary information on the known archaeological sites in the vicinity of the study area was obtained from the Stage 1 to 3 report conducted by Northeaster Archaeological Associates Limited (PIF#: P025-197-2010). According to their report:

> *"A search of the archaeological sites data base of the Ontario Ministry of Culture by data co-ordinator Robert von Bitter on September 21, 2010 did not produce evidence of any recorded archaeological sites within a 2 km radius of the subject property. Given the lack of systematic survey in the area, it is likely that archaeological sites will be discovered in this area in future."*

Section 7.5.8, Standard 2

The subject property is located in the South Slope physiographic region of southern Ontario (Chapman and Putnam 1973). The South Slope is, as its name suggests, the southern slope of the Oak Ridges Interlobate Moraine which was formed when the Simcoe and Ontario lobes of the Northern ice sheet separated about 12,600 years B.P. The south slope in Durham and Ontario counties is drumlinized, with outliers of the Peterborough Drumlin Field common. Streams flow directly down slope and generally have cut deep valleys in the soft slope sediments. (Chapman and Putnam 1973). Locally, the subject property is in an area of sand plains and drumlins. The property itself is in an upland area with good drainage. Most of the vegetation has been cleared in association with cultivation. (Northeastern Archaeological Associates Limited, 2011).

Section 7.5.8, Standard 3

The Stage 2 archaeological fieldwork of the subject property was undertaken on April 29th, 2016 under favourable weather conditions for the assessment.

Section 7.5.8, Standard 4

No previous archaeological fieldwork, with the exception of the above noted Stage 1 to 3 archaeological assessment conducted by Northeastern Archaeological Associates Limited (PIF # P025-197-2010), has taken place within the limits of the project area.

The Stage 1 background study determined that the subject area retained the potential for archaeological resources. The Stage 2 assessment, which consisted of about 950 shovel test and a pedestrian survey of eight ploughed fields, resulted in the discovery of one Euro-Canadian homestead site (BaGm-11), as well as the discovery of three pre-contact ceramic fragments and two lithic fragments (BaGm-12). No further work was recommended for site BaGm-12 since the solar array was shifted away from this field during the course of the assessment. Stage 3 excavation of site BaGm-11 revealed a significantly early Euro-Canadian residence site and the recommendation was made that the site be excluded from the project area with a 20 meter buffer, or a full Stage 4 excavation be performed.

We are not aware of previous archaeological fieldwork carried out immediately adjacent to the project area nor are there sites documented immediately adjacent to the subject property, i.e. within 50 metres.

Section 7.5.8, Standard 5

We are unaware of any previous findings and recommendations relevant to the current stage of work, with the exception of the above noted Stage 1 to 3 archaeological assessment by Northeastern Archaeological Associates Limited.

Section 7.5.8, Standard 6

There are no other features that may have affected fieldwork strategy decisions or the identification of artifacts or cultural features.

Section 7.5.8, Standard 7

There is no additional archaeological information that may be relevant to understanding the choice of fieldwork techniques or the recommendations of this report.

2.0 FIELD METHODS (Section 7.8.1, Standards 1-3)

This section of the report addresses Section 7.8.1 of the 2011 Standards and Guidelines for Consultant Archaeologists. It does not address Section 7.7.2 because no property inspection was done as a separate Stage 1.

Section 7.8.1, Standard 1
The entire project area was surveyed.

Section 7.8.1, Standard 2
As relevant, we provide detailed and explicit descriptions addressing Standards 2a and b.

Section 7.8.1, Standard 2a - The general standards for property survey under Section 2.1 of the 2011 Standards and Guidelines for Consultant Archaeologists were addressed as follows:

- Section 2.1, S1 – All of the subject property was assessed.
- Section 2.1, S2a (land of no or low potential due to physical features such as permanently wet areas, exposed bedrock, and steep slopes) - n/a
- Section 2.1, S2b (no or low potential due to extensive and deep land alterations) – n/a.
- Section 2.1, S2c (lands recommended not to require Stage 2 assessment by a previous Stage 1 report where the ministry has accepted that Stage 1 into the register) - n/a
- Section 2.1, S2d (lands designated for forest management activity w/o potential for impacts to archaeological sites, as determined through Stage 1 forest management plans process) - n/a
- Section 2.1, S2e (lands formally prohibited from alterations) - n/a
- Section 2.1, S2f (lands confirmed to be transferred to a public land holding body, etc) - n/a
- Section 2.1, S3 - The Stage 2 survey was conducted when weather and lighting conditions permitted excellent visibility of features.
- Section 2.1, S4 - No GPS recordings were taken as no artifacts were found during the Stage 2 assessment.
- Section 2.1, S5 - All field activities were mapped in reference to either fixed landmarks, survey stakes and development markers as appropriate. See report section *9.0 Maps*.
- Section 2.1, S6 - See report section *8.0 Images* for photo documentation of examples of field conditions encountered.
- Section 2.1, S7 - n/a

Section 7.8.1, Standard 2b - The subject property was subject to a systematic test pit survey appropriate to the characteristics of the property.

The test pit survey of the property followed the standards within Section 2.1.2 of the *2011 Standards and Guidelines for Consultant Archaeologists*. Test pit survey was only conducted where ploughing was not possible or viable, as per Standard 1. Test pits were spaced at maximum intervals of five metres and to within one metre of built structures, when present, or until test pits show evidence of recent ground disturbance. All test pits were at least 30 cm in diameter. Each test pit was excavated by hand, into the first five cm of subsoil and examined for stratigraphy, cultural features, or evidence of fill. No stratigraphy or cultural features were noted. Soils were screened through 6mm mesh. All test pits were backfilled.

Section 7.8.1, Standard 2c - All areas of the subject property exhibiting moderate to high archaeological potential were surveyed at five metre intervals.

Section 7.8.1, Standard 3

100% of the additional lands on the subject property was surveyed and subject to test pit survey at 5-metre intervals.

3.0 RECORD OF FINDS (Section 7.8.2, Standards 1-3)

This section documents all finds discovered as a result of the Stage 2 archaeological assessment of the subject property.

Section 7.8.2, Standard 1
No archaeological resources or sites were identified in the Stage 2.

Section 7.8.2, Standard 2
An inventory of the documentary record generated in the field is provided in Table 2.

Table 2: Inventory of Documentary Record

Document Type	Description
Field Notes	• This report constitutes the field notes for this project
Photographs	• 5 digital photographs
Maps	• report figures represent all of the maps generated in the field.

***Section 7.8.2, Standard* 3**
Information detailing exact site locations on the property is not submitted because no sites or archaeological resources were identified in the Stage 2 assessment.

4.0 ANALYSIS AND CONCLUSIONS (Section 7.8.3, Standards 1-2)

Section 7.8.3, Standard 1
No archaeological sites were identified. Standard 2 is not addressed because no sites were identified.

5.0 RECOMMENDATIONS (Section 7.8.4, Standards 1-3)

Section 7.8.4, Standard 1
This standard is not applicable as no sites were identified.

Section 7.8.4, Standard 2
The report makes recommendations only regarding archaeological matters.

Section 7.8.4, Standard 3
The stage 2 survey did not identify any archaeological sites requiring further assessment or mitigation of impacts and it is recommended that no further archaeological assessment of the property be required.

6.0 ADVICE ON COMPLIANCE WITH LEGISLATION (Section 7.5.9, Standards 1-2)

Section 7.5.9, Standard 1a

This report is submitted to the Minister of Tourism and Culture as a condition of licensing in accordance with Part VI of the *Ontario Heritage Act*, R.S.O. 1990, c 0.18. The report is reviewed to ensure that it complies with the standards and guidelines that are issued by the Minister, and that the archaeological fieldwork and report recommendations ensure the conservation, protection and preservation of the cultural heritage of Ontario. When all matters relating to archaeological sites within the project area of a development proposal have been addressed to the satisfaction of the Ministry of Tourism and Culture, a letter will be issued by the ministry stating that there are no further concerns with regard to alterations to archaeological sites by the proposed development.

Section 7.5.9, Standard 1b

It is an offence under Sections 48 and 69 of the *Ontario Heritage Act* for any party other than a licensed archaeologist to make any alteration to a known archaeological site or to remove any artifact or other physical evidence of past human use or activity from the site, until such time as a licensed archaeologist has completed archaeological fieldwork on the site, submitted a report to the Minister stating that the site has no further cultural heritage value or interest, and the report has been filed in the Ontario Public Register of Archaeological Reports referred to in Section 65.1 of the *Ontario Heritage Act*.

Section 7.5.9, Standard 1c

Should previously undocumented archaeological resources be discovered, they may be a new archaeological site and therefore subject to Section 48 (1) of the *Ontario Heritage Act*. The proponent or person discovering the archaeological resources must cease alteration of the site immediately and engage a licensed consultant archaeologist to carry out archaeological fieldwork, in compliance with Section 48 (1) of the *Ontario Heritage Act*.

Section 7.5.9, Standard 1d

The *Cemeteries Act*, R.S.O, 1990 c. C.4 and the *Funeral, Burial and Cremation Services Act*, 2002, S.O. 2002, c.33 (when proclaimed in force) require that any person discovering human remains must notify the police or coroner and the Registrar of Cemeteries at the Ministry of Consumer Services.

Section 7.5.9, Standard 2

Not applicable

7.0 BIBLIOGRAPHY AND SOURCES (Section 7.5.10, Standards 1)

Chapman, L.J. and F. Putnam

1984 The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2. Toronto: Government of Ontario, Ministry of Natural Resources.

Ministry of Tourism and Culture

2011 Standards and Guidelines for Consultant Archaeologists.

Illustrated Historical Atlas of Frontenac County, Ontario.

1878 Toronto: Miles & Co.

Northeastern Archaeological Associates Limited

2011 STAGE 1 TO 3 ARCHAEOLOGICAL ASSESSMENT OF THE PENN ENERGY – HAMILTON_PORT HOPE4 SOLAR PROJECT, LOT 3, CONCESSION 2, HAMILTON TOWNSHIP, NORTHUMBERLAND COUNTY, ONTARIO. (PIF# P-025-197-2010).

8.0 IMAGES (Sections 7.5.11, 7.8.6)

Plate 1: Shows conditions of additional lands on subject property – area test pitted at 5-metre intervals.

Plate 2: Shows conditions additional lands on subject property – area test pitted at 5-metre intervals.

9.0 MAPS (Section 7.5.12, 7.8.7)

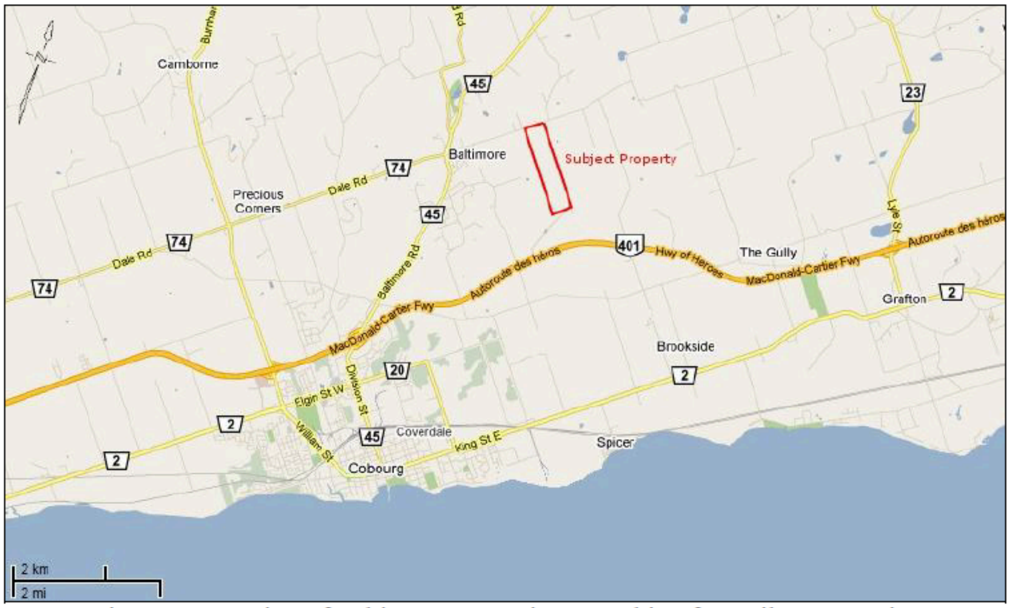


Figure 1: Location of Subject Property in Township of Hamilton, Ontario.

Map 1: Approximate location of subject property. Taken from Stage 1 to 3 archaeological assessment report (Northeastern Archaeological Associates Limited, PIF #P025-197-2010).

Figure 2: Aerial Photo Showing Outline of Subject Property in Red.

Map 2: Approximate location of subject property. Taken from Stage 1 to 3 archaeological assessment report (Northeastern Archaeological Associates Limited, PIF #P025-197-2010).

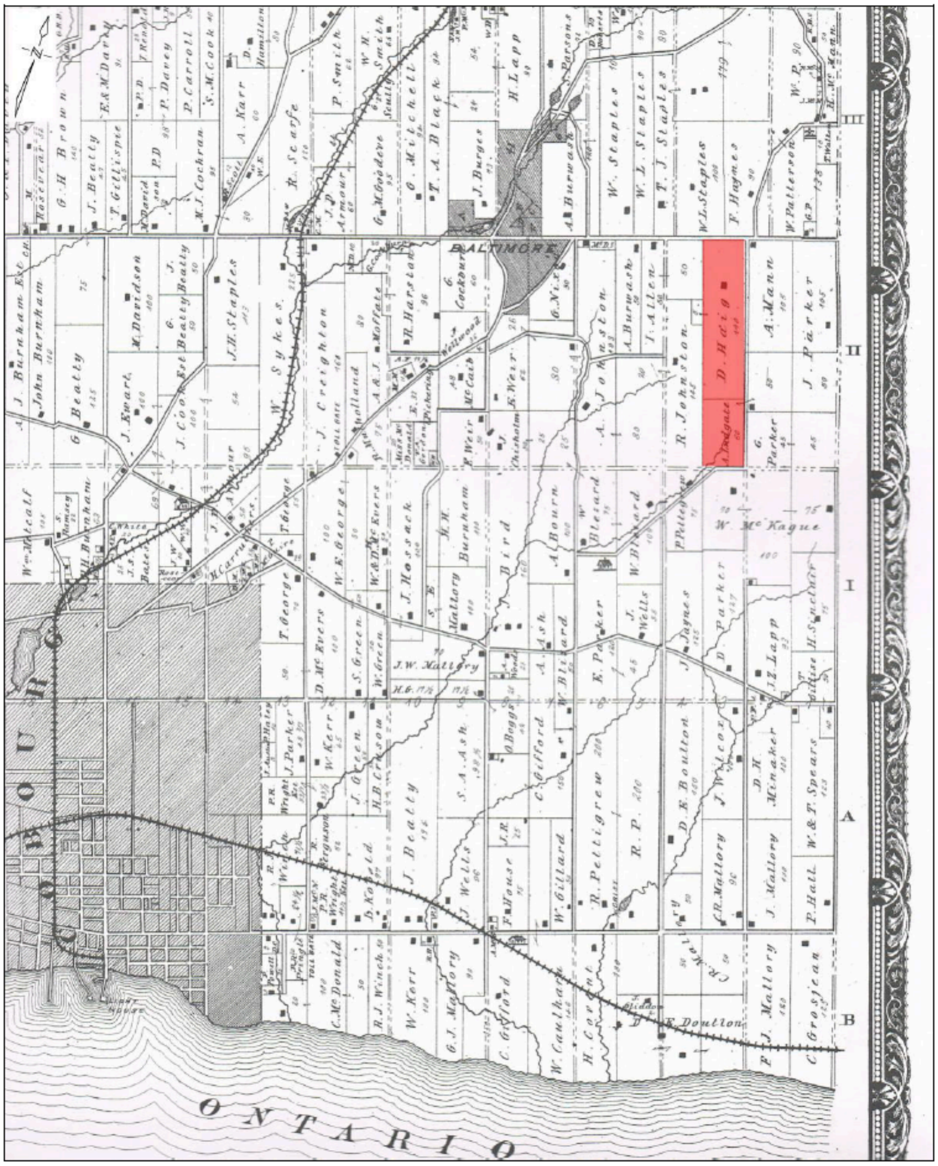
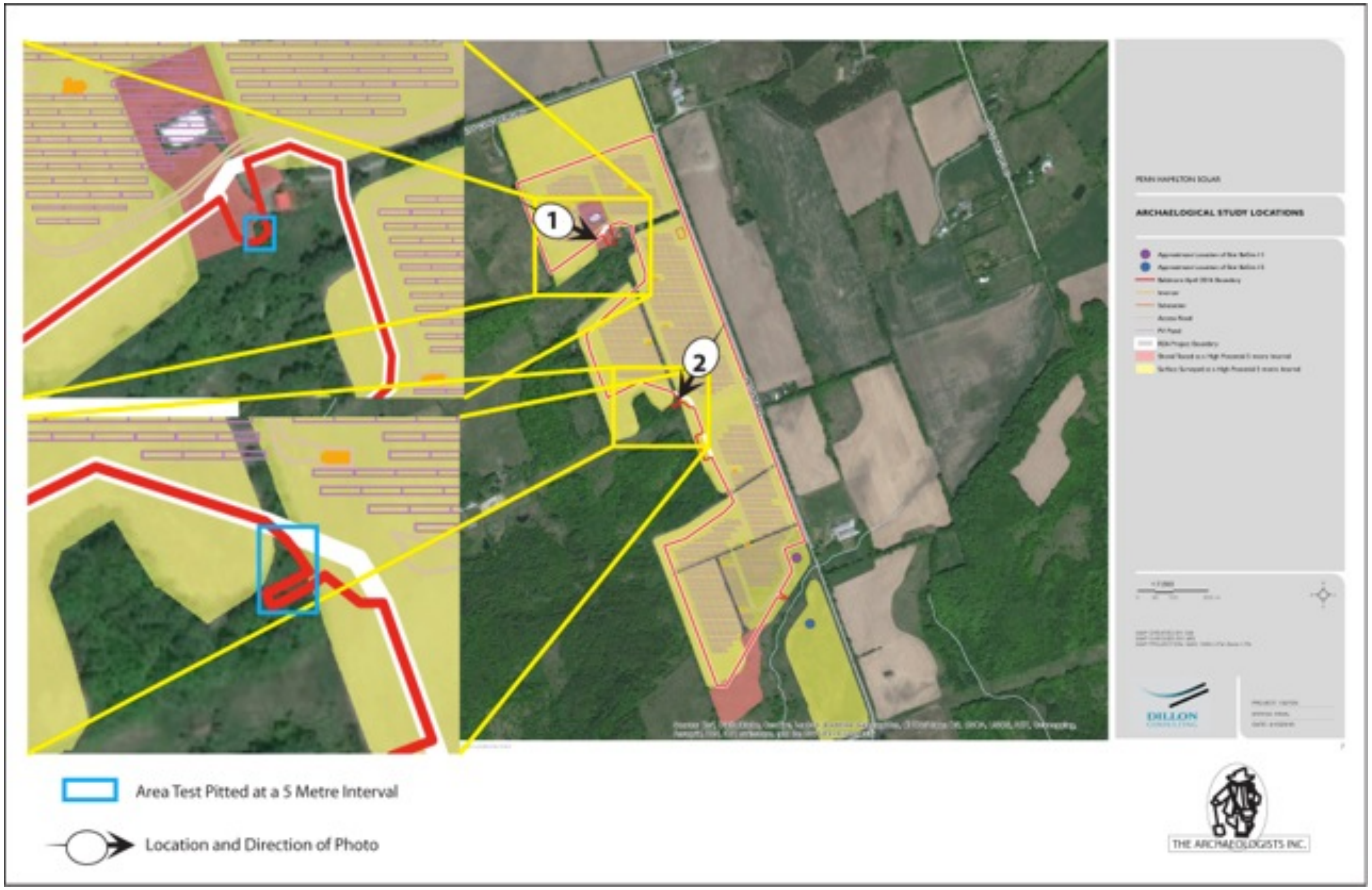


Figure 3: 1878 Historic Atlas Map of Hamilton Township Showing Subject Lot and Concession in Red (after H. Belden & Co. 1878).

Map 3: Approximate location of subject property on 1878 Historic Atlas of Hamilton Township. Taken from Stage 1 to 3 archaeological assessment (Northeastern Archaeological Associates Limited, PIF #P025-197-2010).

Map 4: Map outlining original subject property area. Taken from Stage 1 to 3 archaeological assessment (Northeastern Archaeological Associates Limited, PIF #P025-197-2010).



Map 5: Map depicting areas of additional lands within subject property and results of Stage 2 archaeological assessment of additional lands.

Appendix G

NOTICE OF REA AMENDMENT

NOTICE OF A PROPOSED CHANGE TO AN APPROVED RENEWABLE ENERGY PROJECT (REA No. 0905-8S7M96)

For the Hamilton_Port Hope-4 Solar Farm Facility
By Hamilton Solar Farm Partnership

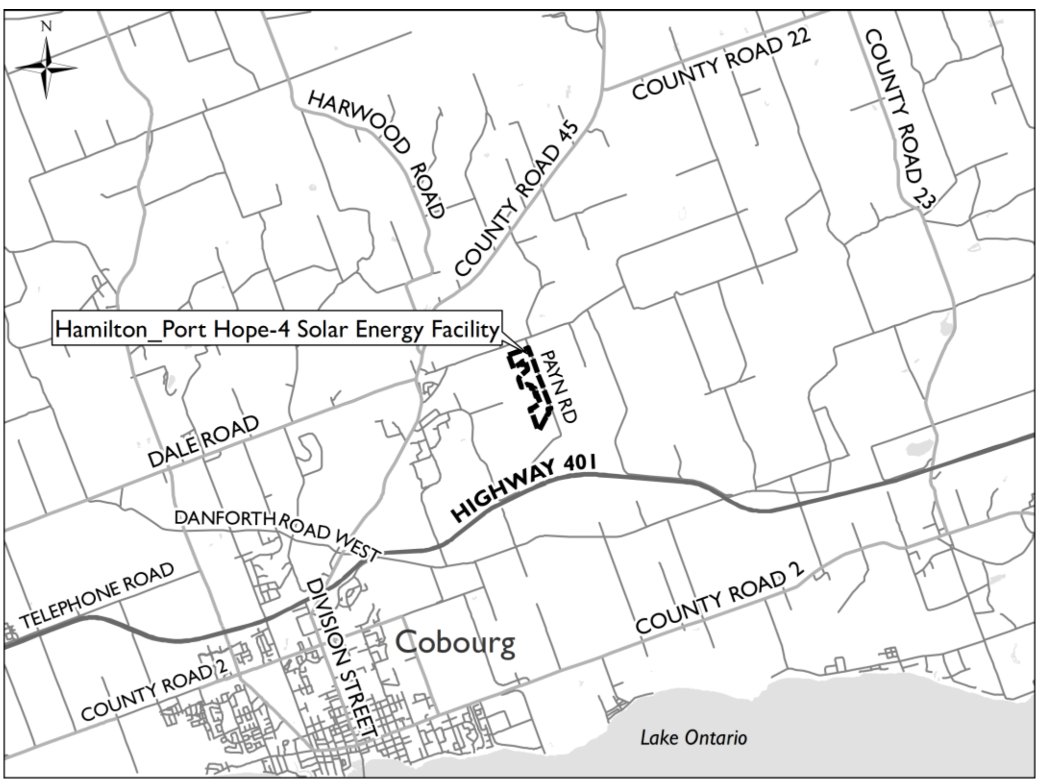
Project Name: Hamilton_Port Hope-4 Solar Energy Facility (Hamilton Solar Project)
IESO FIT Contract ID: F-000687-SPV-130-505 Project Location: 2720 Payn Road (west side of Payne Rd., south of Community Centre Rd.), Baltimore, Ontario
Dated at Toronto this 10th day of November, 2016

Hamilton Solar Farm Partnership was issued a Renewable Energy Approval (REA) on May 16, 2012 in respect of the Hamilton Solar Project. The REA was subsequently amended on October 15, 2012 and March 4, 2014. Information with respect to the decision on this project can be viewed on the Environmental Registry by searching 011-4836.

Hamilton Solar Farm Partnership is proposing to make a change to the project and the project itself is subject to the provisions of the *Environmental Protection Act (Act)* Part V.0.1 and Ontario Regulation 359/09 (Regulation). This notice must be distributed in accordance with section 32.2 of the Regulation. This notice is being distributed to make the public aware of a proposed change to the project.

Project Description and Proposed Changes:
Pursuant to the Act and Regulation, the project, in respect of which the Renewable Energy Approval was issued, is a Class 3 Solar Facility. An application has been made to the Ministry of the Environment and Climate Change to **change the project** and alter the terms and conditions of the existing Renewable Energy Approval. The proposed changes consist of implementing permanent stormwater management best practice features and updating the project location boundary accordingly.

The facility would continue to have a total nameplate capacity of 10 MW with these changes. The project location is shown in the map below.



The Project Location is situated at 2720 Payn Road (west side of Payn Rd., south of Community Centre Rd.), Baltimore, ON.

Documents for Public Inspection:
Hamilton Solar Farm Partnership has been required to update the supporting documents that are required to form part of the application or which must be otherwise submitted to the Ministry of the Environment and Climate Change available to the public (titled *Modifications Document to REA Number 0905-8S7M96)*. An electronic copy of the draft supporting documents will be made available for public inspection on during the week of November 10, 2016 on the project website at: http://www.pennenergyrenewables.com/solar-ontario/hamiltonph4.html

Project Contacts and Information:
To learn more about the REA amendment proposal, please contact:

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