# NORBERT WOERNS SW COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 1. | Lacking details on groundwater monitor construction in or near surface water features. No monitor details or borehole logs in Appendices. Subsequent drive point information has been provided with no information on the soil units encountered. | The groundwater monitoring wells and mini- piezometers near each surface water feature are identified in the Watercourse and Wetland Characterization Tables enclosed as Schedule B and Schedule C of this submission. Appendix A: Hydrogeological Field Investigations of the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report (Earthfx, April 2020) includes further details regarding the groundwater monitoring wells and mini-piezometers. | Additional background borehole information from the Golder studies and the shallow monitors completed by Tatham has been provided. See comment 11 above. It is noted that the shallow monitors completed by Tatham do not have descriptions of soil materials penetrated. | Drive point wells were selected to monitor the shallow groundwater levels beneath each wetland to minimize the disturbance to each wetland during installation. The drive point wells were driven into the overburden in each wetland without removing soil. As such, soils information was not collected at each drive point well installation. |
| 2. | Only five wetlands of the 22 wetlands in the vicinity were instrumented with piezometers to assess vertical hydraulic gradients for water budget purposes. Water budget conclusions regarding the wetlands that have not been instrumented by Tatham therefore cannot be verified against measured data. | The key larger wetlands were instrumented. Matching the dynamics of these features with the integrated surface and groundwater model gave us confidence in our ability to represent the remaining wetlands correctly. The models considered key components of the water budget including, precipitation, canopy interception, overland runoff into and out of the wetlands, ET, infiltration, interflow, groundwater recharge, streamflow in and out of the riparian wetlands, groundwater interaction with the streams, and groundwater interaction with the perennially ponded areas. Detailed water budgets were prepared using simulation period averages of all PRMS and MODFLOW inflows and outflows. The flows were averaged over all cells falling within the polygons defined by the wetland area. The purpose was to compare the flow terms under each scenario to see how they change and re-balance under the different conditions. Quantitative model comparisons were made against observed shallow groundwater levels and ponded water levels. Simulated values of soil moisture were compared against these observations to determine how well the model approximated hydroperiod.<br><br>It needs to be kept in mind that the simulation compares proposed conditions to existing to evaluate any potential adverse impacts caused by the proposal. | The lack of instrumentation of some of the wetlands results in uncertainty with respect to the model predictions. The model relies upon extrapolated or assumed site specific wetland conditions where instrumentation is lacking. Quantification of uncertainty with respect to model predictions because of extrapolations of data should be provided. Applicant could consider a sensitivity analysis for those wetlands not instrumented to determine parametric influence in the modelling. | A feature-based water balance was completed by Tatham to validate the results of the integrated surface and groundwater model. The results of the feature-based water balance are included in the Surface Water Assessment (Tatham Engineering Limited, April 2020).<br><br>Through the development of the AMP, additional wetlands have been instrumented to confirm our understanding of the shallow overburden aquifer, groundwater/surface water interactions and wetland hydroperiods. The additional instrumentation is documented in the MNDMNRF approved AMP (June 2022). |
| 82. | 'The portion of the quarry discharge assigned to Spring J is determined through numerical analysis within the integrated surface water groundwater model. The balance of the quarry discharge resurfaces at Spring K which drains to Willoughby Creek downstream of SW7.'<br><br>There are no flow measurements of Spring J and K except for one occasion April 10, 2006 by Worthington, 2006. There are no field data to confirm flow conditions from these two springs and consequently flow from the tributary of Willoughby Creek which feeds these two springs. It is known that a minimum of 2.0 litres/second of pump discharge from quarry sump 100 is diverted to the tributary of Willoughby Creek but the total flow characteristics of quarry sump discharge into the tributary to Willoughby Creek are not known. It is also not known how much water is diverted from Sump 100 discharge to the existing irrigation ponds on the golf course property. An assessment of impact on this tributary therefore relies upon computer simulations in the absence of critical streamflow information and without the benefit of verification of existing conditions with field measurements. | The discharge to the Unnamed Tributary of Willoughby Creek through the weir structure is monitored at surface water monitoring station SW1. The total flow is the sum of the weir discharge plus the 2 L/s discharge from the head box diversion.<br><br>Refer to response to Comment 51. | The lack of spring flow data provide uncertainty with respect to the model predictions of impact from the proposed quarry expansion. The resulting uncertainty with respect to model predictions should be quantified. | Surface water monitoring station SW1 is maintained year-round (continuously recording monitoring device is not removed in the winter at this location as sufficient water depth prevents the device from freezing) and spring streamflow data is available for spring 2016 and spring 2018 through 2022. Also, the quarry discharge rate is monitored, recorded and available as required by the quarries PTTW. The monitoring data and quarry discharge rate were used in the calibration of the integrated surface and groundwater model. |
| 127. | 'The Willoughby Creek watershed will be reduced in area at SW7 through extraction in the west extension. The overall watershed will be reduced by approximately 19 ha or 6% at SW7. As illustrated in the previous table, the proposed condition integrated surface water groundwater model predicts a minor reduction in Willoughby Creek average monthly streamflow through the Medad Valley due to the reduction in in watershed area, and consequently reduction in surface runoff, and the lowering of the groundwater table in the area through extraction and quarry dewatering. A reduction of 1.1 – 2.9 L/s is predicted at surface water monitoring location SW7. The reduction in streamflow is predicted to be greater in the fall, winter and spring (when more water is available in Willoughby Creek) and less during the summer months. The monitoring data collected to date shows a continuous baseflow of approximately 4 L/s in Willoughby Creek at SW7. However, the quarry discharge contributes to the baseflow at SW7 and it is expected that Willoughby Creek would run dry at SW7 if the quarry discharge were to cease. As proposed, the quarry discharge from Quarry Sump 0100 will be maintained during operations and long-term post rehabilitation. Maintaining the off-site discharge will maintain baseflows in Willoughby Creek downstream of its confluence with its | In the interim condition, between the cessation of off-site discharge and full quarry lake, there is a potential for Willoughby Creek to dry out at surface water monitoring location SW7.<br><br>As per the results of the integrated surface and groundwater model, leakage from the quarry lake, once filled, will help maintain streamflow in the Medad Valley and Willoughby Creek. | The conclusion that 'it is expected that Willoughby Creek would run dry at SW7 (unfortunately we understand that access to SW7 has been lost and this will be a significant gap for ongoing monitoring) if the quarry discharge were to cease' misrepresents the results of the computer model which shows a reduction in flow in Willoughby Creek. The potential for stream flow during rain events has been ignored. It is highly unlikely that flow in the Tributary to Willoughby Creek would cease except perhaps intermittently during seasonally dry periods. The intermittent nature of flow in the Tributary to Willoughby Creek is anticipated to be a natural condition due to its limited drainage area. The elevation of the final west lake needs to be assessed vs known fractures in the aquifer in order to determine the potential insignificance of any leakage to the Medad Valley. | As presented during the meetings held the week of May 16, 2022, additional analysis has been completed to assess the potential impacts the proposed quarry extension will have on the Medad Valley and Willoughby Creek. The analysis also assessed the proposed infiltration pond's ability to mitigate these potential impacts. The supplemental material prepared in support of the meetings should be reviewed for additional clarification regarding comment 127.<br><br>Additional instrumentation (both shallow groundwater and streamflow monitoring stations) is proposed as part of the revised AMP to confirm our understanding of the surface water and groundwater regimes through the Medad Valley and confirm the results of the integrated surface and groundwater model. |

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| | tributary.'<br><br>Why is it expected that Willoughby Creek at SW7 will dry up by stopping pumping into the creek? See Earthfx, page 252, 1st paragraph where the model shows a net reduction in seepage at SW7 of 2.1 litres/second from phases 3456 extraction. This represents over 50.0% of measured base flow of 4.0 litres/second at SW7. By turning off the pumps in rehabilitation scenario 2 (RHB2) the model shows increased surface water flows in adjacent creeks not currently receiving sump discharge from the quarry (see Earthfx Figure 8.106, page 284)). There does not appear to be a complete cost benefit analysis with respect to the two rehabilitation scenarios. | | | |
| 130. | 'The predicted average lake water level (269.00 m) is below the existing sill elevation (269.08 m) of the weir structure constructed by the BSGCC in the weir pond (wetland 13202) which created the weir pond (wetland 13202), maintains water levels in the wetland and controls discharge to the tributary of Willoughby Creek and consequently Willoughby Creek. When the lake water level drops below an elevation of 269.08 m, gravity discharge to the tributary of Willoughby Creek will not occur. Also, the average water level in the weir pond (wetland 13202) is 269.27 m. The wetland water level will drop in response to the lake water levels and cessation of off-site discharge.'<br><br>Have modifications to the weir been considered to maintain gravity flow to the<br>Tributary to Willoughby Creek? | Refer to response to Comment 34. | The wetland upstream of the weir outlet is considered to be a direct result of the quarry sump discharge and the construction of the weir. The proposed Collins Road diversion of surface drainage north of Collins Road to the Tributary of Willoughby Creek will contribute flow to the Tributary to Willoughby Creek. In addition, the eventual filling of the quarry excavation will ultimately restore groundwater levels to approaching pre-quarry conditions resulting in higher groundwater levels and increased baseflow to local drainage channels as predicted in the model. The option of continuing pumping to maintain artificially low groundwater levels appears to have fewer advantages from a groundwater and surface water perspective than allowing groundwater levels to rebound with the filling of the quarry following closure of the quarry operations. Due to the relatively small surface water catchment of the Tributary to Willoughby Creek it is anticipated that this drainage tributary would have seasonal flow. The quarry pump discharge has altered the flow in this drainage tributary to an artificially high level creating surface water characteristics that previously did not exist naturally. | The proposed surface water mitigation strategy for the quarry aims to maintain the existing form and function of the natural heritage features, specifically the unnamed tributary of Willoughby Creek and Willoughby Creek, which have received quarry discharge for over 60 years. The cessation of the quarry discharge from sump 0100 as approved under the current quarry ARA license will alter the streamflow rates and patterns through the unnamed tributary of Willoughby Creek and Willoughby Creek, altering the form and function of these natural heritage features. Given these potential negative impacts, we support pumping in perpetuity from sump 0100 to maintain these features. |
| 131. | 'This is an important consideration as Willoughby Creek and the West Arm have been identified as fish habitat. Baseflow and water temperature are critical to the form and function of these watercourses from a natural heritage, habitat and spawning perspective. Rehabilitating the Burlington Quarry as approved will negatively impact Willoughby Creek and the West Arm as flows will be reduced and/or eliminated. Similarly, the weir pond (wetland 13202) and the wetland 13203 (located along the West Arm adjacent to the south extension) are currently identified as natural heritage features. These features are dependent on the quarry discharge to maintain their hydroperiod and may dry out under the approved rehabilitation plan.'<br><br>Has drying out of features been established with supporting field evidence and analysis. The lack of understanding of the critical flow characteristics of the tributary of Willoughby Creek brings into question the validity of the conclusions regarding the impact from the quarry and quarry discharge on Willoughby Creek. | As illustrated in the streamflow monitoring summaries provided for surface water monitoring location SW1, the depth of water in the wetland has reached 0 m when the quarry discharge ceases for an extended period of time. At the same time, the discharge downstream into the Unnamed Tributary of Willoughby Creek ceases when discharge from the quarry ceases for extended periods of time. | Clarification provided although questions remain. 'SW1 measures the flow through the weir structure to the tributary to Willoughby Creek downstream. The quarry discharge occurs year round, maintaining sufficient water depth and flow at SW1 to prevent freezing of the pressure transducer at SW1' (Tatham Page 9, 3rd paragraph). This appears to contradict the contention that 'the depth of water in the wetland has reached 0 m when the discharge ceases for an extended period of time. | Since monitoring station SW1 was established, there have been extended periods (5+ consecutive days) where quarry discharge has ceased during the year (not restricted to winter months). During these periods, the discharge through the weir structure to the unnamed tributary of Willoughby Creek ceased. This is further substantiated by complaints received from downstream property owners claiming a lack of flow through Willoughby Creek during these periods. |
| 147. | Preliminary baseflow and temperature thresholds are recommended. Water quality thresholds for total suspended solids, pH, and oil and grease for discharge waters are part of the existing quarry Environmental Compliance Approval (ECA). Tatham recommended that these be maintained for the proposed expansion.<br><br>No threshold or target water quality levels for the remaining water quality parameters included in the monitoring program, currently exist. 'Its recommended that the water quality thresholds be established from the results of the historic water quality sampling completed in support of the proposed quarry extension. Specifically, maximum and minimum concentration limits should be established from the sample results collected while considering the Provincial Water Quality Objectives (PWQO) and role water quality plays in the Natural Heritage Features.' (Tatham, page 88, 3rd paragraph.)<br><br>No such recommendation has been made for groundwater quality parameters. | The AMP will be refined moving forward in collaboration with the review agencies and additional water quality thresholds will be established, if necessary. | The proposed rehabilitation Scenario RHB1 proposes to infiltrate quarry sump discharge to maintain groundwater levels in support of down gradient water well supplies. Drinking water quality standards should be applied to the infiltrated sump water as this infiltrated water is intended to provide drinking water supplies for down gradient private wells. See JART Hydrogeology Table comment 7, 8, 18, 193, 208, 269, and 298. | The revised AMP outlines the proposed water quality sampling and water quality thresholds for the quarry extension. The water quality sampling, including testing parameters and objective limits, will be further refined through the necessary amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |
| 148. | 'Extraction will reduce the drainage area to wetland 13201 northwest of No. 2 Sideroad forming the headwaters of the unnamed tributary of Lake Medad. Reducing the drainage area of the wetland has the potential to adversely impact the wetlands hydroperiod. As such, a mitigation strategy has been developed to supplement the flow into the wetland during operations as required. A bottom draw outlet will be constructed in the southeast corner of the proposed replica pond and an outlet pipe | The wetland threshold values will be developed from the wetland hydroperiod monitoring data currently being collected and the results of the integrate surface and groundwater model and wetland water balance moving forward as part of the refinement of the AMP. | No shallow groundwater monitor existed within this wetland for the water balance analysis although Tatham has recommended installation of monitor SW36 at this location. The wetland water balance analysis relied upon data from nearby areas for groundwater information. The wetland water balance may therefore not be representative of conditions at this wetland. Threshold levels should be established for this wetland prior to quarry expansion and based upon sufficient monitoring data to characterize both surface water and groundwater baseline conditions at this wetland. | Both wetland hydroperiod and shallow groundwater monitoring stations were established in wetlands 13200 and 13201 in the spring of 2020. The wetland hydroperiod thresholds will be established in accordance with the revised AMP prior to any site preparation and alteration to surface catchments in the west extension after at least 9 more years of baseline monitoring data is collected. |

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| | complete with a control valve will be installed to discharge water into the roadside ditch along No. 2 Sideroad feeding the wetland. The wetland hydroperiod will be monitored and water will be discharged to the wetland as required to maintain the wetland hydroperiod.'<br><br>What are the threshold levels for the hydroperiod for this wetland? | | | |
| 149. | Mitigation measures are described with respect to meeting thresholds and triggering mitigation for streamflow, stream temperature, wetland hydroperiod, effluent limits, and water quality.<br><br>Changes to surface water regime can change rapidly in response to precipitation events. How will the trigger levels be responded to and mitigative measures be implemented? The current monitoring program consists of continuous data logger recordings plus monthly manual flow measurements, quarterly water quality sampling, and weekly field visits to monitor wetland hydroperiods during the seasonal wetland hydroperiod. | The AMP will be refined moving forward in collaboration with the review agencies providing clear direction on how the triggers will be responded to and mitigative measures will be implemented. | Discharge water quality limits for three parameters, total suspended solids, oil; and grease and pH, are to be continued from the requirements of the existing Environmental Certificate of Approval. Surface water quality maximum and minimum limits have been recommended by Tatham although not yet established with the exception of water temperature thresholds. The are no recommendations for groundwater quality thresholds or maximum limits. These should be established if the proposed infiltration ponds are to receive sump discharge. | The revised AMP outlines the proposed water quality sampling and water quality thresholds for the quarry extension. The water quality sampling, including testing parameters and objective limits, will be further refined through the necessary amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |
| 153 | Manual water level readings are shown on hydrographs in Appendix G. Appendix F summarizes manual shallow groundwater levels although it is not clear what the measuring point was and the significance of negative values. | The datum (existing grade) is provided on the graphs. As the datum is set at existing grade, positive values mean water levels are above existing grade and negative values mean water levels are below existing grade. | Comment noted. | RESOLVED |
| 154. | Water quality results are presented in Appendix H, however there is no discussion of water quality in the report with respect to drinking water quality standards. Infiltration of surface water is proposed to maintain down-gradient private well water supplies. Emphasis is focused upon the threshold values of selected parameters included in the Environmental Compliance Approval (ECA) for the existing quarry. | Refer to the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report for discussion regarding water quality and the impact the infiltration pond will have on down-gradient wells. | The Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment Report assumes that the infiltration ponds will have no negative impact on down gradient wells. This is not supported with a detailed analysis of surface water and groundwater quality. An examination of water quality with respect to the Ontario Drinking Water Standards is required. The existing Environmental Certificate of Approval has water quality limits for three parameters, total suspended solids, oil and grease and pH. The limits for these parameters are surface water limits and do not reflect Ontario Drinking water standards with the exception of pH. | The infiltration pond will intercept direct rainfall and runoff and receive discharge from the existing quarry of the same quality as the existing irrigation ponds constructed on the Burlington Springs Golf and Country Club property, which the infiltration pond has been designed to simulate. The discharge water quality sampling, including testing parameters and objective limits, will be further refined through the amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |

# CITY OF BURLINGTON COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 3. | Nelson Quarry obtained ECA from MECP in June 2017 that permits collection, transmission, treatment and off-site disposal of surface water and quarry water. Will the current PTTW and the ECA revised if the quarry expansions extend southward and westward? | The current PTTW and ECA will have to be amended for the proposed south and west extensions, specifically for the new water taking and discharge from the south extension and discharge into the wetlands associated with the west extension. | Noted. No further comments. | RESOLVED |
| 4. | What is the rate at which Quarry Sump 0100 pumps water to the Colling Road roadside ditch? Will this rate be altered under the future conditions? If so, the conveyance features along Colling Road should be assessed for capacity and erosion potential. | The current PTTW allows a maximum discharge rate of 4,090 L/min (~68 L/s) from Sump 0100 into the roadside ditch along Colling Road. There are currently no plans to increase this discharge rate. | If Nelson constructs a conveyance system alongside Colling Road to redirect external drainage, the combined discharge (external drainage plus the Quarry Sump 0100) could exceed the ditch capacity. | If Nelson elects to proceed with the diversion of flow along Colling Road, the conveyance system will be reviewed or improved to ensure it has adequate capacity from Blind Line to the unnamed tributary of Willoughby Creek. |
| 5. | Similarly, will the pumping rate of Quarry Sump 0200 be maintained in compliance with the ECA? Is there an intention to apply for an amendment of the ECA which was issued in 2017? | The current PTTW allows a maximum discharge rate of 945 L/min (~16 L/s) from Sump 0200 into the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek. The PTTW and ECA will have to be amended as described under response to Comment 3. However, there are currently no plans to increase the discharge rate from Sump 0200. | Clarification provided. | RESOLVED |
| 6. | Did Nelson Quarry encounter a spill incident during any of the effluent monitoring periods? | Minor spills have occurred on-site and they have been addressed through the Quarry's Spills Management Plan. The MECP has been notified of all spills. The water quality sampling program completed under the ECA confirms contaminants from the minor spills have not entered the on-site settling ponds or been discharged off-site. | No further comments. | RESOLVED |
| 7. | The surface water monitoring program has been implemented for the last 6 years. Were any of the public agencies (Conservation Halton, Region of Halton or the City of Burlington) involved in equipment installation and the review of the monitoring observations? | The public agencies listed have not been involved in the monitoring program to date. Several of the surface water monitoring stations were installed in support of the PTTW and ECA. The remainder have been installed in support of the proposed expansion. The monitoring locations were selected to provide a comprehensive surface water monitoring network of the Quarry and its surrounding area based on experience on similar projects and considering the results from previous studies/applications. | Acknowledged. No further comments. | RESOLVED |
| 8. | What steps did the proponent take to ensure quality of the collected data from the monitoring stations? What QA/QC practices was in place to ensure proper functioning of the monitoring equipment. Were any outliers encountered? | Monthly field visits are conducted to each monitoring station to collect in-situ calibration data (water depths, temperatures, flow rates) and confirm the monitoring devices are functioning properly. The continuous monitoring data collected by the data loggers at each monitoring station is adjusted to the monthly in-situ calibration data collected to ensure the data matches field observations. Over the course of the monitoring program, data loggers have malfunctioned, and the loggers were repaired or replaced as expediently as possible to ensure data loss is minimized. | No further comments. | RESOLVED |
| 9. | The Burlington Springs Golf and Country Club has constructed a weir structure which maintains water levels in the wetland, maintains flow downstream to a tributary of Willoughby Creek and diverts flow to a series of constructed irrigation ponds on the golf course via a diversion channel. Will this weir continue to exist under the future conditions or will its function be replicated through another structure? | It is the intent to utilize the existing weir structure and the stop logs employed by the Burlington Springs Golf and Country Club to maintain water levels in the upstream wetland and divert a portion of the quarry discharge to the proposed infiltration pond. | More information is required, and a conceptual design should be included in the AMP. Measure of infiltration ponds discussed separately. | The proposed surface water management strategy for the quarry includes utilizing the existing weir structure and stop logs constructed and used by the Burlington Springs Golf and Country Club. We are not proposing to construct a new weir structure. Please clarify what additional information is required. |
| 10. | Could not locate monitoring station SW11A, SW12A, SW13A and SW16A on the drawings. Please make sure the monitoring station names are consistent in the report and the drawings. | The Existing and Proposed Surface Water Monitoring Locations Plans (Drawings SW-1 and SW-2) have been revised accordingly and are enclosed for reference. Its noted, the wetland hydroperiod and shallow groundwater monitoring stations are located at the same location. As such, we have not differentiated between the wetland hydroperiod and shallow groundwater monitoring stations on the plan. The wetland hydroperiod and shallow groundwater monitoring stations are identified as SW5, SW11, SW12, SW13, SW16, SW36, SW37 and SW38 on the revised drawings. | Comment addressed. | RESOLVED |
| 11. | An assessment of the existing roadside ditches will be required to confirm enough capacity, or the existence of potential capacity to carry flow during design events. | An assessment of the existing roadside ditches downstream of the discharge locations is enclosed for reference. The assessment confirms the roadside ditches have adequate capacity to convey the proposed flows. | Comment addressed. | RESOLVED |
| 12. | Will the new conveyance system which will carry external flows, and which will be located within Nelson property, replace the existing drainage channel that runs roughly parallel to Colling Road within the quarry? | The proposed Colling Road diversion will not replace the existing drainage channel within the Quarry. The existing drainage channel will remain. | More details required to confirm the response. | The existing channel is constructed in the quarry floor from the rehabilitated wetland in the northeast corner of the quarry to sump 0100. The proposed Colling Road diversion will be constructed at grade parallel to Colling Road from Blind Line to the existing quarry discharge location. The intent is to intercept external drainage and convey it around the quarry to the existing outlet reducing the surface water management requirements of the quarry |

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| | | | | while improving the streamflow hydrograph in the unnamed tributary of Willoughby Creek. The only way to accomplish this is to intercept external runoff at grade through the Colling Road diversion, separating it from the existing channel constructed across the quarry floor. Please clarify what additional information is required. |
| 13. | There are several drainage features within the existing quarry. Will those features undergo any changes and realignments after the extraction operations cease? | Yes, some of the current drainage features will be modified as part of the proposed rehabilitation plan for the existing quarry. The proposed site amendment for the existing quarry rehabilitation plan has been provided to the agencies under separate cover. Tatham assisted with the water management components of the rehabilitation design for the existing quarry and proposed extension. | No further comments. | RESOLVED |
| 14. | Will the proposed new conveyance system along Colling Road only carry flow from S100 (84.0 hectares) or will the catchments S113 through S116 (a total of 58.0 hectares) also drain into the new conveyance feature. | The proposed Colling Road diversion will convey surface runoff from Catchment S100 and Colling Road only. The surface runoff from Catchments S113 through S116 currently drain onto the existing quarry floor and will continue to do so if the Colling Road diversion is constructed. | Acknowledged. More information is required to confirm how this would be achieved. | See response to CH comment 12. |
| 15. | Will the proposed conveyance system along Colling Road only carry minor flows? How are the major flows proposed to be managed? | The proposed Colling Road diversion will be designed to convey both minor and major flows from Catchment S100 and Colling Road. | Acknowledged. Capacity of the right-of-way to accommodate the major flows will have to be provided to the City. | If Nelson elects to proceed with the diversion of flow along Colling Road, the diversion system will be engineered to convey the required minor and major storm peak flows to the satisfaction of the City of Burlington. Also, the conveyance system downstream of the diversion will be reviewed or improved to ensure it has adequate capacity from the existing quarry discharge location to the unnamed tributary of Willoughby Creek. |
| 16. | In which direction does catchment S102 drain from the Colling Road and Cedar Springs Road intersection. Does it flow north along Cedar Springs Road towards tributary of Willoughby Creek or does it flow east directly towards Willoughby Creek? | We reviewed the existing drainage patterns at the intersection of Colling Road and Cedar Springs Road and believe surface runoff from Catchment S102 drains north along Cedar Springs Road to the Unnamed Tributary of Willoughby Creek. | Confirmation should be provided with survey or a reasonable alternative. | To establish the drainage patterns, a field visit was conducted, and the drainage patterns were reviewed. It is noted there is a culvert under CollingRoad that conveys surface runoff north to the unnamed tributary of Willoughby Creek. |
| 17. | Is the Wetland 13201 a natural feature or has it formed as a result of the obstructed culvert? Does this wetland feature provide any critical hydrologic function? | It is unknown if Wetland 13201 is a natural feature or if it has been formed by the obstruction of the No. 2 Sideroad culvert. Wetland 13201 is not believed to provide a significant hydrologic function. | Confirmation should be provided with a functional analysis or assessment. | Wetland 13201 was included and assessed through the integrated surface and groundwater model, feature based wetland water balance and natural heritage assessment prepared in support of the quarry extensions. |
| 18. | Thank you for confirming that the existing drainage patterns within Burlington will remain unchanged even if the quarry expands west and south. | No response required. | Acknowledged. | RESOLVED |
| 19. | Will there be operations and maintenance staff to monitor quarry sumps after the extraction operations cease at Burlington quarry? | Operation and maintenance will be the responsibility of the new owners of the property and they will be required to comply with the instruments under the Ontario Water Resources Act. | Acknowledged. Please add the necessary wording to this effect in Section 7 of the Surface Water Report and include it in the AMP. | The revised AMP speaks to the operation and maintenance of the off-site quarry discharge following rehabilitation of the site and surrender of the ARA license (in perpetuity). |
| 20. | Will the discharge from the two expansions follow the existing PTTW or is there a proposal to apply and obtain a separate PTTW and ECA. | Refer to response to Comment 3. | Comment addressed. | RESOLVED |
| 21. | City requests to be circulated on any proposed changes to the configurations of the existing settling ponds. | Understood. | No further comments. | RESOLVED |
| 22. | Please provide existing and proposed conditions Visual OTTHYMO 6 hydrologic model schematic. | Existing and proposed VO6 model schematics are enclosed for reference. | Addressed. | RESOLVED |
| 23. | Extraction in the west extension will reduce the size of sub-catchment draining to wetlands as well as those draining to the municipal drainage systems. This indicates that the drainage will be redistributed during the post development conditions. Please confirm that the extra, redirected flow will be retained in the reconfigured pond and will not result in an increase of flow in a different direction. | The west extension will redistribute the surface runoff draining to the wetlands and municipal drainage systems. The redistributed surface runoff will drain internally to the Quarry's settling ponds where it will be stored and discharged off-site in accordance with the terms and conditions of the PTTW and ECA. As such, the flows draining off-site will not increase under proposed conditions (during operations and post rehabilitation). | Will hydro-period change which could impact environmental features reliant on water volumes at key times of the year? | The proposed monitoring program, wetland hydroperiod thresholds and mitigation measures specified in the revised AMP have been designed to maintain wetland hydroperiod. |
| 24. | It is recommended that the proponent take another look at the proposed rehabilitation plan towards the end of the extraction operation and to make any modifications to the rehabilitation plan to accommodate any hydrologic changes encountered during the extraction period. | The design of the rehabilitated landform needs to be completed now since progressive rehabilitation is required during operations and the work includes significant grading. Mitigation, monitoring and annual reporting of hydrologic conditions will be completed throughout the operations and during rehabilitation to prevent adverse impacts to adjacent key hydrologic features. If the pumping regime requires any future adjustments this can be accommodated based on the proposed rehabilitated landform for the existing quarry and proposed extension. | Applicant should follow principles of adaptive management. | As outlined in the revised AMP, the monitoring and reporting of hydrologic conditions will be completed throughout the duration of the project and the AMP will be revisited every five years to ensure the AMP remains current and any necessary changes to the operation and rehabilitation of the quarry are implemented. |
| 64. | Section 3.1.1 (Page 28 of 601) "As part of ongoing operations within the existing Burlington Quarry, Nelson is exploring options to divert this external drainage from northwest of Colling Road directly to the discharge location of Quarry Sump 0100; preventing the runoff from entering the existing quarry. This would include the construction of a conveyance system (a culvert, ditch or combination of the two) alongside Colling Road within Nelson's property between Blind Line and the quarries existing discharge location (Quarry sump 0100). With this in place, the external runoff would drain to its existing outlet, the tributary of Willoughby Creek, without entering the active quarry operation. This will reduce the surface | Refer to response to Comments 12,14,15, 37 and 65.<br><br>A preliminary design of the proposed Colling Road diversion is enclosed for reference. | Thank you for providing a preliminary design. A revised design will be needed if the flow rate changes. | Understood. |

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| | water management requirements of the active operation."<br><br>Please provide more information about the proposed conveyance system along Colling Road between Blind Line and the weir pond (wetland 13202) which will carry external flows bypassing the active quarry operations. | | | |
| 70. | Section 3.2.3 West Extension (Page 30) "It is noted, the drainage systems, specifically roadside ditches, downstream of the culvert crossings Cedar Springs Road are poorly defined or nonexistent. It is expected that any surface runoff draining through the culverts will either, evaporate, infiltrate or drain overland following the topographic low through the road allowance or across private property to the Medad Valley and Willoughby Creek."<br><br>Further investigation is needed to determine the baseline conditions in order to understand the flow regime. | A summary of the drainage conditions established through additional field inspections and streamflow monitoring is as follows:<br>1) Surface water monitoring location M33 – culvert crossing No. 2 Sideroad is completely obstructed, the downstream end of the culvert could not be located and there is no define channel downstream of No. 2 Sideroad. It is expected surface runoff collects in the wetland upstream and infiltrates or evaporates. Based on monitoring of the wetland completed in 2020 and to date in 2021, little water accumulates in the wetland and the wetland is perched above the groundwater table. The shallow groundwater level increases rapidly during rain events indicating infiltration of surface runoff into the underlying soil.<br>2) Surface water monitoring location M34 – appears to drain east under Cedar Springs Road onto the Quarry property and into Wetland 13201. During our rounds of surface water monitoring, we have not witnessed flow through this culvert.<br>3) Surface water monitoring location M35 –surface runoff drains west through a culvert crossing under Cedar Springs Road and a crossing under Cedar Springs Court. No defined outlet was identified downstream of Cedar Springs<br>4) Court and surface runoff is expected to flow west overland as sheet flow to Willoughby Creek. During our rounds of surface water monitoring, flow has not been witnessed in this the Cedar Springs Road culvert.<br>5) Surface water monitoring location M36 – surface runoff drains west through a culvert crossing under Cedar Springs Road and continues west to Willoughby Creek through a poorly defined channel across private property. During our rounds of surface water monitoring, flow has not been witnessed in this culvert.<br><br>Cedar Springs Road and Colling Road intersection – refer to response to Comment 16. | #1: No further comments.<br><br>#2, #3 and #4: Please confirm the drainage direction. Further analysis is needed to estimate flow at each of those locations during the range of storm events. No flow at a specific time should not lead to a no-flow conclusion.<br><br>#5: Confirmation needed through a survey (please see response to comment # 16). | The drainage patterns described previously were determined through filed investigations.<br><br>At surface water monitoring location M34, surface runoff drains east under Cedar Springs Road onto the quarry property and into Wetland 13201 through the roadside ditch.<br><br>At surface water monitoring location M35, surface runoff drains west through a culvert under Cedar Springs Road then under Cedar Springs Court. There are no defined drainage features west of Cedar Springs Court and surface runoff continues to flow west overland.<br><br>An event based hydrologic analysis was completed in support of the proposed quarry extension and the results of the analysis were presented in the Surface Water Assessment (Tatham Engineering Limited, April 2020) at key locations. Recognizing that the surface catchment areas draining to surface water monitoring locations M34 and M35 will be reduced as part of extraction in the west extension, and consequently peak flows to each culvert will be reduced, we didn't feel it warranted to report the design storm peak flows each culvert crossing and haven't done so with this submission.<br><br>See response to Comment 16. |
| 94. | The results of the event based hydrologic model during operation phase and in the post rehabilitation conditions remain the same. These both results are, however, quite different from the existing conditions hydrologic model results for all locations and for all design events. During the operations and under the rehabilitated conditions the West Arm, Weir Pond and Wetland 13201 flows are reduced, and the Burlington Quarry flows significantly increased as compared to the existing conditions. Please refer to Tables 21, 30, and 37. Were the review agencies previously made aware of the fluctuation in flows and is there any correspondence in this regard? | The review agencies were not previously made aware of these changes. The agencies have been made of aware of the changes through the circulation of the Surface Water Assessment. | Under the proposed conditions, both during operation and rehabilitation, peak flow rates at key nodes must match the flows at the same nodes during existing conditions. | As noted, the design storm peak flows directed to the West Arm, Weir Pond and Wetland 13201 will be reduced under the operational and rehabilitation phases of the project. However, discharge to the West Arm and Weir Pond from sumps 0200 and 0100, respectively, will continue to maintain the form and function of these systems. Also, the hydroperiod of Wetland 13201 will also be maintained through discharge of quarry water as per the recommendations of the revised AMP.<br><br>The Burlington Quarry node identified represents the peak flow rate into the quarry. The runoff into the quarry will drain to the quarries internal settling ponds where it will be treated, stored and discharged off-site at rates approved through the quarries PTTW. |
| 110 | It is understood from Section 4.1.2 "South Extension" that a temporary settling pond will be constructed during the initial three years of extraction which will be ultimately replaced with a larger quarry sump that is proposed to maintain a discharge limit of 50.0 litres/second. Design details of both ponds, the temporary settling pond and quarry sump will be required at the design phase. | Understood. | Acknowledged. | RESOLVED |
| 117. | Section 4.1.3 – "Extraction and quarry dewatering will also lower groundwater levels surrounding the west extension within 350 m of the extraction face. As such, a series of mitigation measures are proposed to address any potential adverse impact that could result from extraction and quarry dewatering."<br><br>Did the study team identify any of the potential adverse impacts? Mitigation measures must ensure that any identified impacts are satisfactorily addressed when the replica pond is constructed. | The potential adverse impacts were identified in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report, the Surface Water Assessment, and the Level 1 and 2 Natural Environment Technical Report.<br><br>Additional information regarding the potential impacts and mitigation measures are included in the Watercourse Characterization Tables enclosed. | Please see JART response to Comment # 25. | Additional information regarding the potential impacts and mitigation measures are included in the Watercourse Characterization Tables previously submitted and the revised AMP. |
| 118. | As suggested in Section 4.1.3, will the proposed replica pond exactly mimic the existing groundwater mounding? Location of the replica pond will essentially be different from the existing irrigation ponds which will result in the mounding being<br>shifted. Will this impact the zone of influence of any wells in the surrounding area?<br>Section 11.3.3.3 of the Burlington Quarry Extension Level 1/2 Assessment Report has further confirmed the impact to the private wells in the vicinity of West Expansion. What would be the strategy for implementing the mitigation measure of deepening the<br>impacted wells? | The purpose of the infiltration pond is to replace the golf course ponds that may have contributed to groundwater recharge in the area. Some of the quarry discharge will be diverted to the infiltration pond, the remaining water will be discharged to the Unnamed Tributary of Willoughby Creek. It was assumed that the pond will be in good hydraulic contact with the bedrock surface and should provide higher leakage than the natural ponds with their accumulated sediments and underlying Halton Till. Some form of long-term maintenance may be required in the final design to ensure that the infiltration pond does not become silted up. The infiltration ponds were represented in the model for the P3456 and RHB1 scenarios. Some of the infiltrated water will likely discharge to the quarry and be recirculated, but the main effect is to recharge the groundwater west of the quarry and maintain higher heads and prevent the private wells from going dry. | Please see JART response to comment #29. | As presented during the meetings held the week of May 16, 2022, additional analysis has been completed to assess the potential impacts the proposed quarry extension will have on the groundwater level west of the west extension, the Medad Valley and Willoughby Creek. The analysis also assessed the proposed infiltration pond's ability to mitigate these potential impacts. The supplemental material prepared in support of the meetings should be reviewed for additional clarification regarding comment 118. |

# CITY OF BURLINGTON COMMENTS

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| 142. | Section 6.1.1 Burlington Quarry – "It is recommended that Nelson seek to permanently increase the maximum allowable discharge rate from Quarry Sump 0100. A permanent increase in the maximum allowable discharge rate is not mandatory, only recommended."<br><br>Will Nelson Aggregate implement this recommendation long term, under the operations and the rehabilitations scenarios? | The recommendation is being considered by Nelson. However, at this time no increase in off-site discharge is proposed. The discharge rates will be further reviewed as part of the AMP update.<br><br>It is noted, an amendment to the Quarry's existing PTTW will be required for any increase to off-site discharge. | The discharge rates will be reviewed as part of AMP update. | RESOLVED |
| 152. | Please add arrows on drawing DP-1 to show direction of flow in drainage channels. | The drawings have been revised accordingly. | No further comments. | RESOLVED |

# CONSERVATION HALTON COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 25. | All studies should be coordinated and integrated. In particular, the findings of the Hydrogeologic and Hydrologic Impact Assessment, Surface Water Assessment and Level 1 and 2 Natural Environment Technical Report should inform each other and should be reviewed for consistency. | The Watercourse and Wetland Characterization Tables enclosed have been prepared by the project team to assemble the results of the various studies in one location for ease of review. | The wetland characterization summaries only provide an annual water budget analysis, and the impact assessment and mitigation sections do not include the requested ecological interpretation for existing (as per TOR with 25 year baseline) interim (for each identified extraction phase) and both post extraction scenarios ( rehabilitation scenario 1 and rehabilitation scenario 2). Please revise, present, and summarize daily water balance analyses as average monthly water volumes in tabular format, showing existing, interim and post extraction (as outlined above) with and without mitigation to establish and confirm seasonal variations and include an ecological interpretation for the results. This will set targets/thresholds required to ensure no negative impacts.<br><br>The watercourse characterization summaries only provide groundwater interactions and proposed reductions, however do not include surface water flow analysis, impact assessment or mitigation sections for existing, interim and post extraction scenarios (as outlined above). Update to integrate surface water analysis, revise to present and summarize with and without mitigation to establish seasonal variations and include ecological interpretation of the results. This will set targets/thresholds required to ensure no negative impacts.<br><br>Comment remains outstanding. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 26. | Pre-quarry conditions should be described and evaluated, where feasible, to allow for comparison with existing and proposed conditions. The report should address cumulative impacts from quarrying operations and outline where a return to pre-quarry conditions would be preferable to existing conditions from a natural heritage and hazard perspective. Consultation with review agency staff is recommended. | Evaluating the pre-quarry condition is a difficult proposition recognizing the quarry is not the only change in the watershed over the past 60+ years and little to no data (topographic mapping, land use data, etc.) is available pre-quarry. As such, numerous assumptions would need to be made to model the pre-quarry condition and we question the validity of setting criteria based on assumptions. We also understand that this has not been required for other quarry applications within Conservation Halton's watershed. In the assessment base line conditions were current conditions and this includes impacts from the existing quarry. As part of the impact assessment Tatham considered impacts from the existing quarry and recommended revisions to the existing quarry rehabilitation plan to maintain current hydrologic conditions to benefit the surrounding environment. | Requirements / recommendations evolve as science and knowledge advance and are tailored based on the unique characteristics of each project.<br><br>We acknowledge there are challenges and limitations to evaluating the pre-quarry condition, however, to address cumulative impacts and achieve the best final outcome for the system, we continue to recommend the submission describe and evaluate the pre-quarry condition. Optimizing environmental functional should be the goal informed by system resiliency rather than maintaining existing runoff regime further details and rationale should be provided which demonstrates that "maintaining current hydrologic conditions" is a suitable objective.<br><br>Comment remains outstanding. | The analysis completed and the proposed surface water mitigation strategy for the quarry aims to maintain the existing form and function of the natural heritage features in and surrounding the quarry property. As such, an analysis of pre-quarry conditions has not been completed. As part of the analysis the existing quarry was considered, and recommendations have been included to enhance the existing approved rehabilitation plan to protect downstream natural heritage features. |
| 52. | Description of Monitoring Location SW31 in Section 2.1.1 does not match location shown on Drawing Dwg. SW-1. Update accordingly. | The Existing and Proposed Surface Water Monitoring Locations Plans (Drawings SW-1 and SW-2) have been revised accordingly. | Comment still applies- SW31 is still shown in the same location on SW-1 and SW-2 as provided in the package. Going forward please provide all drawings and charts in colour. | Surface water monitoring station SW31 is correctly illustrated on the Existing Surface Water Monitoring Locations Plan (Drawing SW-1) included in the Surface Water Assessment (Tatham Engineering Limited, April 2020). The proposed surface water monitoring program has been revised as outlined in the revised AMP. |
| 53. | Add label for Monitoring Location SW-9 to drawing | Existing and Proposed Surface Water Monitoring Locations Plans (Drawings SW-1 and SW-2) have been revised accordingly. | Addressed. | RESOLVED |
| 55. | Remove/correct references to Wetland 13036 | The references to Wetland 13036 will be corrected. | Addressed. | RESOLVED |
| 58. | The study should demonstrate the proposed works will have no negative impacts on sediment transport (erosion and aggradation). The analysis should establish erosion threshold flow rates, and use continuous modeling to assess changes to the duration and frequency of exceedances as well as cumulative effective work and cumulative effective discharge. | The integrated surface and groundwater model (continuous simulation) generally predicts minor reductions in total streamflow through the Unnamed Tributary of Willoughby Creek, Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek as a result of the quarry expansion. Also, the quarry discharge From Sumps 0100 and 0200 are not proposed to be altered. The only changes proposed are:<br><br>The diversion of flow from external Catchment S101 directly to the Unnamed Tributary of Willoughby Creek; and<br>The temporary discharge of water from the south extension into the West Arm.<br><br>The proposed Colling Road diversion will direct surface runoff generated north of Colling Road to the Unnamed Tributary of Willoughby Creek, its current and historic outlet, by-passing the quarry settling ponds and quarry sump. The Colling Road diversion is not expected to have a significant impact on the simulation results. As mentioned, the integrated surface and groundwater model generally predicts minor reductions in streamflow in both the Unnamed Tributary of Willoughby Creek and Willoughby Creek. As such, we do not feel an erosion and sediment transport assessment is warranted for these watercourses. | Not addressed. While the modelling shows a general decrease in flows, that does not necessarily mean no negative impacts on sediment transport.<br><br>Looking at individual flow rates at single points also does not account for possible overlap or duration increases.<br><br>Please establish erosion threshold flow rates and use continuous modeling to assess changes to the duration and frequency of exceedances as well as cumulative effective work and cumulative effective discharge. | The integrated surface and groundwater model is a continuous simulation which generally predicts minor reductions in total streamflow through the unnamed tributary of Willoughby Creek, Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek as a result of the quarry expansion. The quarry discharge from Sumps 0100 and 0200 is not proposed to be altered and, as the model predicts minor reductions in flow, the duration and frequency of the exceedances in the erosion threshold flow rates are not expected to increase. As such, we do not feel an erosion and sediment transport assessment is warranted. |

# CONSERVATION HALTON COMMENTS

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| | | The proposal includes discharging water from the south extension to the West Arm at rates of up to 50 L/s. This discharge rate will be refined through the further development of the AMP. However, this discharge rate represents a streamflow that commonly occurs in the West Arm (see streamflow monitoring data) and is conveyed via the low flow channel through the subject property and downstream (as confirmed through the HEC-RAS hydraulic analysis of the West Arm). As such, we do not feel an erosion and sediment transport assessment is warranted for the West Arm | | |
| 59. | Additional metrics should be used to provide a fulsome assessment of potential impacts to surface water features. At a minimum, the study should include at each key monitoring location (West Arm, East Arm, Willoughby Creek Tributary, Willoughby Creek (SW7 & SW14), Wetland 13201):<br><br>annual runoff volumes presented for each year (from Water Balance calculations as well as Integrated Surface Water Groundwater Model and/or continuous modeling)<br>monthly runoff volumes presented for each month (average, minimum and maximums; from Integrated Surface Water Groundwater Model and/or continuous modeling)<br>monthly average stream flows presented for each month (average, minimum and maximums; from Integrated Surface Water Groundwater Model and/or continuous modeling)<br>peak flow rates for event-based storm events (from event based hydrologic modeling)<br> duration and frequency of exceedances of the watercourse's erosion threshold<br>(from continuous modeling)<br>cumulative effective work on the stream's beds and banks (from continuous modeling)<br> the watercourse's cumulative effective discharge (from continuous modeling)<br><br>Additional metrics may be required, depending on the initial results and final water management strategy. Alternative metrics will be considered through consultation with the JART. | Daily flow data from the integrated surface and groundwater model were provided for the simulation periods. This data was processed to provide monthly, annual, average monthly, and simulation period averages. Hydrographs of daily values were presented and discussed in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report. Simulation period averages were represented in maps and tables as they are the simplest format for comparative analyses. | Not addressed- Comment stands, please provide the additional metrics as requested.<br><br>The missing metrics are important for evaluating the impacts of the project for the following reasons.<br><br>Annual runoff volumes- used to determine any impacts to wetlands<br>Monthly runoff volumes- used to determine any impacts to wetlands on a seasonal level<br>Monthly average stream flows- used to evaluate any impacts on fish and fish habitat due to proposed flow regime on a seasonal level<br>Peak flow rates- used to evaluate erosion, flooding, and other negative impacts on watercourses<br>Duration and frequency exceedances- used to evaluate ecological functions, erosion, and deposition,<br>Cumulative effective work- measure of stream power used to evaluate bank erosion and the effect on stream morphology, as well as erosion and deposition.<br><br>Cumulative effective discharge- watercourse effects. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. Additional metrics have not been provided. |
| 60. | The climate data for the impact assessments should be extended to a minimum of 20 years in keeping with the previously proposed duration and standard industry practices (2000 to 2019+, in conjunction with ongoing monitoring). | The wetland water balance analysis covered a 22-year period from 1998 to 2019. | Not Addressed. The presented results do not show full period of analysis. The analysis is based on 10 years of model results. Please present all results. | The feature-based wetland water balance results for the operations and rehabilitation phases of the project are illustrated for a 22-year period in Appendices N and R of the Surface Water Assessment (Tatham Engineering Limited, April 2020). Similarly, the outlet-based water balance results for the operations and rehabilitation phases of the project are illustrated for a 22-year period in Appendices O and S of the Surface Water Assessment (Tatham Engineering Limited, April 2020). |
| 63 | The accuracy of the survey data used should be included within the document. LiDAR data with a +/- 0.1 metre accuracy is available for purchase from Conservation Halton to improve the accuracy of the results, if necessary. | The topographic mapping was generated from a drone survey completed November 22, 2018 having an accuracy of +/- 3 cm. | Addressed. | RESOLVED |
| 67. | Grading details and invert elevations should be provided for the existing golf course weir pond, diversion channel and irrigation pond system to fully illustrate how the existing water management system functions | The existing weir pond, diversion channel and golf course irrigation ponds have been surveyed. Drawings illustrating the function of these features are enclosed for reference. | Addressed. | RESOLVED |
| 68. | In addition to the information provided in the Existing Condition Water Balance, the depth of water and bathymetry of the wetlands should be provided, in order to assess potential impacts to the wetlands. Changes in water depth should be provided in the interim and ultimate conditions as well. | The existing wetlands have been surveyed and drawings of the bathymetric survey are included in the Wetland Characterization Tables enclosed. The changes in water depth are illustrated on the graphs provided in Appendix N and Appendix R of the Surface Water Assessment. | Partially addressed. Bathymetry provided in watercourse and wetland characterization report. Please provide the hydroperiod depths for all wetlands in tabular form as well as graph to allow for easier comparison. | As discussed, the wetland hydroperiod depths are illustrated on the graphs provided in Appendix N and Appendix R of the Surface Water Assessment (Tatham Engineering Limited, April 2020). |
| 69. | Please provide digital, daily water levels, presented graphically (to depict the wetland hydroperiod) and summarize daily water balance analyses as average monthly water volumes presented in tabular format integrated in the report. Compare driest year, average and wettest year monthly water volumes to assess potential impact. | The wetland hydroperiod monitoring data is illustrated graphically in Appendix F of the Surface Water Assessment. Updated graphs including the remainder of the monitoring data for 2019 and the data for 2020 are enclosed. The results of the water balance analysis are illustrated on the graphs included in Appendix I, N and R of the Surface Water Assessment. | Partially Addressed. Present and summarize daily water balance analyses as average monthly water volumes in tabular format integrated in the report. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. Additional metrics have not been provided. |
| 71. | Parameter assumptions (e.g. soil water holding capacity, SCS curve numbers, etc.) and detailed calculations should be provided in a supporting appendix. | The wetland water balance and event based hydrologic model input parameters have been summarized in a table enclosed for reference. | Addressed. | RESOLVED |

# CONSERVATION HALTON COMMENTS

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| 72. | The initial wetland volume, stage-discharge curve, storage correction factor and overflow correction factor for each wetland should be provided to illustrate the scale of adjustment used and support the validity of the water balance calibration. | Refer to response to Comment 39.<br><br>The initial wetland volumes, stage-storage- discharge curves, storage correction factors and overflow correction factors for each wetland are summarized in a table enclosed. | Not Addressed.<br><br>We are of the opinion that this cannot be deferred to the AMP as it is an important piece of the impact analysis.<br><br>The correction factors provided seem to indicate that 3 of the 4 calibrated wetlands are providing double the storage for a given depth than what they would have anticipated based on the stage-storage-discharge curve that was based on Topo. This seems counterintuitive since the correction factors were to address vegetation /topo variations which would likely be losses of flood storage. Please provide more details and example calculations to better explain these factors. Please also provide an explanation as to why some of the units of measurements vary by location. | The wetland bathymetric survey included collecting cross-sections of the wetland bottom at intervals across the wetland, leading to some uncertainty in the wetland elevations between the cross-sections. Based on our field investigations of the wetlands, the wetland bottoms are highly irregular and there are large areas of the wetlands that contain isolated pockets of wetland storage that is not reflected in the bathymetric survey. To account for the additional storage provided in these pockets, a correction factor was applied to the wetland storage volumes. |
| 77. | While the daily water balance is a reasonable predictor of the wetland hydroperiods in 2016 through 2018, the report should discuss the weaker agreement for 2015 and 2019. | Refer to response to Comment 39. | Not addressed. CH does not agree that performing calibration during the AMP instead as part of this analysis is appropriate. Comment stands. | There are several factors that impact the calibration of the feature-based wetland water balance which may be causing the differences noted as follows:<br><br>1) Accuracy of the precipitation and climate data;<br>2) The location of the climate station relative to the site;<br>3) Missing climate records;<br>4) Hydrologic parameters (hydraulic conductivity, void ratio, etc.); and<br>5) Wetland storage volumes.<br><br>There is an inherent degree of accuracy associated with rain gauges and climate gauges which needs to be recognized. There is also a degree of error when using data for an off-site climate station which increases with distance from the site. Rain gauges and climate gauges also suffer from technical issues leading to losses of data which can impact results. Inconsistencies in soil parameters across as site and well as the hydrologic/hydraulic parameters assigned to the wetland can lead to reduced accuracy. However, given the complexity of the system, we believe the integrated surface and groundwater model and feature-based wetland water balance generally provide a good predictor of wetland hydroperiod. It is also noted that the feature-based water balance can be updated and refined in the future as additional monitoring data is collected to ensure proper wetland hydroperiod thresholds are assigned to each wetland. |
| 78. | Staff have assumed the Key Points of Interest on this drawing coincide with the five outlet points outlined in Table 19. Please confirm within the report. | The Key Points of Interest illustrated on the Drainage Plans (Drawings DP-1, DP-2 and DP-3) coincide with the five locations presented in Table 19. | Addressed. | RESOLVED |
| 85. | The report should include the following:<br>A schematic supporting the hydrologic model.<br>A summary of the sources/rationale for the selected hydrologic parameter values.<br>A table of all input parameters for each subcatchment. d. Hard copy of input and output files. | Refer to response to Comments 71 and 83. A summary of the sources/rationale for the selected hydrologic parameters is enclosed for reference.<br><br>The digital VO6 model files have been provided in lieu of hard copy input and output files. Please advise if you still require hard copy input and output files. | While Catchment input parameter tables were provided, several sub catchments appear to be missing: 101, 131, west, south.<br><br>These missing subcatchments are included in the summary CN tables, but do not have detailed parameter tables. | The additional catchment input parameter tables are enclosed for reference. See **Tab 1**. |
| 86. | MTO IDF data was not provided in Appendix L. Conservation Halton staff recommend City of Burlington IDF curves be compared to the MTO data, and the more appropriate values used and provided in the report. | A comparison of the MTO and City of Burlington IDF data is enclosed for reference along with a comparison of the hydrologic model results for each. | Addressed. | RESOLVED |
| 87. | Revisit drainage areas to ensure model and Existing Conditions Drainage Plan, DP-1 match. | The hydrologic model and Existing Conditions Drainage Plan (Drawing DP-1) have been reviewed and revised to ensure consistency. | Addressed. | RESOLVED |
| 88. | CN values used in the hydrologic model are low for the soil types in the subject area. Values used should be justified or revised accordingly. AMC III conditions should be used for the Regional Storm. | Refer to response to Comment 85.<br><br>Regional Storm model runs have been completed using AMCIII antecedent moisture conditions. The Regional Storm model runs are included with the digital VO files enclosed. | Please explain the rationale for selecting CN numbers for "small grain, contoured, poor" as the cultivated category CN.<br><br>AMCIII has been addressed. | The CN values assigned to the cultivated land use type are typical of published values throughout Ontario. |
| 89. | As only the last 12 hours of the Regional Storm were modeled, the Initial Abstraction (Ia) rate used does not adequately account for saturated soil conditions and should be reduced. | The initial abstraction values included in the Regional Storm model runs have been revised accordingly. | Ia values still seem high for the Regional Storm event. The Ia rates assume Ia=0.2*S, or that 20% of the storage is assumed to be the initial abstraction.<br><br>It would be more appropriate to set the Ia to 0 mm as the preceeding rain fills the available storage prior to the Regional Storm. | The IA values were previously revised as requested. The revised IA = 0.2S as recommended for the SCS Curve Number Method. |
| 95. | Explanation for the difference in the Regional Storm flow for the West Arm of the West Branch identified in Table 22 (as used in the hydraulic model) and from that provided in Table 21 (Section 3.4.3) should be provided, or the analysis updated accordingly. | The Regional Storm peak flows have been updated accordingly. | Addressed, but please confirm that Table 22 has been updated. | The revised table is enclosed for reference. See **Tab 2**. |
| 96. | The accuracy and extent of the drone survey data in the vicinity of the Quarry and expansion lands should be included within the document, confirming it is sufficient to support hazard delineations in keeping with Provincial Guidelines. To improve the | The topographic mapping was generated from a drone survey completed November 22, 2018 having an accuracy of +/- 3 cm. | Addressed. | RESOLVED |

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| | accuracy of the results, LiDAR data with a +/- 0.1 metre accuracy is available from the Land Information Ontario Data Hub (https://geohub.lio.gov.on.ca/), if necessary. | A geodetic topographic survey of the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek was completed across the south extension lands in support of the Natural Hazards Assessment. The topographic survey was completed by Tatham Engineering Limited January 2020. The topographic survey data has been supplemented with the Drone survey data for the channel overbanks. | | |
| 97. | The Natural Hazards Plan, Dwg NH-1 should include:<br><br>• Source of topographical information including vertical datum.<br>• Stamps and signatures of the qualified professional(s) responsible for the hazard delineation. | The Natural Hazards Plan (Drawing NH-1) has been revised accordingly (see enclosed). | Addressed. | RESOLVED |
| 98. | Saturated soils (i.e. AMCIII conditions) should be assumed when modeling the Regional Storm using the last 12 hours of the Hurricane Hazel rainfall distribution. Modeling and the report should be updated accordingly. | Refer to response to Comments 88 and 89. | Not Addressed. Please see Comment No. 89 response. | The Regional Storm has been assessed under AMCIII conditions as acknowledged in Interim JART Response (February 2022) Comment 88. The updated hydrologic model results were submitted as part of First Response submission package. |
| 102. | Parameterization concerns identified for Existing Conditions should also be addressed within Proposed Conditions models | Understood. Refer to response to Comment 101. | Addressed. Please see Comment Nos. 88 and 89 for additional questions on parameters. | RESOLVED |
| 103. | Results are presented in different locations throughout the report. Recommend for each monitoring location a table for each metric, that summarizes results for pre-quarry (where applicable), existing, operational phases, and rehabilitation conditions. | Refer to response to Comment 59. | Not addressed. See additional response for Comment No. 59. | The results of the assessment are presented in the Surface Water Assessment (Tatham Engineering Limited, April 2020) and the Wetland and Watercourse Characterization Tables. |
| 104. | Proposed Conditions should also document and consider impacts during north and south lake filling. | Refer to response to Comment 43.<br><br>In addition, the integrated surface and groundwater model evaluated the impacts of both rehabilitation scenarios for the existing quarry which are included in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report.<br><br>As noted in the Surface Water Assessment, allowing the existing quarry to fill and form a lake in accordance with the approved rehabilitation plan will cease all discharge from the quarry to the Unnamed Tributary of Willoughby Creek and an alternative rehabilitation scenario is recommended. | Not addressed. Comment stands. | The assessment completed, through both the integrated surface and groundwater model and feature-based wetland water balance, considered worst case scenarios for Phases 1 and 2, Phases 3 through 6 and the two rehabilitation scenarios. Additional analysis is not warranted. |
| 105. | Quarry discharges and the Colling Road diversion are not applied consistently in the different analyses. Results should incorporate the proposed pumping regime with and without the proposed diversion at Colling Road. | The event based hydrologic model has been updated to include proposed conditions with and without the Colling Road diversion. The digital VO files are enclosed for reference. | Updated model includes requested scenarios. Please ensure reporting is updated to provide the results of all the scenarios. | The updated hydrologic model results were submitted as part of the First Response submission package. |
| 106. | Results should be evaluated by the appropriate qualified professional (e.g. water resources engineer, ecologist, or fluvial geomorphologist). | It is unclear as to what results have not been evaluated by a qualified professional. The Surface Water Assessment has been prepared by a water resource engineer, the Level 1 and 2 Natural Environment Technical Report was prepared by ecologists, and the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report was prepared by professional engineers. | As CH requested the analysis be updated, we wanted to ensure the updated results continue to be evaluated and discussed by the appropriate qualified professional within this document (and through integration of the various reports). | We confirm, the analysis and all results have been prepared and evaluated by appropriate qualified professionals. |
| 107. | The depth of water and bathymetry of the wetlands should be provided for any interim phases and in the ultimate condition, in order to assess potential impacts to the wetlands. | Refer to response to Comment 68. | See response to Comment No. 68. | As discussed, the wetland hydroperiod depths are illustrated on the graphs provided in Appendix N and Appendix R of the Surface Water Assessment (Tatham Engineering Limited, April 2020). |
| 122. | Further to above comments, it is noted specifically for Table 28, Proposed Condition (Operations) Outlet Water Balance Results Summary & Table 36, Proposed Condition (Rehabilitation) Outlet Water Balance Results Summary:<br><br>Existing conditions should be presented in the same tables as Proposed conditions to facilitate reviews.<br>Runoff volumes with mitigation measures (Quarry Sump Q100 & Q200 discharges) should be presented. Currently significant reductions in West Arm Runoff Volumes are indicated in the tables but proposed mitigation measures have not been included in the analysis.<br>Significant increases in Weir Pond Runoff Volumes are predicted because of the proposed diversion of external runoff along Colling Road. An assessment of pre-Quarry conditions should be included in the report to support the claim this increase is reflective of a more natural streamflow hydrograph. | Refer to response to Comment 59.<br><br>Tables 28 and 36 have been revised accordingly. | Partially addressed.<br><br>See response to Comment No. 59 outlining the requested additional metrics. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. Additional metrics have not been provided. |
| 126. | Further to above comments, it is noted the ISWGA does not discuss the proposed diversion along Colling Road. Table 29, Proposed Condition Integrated Surface Water Groundwater Model Results may require revision. | Understood. The surface water management strategy/report will be revised as necessary through the development/refinement of the AMP in consultation with the agencies. | Agreed. | RESOLVED |
| 128. | Further to above comments, it is noted specifically for Table 30, Proposed Condition (Operations) Hydrologic Model Results Summary & Table 37, Proposed Condition (Rehabilitation) Hydrologic Model Results Summary –<br><br>Willoughby Creek Tributary on the downstream side of Colling Road should be | Refer to response to Comments 51, 59 and 105.<br><br>The peak quarry discharge flow rate has been added to Tables 30 and 37 as requested. | Partially addressed.<br><br>See response to Comment No. 59 outlining the requested additional metrics. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April |

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| | included in as a point of interest in addition to or instead of the Weir Pond. Results both with and without the diversion of runoff along at Colling Road should be provided. For consistency, peak quarry sump discharge peak flow rates should be added to the peak flows provided in the tables. | | | 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. Additional metrics have not been provided. |
| 151. | Update recommendations and the summary as necessary to reflect any changes resulting from the above feedback. | The surface water management strategy will be revised as necessary through the development/refinement of the AMP in consultation with the agencies. | Comment partially addressed. This section should be updated both separately for the assessment and in conjunction with the AMP work. | The Surface Water Assessment has not been updated as we don't believe it is warranted at this time. |

# NEC SW COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 27. | The report should include analysis of pre-golf course/quarry conditions and speak to how the drainage patterns of the area may have been impacted as a result of the existing extraction operation. Part 2.2.1 of the NEP requires the consideration of single, multiple, or successive development that has occurred or is likely to occur.<br><br>The report should also clarify language used in reference to the existing water features on the golf course lands. If they are features that contribute to the water balance and hydrological system of the area, a broader analysis of the impact of removing them on key natural and key hydrologic features should be incorporated. Any link to the proposed rehabilitation plan should be focused on protecting or enhancing the function of key hydrologic features including any identified wetlands (Part 2.6.3, 2.7.3, 2.7.6 (d), 2.9.3 (d & e), 2.9.11 (a & b).<br><br>If the ponds are considered man-made and their function and impact on the surface/groundwater artificial, a broader analysis of cumulative impacts should be incorporated as this will be the second identifiable time that key hydrologic functions of the golf course lands will have been altered. Coupled with better details on pre-golf course/quarry conditions, this analysis should drive proposed rehabilitation efforts. | Refer to response to Comment 26. Similar to the Quarry, the Burlington Springs Golf and Country Club was constructed in 1962 and little information exists regarding the topography and land use prior to golf course construction.<br><br>Its noted, the integrated surface and groundwater model provides a detailed analysis of the impact of removing these features on the surrounding key hydrologic features. The Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report (Earthfx, April 2020) provides a detailed description of the integrated surface and groundwater model and the impact assessment completed. | Not addressed. As per the response to Comment 26, mapping data for ground conditions, albeit at a less granular level, are available from the National Topographic Series from 1909 to present day. These provide accurate approximations of watercourses on and around the subject properties prior to initiation of aggregate extraction activities and golf course construction, and subsequent evolution of the landscape and watersheds. Similar aerial photo data are available starting from 1934. Given the availability of these data, it is prudent to include this information in the surface water analysis and rehabilitation efforts.<br><br>While restoration and enhancement following development that has occurred or may occur is not predicated on recreation of pre-1950s conditions, rehabilitation can be framed in reference to historical data available for prior surface conditions and informed by system resiliency and not a strategy of "maintaining current hydrologic conditions" that reflect a modern intervention. | The analysis completed and the proposed surface water mitigation strategy for the quarry aims to maintain the existing form and function of the natural heritage features in and surrounding the quarry property. As such, an analysis of pre-quarry conditions has not been completed. As part of the analysis the existing quarry was considered, and recommendations have been included to enhance the existing approved rehabilitation plan to protect downstream natural heritage features. |
| 28. | It is noted that extraction will reduce the drainage area to wetlands 13200 & 13201 but that the area will be supplemented with water pumped from the quarry in order to maintain hydroperiods.<br><br>Is this proposed in perpetuity? Will flows to this wetland be protected through the proposed rehabilitation strategy?<br><br>NEC Staff would not agree that pumping water into a wetland to maintain its hydroperiod fundamentally protects or enhances the feature. This proposed approach should be sufficiently evaluated by a qualified ecology professional to ascertain any additional mitigation strategies required to maintain the wetlands beyond balancing hydroperiods. | The drainage area to Wetland 13200 will be reinstated as part of rehabilitation of the site and the discharge into this feature will cease post rehabilitation. The proposed discharge to Wetland 13201 will continue in perpetuity as part of the rehabilitation plan for the site. | Partially addressed. The quarry discharge rate of flow to the Mount Nemo Creek tributary is relatively brief given the life of the quarry vs. the extant landscape. Estimates of quarry discharge contributions in proportion to overall flow where fish habitat occurs in this watershed would be informative as the hydro-geological report indicates that absent perpetual pumping the resulting lake will be at a level conforming to the water table. Potential impacts to downstream water volumes are relative, given the life of the existing quarry and pumping regime vs. the age of the overall landscape. | Wetland 13201 has no outlet and does not drain to the unnamed tributary of Lake Medad. The culvert crossing No. 2 Sideroad at Wetland 13201 is completely obstructed and there is no direct hydraulic connection between the wetland and the unnamed tributary. As such, the drainage area contributing surface runoff to the unnamed tributary will not be altered through extraction in the west extension. The integrated surface and groundwater model does predict a minor reduction in groundwater contributions to the unnamed tributary. To mitigate the reduction in groundwater contributions, the hydroperiod of Wetland 13201 will be maintained, maintaining the existing infiltration into the overburden aquifer, and the proposed infiltration pond will supplement the groundwater system in this area. |
| 29. | Additional details for the 'replica pond' along Collings Road are being sought.<br><br>How does shifting the current irrigation ponds and implementing a longer diversion channel maintain or enhance the key hydrologic functions of the site?<br><br>Mitigation methods suggest that "a portion" of wetland 13200's drainage area will be reinstated as part of the rehabilitation plan. As part of this it is identified that fill will be imported to raise grade in the area to original ground level. How much fill is required? Why is only 'a portion' being reinstated? Is some pumping still going to be required if the drainage area cannot be replicated?<br><br>New 'replica' ponds should be justified per Part 2.6.7 of the NEP (2017) that requires ponds be designed to avoid key natural and hydrologic features and shall be designed to be offline. | The golf course ponds and diversion channel are not key hydrologic features. They are man-made features constructed to irrigate the golf course. The primary source of water for the diversion channel and golf course ponds is the quarry discharge which is diverted from the weir pond (Wetland 13202) onto the golf course property. The infiltration pond is proposed to mimic existing conditions, specifically the diversion channel and golf course irrigation ponds.<br><br>The portion of Wetland 13200 drainage area that is removed during extraction will be reinstated as part of the rehabilitation of the site; reinstating the entire drainage area to Wetland 13200. The quantity of fill required to reinstate the drainage area is 305,000 $m^3$. Once the drainage area is reinstated, pumping from the quarry into the wetland will cease as it is no longer required.<br><br>The infiltration pond is proposed to mimic existing conditions and will be constructed offline with a passive inlet structure (diversion pipe). | Partially addressed. The role of the proposed infiltration pond, to mimic existing conditions, including the diversion channel and golf course irrigation ponds, does not address Part 2.9.11 (a & b). Comment 27 has a bearing on whether the existing golf-course ponds and watercourses may overlap historic surface water drainage patterns in this portion of the project area, allowing an evaluation of any authentication for their description and/or categorization as key hydrologic features. In short, rehabilitation as part of the West Extension should take these pre-golf course and quarry conditions into account. The sustainability of the pumping in perpetuity to maintain waterflow to Collings Road / 13202 should be evaluated in the comparison to no-pumping ground and surface water conditions. In this context, the need for an infiltration pond along Collings Road may be obviated, lacking a drawdown from pumping, and negating NEP 2.6.7 concerns.<br><br>No details are provided for the source and duration of the proposed fill material and activity, which are required to evaluate this method of rehabilitation. | From a review of the available historic aerial photos, it does not appear that a historic watercourse or ponds existed on the Burlington Springs Golf and Country Club prior to the construction of the diversion channel and irrigation ponds. A watercourse is visible in the aerial photos on the quarry property which drained into the Colling Road roadside ditch and unnamed tributary of Willoughby Creek, like the existing quarry discharge from sump 0100.<br><br>The golf course ponds, and diversion channel are not key hydrologic features. They are man-made features constructed to irrigate the golf course.<br><br>The proposed surface water mitigation strategy for the quarry aims to maintain the existing form and function of the natural heritage features, specifically the unnamed tributary of Willoughby Creek and Willoughby Creek, which have received quarry discharge for over 60 years. An assessment of the pre-quarry condition has not been completed. |

# MATRIX SOLUTIONS SW COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 30. | The surface water assessment establishes surface water drainage conditions across the Burlington Quarry, South Extension, and West Extension lands to assess impacts from the proposed quarry extension and provides context to surface water hydrology and hydrogeology, which is directly linked to fish habitat impacts. This assessment was completed primarily through identification of existing drainage patterns, water balance, and event based hydrologic modelling. There is an overall lack of integration with the surface water report with regards to the 2020 NETR- this is primarily on the basis that the surface water discussion extends beyond the 120.0 metre limit of the extraction footprint. | As noted by the reviewer, it was important to assess the likely changes to the local hydrology and to the groundwater system as a result of the proposed quarry extension because they are directly linked to fish habitat impacts. The purpose of building an integrated surface and groundwater model was to provide a quantitative framework for assessing these impacts in the vicinity of the quarry (which extended well beyond the 120 m limit). The data collection effort was a key part of the study as it provides targets for calibrating the model to ensure it represents current conditions regionally and in the quarry vicinity.<br><br>Please refer to the Watercourse and Wetland Characterization Tables enclosed as Schedule B and Schedule C with this submission for additional information regarding the surface water impacts on fish and fish habitat. | A general lack of integration remains. Please see JART response to Comment #25.<br><br>Comment Noted- The review comment was referring to the integration between the NETR and the surface water studies. The inclusion of watercourse and wetland characterization does provide additional resolution of fish related impacts that may be due to hydrology. Although the surface water quality impacts do extend beyond 120m, the fisheries data relies on data that is from 2003/ 2006 and more recent fish data is limited.<br><br>Given the gap in time, the reviewer is to assume that the data from 2003/2006 is still the baseline condition to which fisheries impacts would be based on. Given increasing drought conditions and warmer climates experienced during that time interval and present-day conditions, the concern is if this fisheries data is still relevant or if has changed.<br><br>Fish community response should be described according to more recent model predictions. This will determine if fish community response changes over time during future quarry operation. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 31. | The surface water assessment acknowledges Willoughby Creek and West Arm as fish habitat, and that baseflows and water temperature are critical to the form and function of the watercourses from a natural heritage and fish spawning perspective. The proposed condition integrated surface water/groundwater analysis predicts a minor reduction in monthly streamflow due to the lowering of groundwater and suggests maintaining the discharge from the Quarry Sump 0100 to ensure that some reaches of Willoughby Creek does not run dry. Furthermore, it mentions that the predictive water/groundwater model predicts a measurable reduction in flow of the unnamed tributary of Lake Medad during operations and quarrying. For this reason, the surface water assessment report recommends that streamflow and water temperature thresholds be established from historic surface water monitoring completed in support of the proposed quarry extension. The rationale for future management of quarry water as is lacking in critical details such as "how does the hydroperiods function in terms of downstream fisheries". There is also no table or rationale illustrating how the reductions streamflow and lowering of groundwater as predicted by the groundwater models will be offset by pumping operations. | Additional information is provided in the JART NETR response to comments and the Watercourse Characterization Tables enclosed (Schedule C).<br><br>Pumping is done under current (baseline) conditions to dewater the existing quarry. The water is discharged from the quarry sumps into the Unnamed Tributary of Willoughby Creek and to the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek. Some of the discharge in these streams seep into the underlying aquifer. This practice is proposed to continue as part of the proposed quarry extensions. Streams close to the new excavations will likely experience a decrease in flows while the Unnamed Tributary to Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek will have higher flows and higher losses to groundwater. Determining the like changes in these volumes under the different scenarios was a key objective of the integrated model.<br><br>The primary source of flow into the Unnamed Tributary of Willoughby Creek and to the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek is quarry discharge. As mentioned, the reductions in streamflow are predicted to be minor and quarry discharge is proposed to occur long-term to maintain streamflow in these features. Additional rationale and details regarding off-site discharge will be provided as the AMP is refined in consultation with the agencies moving forward. | Noted- the response provided is to continue with pumping in perpetuity to maintain adequate stream discharge conditions which will benefit the fisheries community downstream of the quarry extension. The question relates how the pumping scenario will be maintained to balance the predicted losses due to quarrying. Based on this response, details will be provided in the AMP, which has not been provided. | The revised AMP outlines the proposed surface water management strategy for the quarry extension including pumping rates and volumes. The quarry discharge will be further refined through the necessary amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |
| 32. | Drainage to the South Extension is anticipated to be reduced in size as open extraction will intercept rainfall, groundwater, and surface runoff. To alleviate the reduced drainage, discharge to the West Arm from the Quarry Sump 0200 is proposed to continue throughout its operations in accordance with Nelson's Permit to Take Water (PTTW) and Environmental Compliance Approval (ECA) that will require an amendment to include the discharge from the south extension. For the West Extension, extraction activities will reduce the size of the sub catchments draining to several of its existing outlets. Extraction and quarry dewatering are predicted to lower groundwater levels surrounding the west extension within 350.0 metres of the extraction face. Similar to the West Arm discharges, discharge to the Colling Road roadside ditch and Willoughby Creek will be maintained from the Quarry Sump 0100 and is proposed to continue throughout the duration of quarry operations in accordance with Nelson's PTTW and ECA that will require an amendment to include the discharge from the west extension. The runoff regime to the discharge outlets requires further detail. For example, how is the reduced drainage from quarrying balanced by the pumping? As it is understood that the Assessment of impact to Willoughby Creek is based on computer simulations and not real field measurements to verify existing conditions, how is the flow to the downstream reaches validated? If the discharge regime is set to mimic existing conditions, how will this be operationalized in terms of pumping rate? | Continuous streamflow monitoring data has been collected at three locations (SW14, SW7 and SW2) along Willoughby Creek and at SW1 at the upstream end of the Unnamed Tributary of Willoughby Creek since 2014. The integrated surface and groundwater model has been calibrated to the streamflow monitoring data from these monitoring stations. The streamflow data collection effort was a key part of the study as it provides targets for calibrating the model to ensure it represents current conditions regionally and in the quarry vicinity. The calibrated integrated surface and groundwater model has been used to predict the impacts the proposed quarry expansion will have on surface and groundwater features.<br><br>As mentioned, the primary source of flow into the Unnamed Tributary of Willoughby Creek and Willoughby Creek is quarry discharge. As mentioned, the reductions in streamflow are predicted to be minor and quarry discharge is proposed to occur long-term to maintain streamflow in these features. Additional rationale and details regarding off-site discharge will be provided as the AMP is refined in consultation with the agencies moving forward. | The response on validation of the model appears to be on the basis of calibration with monitoring data. The response provided seems to be similar to that noted in comment 31, which is that details will be provided in the AMP, which has not been currently provided yet. | The integrated surface water groundwater model was calibrated and validated against streamflow monitoring data for use as a predictive tool. As discussed, the calibrated integrated surface and groundwater model has been used to predict the impacts the proposed quarry expansion will have on surface and groundwater features.<br><br>The revised AMP outlines the proposed surface water management strategy for the quarry extension including pumping rates and volumes. The quarry discharge will be further refined through the necessary amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |

# MATRIX SOLUTIONS SW COMMENTS

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| 33. | The other aspect of the surface water assessment that should be discussed is the water quality of the discharge waters. If the extraction were to continue to occur in phases, is the water quality of the discharge assumed to be the same? There is a possibility that excavation procedures including blasting may result in the release of contaminants. There is also a possibility that the Enbridge Pipeline which runs along Colling Road could be ruptured through blasting and could impact downstream fish habitat. The cumulative effects of the extraction with respect to water quality and quantity should be explained further in this section. | The discharge from the existing quarry operates under an ECA which specifies a sampling program to confirm the discharge water is of appropriate quality to discharge off-site. Moving forward, the quarry will continue to operate under the terms and conditions of the ECA.<br><br>Also, the quarry operates a series of settling ponds on the quarry floor to settle sediment and contaminants out of the water before being discharged off-site. The settling ponds will remain throughout operations and post rehabilitation to ensure the water is adequately treated before being discharged off-site.<br><br>It's noted, the quarry has operated in this manner for years and has remained in compliance with the terms and conditions of the ECA since issued. | Please confirm that it is intended to amend/ update the ECA.<br><br>Are not the existing settling ponds proposed to be removed long term (I.e. post-rehabilitation)?<br><br>Noted- it is assumed that the ECA will ensure that water quality parameters for discharge water will be adhered to during the quarry extension. The concern relates to water quality discharging into fish habitat- as this is also a DFO requirement, it is assumed that this will also be reflected in the revised AMP which has not been received by the JART Team. | The quarries existing ECA will have to be amended to include the proposed surface water management strategy if the ARA license is issued.<br><br>The existing settling ponds will be expanded during operations to store and treat the quarry water prior to off-site discharge. As part of rehabilitation, the settling ponds will remain as a lake on the quarry floor to store and treat quarry water prior to off-site discharge.<br><br>The revised AMP outlines the proposed water quality sampling and water quality thresholds for the quarry extension. The water quality sampling, including testing parameters and objective limits, will be further refined through the necessary amendment to the quarries MECP Environmental Compliance Approval to protect the downstream natural heritage features and groundwater resources. |
| 34. | The approved rehabilitation plan envisions that the existing Burlington Quarry will be rehabilitated into a lake upon completion of extraction activities, which will result in no further discharges to both Willoughby Creek and West Arm unless water levels in the lake rise in response to wet conditions. This scenario is anticipated to reduce or eliminate baseflows to these systems. As this scenario is considered a negative effect, a new proposed rehabilitation plan proposes rehabilitation of the west extension into a lake (mentioned originally as part of the adaptive management plan) but in the surface water management plan, this has been changed to a conversion of the lands to a landform suitable for recreational, natural heritage and water management purposes. This scenario also includes maintaining the long-term offsite discharge from Quarry Sump 0100 and Quarry Sump 0200 to the tributary of Willoughby Creek and West Arm as part of the new rehabilitation plan for the Burlington Quarry and West Extension. The discussion of continual pumping and controlled release of water coming from the lake should be explored further as there may be some benefit to having the lake discharge provide a more stable flow regime that is less susceptible to mechanical failure or disruptions. There is also a diversion from Colling Road that has been proposed and the resultant effects on downstream fisheries habitat along Willoughby Creek should also be discussed. | If the existing quarry is rehabilitated as currently approved (into a lake), the predicted lake water level is expected to fluctuate from approximately 268.75 m to 269.30 m, with an average water level of 269.05 m. The existing weir discharging water to the Unnamed Tributary of Willoughby Creek at Collings Road has a sill elevation of 269.08 m and upstream wetland average water level is 269.27 m. As such, a rehabilitated quarry lake will not drain into the wetland via gravity flow. To achieve gravity flow into the Unnamed Tributary of Willoughby Creek, the existing weir will have to be lowered, adversely impacting the wetland upstream. The existing culvert crossing Collings Road downstream of the weir has an invert elevation of 268.85 m and a weir or outlet elevation below 268.85 m cannot be achieved. Its noted, even if the weir and wetland are removed and the rehabilitated lake outlet set to 268.85 m, there will be periods when discharge to the Unnamed Tributary of Willoughby Creek ceases.<br><br>The proposed Colling Road diversion will direct surface runoff generated north of Colling Road to the Unnamed Tributary of Willoughby Creek, its current and historic outlet, by-passing the quarry settling ponds and quarry sump. | Agreed- explanation regarding the sill elevations does not facilitate the use of the lake to provide the necessary flows through gravity discharge.<br><br>Clarification if there will be a change in the current hydroperiod during interim and post extraction scenarios and this information should be provided in the AMP in regards to mitigation measures. | Any reduction in wetland hydroperiod is to be mitigated. The revised AMP outlines the proposed monitoring program, wetland hydroperiod thresholds and mitigation measures. |

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 146. | Surface water thresholds for wetland hydroperiod are proposed in this report (Section 6.4). It is noted on Page 86 that "If the wetland water level drops to zero at a monitoring location (0.0 water level staff gauge reading) before the hydroperiod threshold stipulated in the previous table, the applicable mitigation measures described in Section 6.5 are to be implemented while the cause of the potential impact is evaluated to determine if it has been caused by extraction and/or quarry dewatering." These thresholds are therefore critical for maintaining wetland functions related to hydroperiod.<br><br>The thresholds are not sufficiently conservative to protect the function of these ponds should the quarry affect their hydroperiod. Pond functions such as amphibian breeding rely on "good" years (years where water remains late into spring and summer) to make up for years where ponds dry up unusually early. The individual monitoring results for each wetland shown in Tables 32 to 35 show that these wetlands generally dry up in late spring or early summer, while the monitoring thresholds in Table 42 show thresholds in the early spring, generally the end of April or beginning of May. Wetlands that consistently dry up in early spring have low capacity to support amphibian breeding and other functions. Later thresholds should be established to ensure standing water is maintained for long enough to promote amphibian breeding and other functions.<br><br>Wetland 13023 (the wetland immediately to the west of the south extension, which supports SWH for breeding amphibians as well as Painted Turtle), is not included in these analyses. The report should discuss monitoring and thresholds for this wetland, even though it is supported by quarry discharge. | The wetland hydroperiod thresholds have been established to identify potential impacts related to the quarry expansion based on wetland hydroperiod monitoring data. Establishing sufficiently conservative thresholds will lead to false triggers caused by climatic conditions during dry years. The intention is to set thresholds, so the existing function of the wetlands is maintained. It is not the intention to set conservative thresholds to increase the length of time the wetlands hold water to improve amphibian breeding.<br><br>The AMP will be refined moving forward in collaboration with the review agencies establishing appropriate thresholds for the wetlands.<br><br>Wetland 13023 is included in the integrated surface and groundwater model and wetland water balance analysis. | Concerns remain about the thresholds that have been set but we will review this in the AMP. | The revised AMP outlines the proposed monitoring program, wetland hydroperiod thresholds and mitigation measures. |

# WOOD ENVIRONMENTAL SW COMMENTS

## Proposed Burlington Quarry Expansion
## Interim JART COMMENT SUMMARY TABLE – Surface Water

Please accept the following as interim feedback from the Burlington Quarry Joint Agency Review Team (JART). Fully addressing each comment below will help expedite the potential for resolutions of the consolidated JART objections and individual agency objections. **These interim comments will be finalized following the breakout meetings between JART and Nelson and any changes will be marked using "track changes". Additional, new comments may be provided once a response has been prepared to the comments raised below and additional information provided**.

| | JART Comments (February 2021) | Applicant Response (July 2021) | Interim JART Response (February 2022) | Applicant Response (June 2022) |
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| 35. | Evolution and background details on the purpose and development of the Terms of Reference would be helpful to understand the context of the scope of the surface water assessment. | The Terms of Reference were developed in accordance with the Halton Region Aggregate Resources Reference Manual. | Can Tatham provide a summary as to how the TOR are in compliance with the HR ARRM? | The Terms of Reference are enclosed for reference. See **Tab 3**. |
| 36. | Rating Curve development is unclear; given the importance to corroborating modelling results this should be discussed in further detail including an indication of potential error bands. | The rating curves at each surface water monitoring station have been developed from in-situ streamflow and depth measurements collected since the stations were established. A staff gauge has been installed at each monitoring location to provide a consistent water depth measurement for each streamflow measurement collected. The rating curves development for each streamflow monitoring station are enclosed for reference. | For each rating curve Tatham should consider a level of confidence assessment given the weight placed on this numerical transformation . Also there are some rating curves developed from very few points (i.e. 2 and 3 respectively for SW 25 and 26). In addition, it would appear that a rating point was secured for SW2 at 6 m3/s – is this correct? This seems very high … | The in-situ streamflow measurements collected are compared and scrutinized and outliers have been removed from the streamflow rating curves. The rating curves with few data points will continue to be developed as additional in-situ streamflow measurements are collected. It is noted, the rating curves for the streamflow monitoring locations used to calibrate the integrated surface and groundwater model have been developed from a series of in-situ streamflow measurements (12 or more). For SW2, hydraulic calculations were completed to estimate a theoretical peak flow to extrapolate the rating curve. This 6 $m^3/s$ peak flow included in the rating curve is the theoretical peak flow. |
| 37. | The Colling Rd. diversion seems central to future management of quarry water; additional background and status on this proposal is required including the potential for a back-up strategy in the event this is not ultimately feasible. | The Colling Road diversion is not central to the management of quarry water. If the diversion is not approved, the surface runoff from north of Colling Road will continue to drain through the quarry as it currently does. To accommodate the surface runoff from north of Colling road, the on- site settling ponds will be reconfigured to provide sufficient on-site volume to store the additional water until it can be discharged off-site in accordance with the terms and conditions of the PTTW. | Spatial and functional implications of this option should be included in the reporting | The proposed Colling Road diversion was included in the integrated surface and groundwater model. The implications of the diversion have been considered along the unnamed tributary of Willoughby Creek and Willoughby Creek. The results of the integrated surface and groundwater model are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), the Watercourse Characterization Tables, and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 38. | Cross-references to the Hydrogeological Assessment reporting should be minimized and relevant text supporting the findings/recommendations in the Surface Water reporting should be extracted and repeated in the Surface Water reporting for completeness. | The Watercourse and Wetland Characterization Tables enclosed (Schedule B and Schedule C) have been prepared by the project team to assemble the results of the various studies in one location for ease of review. | Additional text and graphical data should be integrated as requested beyond the 2 Schedules cited | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 39. | Rationale as to why runoff parameters to wetlands were not adjusted for the wetland results calibration (validation) should be provided. Further, the methodology to establishing wetland "storage correction factors" should be expanded upon as this is a key aspect of validating the model's performance. | The wetland water balance calibration will be refined as additional surface water monitoring data is collected. The wetland water balance calibration methodology will be fully described as the AMP is further developed/refined. | The risks and sensitivity of applying the current runoff parameters vs future updated parameters should be reviewed and discussed in the current reporting; consider a sensitivity analysis | Wetland storage correction factors - The wetland bathymetric survey included collecting cross-sections of the wetland bottom at intervals across the wetland, leading to some uncertainty in the wetland elevations between cross-sections. Based on our field investigations of the wetlands, the wetland bottoms are highly irregular and there are large areas of the wetlands that contain isolated pockets of wetland storage that is not reflected in the bathymetric survey. To account for the additional storage provided in these pockets, a correction factor was applied to the wetland storage volumes.<br><br>As a first step in calibration, a sensitivity analysis was completed to evaluate the impact each hydrologic model parameter has on wetland hydroperiod and water levels. The hydrologic parameters were altered within acceptable ranges to evaluate their impact on the water balance results.<br><br>Given the feature-based wetland water balances generally provide a good fit to the available monitoring data, it is not expected that any future calibration will result in significant changes to the hydrologic parameters. The hydrologic parameters are expected to be tweaked, if necessary, to provide an improved fit as additional monitoring data is collected. |
| 40. | Why was the hydrologic modelling conducted with a simplistic SCS event-based technique rather than a more detailed continuous modelling approach? | The integrated surface and groundwater model is a continuous hydrologic simulation which has been used for the impact assessment in support of the quarry expansion. The simplistic SCS event based hydrologic model was used to estimate the volume of storage required to manage surface runoff on-site during operations and post rehabilitation for the various design storms and Regional Storm. The volume of storage provided on-site is the greater of the storage estimated through the event based and continuous simulations. | Tatham should provide comparisons between the event and continuous simulation results and also examine the use of similar timesteps in the assessment | The integrated surface and groundwater model is a continuous simulation using actual precipitation data and completed on a daily timestep. The event-based simulation assessed theoretical design storms and the Regional Storm. The two analyses were completed for different purposes and provide different results. As such, we don't believe the comparison is warranted. |

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| 41. | The integration of the natural systems feature characteristics and their water needs is not well established. The form and function of these features should be elaborated on and better connected to the results interpretation. | Watercourse and Wetland Characterization Tables (enclosed – Schedule B and Schedule C) have been prepared to better integrate the potential impacts changes in surface and groundwater quantity will have on the natural heritage features. | Please see JART Comment #25. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 42. | The reporting states that there was an iterative process used to refine the Site Plan however no details are provided; documentation of this process should be included in the reporting. | The Site Plans have been revised as the project progressed from initiation through to first submission based on the results of the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report, the Surface Water Assessment, and the Level 1 and 2 Natural Environment Technical Report. The Site Plans were revised to protect the existing Natural Heritage Features and key hydrologic features on and off-site. For example, the extraction limit was revised to maintain the drainage areas to the wetlands adjacent to the south extension, to provide adequate buffers around natural heritage features and eliminate disturbances to significant woodlands. We don't feel it is warranted to include a description of each Site Plan change in the reports. It is just important to know the Site Plans have been developed considering the recommendations and conclusions of the various technical studies. | We respectfully disagree – the documentation of the iterative process is considered important to gain an understanding of the applicants work leading to the current proposal – pls reconsider | The work completed in support of the Site Plans is outlined in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. Again, we don't feel it is warranted to include a description of each Site Plan change in the reports. It is just important to know the Site Plans have been developed considering the recommendations and conclusions of the various technical studies. |
| 43. | Details of impacts during remediation when the lake is filling are not provided; these need to be documented and considered in the assessment of impacts to surrounding systems. | Upon completion of extraction in the south extension, the discharge from the south extension will cease and the quarry will be allowed to fill with water forming a lake. However, the discharge to the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek will continue. The potential impacts during rehabilitation of the south extension are the same as those for extraction in the west extension (under Scenario PH3456). | Consider including provided explanation in the updated reporting | The explanation was provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 44. | The study is understood to have been guided by the TOR developed for the Level 1 and 2 Hydrogeologic and Hydrologic Assessment; these are dated Feb 2020 and the submitted report is April 2020. While it is acknowledged that considerable work occurred for several years prior to the submission of the subject reporting, the authors should consider adding a section which outlines how the TOR evolved, what was their purpose and how the reporting has met the requirements of the TOR, including any deviations. | Refer to response to Comment 35.<br><br>The primary deviation from the TOR was the use of a 10-year rather than 25-year simulation period to determine long-term average components of the water budget. Long run times and model stability issues created practical limitations for the model run times. The stability issues were not related to the quarry but rather to conditions at Mt. Nemo, where the Escarpment is very steep. The model simulation started in 2009 (WY2010) and extends to 2019. There are dry periods and wet periods within that span. It also represents a period for which the best (continuous) observational data were available. There were limited data prior to 2006. | Please see JART response to Comment #35. | The Terms of Reference are enclosed for reference. See **Tab 3.** |
| 45. | The text indicates that the "objective" of the study is to "establish the existing form and function of the surface water features on-site and in the surrounding area and determine if the proposed quarry extension will have an adverse impact …". As noted in several of the comments that follow, the study tends to focus on water balance and hydroperiod as the only markers for impacts to wetlands and outlet receivers. Form and function are not explicitly integrated into the assessment as this requires input and support from the natural ecology study. As such, there is a need to further and more directly integrate the understanding of impacts from an ecological perspective to further inform and guide the overall water management strategy. | Refer to response to Comment 41. | Please refer to JART response to Comment #25. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 46. | Were the monitoring locations advanced by Nelson reviewed and approved by the regulators/agencies either before or after installation? Also, what was the basis for establishing the locations of the gauges in the surrounding area? | Refer to Response to Comment 7. | Please refer to JART response to Comment #7. | The surface and groundwater monitoring locations included in the revised AMP have been developed in cooperation with the MNDMNRF. |
| 47. | The report states that there are two (2) additional wetlands (within the west extension area) which were to be monitored this spring (2020); have these data been collected and if so do they have any impact on recommendations for water management? | Continuous wetland and shallow groundwater monitoring stations were established in each wetland in the west extension lands in the spring of 2020. The wetland hydroperiod and shallow groundwater monitoring data collected to date is illustrated on graphs enclosed. Based on the results from 2020, both wetlands are perched and have short hydroperiods. The collected data does not change our conclusions or recommendations. Monitoring in both wetlands will continue throughout the ARA licensing process and they are both suggested as part of the long-term monitoring program for the quarry. | Acknowledged. Data will need to be reviewed by JART. | RESOLVED |
| 48. | The report indicates that the monitoring period was established as six (6) years; as Tatham is aware not all gauges have 6 years of data with some only having 2 years and others no data (i.e. those proposed for this past spring). Can Tatham comment as to how the lack of a full (6-year) and consistent monitoring period for all gauges affects the findings? Further, has each monitoring year been reviewed in terms of its relationship to climatic norms? This is important when reviewing the results at gauges with different monitoring periods | The monitoring program implemented for this license application has evolved over the past six plus years with the findings and conclusions of the various technical studies. Monitoring data will continue to be collected throughout the licensing process and our conclusions and recommendations will be re-evaluated as additional data is collected.<br><br>Our findings are based on a combination of monitoring data and simulation results. | OK<br><br>The data provided for climatic comparison is unclear – substantial differences are evident between RBG and EarthFx records – these need to be rationalized against long term means on a year by year basis to establish the adequacy of the selected time period | As specified in the revised AMP, a minimum of three years of data will be collected and used to establish threshold values moving forward.<br><br>The best available climate data was used for the simulation period, specifically the period of available monitoring data, of the integrated surface and groundwater model and feature-based wetland water balance.<br><br>Moving forward, Nelson has invested in an on-site climate station that will be |

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| | | The lack of a full 6-year monitoring period does not impact our findings. The use of on-going monitoring data to establish targets where required will be considered in development of the AMP in consultation with the appropriate agencies.<br><br>Each monitoring year has been reviewed in terms of its relationship to climate normals, particularly in terms of wet and dry years. It is important to understand how climate impacts surface water features and this is considered in our analysis as our wetland water balance has been simulated over a year period and the integrated surface and groundwater model simulation covers a 10 year period. A climate summary is enclosed for reference. | | used to collect site specific climate and precipitation data. |
| 49. | Rating curves at each gauge site were noted to be developed by Tatham however no details have been provided. How many data points have been collected at each site and how many reflect storm conditions vs. non-storm conditions? Further has there been any effort to corroborate the water levels to flows using theoretical hydraulics of the local reaches? | Refer to response to Comment 36.<br><br>The number of in-situ streamflow measurements used to develop the rating curves are illustrated on the enclosed graphs. In-situ streamflow measurements have been collected during a variety of climate conditions including spring freshet and during rain events. The rating curves will continue to be refined moving forward as additional in-situ streamflow measurements are collected. | As noted under the response to the reply to comment 36, there are some concerns with the rating curves. Can Tatham comment on the upper levels (rates) determined in the rating curves vs the upper flow rates from the modelling and associated reliability in transformation of levels to flow rates? | The rating curves for the streamflow monitoring locations used to calibrate the integrated surface and groundwater model have been developed from a series of in-situ streamflow measurements (12 or more) of varying flows. For SW2, hydraulic calculations were completed to estimate a theoretical peak flow to extrapolate the rating curve. The 6 $m^3/s$ peak flow included in the rating curve is the theoretical peak flow. Also, additional hydraulic calculations have been undertaken to validate the results of the streamflow monitoring at the surface water monitoring locations. However, we prefer to use, and have used, the in-situ streamflow measurements to develop the rating curves whenever possible. |
| 50. | The reports states that monitoring at all sites was to continue beyond the September 15, 2019 period selected as the end of reporting. Can Tatham verify that all gauges have continued and that the data from these gauges will be used to support decision- making in the future? | All surface water monitoring stations remain in operation except SW7. SW7 was located on private property and the owner of the property asked for the device to be removed in 2020. All of the surface water monitoring locations currently in operation will remain operational throughout the ARA licensing process and it is expected a majority will be maintained throughout extraction in the expansion areas as a condition the Quarry's AMP. | As data are collected the influence of new information on study recommendations needs to be considered ; what is the process? Will this be detailed in the AMP? | The additional data collected will be used to assess impacts, establish thresholds and direct mitigation as described in the revised AMP. |
| 54. | What was the protocol for the manual in-situ measurements taken at the 38 locations surrounding the existing quarry? Was there an inter-event time? Were they always dry periods or also wet periods? Were results adjusted for actual antecedent conditions? | In-situ streamflow measurements were collected every other month from the 38 locations surrounding the existing quarry to confirm the presence of flow. The measurements were generally collected in the spring, summer and fall to understand the seasonality of flow in these watercourses. | Stated protocol needs to be incorporated into updated reporting | The protocol was provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 56. | The report states that a single drivepoint piezometer was installed adjacent to each wetland to monitor shallow groundwater to assist in baseline monitoring. Can Tatham advise as to the rationale for only having a single gauge and what the potential for up and downgradient variation may be and how this may affect the baseline conditions? Based on more common industry practices, wetlands are typically instrumented with multiple gauges to improve the understanding of groundwater/surface water interactions in complex settings. | A single shallow groundwater monitoring mini- piezometer was installed in each monitored wetland based on the results of previous monitoring and our understanding that the wetlands in the area are generally perched. As illustrated through the results of the groundwater monitoring and integrated surface and groundwater model, the wetlands are generally perched, receiving no to minor groundwater contributions (less than 3% of total annual inflow) during spring freshet. | Based on the hydrograph there is seasonal groundwater and based on this one piezometer may not be sufficient to characterize the wetland function. A rationalization for the approach should be documented. The data will need to be reviewed by JART. | As outlined in the revised AMP, additional drive point wells have been installed in the wetlands east of the south extension and in the west extension to collect additional data and confirm our understanding of the overburden aquifer. |
| 57. | Water quality samples were collected from selected surface water monitoring sites for 2018 and 2019 and tested for a limited suite of parameters (TSS, pH and Conductivity); can Tatham advise how these sites were selected and the sampling period determined and why only 3 parameters were tested? Further there seems to be limited interpretation of these data in terms of physical characterization - how is this information being used? | The sampling sites were selected to characterize the water quality as follows:<br>• SW15 – external water quality entering the quarry;<br>• SW1 – water quality entering Unnamed Tributary of Willoughby Creek;<br>• SW2 – water quality of Willoughby Creek at downstream limit of study;<br>• SW14 – water quality of Willoughby Creek upstream of quarry discharge;<br>• SW29 – water quality in Unnamed Tributary of Lake Medad;<br>• SW6 – water quality of West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek leaving the south extension lands;<br>• SW10 – water quality of the West Branch downstream of confluence of West and East Arms;<br>• SW28 – water quality of the East Branch; and<br>• SW30/SW31/SW32/SW35/SW24 – water quality of watercourses in the surrounding area.<br><br>Its noted, water quality samples are collected from the quarry discharge in accordance with the ECA.<br><br>The water quality sampling was not restricted to three parameters. A full spectrum of parameters was tested including general chemistry, metals and nutrients as illustrated in the water quality sample results summaries included in Appendix H of the Surface Water Assessment. | Further clarity on the rationale, objective and use of these data should be incorporated into the updated reporting. | How the sampling sites were selected is provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 61. | Can the source and vintage of the topographic and aerial mapping be provided? Further there is reference to field survey - can this report provide documentation on the extent and purpose of the field survey? | The topographic mapping was generated from a drone survey completed November 22, 2018 having an accuracy of +/- 3 cm.<br><br>A topographic survey was completed of various on-site features including:<br>• Groundwater monitoring wells;<br>• Surface water monitoring stations;<br>• Wetland bathymetry;<br>• Golf course diversion channel and irrigation ponds; | Please include this information in updated report – also please document differences with publicly available data/mapping | The sources of the topographic data are provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |

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| | | • Weir pond outlet structure;<br>• Various culvert crossings; and<br>• West Arm through the south extension lands. | | |
| 62. | Has Tatham compared drainage area mapping with that available through other sources? i.e. CH, MNRF, etc. This would be beneficial to assist in a comparative verification of the mapping. | Our watershed/catchment delineation has been compared against catchment delineations from the MNRF OFAT tool and Conservation Halton's watershed boundaries. Only minor discrepancies exist between the various catchment delineations compared. | Please include details of minor differences in updated report – also pls document differences with publicly available data/mapping. | A description of the comparison completed is provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 65. | Report states that Nelson is exploring options to divert drainage external to the quarry along Colling Rd. This alternative/option is cited in subsequent sections of the reporting as a core requirement of the mitigation strategy. Can Tatham provide additional details on what Nelson has done to "explore" this alternative? Has the City of Burlington been contacted in terms of potential influence on roadway drainage? Has CH been contacted in terms of transferred impacts? Have neighbours been contacted? Have there been any earlier analyses and or design proposals? | The feasibility of diverting the flow has been explored and it has been confirmed that the flow can be diverted through a combination culvert and ditch system. The City of Burlington and Conservation Halton have been made of aware of the proposal through the circulation of the Surface Water Assessment. Local residents have not been contacted regarding the proposal.<br><br>Refer to response to Comment 37 and 64 for additional details. | Functional implications need to be reviewed with all potential affected parties. | The Colling Road diversion is not central to the management of quarry water. If the diversion is not approved, the surface runoff from north of Colling Road will continue to drain through the quarry as it currently does. If Nelson elects to proceed with the diversion of flow along Colling Road, the diversion system will be engineered to convey the required minor and major storm peak flows to the satisfaction of the City of Burlington. Also, the conveyance system downstream of the diversion will be reviewed or improved to ensure it has adequate capacity from the existing quarry discharge location to the unnamed tributary of Willoughby Creek. |
| 66. | The south extension is discussed in terms of drainage area which discharges to the West Arm (36.0 hectares). There is also reference to a further drainage area draining overland into wetlands which are part of the East Arm however no drainage area is provided? Can Tatham advise? | The drainage area to the East Arm is not being altered through the south extension. As such, changes were not discussed. The drainage areas to the East Arm are illustrated on the various Drainage Plans (Drawings DP-1, DP-2 and DP-3) enclosed. | For completeness consider adding clarification as noted in response. | Clarification is provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 73. | The Water Balance Calibration section provides details on the approach and suggests that there was a topographic survey - can details of this survey be provided? Also the calculations have been reported daily and monthly; it is also suggested that these be considered/assessed at a seasonal time period. It should also be noted that there are numerous cross-references in this section and others to the Level 1 and 2 Hydrolgeological Assessment; for completeness and readability it is suggested that relevant details be repeated in this document to improve the flow of content. | Refer to response to Comment 68.<br><br>The wetland water balance has been completed on a daily time step for a period of 22 years (1998 to 2019) to consider seasonality.<br><br>The Wetland Characterization Tables enclosed include the relevant conclusions and recommendations of the various reports in one location. | Please refer to JART responses for Comments #25 and #60. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 74. | Given that only 4 years of data have been used for model performance review it is respectfully suggested that the analysis be re-titled to "Water Balance Validation" as 4 years of data would be considered insufficient for the purpose of model "calibration". | Refer to response to Comment 39. | Response is not acceptable. | Refer to response to Comment 39. |
| 75. | This section indicates that the basis for the calibration (validation) was founded on the wetland discharge parameters rather than any of the runoff generating parameters. Tatham states that this is due to a review of the results which suggests this approach was "reasonable and did not warrant adjustment". Further it is unclear as to how the "correction factors" were established, along with the storage discharge curves and the "broad crested weir equation". Wetland discharge relationships are inherently complex and it is unclear as to how these have been represented accurately. Can Tatham offer more details? | Refer to Response to Comment 39. | Please see JART response to Comment #39.<br><br>Response is not acceptable. | Refer to response to Comment 39.<br><br>The discharge curves were developed directly from the topographic survey of each wetland's outlet using approved broad crested weir equations. |
| 76. | The differences between observed and modelled hydroperiods ranges between 7 and 10 days - has the Nelson Team's ecological specialists weighed in on the adequacy of this predictive range? | The spring hydroperiod has generally been predicted within seven days or less and the fall hydroperiod within 10 days or less. It is our opinion the daily water balance is a reasonable predictor of the wetland hydroperiod and can be used to predict potential impacts from the proposed quarry extensions and dewatering.<br><br>It needs to be kept in mind that the simulation compares proposed conditions to existing to evaluate any potential adverse impacts caused by the proposal. | The 7-10 day shortening could have impact on wetland function over the long term. Additional years of modelling data would improve the understanding and provide guidance for appropriate mitigation measures. | Additional monitoring data will be collected and used to establish appropriate wetland hydroperiod thresholds and mitigation measures. |
| 79. | Table 19 results for some years indicate more runoff than precipitation (e.g. 2009). Can Tatham advise as to the rationale? | There are no locations presented in Table 19 where runoff volume exceeds precipitation. | | RESOLVED |
| 80. | The surface-groundwater model has assumed the quarry discharge as fixed at 67.0 litres/second. It is questioned whether this assumption is valid and what the range of discharge rates are based on actual monitoring? | Quarry discharge was fixed in an earlier version of the baseline model. Because the model had to be capable of predicting quarry discharge under future conditions, the model was modified so that it could predict quarry discharge on a daily basis. The value calculated depended on simulated groundwater and surface water inflows (precipitation and runoff) inflows. The model was calibrated so that it reasonably matched the recorded discharges from the quarry which averaged 67 L/s. | These details should be included in the updated reporting. | The details are provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 81. | Are the flows reported in Table 20 based on the calibrated (validated) modelling? | The flows depicted in Table 20 are results from the calibrated existing condition integrated surface and groundwater model. | Thank you for the clarification, comment addressed | RESOLVED |
| 83. | Can a modelling schematic be provided for the OTTHYMO modelling? | VO model schematics are enclosed for reference. | Comment addressed; no further comments. | RESOLVED |
| 84. | For the surface water assessment for the hazard and erosion impact assessment why has a simplistic event based model been used rather than a more complex and comprehensive modelling approach (continuous simulation)? It is suggested that | The flood and erosion hazard limits have been established in accordance with the Provincial Policy Statement and the MNRF Natural Hazard Technical Guides (Flooding and Erosion Hazard Limits). | Tatham should consider documenting how the work is consistent with the PPS and Technical Guidelines. | We confirm the flood and erosion hazard limits have been established in accordance with the PPS and Technical Guides and additional documentation |

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| | continuous modelling will provide a better and more representative result for the surface water flow regime, including sub-annual events. Further, the SCS CN methodology has been used for this assessment which again tends to be limiting and more black box in its methodology. Other time varying approaches for soil properties applied in long term continuous modelling are considered more accurate and superior to SCS and also eliminate bias when using design storm-based methodologies. | | | will not be provided. |
| 90. | It is noted that the MTO IDF has been selected - have these values been compared to local data available from the City of Burlington and CH? | Refer to response to Comment 86. | It appears as if the COB data are more conservative for the 15 minute to 12 hour range – why have these not been applied? | The 24-hour design storm distribution produces the greater peak flows. The MTO IDF data has been used as it is more conservative for the 24-hour storm. |
| 92. | It is noted that Table 21 reports on the SCS 24-hour distribution but unclear as to why that distribution has been reported rather than the Chicago 4 hour which is also noted to have been executed - please advise; also the timestep is not documented in this section - please advise and outline supporting rationale for its selection | The SCS 24-hour design storm distribution produces greater peak flows than the Chicago 4- hour design storm distribution and therefore the SCS flows have been reported.<br><br>Refer to response to Comment 85. | Thank you for the clarification; can test beaded to the report accordingly and also include reference to the timestep and selection rationale? | Clarification was provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 93. | Why was the quarry discharge not included in the event-based results from Quarry Sumps 100 and 200? | The simplistic SCS event based hydrologic model was used to estimate the volume of storage required on-site during operations and post rehabilitation for the various design storms and Regional Storm. The volume of storage provided on-site is the greater of the storage estimated through the event based and continuous simulations. The results represent the surface runoff, and only surface runoff, draining to each outlet. | Still unclear why sump discharges have not been included? | The event-based simulation was completed to estimate the volume of water entering the quarry to establish the volume of storage required on-site to manage the quarry water during each phase of operation and rehabilitation. The sump discharges from the quarry, removing flow from the sump. The quarry discharge does not contribute flow to the on-site storage system. The volume of water discharged from the quarry sumps during a 24-hour period is relatively small compared to the surface runoff entering the quarry during the 1:100-year return frequency design storm and Regional Storm. |
| 99. | Why was the flood hazard assessment restricted to the West Arm? Should not all outlets be examined for potential impacts due to the alteration of quarry surface water changes? | The Natural Hazards Assessment has been completed for the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek to confirm the proposed extraction limit does not encroach into the existing natural hazards on-site. There are no other natural hazards identified on-site requiring a Natural Hazards Assessment. | Comment addressed. | RESOLVED |
| 100. | It is suggested that a Stream Morphologist be retained to review the erosion thresholds associated with the current predicted flow regime. | Refer to response to Comment 58. | Response to Comment 58 does not provide a reply to stated concern. | The integrated surface and groundwater model is a continuous simulation which generally predicts minor reductions in total streamflow through the unnamed tributary of Willoughby Creek, Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek as a result of the quarry expansion. The quarry discharge from Sumps 0100 and 0200 is not proposed to be altered and, as the model predicts minor reductions in flow, the duration and frequency of the exceedances in the erosion threshold flow rates are not expected to increase. As such, we do not feel an erosion and sediment transport assessment is warranted. |
| 108. | Tatham references an "iterative" process to Site Plan development - for completeness and a more fulsome understanding of the process followed by the Nelson Team, can the iterative changes/adjustments be documented for the record? | Refer to response to Comment 42. | We respectfully disagree – the documentation of the iterative process is considered important to gain an understanding of the applicants work leading to the current proposal – please reconsider. | Refer to response to comment 42. |
| 109. | Per earlier comment on section 3.1.1. pg 28 - can Nelson provide details on the process to-date on establishing a diversion along Colling Rd? | Refer to response to Comments 64 and 65. | Please see JART responses to Comments #64 and #65. | A preliminary design of the Colling Road diversion was submitted as part of the response to JART first submission comments. The implications of the diversion have been considered along the unnamed tributary of Willoughby Creek and Willoughby Creek. The results of the integrated surface and groundwater model are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), the Watercourse Characterization Tables, and subsequent materials presented/submitted in response to JART and MNDMNRF comments. The Colling Road diversion is not central to the management of quarry water. |
| 111. | For the South extension it states that the quarry water is being treated at rates "set to mimic existing conditions"; can Tatham elaborate on how this is going to be operationalized? | The proposed temporary settling pond will be designed to treat the discharge from the south extension in accordance with the effluent criteria established in the ECA. The discharge rates will be established to mimic existing flow rates and volumes in the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek. Additional rationale and details regarding off-site discharge will be provided as the AMP is refined in consultation with the agencies moving forward. | Details need to be elaborated on and included in updated reporting. | Preliminary settling calculations demonstrate that a three-cell settling pond, with 40 m long and 25 m, 15 m, and 5 m widths, will provide sufficient treatment for the proposed discharge rate of 3,000 L/min. The preliminary settling calculations were previously submitted. The design of the settling pond will be completed as part of the ECA amendment process with the MECP. |
| 112. | Can Tatham provide additional details as to how the 50.0 litres/second was established as a limit for pumping? This approach assumes a rate but has there also been a check on volumes? To this end can calculations and assumptions be provided for the 1800.0 cubic metres settling pond sizing? | Refer to response to Comment 111.<br><br>The settling pond has been sized to settle the anticipated particle size distribution in the quarry effluent in accordance with the effluent criteria of the ECA for a flow rate of 50 L/s. The settling calculations are enclosed for reference. | Please refer to JART response to Comment #111. | The discharge rate was established from a review of the available streamflow monitoring data and from the results of the West Arm hydraulic analysis. The streamflow monitoring data collected to date illustrates that existing flows rates typically vary between 20 and 90 l/s during the year. The results of the hydraulic analysis confirm the limiting capacity of the West Arm's low flow channel is 270 l/s. A discharge rate of 50 l/s was selected to remain within the typically streamflow range while ensuring the low flow channel has sufficient capacity to convey the flow within its banks downstream. |

# WOOD ENVIRONMENTAL SW COMMENTS

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| 113. | The report states that 5.0 hectares is a threshold condition for extraction which triggers implementation of a new sump; can Tatham provide details on this determination? Why 5.0 hectares? | The 5.0 hectare threshold was established based on the required floor area to construct a sump with 1800 $m^3$ of available storage while providing sufficient space for operations. This threshold will be re-evaluated as the discharge rate from the south extension is finalized. | When is it planned to re-evaluate the stated threshold? | The thresholds will be reevaluated and finalized prior to site operations in the south extension in accordance with the revised AMP . |
| 114. | What is the source of the 350.0 metre dimension from the face as a point of comparison? | The reference to 350 m is incorrect. The drawdown in water levels, as per the integrated surface and groundwater model, is less than 2.0 m at a distance of 500 m from the active quarry face. | Comment addressed. | RESOLVED |
| 115. | As a means of mitigating impacts to off-site systems Tatham is proposing a "replica" pond. This appears to be a long linear feature extending approx. 3/4 of the distance between No. 2 SR to Colling Rd. From the available documentation it appears that there is no preliminary design for this feature, rather it is shown as a concept in plan form on the Site Plan, with basic sections only. Given the importance which Tatham places on this "replica" facility to service off-site systems and maintain overall water balance can Tatham provide additional design details to ensure that the facility as conceptualized is feasible, particularly in light of its length and the number of inlets and outlets. | The preliminary design of the infiltration pond is illustrated on the Site Plans. The preliminary pond includes the proposed pond grading, the diversion pipe invert elevations and alignment, and the outlet pipe location. We believe the information provided on the Site Plans is sufficient to confirm the feasibility of the infiltration pond and additional details will be provided at detailed design. | Reply to follow discussions with Nelson regarding the infiltration ponds. | Please refer to our previous response to comment 115. |
| 116. | It is postulated by Tatham that reducing flows to the roadside ditch and ultimately the Medad Valley and Willoughby Creek is positive for the function of the ditches however no comment is provided as to the potential environmental impact to the Medad Valley and Willoughby Creek - has this been assessed by Nelson's ecologist? | Refer to response to Comment 70.<br><br>The potential adverse impacts were identified in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report, the Surface Water Assessment, and the Level 1 and 2 Natural Environment Technical Report. Additional information regarding the potential impacts and mitigation measures are included in the Watercourse Characterization Tables enclosed. | Please see JART response to Comment #25. | As presented during the meetings held the week of May 16, 2022, additional analysis has been completed to assess the potential impacts the proposed quarry extension will have on the Medad Valley and Willoughby Creek. The analysis also assessed the proposed infiltration pond's ability to mitigate these potential impacts. The supplemental material prepared in support of the meetings should be reviewed for additional clarification regarding comment 127.<br><br>Additional instrumentation (both shallow groundwater and streamflow monitoring stations) is proposed as part of the updated AMP to confirm our understanding of the surface water and groundwater regimes through the Medad Valley and confirm the results of the integrated surface and groundwater model. |
| 119. | All of the mitigation relies on the diversion of external flow along Colling Rd.; has Tatham considered a back-up or alternate strategy should this not be feasible or approved? | Refer to response to Comment 37. | Please refer to JART response to Comment #37. | The Colling Road diversion is not central to the management of quarry water. If the diversion is not approved, the surface runoff from north of Colling Road will continue to drain through the quarry as it currently does and the on-site settling ponds will be expanded to accommodate this additional surface runoff. |
| 120. | Can Tatham confirm the statement that all surface drainage catchments draining to the wetlands under assessment will not change in area or use over the course of the extraction and post extraction? | The south extension extraction area has been refined during the project to ensure the catchment areas of the wetlands east and south of the south extension will not be altered. As discussed in the Surface Water Assessment, the catchment areas to Wetlands 13200, 13201, 13202 and 13203 will be altered through extraction in the south and west extensions and mitigation measures have been prescribed accordingly. | Will the statement be amended? | Clarification was provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 121 | Tatham indicates that for 7 of the 10 years analysed the hydroperiod would be delayed 5 days or less; can Tatham indicate why the other 3 years have not been reported. | All ten years analysed have been reported in Table 24. | Comment addressed. | RESOLVED |
| 123. | This section is understood to document the impacts to the runoff regime to the various outlets from the Quarry Study area; the last sentence in para. 2 in this section indicates that "if necessary, mitigation measures have been developed that could | You are correct, the sentence should refer to the outlets or watercourses. | AMP details will need to be developed sooner than later. | The revised AMP outlines the proposed surface water monitoring program, streamflow and temperature thresholds and mitigation measures. |
| 124. | Can Table 28 be re-structured to include a comparison between existing and proposed runoff volume at the respective outlets? Further can a table be added which provides a monthly or seasonal comparison at the outlets? | Refer to response to Comment 59. Table 28 has been revised accordingly. | Depending on the modelled year there are significant differences in runoff volume under existing and proposed conditions – the ecological implications of these changes need to be discussed in the reporting. | The results of the integrated surface and ground water model, feature-based wetland water balance and outlet-based water balance analysis along with the conclusions of the Natural Heritage Assessment are included in the Level 1 and Level 2 Hydrogeological and Hydrological Impact Assessment (Earthfx, April 2020), Surface Water Assessment (Tatham Engineering Limited, April 2020), the Level 1 and Level 2 Natural Environment Technical Report (Savanta, April 2020), the Wetland and Watercourse Characterization Tables, the revised AMP and subsequent materials presented/submitted in response to JART and MNDMNRF comments. |
| 125. | Can Tatham provide details on how the system would be performing while the Lake is filling and how long this is predicted to take? | During filling of the lake, the discharge to the Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek will continue from sumps 0100 and 0200.<br><br>Water not needed to maintain discharge to the surface water systems will be pumped into the south extension, which will supplement the groundwater influx and direct precipitation to fill the lake. Currently the existing quarry stores approximately 1 billion litres of water. It will take 3 billion litres to fill the south extension. It is reasonable to suggest that Nelson could pump 5,000 L/min from the existing quarry to the south quarry extension. At this rate, the south extension | Will these details and associated calculations be included in the updated report? | The requested details were provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |

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| | | would fill in 417 days, assuming no inputs from groundwater or direct precipitation. However, the downstream water demands and available water in the Quarry need to be considered. Recognizing the quarry currently holds approximately 1 billion litres of water, 3 billion are required, and the discharge from sump 0100 and 0200 need to be maintained, it is estimated it will take 2 to 5 years to fill the lake. | | |
| 129. | Can Table 30 be re-structured to include a comparison between existing and proposed runoff volume at the respective outlets? Further can a table be added which provides a monthly or seasonal comparison at the outlets? | Refer to response to Comment 59.<br><br>Table 30 has been revised accordingly. | Depending on the event and location peak flows vary significantly under existing and proposed conditions – the ecological impacts need to be reported and considered. | The ecological impacts have been reviewed and considered as part of the natural heritage assessment conducted for the project. |
| 136. | It is unclear if under the rehabilitated condition whether the water balance will change in the vicinity of the replica pond - can Tatham advise? | As noted, the infiltration pond will remain active and receive a portion of the discharge used to maintain low groundwater levels within the excavated area. This water will infiltrate the shallow bedrock and raise groundwater levels in its vicinity. Some of the infiltrating water would flow back into the excavation while the remainder would discharge to the Medad Valley. Simulated changes in the water balance in nearby streams and wetlands are discussed in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report. | Suggest that Additional details to be added to updated report. | As presented during the meetings held the week of May 16, 2022, additional analysis has been completed to assess the potential impacts the proposed quarry extension will have on groundwater levels, the Medad Valley and Willoughby Creek. The analysis also assessed the proposed infiltration pond's ability to mitigate these potential impacts. The supplemental material prepared in support of the meetings should be reviewed for additional clarification regarding comment 136. |
| 132. | Section 5.2 makes reference to a new rehabilitation plan which proposes to convert the Burlington Quarry into a landform rather than a lake. Drawing 3 of the Site Plan set outlines the proposed rehabilitation for the west extension however no plan(s) are provided for the existing Burlington Quarry. In order to fully understand the drainage patterns and operations affecting surface water, a plan should be provided at this stage which illustrates the full rehabilitation plan, including the existing quarry. | Refer to response to Comment 13. | In the reply to comment #13 Tatham indicates that "…Tatham assisted with the water management components of the rehabilitation design for the existing quarry and proposed extension." Can further details be provided? | The proposed surface water mitigation strategy for the quarry aims to maintain the existing form and function of the natural heritage features, specifically the unnamed tributary of Willoughby Creek and Willoughby Creek, which have received quarry discharge for over 60 years. The cessation of the quarry discharge from sump 0100 as approved under the current quarry ARA license will alter the streamflow rates and patterns through the unnamed tributary of Willoughby Creek and Willoughby Creek, altering the form and function of these natural heritage features.<br><br>A recommendation of the Tatham report was to amend the rehabilitation plan for the existing quarry to maintain the current pumping regime to protect adjacent features from negative impacts. As part of this recommendation, Tatham assisted with the proposed design of the pond, lakes and discharge points to ensure the proposed rehabilitation plan includes a landform capable of maintaining the current pumping regime. |
| 133 | Tatham references an "iterative" process to Site Plan development - for completeness and a more fulsome understanding can the iterative changes/adjustments be documented for the record | Refer to response to Comment 42. | Please refer to JART response to Comment #42. | See response to Comment # 42. |
| 134. | This section describes long term water management objectives for the Quarry but does not provide any indication as to the overall water budget nor the needs for each of the proposed features requiring water. Can Tatham outline the water demands and associated tolerances for each element cited and also provide an indication of sustainability? | The long-term water management objective of the Quarry is to maintain the existing discharge (rate and volume) to the Unnamed Tributary of Willoughby Creek and the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek.<br><br>Also, the discharge of quarry water into Wetland 13201 via the bottom draw outlet and the infiltration pond is required to maintain the wetland hydroperiod. The wetland hydroperiod will be established as additional baseline monitoring data is collected from the wetland. Also, the wetland water balance will be updated and recalibrated to identify the water demands to the wetland long-term. | Suggest that Additional details to be added to updated report. | The details are provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 135 | Tatham indicates that a water level control is not proposed for the lake - can the reason and rationale be provided? It is suggested that without some form of control adaptive management opportunities may be compromised | Based on the results of the integrated surface and groundwater model, the lake will fill to an elevation of 271.0 m. Minimum existing grade around the proposed south extension lake is<br>272.0 m and the grade will be raised via earthworks to contain the pond water level. An overflow weir will be installed to discharge water from the lake to the West Arm of the West Branch of the Mount Nemo Tributary of Grindstone Creek, preventing failure of the lake banks in case of an emergency. Although, the overflow weir is not expected to be used.<br><br>If streamflow mitigation is required in the West Arm, there are opportunities to construct an outlet to the watercourse. However, discharge from quarry sump 0200 to the West Arm is proposed long-term and may also be adjusted to mitigate adverse impacts in the West Arm.<br><br>The AMP will be refined moving forward in collaboration with the review agencies establishing appropriate mitigation measures for the watercourses. | Suggest that Additional details to be added to updated report. | The details are provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 136. | It is unclear if under the rehabilitated condition whether the water balance will change in the vicinity of the replica pond - can Tatham advise? | As noted, the infiltration pond will remain active and receive a portion of the discharge used to maintain low groundwater levels within the excavated area. This water will infiltrate the shallow bedrock and raise groundwater levels in its vicinity. Some of the infiltrating water would flow back into the excavation while | Suggest that Additional details to be added to updated report. | The details are provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |

| | | | | |
|---|---|---|---|---|
| | | the remainder would discharge to the Medad Valley. Simulated changes in the water balance in nearby streams and wetlands are discussed in the Level 1 and 2 Hydrogeological and Hydrological Impact Assessment Report. | | |
| 137. | Tatham notes that a bottom draw outlet control will be maintained post extraction and monitoring of the wetland will be completed to maintain the hydroperiod; can Tatham advise on the triggers for adaptive management and the adjustments which may be required if those triggers are not met? | The AMP will be refined moving forward in collaboration with the review agencies establishing appropriate thresholds and mitigation measures for Wetland 13201. | Details should be developed sooner than later. | The wetland monitoring program, hydroperiod thresholds and mitigation measures are provided in the revised AMP. |
| 138. | Can Table 36 be re-structured to include a comparison between existing and proposed runoff volume at the respective outlets? Further can a table be added which provides a monthly or seasonal comparison at the outlets? | Refer to response to comment 59.<br><br>Table 36 has been revised as requested. | Depending on the event and location peak flows vary significantly under existing and proposed conditions – the ecological impacts need to be reported and considered. | The ecological impacts have been reviewed and considered as part of the natural heritage assessment conducted for the project. |
| 139. | Can Table 37 be re-structured to include a comparison between existing and proposed peak flows at the respective outlets? | Table 37 has been revised as requested. | Depending on the event and location peak flows vary significantly under existing and proposed conditions – the ecological impacts need to be reported and considered. | The ecological impacts have been reviewed and considered as part of the natural heritage assessment conducted for the project. |
| 140. | Revisit and revise the Surface Water Management Strategy in conjunction with addressing the feedback on the Surface Water Assessment and other supporting studies. | The surface water management strategy will be revised as necessary through the development/refinement of the AMP in consultation with the agencies. | Agreed. | RESOLVED |
| 141. | Can Tatham provide a basis for the range in active storage requirements - i.e. 700,000.0 to 800,000.0 cubic metres? | Refer to response to Comment 40. | So for clarity is Tatham stating that this represents the difference between the results from the 2 modelling approaches? If so consider including this detail in the updated report. | Clarification was provided in our response to the JART first submission comments which we feel is sufficient to address this comment. |
| 142. | For clarity can Tatham indicate which gauges were installed for this study and which will remain and which will be added post extraction? Suggest adding these details to Tables 38 and 39. | The existing and proposed surface water monitoring locations are illustrated on the Existing and Proposed Surface Water Monitoring Locations Plans (Drawings SW-1 and SW-2). | Comment addressed. | RESOLVED |
| 143. | Can Tatham outline the elements of the adaptive management plan which will potentially be available to meet the environmental management goals? | The AMP will be refined moving forward in collaboration with the review agencies to satisfy the environmental management goals. | Details should be developed sooner than later. | RESOLVED |
| 144. | Can Tatham outline the elements of the adaptive management plan which will potentially be available to meet the environmental management goals? | The AMP will be refined moving forward in collaboration with the review agencies to satisfy the environmental management goals. | Details should be developed sooner than later. | The elements are outlined in the revised AMP. |
| 145. | Can Tatham describe the methodology proposed for Nelson to establish a long-term discharge protocol? | All discharge to Wetland 13201 should be recorded and analysed overtime to identify any trends in discharge. If trends are identified, a discharge protocol should be established to further protect the wetland and reduce the reliance of the weekly recommended monitoring to identify impacts on hydroperiod. | Consider adding these details to the updated reporting. | The methodology is described in the revised AMP. |

# Tab **1**

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** S100 **Area** 248.20 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 164.49 | 0.66 | 6.88 | 0.04 | 60 | 0.08 | 0.00 | 69 | 0.00 | 0.00 | 65 | 46.78 | 0.28 | 74 | 5.01 | 0.03 | 100 | 26.64 | 0.16 | 50 | 79.12 | 0.48 | 100 | 82.83 |
| C | 3 | 83.71 | 0.34 | 0.00 | 0.00 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 31.71 | 0.38 | 82 | 2.07 | 0.02 | 100 | 26.11 | 0.31 | 50 | 23.81 | 0.28 | 100 | 77.58 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **248.20** | **1.00** | **6.88** | **0.03** | | **0.08** | **0.00** | | **0.00** | **0.00** | | **78.49** | **0.32** | | **7.09** | **0.03** | | **52.75** | **0.21** | | **102.93** | **0.41** | | **81.06** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1850 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 248.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 65.24 |
| **Time of Concentration (Hours)** | 1.09 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.72 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1850 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 248.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 125.96 |
| **Time of Concentration (Hours)** | 2.10 |
| **Time to Peak (2/3 x Time of Concentration)** | 1.40 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.34** | mm |
| **Runoff Coefficient** | **0.30** | |
| **Time to Peak** | **1.40** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.27 | 0.35 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 101 **Area** 84.22 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 41.56 | 0.49 | 3.72 | 0.09 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 31.10 | 0.75 | 74 | 4.28 | 0.10 | 100 | 2.47 | 0.06 | 50 | 0.00 | 0.00 | 85 | 74.00 |
| C | 3 | 42.66 | 0.51 | 3.34 | 0.08 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 23.61 | 0.55 | 82 | 3.01 | 0.07 | 100 | 12.70 | 0.30 | 50 | 0.00 | 0.00 | 89 | 73.04 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **84.22** | **1.00** | **7.05** | **0.08** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **54.71** | **0.65** | | **7.29** | **0.09** | | **15.17** | **0.18** | | **0.00** | **0.00** | | **73.51** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1150 | m |
| Catchment Slope | 0.50% | |
| Catchment Area | 84.22 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 48.33 |
| **Time of Concentration (Hours)** | 0.81 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.54 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1150 | m |
| Catchment Slope | 0.50% | |
| Catchment Area | 84.22 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 97.33 |
| **Time of Concentration (Hours)** | 1.62 |
| **Time to Peak (2/3 x Time of Concentration)** | 1.08 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.72** | mm |
| **Runoff Coefficient** | **0.40** | |
| **Time to Peak** | **1.08** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.39 | 0.41 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 102 **Area** 6.70 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 6.70 | 1.00 | 1.07 | 0.16 | 60 | 4.69 | 0.70 | 69 | 0.00 | 0.00 | 65 | 0.02 | 0.00 | 74 | 0.92 | 0.14 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 71.84 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.70** | **1.00** | **1.07** | **0.16** | | **4.69** | **0.70** | | **0.00** | **0.00** | | **0.02** | **0.00** | | **0.92** | **0.14** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **71.84** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 250 | m |
| Catchment Slope | 5.40% | |
| Catchment Area | 6.70 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 8.41 |
| **Time of Concentration (Hours)** | 0.14 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.09 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 250 | m |
| Catchment Slope | 5.40% | |
| Catchment Area | 6.70 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 19.95 |
| **Time of Concentration (Hours)** | 0.33 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.22 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **5.39** | mm |
| **Runoff Coefficient** | **0.42** | |
| **Time to Peak** | **0.09** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.30 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.45 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.35 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.33 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.33 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.42 | 0.00 | 0.00 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 103 **Area** 16.50 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 16.50 | 1.00 | 2.68 | 0.16 | 60 | 12.26 | 0.74 | 69 | 0.00 | 0.00 | 65 | 0.20 | 0.01 | 74 | 1.36 | 0.08 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 70.16 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **16.50** | **1.00** | **2.68** | **0.16** | | **12.26** | **0.74** | | **0.00** | **0.00** | | **0.20** | **0.01** | | **1.36** | **0.08** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **70.16** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 430 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 16.50 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 18.17 |
| **Time of Concentration (Hours)** | 0.30 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.20 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 430 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 16.50 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 50.36 |
| **Time of Concentration (Hours)** | 0.84 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.56 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **5.59** | mm |
| **Runoff Coefficient** | **0.33** | |
| **Time to Peak** | **0.56** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.33 | 0.00 | 0.00 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 104 **Area** 6.91 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 6.91 | 1.00 | 1.68 | 0.24 | 60 | 1.51 | 0.22 | 69 | 0.00 | 0.00 | 65 | 2.72 | 0.39 | 74 | 1.00 | 0.14 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 73.26 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.91** | **1.00** | **1.68** | **0.24** | | **1.51** | **0.22** | | **0.00** | **0.00** | | **2.72** | **0.39** | | **1.00** | **0.14** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **73.26** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4,**
**Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 260 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 6.91 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 10.74 |
| **Time of Concentration (Hours)** | 0.18 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.12 |

**For Runoff Coefficients less than 0.4,**
**Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 260 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 6.91 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 29.89 |
| **Time of Concentration (Hours)** | 0.50 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.33 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.57** | mm |
| **Runoff Coefficient** | **0.40** | |
| **Time to Peak** | **0.33** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.40 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 105 **Area** 1.67 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.67 | 1.00 | 0.28 | 0.17 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 1.17 | 0.70 | 74 | 0.23 | 0.14 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 75.23 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.67** | **1.00** | **0.28** | **0.17** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **1.17** | **0.70** | | **0.23** | **0.14** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **75.23** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 1.67 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 7.58 |
| **Time of Concentration (Hours)** | 0.13 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.08 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 1.67 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.40 |
| **Time of Concentration (Hours)** | 0.44 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.81** | mm |
| **Runoff Coefficient** | **0.42** | |
| **Time to Peak** | **0.08** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.42 | 0.00 | 0.00 | 0.00 |

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 106 **Area** 2.32 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | 
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** |
| B | 2 | 2.32 | 1.00 | 0.30 | 0.13 | 60 | 1.79 | 0.77 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.14 | 0.06 | 100 | 0.08 | 0.04 | 50 | 0.00 | 0.00 | 85 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A |
| | **Totals** | **2.32** | **1.00** | **0.30** | **0.13** | | **1.79** | **0.77** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.14** | **0.06** | | **0.08** | **0.04** | | **0.00** | **0.00** | |

| Hydrologic Soil Group | Average CN for Soil Type |
|---|---|
| B | 69.06 |
| | 0.00 |
| | 0.00 |
| | 0.00 |
| **Totals** | **69.06** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 190 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 2.32 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 9.96 |
| **Time of Concentration (Hours)** | 0.17 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.11 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 190 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 2.32 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 35.54 |
| **Time of Concentration (Hours)** | 0.59 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.39 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **5.71** | mm |
| **Runoff Coefficient** | **0.31** | |
| **Time to Peak** | **0.39** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.31 | 0.00 | 0.00 | 0.00 |

| | |
|---|---|
| **Project:** | Project Sideways |
| **File No.:** | 113187 |
| **Revision No.:** | 1 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations |
| **Prepared By:** | DAM |
| **Reviewed By:** | DRT |
| **Date:** | 21-May-19 |

## EXISTING CONDITIONS

**Catchment** 107 **Area** 8.67 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 8.67 | 1.00 | 0.49 | 0.06 | 60 | 8.15 | 0.94 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.03 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 68.58 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **8.67** | **1.00** | **0.49** | **0.06** | | **8.15** | **0.94** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.03** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **68.58** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 280 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 8.67 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 12.20 |
| **Time of Concentration (Hours)** | 0.20 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.14 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 280 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 8.67 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 41.01 |
| **Time of Concentration (Hours)** | 0.68 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.46 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **5.28** | mm |
| **Runoff Coefficient** | **0.28** | |
| **Time to Peak** | **0.46** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.28 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 108 **Area** 6.56 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 6.56 | 1.00 | 1.95 | 0.30 | 60 | 3.48 | 0.53 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.01 | 0.00 | 100 | 1.12 | 0.17 | 50 | 0.00 | 0.00 | 85 | 63.12 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.56** | **1.00** | **1.95** | **0.30** | | **3.48** | **0.53** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.01** | **0.00** | | **1.12** | **0.17** | | **0.00** | **0.00** | | **63.12** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 6.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 15.22 |
| **Time of Concentration (Hours)** | 0.25 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.17 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 6.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 55.10 |
| **Time of Concentration (Hours)** | 0.92 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.61 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.68** | mm |
| **Runoff Coefficient** | **0.23** | |
| **Time to Peak** | **0.61** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.23 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 109 **Area** 7.38 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 7.38 | 1.00 | 4.64 | 0.63 | 60 | 2.59 | 0.35 | 69 | 0.00 | 0.00 | 65 | 0.12 | 0.02 | 74 | 0.00 | 0.00 | 100 | 0.03 | 0.00 | 50 | 0.00 | 0.00 | 85 | 63.33 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **7.38** | **1.00** | **4.64** | **0.63** | | **2.59** | **0.35** | | **0.00** | **0.00** | | **0.12** | **0.02** | | **0.00** | **0.00** | | **0.03** | **0.00** | | **0.00** | **0.00** | | **63.33** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 7.38 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 14.00 |
| **Time of Concentration (Hours)** | 0.23 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.16 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 7.38 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 47.36 |
| **Time of Concentration (Hours)** | 0.79 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.53 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.21** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.53** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 110 **Area** 6.54 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 6.54 | 1.00 | 0.40 | 0.06 | 60 | 4.02 | 0.61 | 69 | 0.00 | 0.00 | 65 | 0.83 | 0.13 | 74 | 0.00 | 0.00 | 100 | 1.29 | 0.20 | 50 | 0.00 | 0.00 | 85 | 65.34 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.54** | **1.00** | **0.40** | **0.06** | | **4.02** | **0.61** | | **0.00** | **0.00** | | **0.83** | **0.13** | | **0.00** | **0.00** | | **1.29** | **0.20** | | **0.00** | **0.00** | | **65.34** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 360 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 6.54 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 16.69 |
| **Time of Concentration (Hours)** | 0.28 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.19 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 360 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 6.54 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 51.44 |
| **Time of Concentration (Hours)** | 0.86 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.57 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.94** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.57** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 111 **Area** 14.85 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 10.19 | 0.69 | 1.61 | 0.16 | 60 | 5.09 | 0.50 | 69 | 0.00 | 0.00 | 65 | 1.96 | 0.19 | 74 | 0.34 | 0.03 | 100 | 1.13 | 0.11 | 50 | 0.07 | 0.01 | 85 | 67.59 |
| C | 3 | 1.58 | 0.11 | 0.00 | 0.00 | 73 | 0.48 | 0.31 | 79 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 82 | 0.14 | 0.09 | 100 | 0.96 | 0.61 | 50 | 0.00 | 0.00 | 89 | 63.33 |
| D | 3 | 3.08 | 0.21 | 0.00 | 0.00 | 79 | 2.85 | 0.92 | 84 | 0.00 | 0.00 | 81 | 0.00 | 0.00 | 86 | 0.00 | 0.00 | 100 | 0.23 | 0.08 | 50 | 0.00 | 0.00 | 91 | 81.42 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **14.85** | **1.00** | **1.61** | **0.11** | | **8.42** | **0.57** | | **0.00** | **0.00** | | **1.96** | **0.13** | | **0.49** | **0.03** | | **2.32** | **0.16** | | **0.07** | **0.00** | | **70.01** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 420 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 14.85 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 16.08 |
| **Time of Concentration (Hours)** | 0.27 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.18 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 420 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 14.85 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 43.31 |
| **Time of Concentration (Hours)** | 0.72 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.48 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.79** | mm |
| **Runoff Coefficient** | **0.30** | |
| **Time to Peak** | **0.48** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | D | 0 |
| | 2 | 3 | 3 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.35 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.55 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.40 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.95 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.05 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.38 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.38 | 0.00 |
| Soil Series Total | 0.29 | 0.24 | 0.37 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 112 **Area** 26.24 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 22.21 | 0.85 | 3.64 | 0.16 | 60 | 2.53 | 0.11 | 69 | 0.00 | 0.00 | 65 | 14.11 | 0.64 | 74 | 0.63 | 0.03 | 100 | 1.30 | 0.06 | 50 | 0.00 | 0.00 | 85 | 70.48 |
| C | 3 | 2.53 | 0.10 | 1.15 | 0.46 | 73 | 0.20 | 0.08 | 79 | 0.00 | 0.00 | 76 | 1.03 | 0.41 | 82 | 0.13 | 0.05 | 100 | 0.02 | 0.01 | 50 | 0.00 | 0.00 | 89 | 78.27 |
| C | 3 | 1.50 | 0.06 | 0.55 | 0.36 | 73 | 0.35 | 0.23 | 79 | 0.00 | 0.00 | 76 | 0.08 | 0.05 | 82 | 0.00 | 0.00 | 100 | 0.52 | 0.35 | 50 | 0.00 | 0.00 | 89 | 66.90 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **26.24** | **1.00** | **5.34** | **0.20** | | **3.08** | **0.12** | | **0.00** | **0.00** | | **15.22** | **0.58** | | **0.76** | **0.03** | | **1.84** | **0.07** | | **0.00** | **0.00** | | **71.03** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 640 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 26.24 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 25.82 |
| **Time of Concentration (Hours)** | 0.43 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 640 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 26.24 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 61.12 |
| **Time of Concentration (Hours)** | 1.02 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.68 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.58** | mm |
| **Runoff Coefficient** | **0.34** | |
| **Time to Peak** | **0.68** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | C | 0 |
| | 2 | 3 | 3 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.35 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.55 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.40 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.95 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.05 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.38 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.38 | 0.00 |
| Soil Series Total | 0.33 | 0.46 | 0.27 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 113 **Area** 10.55 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 10.55 | 1.00 | 5.75 | 0.54 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 3.87 | 0.37 | 74 | 0.67 | 0.06 | 100 | 0.27 | 0.03 | 50 | 0.00 | 0.00 | 85 | 67.41 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **10.55** | **1.00** | **5.75** | **0.54** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **3.87** | **0.37** | | **0.67** | **0.06** | | **0.27** | **0.03** | | **0.00** | **0.00** | | **67.41** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 370 | m |
| Catchment Slope | 0.90% | |
| Catchment Area | 10.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 17.02 |
| **Time of Concentration (Hours)** | 0.28 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.19 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 370 | m |
| Catchment Slope | 0.90% | |
| Catchment Area | 10.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 50.26 |
| **Time of Concentration (Hours)** | 0.84 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.56 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.44** | mm |
| **Runoff Coefficient** | **0.33** | |
| **Time to Peak** | **0.56** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.33 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 114 **Area** 6.75 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 6.75 | 1.00 | 1.40 | 0.21 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 4.49 | 0.66 | 74 | 0.87 | 0.13 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 74.44 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.75** | **1.00** | **1.40** | **0.21** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **4.49** | **0.66** | | **0.87** | **0.13** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **74.44** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 290 | m |
| Catchment Slope | 2.70% | |
| Catchment Area | 6.75 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 11.20 |
| **Time of Concentration (Hours)** | 0.19 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.12 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 290 | m |
| Catchment Slope | 2.70% | |
| Catchment Area | 6.75 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.74 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.98** | mm |
| **Runoff Coefficient** | **0.41** | |
| **Time to Peak** | **0.12** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.41 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 115 **Area** 17.47 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 16.88 | 0.97 | 6.38 | 0.38 | 60 | 0.78 | 0.05 | 69 | 0.00 | 0.00 | 65 | 3.44 | 0.20 | 74 | 2.32 | 0.14 | 100 | 3.97 | 0.23 | 50 | 0.00 | 0.00 | 85 | 66.40 |
| C | 3 | 0.59 | 0.03 | 0.59 | 1.00 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 82 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 89 | 72.99 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **17.47** | **1.00** | **6.97** | **0.40** | | **0.78** | **0.04** | | **0.00** | **0.00** | | **3.44** | **0.20** | | **2.32** | **0.13** | | **3.97** | **0.23** | | **0.00** | **0.00** | | **66.63** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 490 | m |
| Catchment Slope | 2.00% | |
| Catchment Area | 17.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 18.27 |
| **Time of Concentration (Hours)** | 0.30 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.20 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 490 | m |
| Catchment Slope | 2.00% | |
| Catchment Area | 17.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 44.68 |
| **Time of Concentration (Hours)** | 0.74 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.50 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.58** | mm |
| **Runoff Coefficient** | **0.32** | |
| **Time to Peak** | **0.50** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.32 | 0.35 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 116 **Area** 22.73 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 22.73 | 1.00 | 5.76 | 0.25 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 10.35 | 0.46 | 74 | 1.91 | 0.08 | 100 | 4.70 | 0.21 | 50 | 0.00 | 0.00 | 85 | 67.67 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **22.73** | **1.00** | **5.76** | **0.25** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **10.35** | **0.46** | | **1.91** | **0.08** | | **4.70** | **0.21** | | **0.00** | **0.00** | | **67.67** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 520 | m |
| Catchment Slope | 0.40% | |
| Catchment Area | 22.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.05 |
| **Time of Concentration (Hours)** | 0.43 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 520 | m |
| Catchment Slope | 0.40% | |
| Catchment Area | 22.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 79.17 |
| **Time of Concentration (Hours)** | 1.32 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.88 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.38** | mm |
| **Runoff Coefficient** | **0.31** | |
| **Time to Peak** | **0.88** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.31 | 0.00 | 0.00 | 0.00 |

| Project: | Project Sideways | Prepared By: | DAM |
|---|---|---|---|
| File No.: | 113187 | Reviewed By: | DRT |
| Revision No.: | 1 | Date: | 21-May-19 |
| Description: | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 117 **Area** 1.55 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.55 | 1.00 | 0.73 | 0.47 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.54 | 0.35 | 74 | 0.00 | 0.00 | 100 | 0.28 | 0.18 | 50 | 0.00 | 0.00 | 85 | 63.08 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.55** | **1.00** | **0.73** | **0.47** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.54** | **0.35** | | **0.00** | **0.00** | | **0.28** | **0.18** | | **0.00** | **0.00** | | **63.08** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4,**
**Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 1.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.21 |
| **Time of Concentration (Hours)** | 0.10 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4,**
**Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 1.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.88 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.32** | mm |
| **Runoff Coefficient** | **0.25** | |
| **Time to Peak** | **0.31** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.25 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 118 **Area** 1.48 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 1.48 | 1.00 | 0.50 | 0.34 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.69 | 0.47 | 74 | 0.00 | 0.00 | 100 | 0.28 | 0.19 | 50 | 0.00 | 0.00 | 85 | 64.64 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.48** | **1.00** | **0.50** | **0.34** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.69** | **0.47** | | **0.00** | **0.00** | | **0.28** | **0.19** | | **0.00** | **0.00** | | **64.64** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 130 | m |
| Catchment Slope | 1.50% | |
| Catchment Area | 1.48 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.57 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 130 | m |
| Catchment Slope | 1.50% | |
| Catchment Area | 1.48 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.36 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.30 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.98** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.30** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

**EXISTING CONDITIONS**

**Catchment** 119 **Area** 3.07 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 3.07 | 1.00 | 0.61 | 0.20 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 1.75 | 0.57 | 74 | 0.00 | 0.00 | 100 | 0.71 | 0.23 | 50 | 0.00 | 0.00 | 85 | 65.64 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **3.07** | **1.00** | **0.61** | **0.20** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **1.75** | **0.57** | | **0.00** | **0.00** | | **0.71** | **0.23** | | **0.00** | **0.00** | | **65.64** |

**Time of Concentration Calculations**

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.20% | |
| Catchment Area | 3.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.88 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.08 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.20% | |
| Catchment Area | 3.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 30.49 |
| **Time of Concentration (Hours)** | 0.51 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.34 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.76** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.34** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 120 **Area** 1.56 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.56 | 1.00 | 0.00 | 0.00 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.52 | 0.33 | 74 | 0.00 | 0.00 | 100 | 1.04 | 0.67 | 50 | 0.00 | 0.00 | 85 | 57.96 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.56** | **1.00** | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.52** | **0.33** | | **0.00** | **0.00** | | **1.04** | **0.67** | | **0.00** | **0.00** | | **57.96** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 150 | m |
| Catchment Slope | 3.00% | |
| Catchment Area | 1.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.56 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 150 | m |
| Catchment Slope | 3.00% | |
| Catchment Area | 1.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.41 |
| **Time of Concentration (Hours)** | 0.44 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **10.34** | mm |
| **Runoff Coefficient** | **0.15** | |
| **Time to Peak** | **0.29** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.15 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 121 **Area** 0.46 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 0.46 | 1.00 | 0.00 | 0.00 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.30 | 0.65 | 74 | 0.00 | 0.00 | 100 | 0.16 | 0.35 | 50 | 0.00 | 0.00 | 85 | 65.59 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **0.46** | **1.00** | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.30** | **0.65** | | **0.00** | **0.00** | | **0.16** | **0.35** | | **0.00** | **0.00** | | **65.59** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 100 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 0.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 5.61 |
| **Time of Concentration (Hours)** | 0.09 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.06 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 100 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 0.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 23.87 |
| **Time of Concentration (Hours)** | 0.40 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.27 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.75** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.27** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 122 **Area** 8.15 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 8.15 | 1.00 | 7.01 | 0.86 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.59 | 0.07 | 74 | 0.00 | 0.00 | 100 | 0.55 | 0.07 | 50 | 0.00 | 0.00 | 85 | 60.34 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **8.15** | **1.00** | **7.01** | **0.86** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.59** | **0.07** | | **0.00** | **0.00** | | **0.55** | **0.07** | | **0.00** | **0.00** | | **60.34** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 8.15 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 15.98 |
| **Time of Concentration (Hours)** | 0.27 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.18 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 8.15 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 46.59 |
| **Time of Concentration (Hours)** | 0.78 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.52 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.92** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.52** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 123 **Area** 17.21 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 17.21 | 1.00 | 0.25 | 0.01 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 14.56 | 0.85 | 74 | 0.42 | 0.02 | 100 | 1.98 | 0.12 | 50 | 0.00 | 0.00 | 85 | 71.67 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **17.21** | **1.00** | **0.25** | **0.01** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **14.56** | **0.85** | | **0.42** | **0.02** | | **1.98** | **0.12** | | **0.00** | **0.00** | | **71.67** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 570 | m |
| Catchment Slope | 0.60% | |
| Catchment Area | 17.21 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.07 |
| **Time of Concentration (Hours)** | 0.45 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.30 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 570 | m |
| Catchment Slope | 0.60% | |
| Catchment Area | 17.21 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 71.06 |
| **Time of Concentration (Hours)** | 1.18 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.79 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.50** | mm |
| **Runoff Coefficient** | **0.33** | |
| **Time to Peak** | **0.79** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.33 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 124 **Area** 22.04 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 22.04 | 1.00 | 4.22 | 0.19 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 11.30 | 0.51 | 74 | 0.00 | 0.00 | 100 | 6.53 | 0.30 | 50 | 0.00 | 0.00 | 85 | 64.21 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **22.04** | **1.00** | **4.22** | **0.19** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **11.30** | **0.51** | | **0.00** | **0.00** | | **6.53** | **0.30** | | **0.00** | **0.00** | | **64.21** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 620 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 22.04 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 25.94 |
| **Time of Concentration (Hours)** | 0.43 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 620 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 22.04 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 69.65 |
| **Time of Concentration (Hours)** | 1.16 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.77 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.06** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.77** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 125 **Area** 0.86 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 0.86 | 1.00 | 0.26 | 0.31 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.54 | 0.63 | 74 | 0.00 | 0.00 | 100 | 0.05 | 0.06 | 50 | 0.00 | 0.00 | 85 | 68.21 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **0.86** | **1.00** | **0.26** | **0.31** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.54** | **0.63** | | **0.00** | **0.00** | | **0.05** | **0.06** | | **0.00** | **0.00** | | **68.21** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 110 | m |
| Catchment Slope | 6.00% | |
| Catchment Area | 0.86 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 4.45 |
| **Time of Concentration (Hours)** | 0.07 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.05 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 110 | m |
| Catchment Slope | 6.00% | |
| Catchment Area | 0.86 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 13.64 |
| **Time of Concentration (Hours)** | 0.23 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.15 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.23** | mm |
| **Runoff Coefficient** | **0.38** | |
| **Time to Peak** | **0.15** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.30 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.45 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.35 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.33 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.33 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.38 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 126 **Area** 9.19 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 9.19 | 1.00 | 3.08 | 0.34 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 5.10 | 0.56 | 74 | 0.00 | 0.00 | 100 | 1.00 | 0.11 | 50 | 0.00 | 0.00 | 85 | 66.68 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **9.19** | **1.00** | **3.08** | **0.34** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **5.10** | **0.56** | | **0.00** | **0.00** | | **1.00** | **0.11** | | **0.00** | **0.00** | | **66.68** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.80% | |
| Catchment Area | 9.19 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 15.43 |
| **Time of Concentration (Hours)** | 0.26 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.17 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.80% | |
| Catchment Area | 9.19 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 42.73 |
| **Time of Concentration (Hours)** | 0.71 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.47 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.55** | mm |
| **Runoff Coefficient** | **0.28** | |
| **Time to Peak** | **0.47** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.28 | 0.00 | 0.00 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** S127 **Area** 4.07 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 3.51 | 0.86 | 0.42 | 0.12 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 3.09 | 0.88 | 74 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 72.32 |
| C | 3 | 0.55 | 0.14 | 0.06 | 0.11 | 73 | 0.19 | 0.34 | 79 | 0.00 | 0.00 | 76 | 0.31 | 0.56 | 82 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 89 | 80.02 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **4.07** | **1.00** | **0.48** | **0.12** | | **0.19** | **0.05** | | **0.00** | **0.00** | | **3.40** | **0.84** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **73.36** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 2.40% | |
| Catchment Area | 4.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 12.47 |
| **Time of Concentration (Hours)** | 0.21 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.14 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 2.40% | |
| Catchment Area | 4.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 31.43 |
| **Time of Concentration (Hours)** | 0.52 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.35 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.26** | mm |
| **Runoff Coefficient** | **0.36** | |
| **Time to Peak** | **0.35** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.34 | 0.48 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** S100 **Area** 248.20 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 164.49 | 0.66 | 6.88 | 0.04 | 60 | 0.08 | 0.00 | 69 | 0.00 | 0.00 | 65 | 46.78 | 0.28 | 74 | 5.01 | 0.03 | 100 | 26.64 | 0.16 | 50 | 79.12 | 0.48 | 100 | 82.83 |
| C | 3 | 83.71 | 0.34 | 0.00 | 0.00 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 31.71 | 0.38 | 82 | 2.07 | 0.02 | 100 | 26.11 | 0.31 | 50 | 23.81 | 0.28 | 100 | 77.58 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **248.20** | **1.00** | **6.88** | **0.03** | | **0.08** | **0.00** | | **0.00** | **0.00** | | **78.49** | **0.32** | | **7.09** | **0.03** | | **52.75** | **0.21** | | **102.93** | **0.41** | | **81.06** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1850 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 248.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 65.24 |
| **Time of Concentration (Hours)** | 1.09 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.72 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1850 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 248.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 125.96 |
| **Time of Concentration (Hours)** | 2.10 |
| **Time to Peak (2/3 x Time of Concentration)** | 1.40 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.34** | mm |
| **Runoff Coefficient** | **0.30** | |
| **Time to Peak** | **1.40** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.27 | 0.35 | 0.00 | 0.00 |

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 101 **Area** 84.22 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 41.56 | 0.49 | 3.72 | 0.09 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 31.10 | 0.75 | 74 | 4.28 | 0.10 | 100 | 2.47 | 0.06 | 50 | 0.00 | 0.00 | 85 | 74.00 |
| C | 3 | 42.66 | 0.51 | 3.34 | 0.08 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 23.61 | 0.55 | 82 | 3.01 | 0.07 | 100 | 12.70 | 0.30 | 50 | 0.00 | 0.00 | 89 | 73.04 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **84.22** | **1.00** | **7.05** | **0.08** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **54.71** | **0.65** | | **7.29** | **0.09** | | **15.17** | **0.18** | | **0.00** | **0.00** | | **73.51** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1150 | m |
| Catchment Slope | 0.50% | |
| Catchment Area | 84.22 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 48.33 |
| **Time of Concentration (Hours)** | 0.81 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.54 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 1150 | m |
| Catchment Slope | 0.50% | |
| Catchment Area | 84.22 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 97.33 |
| **Time of Concentration (Hours)** | 1.62 |
| **Time to Peak (2/3 x Time of Concentration)** | 1.08 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.72** | mm |
| **Runoff Coefficient** | **0.40** | |
| **Time to Peak** | **1.08** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.39 | 0.41 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 102 **Area** 4.96 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 4.96 | 1.00 | 0.85 | 0.17 | 60 | 3.16 | 0.64 | 69 | 0.00 | 0.00 | 65 | 0.02 | 0.00 | 74 | 0.92 | 0.19 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 73.22 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **4.96** | **1.00** | **0.85** | **0.17** | | **3.16** | **0.64** | | **0.00** | **0.00** | | **0.02** | **0.00** | | **0.92** | **0.19** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **73.22** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 250 | m |
| Catchment Slope | 5.40% | |
| Catchment Area | 4.96 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 8.67 |
| **Time of Concentration (Hours)** | 0.14 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.10 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 250 | m |
| Catchment Slope | 5.40% | |
| Catchment Area | 4.96 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 19.11 |
| **Time of Concentration (Hours)** | 0.32 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.21 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **5.31** | mm |
| **Runoff Coefficient** | **0.45** | |
| **Time to Peak** | **0.10** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.30 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.45 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.35 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.33 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.33 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.45 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 103 **Area** 4.37 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 4.37 | 1.00 | 1.10 | 0.25 | 60 | 3.00 | 0.69 | 69 | 0.00 | 0.00 | 65 | 0.08 | 0.02 | 74 | 0.19 | 0.04 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 68.17 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **4.37** | **1.00** | **1.10** | **0.25** | | **3.00** | **0.69** | | **0.00** | **0.00** | | **0.08** | **0.02** | | **0.19** | **0.04** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **68.17** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 430 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 4.37 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 20.75 |
| **Time of Concentration (Hours)** | 0.35 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.23 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 430 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 4.37 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 52.23 |
| **Time of Concentration (Hours)** | 0.87 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.58 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.16** | mm |
| **Runoff Coefficient** | **0.30** | |
| **Time to Peak** | **0.58** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.30 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 104 **Area** 3.20 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 3.20 | 1.00 | 0.83 | 0.26 | 60 | 0.55 | 0.17 | 69 | 0.00 | 0.00 | 65 | 1.34 | 0.42 | 74 | 0.49 | 0.15 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 73.52 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **3.20** | **1.00** | **0.83** | **0.26** | | **0.55** | **0.17** | | **0.00** | **0.00** | | **1.34** | **0.42** | | **0.49** | **0.15** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **73.52** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 260 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 3.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 11.60 |
| **Time of Concentration (Hours)** | 0.19 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.13 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 260 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 3.20 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 29.59 |
| **Time of Concentration (Hours)** | 0.49 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.33 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.67** | mm |
| **Runoff Coefficient** | **0.40** | |
| **Time to Peak** | **0.13** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.40 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

**EXISTING CONDITIONS**

**Catchment** 105 **Area** 0.61 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 0.61 | 1.00 | 0.10 | 0.17 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.43 | 0.70 | 74 | 0.08 | 0.14 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 75.23 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **0.61** | **1.00** | **0.10** | **0.17** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.43** | **0.70** | | **0.08** | **0.14** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **75.23** |

**Time of Concentration Calculations**

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 0.61 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 8.38 |
| **Time of Concentration (Hours)** | 0.14 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.09 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 0.61 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.40 |
| **Time of Concentration (Hours)** | 0.44 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.81** | mm |
| **Runoff Coefficient** | **0.42** | |
| **Time to Peak** | **0.09** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.42 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 106 **Area** 1.46 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.46 | 1.00 | 0.38 | 0.26 | 60 | 0.88 | 0.60 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.12 | 0.08 | 100 | 0.08 | 0.06 | 50 | 0.00 | 0.00 | 85 | 68.14 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.46** | **1.00** | **0.38** | **0.26** | | **0.88** | **0.60** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.12** | **0.08** | | **0.08** | **0.06** | | **0.00** | **0.00** | | **68.14** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 190 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 1.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 10.43 |
| **Time of Concentration (Hours)** | 0.17 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.12 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 190 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 1.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 35.31 |
| **Time of Concentration (Hours)** | 0.59 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.39 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.45** | mm |
| **Runoff Coefficient** | **0.31** | |
| **Time to Peak** | **0.39** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.31 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 108 **Area** 2.00 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 2.00 | 1.00 | 1.12 | 0.56 | 60 | 0.88 | 0.44 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 64.04 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **2.00** | **1.00** | **1.12** | **0.56** | | **0.88** | **0.44** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **64.04** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 2.00 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.85 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.08 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 0.70% | |
| Catchment Area | 2.00 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 33.58 |
| **Time of Concentration (Hours)** | 0.56 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.37 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.80** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.37** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 109 **Area** 6.47 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 6.47 | 1.00 | 4.61 | 0.71 | 60 | 1.69 | 0.26 | 69 | 0.00 | 0.00 | 65 | 0.14 | 0.02 | 74 | 0.00 | 0.00 | 100 | 0.03 | 0.01 | 50 | 0.00 | 0.00 | 85 | 62.53 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.47** | **1.00** | **4.61** | **0.71** | | **1.69** | **0.26** | | **0.00** | **0.00** | | **0.14** | **0.02** | | **0.00** | **0.00** | | **0.03** | **0.01** | | **0.00** | **0.00** | | **62.53** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 6.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 14.19 |
| **Time of Concentration (Hours)** | 0.24 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.16 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 300 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 6.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 47.51 |
| **Time of Concentration (Hours)** | 0.79 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.53 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.63** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.53** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 111 **Area** 7.64 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 5.52 | 0.72 | 1.02 | 0.18 | 60 | 1.45 | 0.26 | 69 | 0.00 | 0.00 | 65 | 1.76 | 0.32 | 74 | 0.00 | 0.00 | 100 | 1.30 | 0.24 | 50 | 0.00 | 0.00 | 85 | 64.45 |
| C | 3 | 1.31 | 0.17 | 0.00 | 0.00 | 73 | 0.32 | 0.24 | 79 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 82 | 0.13 | 0.10 | 100 | 0.86 | 0.66 | 50 | 0.00 | 0.00 | 89 | 61.95 |
| D | 3 | 0.81 | 0.11 | 0.00 | 0.00 | 79 | 0.60 | 0.74 | 84 | 0.00 | 0.00 | 81 | 0.00 | 0.00 | 86 | 0.00 | 0.00 | 100 | 0.21 | 0.26 | 50 | 0.00 | 0.00 | 91 | 75.12 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **7.64** | **1.00** | **1.02** | **0.13** | | **2.36** | **0.31** | | **0.00** | **0.00** | | **1.76** | **0.23** | | **0.13** | **0.02** | | **2.32** | **0.30** | | **0.00** | **0.00** | | **65.15** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 420 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 7.64 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 17.18 |
| **Time of Concentration (Hours)** | 0.29 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.19 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 420 | m |
| Catchment Slope | 1.90% | |
| Catchment Area | 7.64 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 46.16 |
| **Time of Concentration (Hours)** | 0.77 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.51 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.16** | mm |
| **Runoff Coefficient** | **0.25** | |
| **Time to Peak** | **0.51** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | D | 0 |
| | 2 | 3 | 3 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.35 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.55 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.40 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.95 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.05 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.38 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.38 | 0.00 |
| Soil Series Total | 0.24 | 0.22 | 0.31 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 112 **Area** 14.05 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 10.14 | 0.72 | 1.37 | 0.13 | 60 | 2.57 | 0.25 | 69 | 0.00 | 0.00 | 65 | 4.33 | 0.43 | 74 | 0.55 | 0.05 | 100 | 1.32 | 0.13 | 50 | 0.00 | 0.00 | 85 | 69.15 |
| C | 3 | 2.38 | 0.17 | 1.17 | 0.49 | 73 | 0.20 | 0.08 | 79 | 0.00 | 0.00 | 76 | 0.86 | 0.36 | 82 | 0.13 | 0.05 | 100 | 0.02 | 0.01 | 50 | 0.00 | 0.00 | 89 | 77.99 |
| C | 3 | 1.53 | 0.11 | 0.56 | 0.36 | 73 | 0.36 | 0.23 | 79 | 0.00 | 0.00 | 76 | 0.08 | 0.05 | 82 | 0.00 | 0.00 | 100 | 0.53 | 0.35 | 50 | 0.00 | 0.00 | 89 | 66.90 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **14.05** | **1.00** | **3.09** | **0.22** | | **3.13** | **0.22** | | **0.00** | **0.00** | | **5.28** | **0.38** | | **0.68** | **0.05** | | **1.87** | **0.13** | | **0.00** | **0.00** | | **70.40** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 640 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 14.05 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.48 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 640 | m |
| Catchment Slope | 1.10% | |
| Catchment Area | 14.05 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 61.38 |
| **Time of Concentration (Hours)** | 1.02 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.68 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.64** | mm |
| **Runoff Coefficient** | **0.33** | |
| **Time to Peak** | **0.68** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | C | 0 |
| | 2 | 3 | 3 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.35 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.55 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.40 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.95 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.05 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.38 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.38 | 0.00 |
| Soil Series Total | 0.31 | 0.46 | 0.27 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 113 **Area** 9.73 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 9.73 | 1.00 | 5.69 | 0.58 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 3.12 | 0.32 | 74 | 0.65 | 0.07 | 100 | 0.27 | 0.03 | 50 | 0.00 | 0.00 | 85 | 66.91 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **9.73** | **1.00** | **5.69** | **0.58** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **3.12** | **0.32** | | **0.65** | **0.07** | | **0.27** | **0.03** | | **0.00** | **0.00** | | **66.91** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 370 | m |
| Catchment Slope | 0.90% | |
| Catchment Area | 9.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 17.16 |
| **Time of Concentration (Hours)** | 0.29 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.19 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 370 | m |
| Catchment Slope | 0.90% | |
| Catchment Area | 9.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 50.40 |
| **Time of Concentration (Hours)** | 0.84 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.56 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.55** | mm |
| **Runoff Coefficient** | **0.32** | |
| **Time to Peak** | **0.56** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.32 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 114 **Area** 6.75 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 6.75 | 1.00 | 1.40 | 0.21 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 4.49 | 0.66 | 74 | 0.87 | 0.13 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 74.44 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **6.75** | **1.00** | **1.40** | **0.21** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **4.49** | **0.66** | | **0.87** | **0.13** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **74.44** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 290 | m |
| Catchment Slope | 2.70% | |
| Catchment Area | 6.75 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 11.20 |
| **Time of Concentration (Hours)** | 0.19 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.12 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 290 | m |
| Catchment Slope | 2.70% | |
| Catchment Area | 6.75 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.74 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **6.98** | mm |
| **Runoff Coefficient** | **0.41** | |
| **Time to Peak** | **0.12** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.41 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 115 **Area** 17.47 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 16.88 | 0.97 | 6.38 | 0.38 | 60 | 0.78 | 0.05 | 69 | 0.00 | 0.00 | 65 | 3.44 | 0.20 | 74 | 2.32 | 0.14 | 100 | 3.97 | 0.23 | 50 | 0.00 | 0.00 | 85 | 66.40 |
| C | 3 | 0.59 | 0.03 | 0.59 | 1.00 | 73 | 0.00 | 0.00 | 79 | 0.00 | 0.00 | 76 | 0.00 | 0.00 | 82 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 89 | 72.99 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **17.47** | **1.00** | **6.97** | **0.40** | | **0.78** | **0.04** | | **0.00** | **0.00** | | **3.44** | **0.20** | | **2.32** | **0.13** | | **3.97** | **0.23** | | **0.00** | **0.00** | | **66.63** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 490 | m |
| Catchment Slope | 2.00% | |
| Catchment Area | 17.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 18.27 |
| **Time of Concentration (Hours)** | 0.30 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.20 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 490 | m |
| Catchment Slope | 2.00% | |
| Catchment Area | 17.47 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 44.68 |
| **Time of Concentration (Hours)** | 0.74 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.50 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.58** | mm |
| **Runoff Coefficient** | **0.32** | |
| **Time to Peak** | **0.50** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.32 | 0.35 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

**EXISTING CONDITIONS**

**Catchment** 116 **Area** 22.73 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 22.73 | 1.00 | 5.76 | 0.25 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 10.35 | 0.46 | 74 | 1.91 | 0.08 | 100 | 4.70 | 0.21 | 50 | 0.00 | 0.00 | 85 | 67.67 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **22.73** | **1.00** | **5.76** | **0.25** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **10.35** | **0.46** | | **1.91** | **0.08** | | **4.70** | **0.21** | | **0.00** | **0.00** | | **67.67** |

**Time of Concentration Calculations**

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 520 | m |
| Catchment Slope | 0.40% | |
| Catchment Area | 22.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.05 |
| **Time of Concentration (Hours)** | 0.43 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 520 | m |
| Catchment Slope | 0.40% | |
| Catchment Area | 22.73 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 79.17 |
| **Time of Concentration (Hours)** | 1.32 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.88 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.38** | mm |
| **Runoff Coefficient** | **0.31** | |
| **Time to Peak** | **0.88** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.31 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 117 **Area** 1.55 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.55 | 1.00 | 0.73 | 0.47 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.54 | 0.35 | 74 | 0.00 | 0.00 | 100 | 0.28 | 0.18 | 50 | 0.00 | 0.00 | 85 | 63.08 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.55** | **1.00** | **0.73** | **0.47** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.54** | **0.35** | | **0.00** | **0.00** | | **0.28** | **0.18** | | **0.00** | **0.00** | | **63.08** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 1.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.21 |
| **Time of Concentration (Hours)** | 0.10 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 120 | m |
| Catchment Slope | 1.30% | |
| Catchment Area | 1.55 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.88 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.32** | mm |
| **Runoff Coefficient** | **0.25** | |
| **Time to Peak** | **0.31** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.25 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 118 **Area** 1.48 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.48 | 1.00 | 0.50 | 0.34 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.69 | 0.47 | 74 | 0.00 | 0.00 | 100 | 0.28 | 0.19 | 50 | 0.00 | 0.00 | 85 | 64.64 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.48** | **1.00** | **0.50** | **0.34** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.69** | **0.47** | | **0.00** | **0.00** | | **0.28** | **0.19** | | **0.00** | **0.00** | | **64.64** |

**Time of Concentration Calculations**

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 130 | m |
| Catchment Slope | 1.50% | |
| Catchment Area | 1.48 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.57 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 130 | m |
| Catchment Slope | 1.50% | |
| Catchment Area | 1.48 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.36 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.30 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.98** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.30** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

**TATHAM ENGINEERING**

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 119 **Area** 3.07 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 3.07 | 1.00 | 0.61 | 0.20 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 1.75 | 0.57 | 74 | 0.00 | 0.00 | 100 | 0.71 | 0.23 | 50 | 0.00 | 0.00 | 85 | 65.64 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **3.07** | **1.00** | **0.61** | **0.20** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **1.75** | **0.57** | | **0.00** | **0.00** | | **0.71** | **0.23** | | **0.00** | **0.00** | | **65.64** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.20% | |
| Catchment Area | 3.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.88 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.08 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 140 | m |
| Catchment Slope | 1.20% | |
| Catchment Area | 3.07 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 30.49 |
| **Time of Concentration (Hours)** | 0.51 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.34 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.76** | mm |
| **Runoff Coefficient** | **0.26** | |
| **Time to Peak** | **0.34** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.26 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 120 **Area** 1.56 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 1.56 | 1.00 | 0.00 | 0.00 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.52 | 0.33 | 74 | 0.00 | 0.00 | 100 | 1.04 | 0.67 | 50 | 0.00 | 0.00 | 85 | 57.96 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.56** | **1.00** | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.52** | **0.33** | | **0.00** | **0.00** | | **1.04** | **0.67** | | **0.00** | **0.00** | | **57.96** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 150 | m |
| Catchment Slope | 3.00% | |
| Catchment Area | 1.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 6.56 |
| **Time of Concentration (Hours)** | 0.11 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.07 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 150 | m |
| Catchment Slope | 3.00% | |
| Catchment Area | 1.56 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 26.41 |
| **Time of Concentration (Hours)** | 0.44 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **10.34** | mm |
| **Runoff Coefficient** | **0.15** | |
| **Time to Peak** | **0.29** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.15 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 121 **Area** 0.46 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 0.46 | 1.00 | 0.00 | 0.00 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.30 | 0.65 | 74 | 0.00 | 0.00 | 100 | 0.16 | 0.35 | 50 | 0.00 | 0.00 | 85 | 65.59 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **0.46** | **1.00** | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.30** | **0.65** | | **0.00** | **0.00** | | **0.16** | **0.35** | | **0.00** | **0.00** | | **65.59** |

## Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 100 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 0.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 5.61 |
| **Time of Concentration (Hours)** | 0.09 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.06 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 100 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 0.46 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 23.87 |
| **Time of Concentration (Hours)** | 0.40 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.27 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.75** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.27** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 122 **Area** 8.15 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 8.15 | 1.00 | 7.01 | 0.86 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.59 | 0.07 | 74 | 0.00 | 0.00 | 100 | 0.55 | 0.07 | 50 | 0.00 | 0.00 | 85 | 60.34 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **8.15** | **1.00** | **7.01** | **0.86** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.59** | **0.07** | | **0.00** | **0.00** | | **0.55** | **0.07** | | **0.00** | **0.00** | | **60.34** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4,**
**Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 8.15 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 15.98 |
| **Time of Concentration (Hours)** | 0.27 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.18 |

**For Runoff Coefficients less than 0.4,**
**Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.60% | |
| Catchment Area | 8.15 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 46.59 |
| **Time of Concentration (Hours)** | 0.78 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.52 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.92** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.52** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 123 **Area** 17.21 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 17.21 | 1.00 | 0.25 | 0.01 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 14.56 | 0.85 | 74 | 0.42 | 0.02 | 100 | 1.98 | 0.12 | 50 | 0.00 | 0.00 | 85 | 71.67 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **17.21** | **1.00** | **0.25** | **0.01** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **14.56** | **0.85** | | **0.42** | **0.02** | | **1.98** | **0.12** | | **0.00** | **0.00** | | **71.67** |

## Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 570 | m |
| Catchment Slope | 0.60% | |
| Catchment Area | 17.21 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.07 |
| **Time of Concentration (Hours)** | 0.45 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.30 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 570 | m |
| Catchment Slope | 0.60% | |
| Catchment Area | 17.21 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 71.06 |
| **Time of Concentration (Hours)** | 1.18 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.79 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.50** | mm |
| **Runoff Coefficient** | **0.33** | |
| **Time to Peak** | **0.79** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.33 | 0.00 | 0.00 | 0.00 |

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 124 **Area** 22.04 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 22.04 | 1.00 | 4.22 | 0.19 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 11.30 | 0.51 | 74 | 0.00 | 0.00 | 100 | 6.53 | 0.30 | 50 | 0.00 | 0.00 | 85 | 64.21 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **22.04** | **1.00** | **4.22** | **0.19** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **11.30** | **0.51** | | **0.00** | **0.00** | | **6.53** | **0.30** | | **0.00** | **0.00** | | **64.21** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 620 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 22.04 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 25.94 |
| **Time of Concentration (Hours)** | 0.43 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.29 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 620 | m |
| Catchment Slope | 1.00% | |
| Catchment Area | 22.04 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 69.65 |
| **Time of Concentration (Hours)** | 1.16 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.77 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **9.06** | mm |
| **Runoff Coefficient** | **0.24** | |
| **Time to Peak** | **0.77** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.24 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 125 **Area** 0.86 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hydrologic Soil Group** | **Runoff Coefficient Type** | **Catchment Soil Characteristics** | | **Forest / Woodland** | | | **Pasture / Lawns** | | | **Meadows** | | | **Cultivated** | | | **Impervious** | | | **Wetland / Lakes / SWMF** | | | **Gravel** | | | **Average CN for Soil Type** |
| | | **Area** | **Percent** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | **Area** | **Percent** | **CN** | |
| B | 2 | 0.86 | 1.00 | 0.26 | 0.31 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.54 | 0.63 | 74 | 0.00 | 0.00 | 100 | 0.05 | 0.06 | 50 | 0.00 | 0.00 | 85 | 68.21 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **0.86** | **1.00** | **0.26** | **0.31** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.54** | **0.63** | | **0.00** | **0.00** | | **0.05** | **0.06** | | **0.00** | **0.00** | | **68.21** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 110 | m |
| Catchment Slope | 6.00% | |
| Catchment Area | 0.86 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 4.45 |
| **Time of Concentration (Hours)** | 0.07 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.05 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 110 | m |
| Catchment Slope | 6.00% | |
| Catchment Area | 0.86 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 13.64 |
| **Time of Concentration (Hours)** | 0.23 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.15 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.23** | mm |
| **Runoff Coefficient** | **0.38** | |
| **Time to Peak** | **0.15** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.30 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.45 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.35 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.33 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.33 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.38 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 126 **Area** 9.19 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 9.19 | 1.00 | 3.08 | 0.34 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 5.10 | 0.56 | 74 | 0.00 | 0.00 | 100 | 1.00 | 0.11 | 50 | 0.00 | 0.00 | 85 | 66.68 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **9.19** | **1.00** | **3.08** | **0.34** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **5.10** | **0.56** | | **0.00** | **0.00** | | **1.00** | **0.11** | | **0.00** | **0.00** | | **66.68** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4,**
**Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.80% | |
| Catchment Area | 9.19 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 15.43 |
| **Time of Concentration (Hours)** | 0.26 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.17 |

**For Runoff Coefficients less than 0.4,**
**Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 380 | m |
| Catchment Slope | 1.80% | |
| Catchment Area | 9.19 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 42.73 |
| **Time of Concentration (Hours)** | 0.71 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.47 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **8.55** | mm |
| **Runoff Coefficient** | **0.28** | |
| **Time to Peak** | **0.47** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.28 | 0.00 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** S127 **Area** 1.24 ha

**WEIGHTED CN VALUE**

| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 0.69 | 0.56 | 0.15 | 0.21 | 60 | 0.00 | 0.00 | 69 | 0.00 | 0.00 | 65 | 0.55 | 0.79 | 74 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 85 | 71.06 |
| C | 3 | 0.54 | 0.44 | 0.06 | 0.11 | 73 | 0.19 | 0.34 | 79 | 0.00 | 0.00 | 76 | 0.30 | 0.55 | 82 | 0.00 | 0.00 | 100 | 0.00 | 0.00 | 50 | 0.00 | 0.00 | 89 | 79.99 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **1.24** | **1.00** | **0.20** | **0.17** | | **0.19** | **0.15** | | **0.00** | **0.00** | | **0.84** | **0.68** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **74.98** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 215 | m |
| Catchment Slope | 1.86% | |
| Catchment Area | 1.24 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 10.60 |
| **Time of Concentration (Hours)** | 0.18 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.12 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | - | m |
| Minimum Catchment Elevation | - | m |
| Catchment length | 215 | m |
| Catchment Slope | 1.86% | |
| Catchment Area | 1.24 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 27.50 |
| **Time of Concentration (Hours)** | 0.46 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.31 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **7.20** | mm |
| **Runoff Coefficient** | **0.39** | |
| **Time to Peak** | **0.31** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | C | 0 | 0 |
| | 2 | 3 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.35 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.55 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.40 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.95 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.05 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.38 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.38 | 0.00 | 0.00 |
| Soil Series Total | 0.33 | 0.48 | 0.00 | 0.00 |

TATHAM ENGINEERING

| | | | |
|---|---|---|---|
| **Project:** | Project Sideways | **Prepared By:** | DAM |
| **File No.:** | 113187 | **Reviewed By:** | DRT |
| **Revision No.:** | 1 | **Date:** | 21-May-19 |
| **Description:** | Curve Number, Initial Abstraction & Time to Peak Calculations | | |

## EXISTING CONDITIONS

**Catchment** 128 **Area** 11.29 ha

| WEIGHTED CN VALUE | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Soil Group | Runoff Coefficient Type | Catchment Soil Characteristics | | Forest / Woodland | | | Pasture / Lawns | | | Meadows | | | Cultivated | | | Impervious | | | Wetland / Lakes / SWMF | | | Gravel | | | Average CN for Soil Type |
| | | Area | Percent | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | Area | Percent | CN | |
| B | 2 | 11.29 | 1.00 | 0.00 | 0.00 | 60 | 4.52 | 0.40 | 69 | 0.00 | 0.00 | 65 | 0.00 | 0.00 | 74 | 0.00 | 0.00 | 100 | 6.77 | 0.60 | 50 | 0.00 | 0.00 | 85 | 57.60 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | 3 | 0.00 | | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 | | #N/A | 0.00 |
| | **Totals** | **11.29** | **1.00** | **0.00** | **0.00** | | **4.52** | **0.40** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **0.00** | **0.00** | | **2.32** | **0.21** | | **0.00** | **0.00** | | **57.60** |

### Time of Concentration Calculations

**For Runoff Coefficients greater than 0.4, Bransby-Williams Formula**

| | | |
|---|---|---|
| Maximum Catchment Elevation | 272.00 | m |
| Minimum Catchment Elevation | 270.00 | m |
| Catchment length | 1100 | m |
| Catchment Slope | 0.18% | |
| Catchment Area | 11.29 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 69.19 |
| **Time of Concentration (Hours)** | 1.15 |
| **Time to Peak (2/3 x Time of Concentration)** | 0.77 |

**For Runoff Coefficients less than 0.4, Airport Method**

| | | |
|---|---|---|
| Maximum Catchment Elevation | 272.00 | m |
| Minimum Catchment Elevation | 270.00 | m |
| Catchment length | 1100 | m |
| Catchment Slope | 0.18% | |
| Catchment Area | 11.29 | ha |

| | |
|---|---|
| **Time of Concentration (Minutes)** | 181.80 |
| **Time of Concentration (Hours)** | 3.03 |
| **Time to Peak (2/3 x Time of Concentration)** | 2.02 |

| Initial Abstraction | |
|---|---|
| Wetlands | 12 |
| Woods | 10 |
| Meadows | 8 |
| Cultivated | 7 |
| Lawns | 5 |
| Impervious | 2 |
| Gravel | 3 |

| | | |
|---|---|---|
| **Initial Abstraction** | **4.46** | mm |
| **Runoff Coefficient** | **0.14** | |
| **Time to Peak** | **2.02** | hrs |

| Soil Series | | | | |
|---|---|---|---|---|
| Land Use Type | B | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| Forest/Woodland | 0.25 | 0.00 | 0.00 | 0.00 |
| Cultivated | 0.35 | 0.00 | 0.00 | 0.00 |
| Pasture/Lawn | 0.28 | 0.00 | 0.00 | 0.00 |
| Impervious | 0.95 | 0.00 | 0.00 | 0.00 |
| Wetland/Lake/SWMF | 0.05 | 0.00 | 0.00 | 0.00 |
| Meadows | 0.27 | 0.00 | 0.00 | 0.00 |
| Gravel | 0.27 | 0.00 | 0.00 | 0.00 |
| Soil Series Total | 0.14 | 0.00 | 0.00 | 0.00 |

# Tab **2**

**Table 1: Existing Condition Hydrologic Model Results Summary**

| DESIGN STORM | PEAK FLOW ($m^3/s$) | | | |
|---|---|---|---|---|
| | West Arm | Weir Pond | Burlington Quarry | Wetland 13201 |
| 25 mm | 0.07 | 0.04 | 0.97 | 0.05 |
| 1:2-Year | 0.44 | 0.25 | 4.34 | 0.32 |
| 1:5-Year | 0.76 | 0.42 | 7.17 | 0.54 |
| 1:10-Year | 0.99 | 0.55 | 9.18 | 0.71 |
| 1:25-Year | 1.31 | 0.72 | 11.83 | 0.94 |
| 1:50-Year | 1.56 | 0.86 | 13.88 | 1.11 |
| 1:100-Year | 1.81 | 1.00 | 15.94 | 1.30 |
| Regional | 2.55 | 1.24 | 27.04 | 1.56 |

Note: Table summarizes results of SCS Type II 24-hour design storms

**Table 2: Natural Hazards Assessment Peak Flow Summary**

| WATERSHED | PEAK FLOW ($m^3/s$) | | |
|---|---|---|---|
| | Regional Storm | Quarry Discharge | Total |
| West Arm | 2.549 | 0.016 | 2.565 |

# Tab **3**

# Terms of Reference:

# Level 1 and 2 Hydrogeologic and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension, Nelson Aggregates Co.

Earthfx Incorporated

Azimuth Environmental Consulting, Inc.
Environmental Assessments & Approvals

Tatham Engineering

Worthington Groundwater

**February 2020**
**Version 2.0**

# Table of Contents

# 1 PROJECT UNDERSTANDING

## *1.1 Introduction*

Nelson Aggregates owns and operates the Burlington Quarry near the intersection of Side Road 2 and Guelph Line, in the City of Burlington, Region of Halton. The quarry is 218.7 ha in size and is located on the watershed divide between the Bronte Creek and Grindstone Creek near Mount Nemo. The quarry has been in existence since 1953 and has been operated by Nelson since 1983.

Nelson will be submitting applications for an extension to the Burlington Quarry. This proposal requires the continued de-watering to allow the quarry floor to remain dry during excavation. The proposal includes having rock from the expansion areas to be extracted for processing in the existing quarry, utilizing the existing infrastructure.

To support the applications, a Level 1 and 2 Hydrogeological Assessment and Adaptive Management Plan will be prepared to demonstrate how:

1. Municipal and private drinking water supplies for people and livestock and designated vulnerable areas such as wellhead protection areas will be protected.
2. Vulnerable surface and ground water, sensitive surface water features and sensitive ground water features and their hydrologic functions will be protected, improved or restored.
3. The water resource system will be protected or enhanced.
4. The proposal conforms to approved watershed and sub-watershed studies.

The Level 1 and 2 Hydrogeological Assessment and Adaptive Management Plan will be completed to exceed the minimum requirements of the relevant legislation and agency standards, including:

1. The Provincial Standards, which support the Aggregate Resources Act.
2. The Provincial Policy Statement.
3. The Niagara Escarpment Plan.
4. Region of Halton Official Plan
5. Halton Region's Aggregate Resources Reference Manual Guidelines
6. City of Burlington Official Plan

In order to develop a detailed understanding of the surface and groundwater processes and interactions at the site and the potential impacts associated with the quarry expansion, a comprehensive hydrogeological and hydrological assessment is required. The study team is proposing that the assessment includes the application of the numerical model: GSFlow. GSFlow is fully integrated SW/GW model that can represent all surface water bodies (streams, wetlands, lakes, and ponds) and subsurface geologic and hydrogeologic features in the area.

A fully transient simulation approach will be used to represent actual water takings and impacts daily. Once the baseline model is constructed, the expansion plans can be represented in the model, and simulations can be undertaken to evaluate and minimize the impacts of the proposed expansion.

# 2 STUDY TEAM

The team includes:

1. Earthfx Inc.
2. Azimuth Environmental Consulting Inc. (Azimuth)

3. Tatham Engineering (Tatham)
4. Worthington Groundwater (Worthington)

The following sections summarize the team's involvement in the project and in the completion of the Hydrogeologic and Hydrologic Impact Assessment of the Proposed Burlington Quarry Extension.

### *2.1 Earthfx Inc.*

Earthfx will act as project lead as well as the numerical modelers for the project. Their work plan presents a state-of-the-art approach for the assessment of the impacts of the proposed quarry expansion. Earthfx has used this GSFLOW approach to complete Ministry of Natural Resources and Forestry and Ministry of the Environment, Conservation and Parks Source Water Protection studies. Nearby, the City of Hamilton used GSFLOW for the Tier 3 Water Quantity Risk Assessment in Greensville, and the Region of Halton used GSFLOW for a similar Tier 3 assessment of the Kelso Wellfield (both by Earthfx). This approach is clearly the preferred methodology for integrated cumulative impact and water quantity risk evaluation.

### *2.2 Azimuth Environmental Consulting Inc.*

Azimuth is an integral part of the hydrogeological team with their expertise in environmental planning, regulation/policy development, agriculture, hydrogeology, hydrogeology of fractured rock, and geochemistry.

Azimuth's work plan focuses on three main aspects which will support the development of the fully integrated GW/SW flow model:

- geological and hydrogeological characterization of overburden and bedrock;
- description of the ground water regime and ground water budget, including infiltration, migration rates and directions, and discharge to the surface environment. This is particularly relevant to the south expansion due to the potential interaction with the water budget of nearby wetlands and wetland pockets that can provide habitat function. The hydrogeological information is a basis for evaluation of wetland hydraulics and the ecological evaluation;
- description of existing users and natural receivers and impact analysis related to the expansion activities. This is particularly relevant for the west expansion due to the number of private wells along Cedar Springs Road to define the potential zone of influence for the quarry to the west. It is also relevant to the south but there are fewer homes and the influence of the existing quarry provides a boundary towards the northeast.

The field work program includes the following tasks:

- drilling and constructing groundwater monitoring wells (both bedrock and overburden) to supplement the existing groundwater monitoring network, which brings the number of monitoring wells to over 100;
- complete downhole geophysical methods (televiewer – acoustic and/or visual), dynamic flow metering, and gamma);
- to assess the bedrock hydraulic characteristics, Azimuth will complete a comprehensive packer testing program and a long-term aquifer test (24-72 hours depending on aquifer response);
- to assess the overburden hydraulic characteristics, Azimuth will complete a slug testing program on the overburden wells;
- water level monitoring (manual and continuous) at the groundwater monitoring wells;
- water quality analyses of the bedrock aquifer; and

- analysis/interpretation of all hydrogeological data and assistance with preparation of the Hydrogeological Level 1 and 2 Numerical Modelling Report.

In addition, a domestic water well survey and monitoring program will be offered to residents within 1 km of the expansion lands. This survey will be completed in the summer of 2019 and residents will be offered the opportunity to have their well included in the groundwater monitoring program (both water levels and water quality).

### *2.3 Tatham Engineering*

Tatham are experts in surface water resources, including but not limited to surface water monitoring, hydrologic and hydraulic modelling, stormwater management planning, water quality and quantity control, and low impact development features.

Tatham's work plan is intended to provide the necessary surface water and hydrologic input to the hydrogeological team (Azimuth and Earthfx) such that the various studies and models can be developed to support applications for both expansion sites being considered. Tatham will be assisting the hydrogeological team with surface water work covering two primary areas:

1. consolidation of the existing surface water monitoring data and expand on the surface water monitoring program for the expansion areas;
2. to develop existing and proposed condition monthly surface water balances for the surface and groundwater catchments potentially impacted by the expansion area;
3. Preparation of a Surface Water Management Strategy that details how the quarry will manage and discharge its surface water; and
4. Preparation of a Flood and Erosion Hazard Delineation Study for the West Tributary of the West Branch of Mount Nemo Tributary.

### *2.4 Worthington Groundwater.*

Worthington specializes in evaluating preferential flow and transport in bedrock aquifers (i.e. karst).

Worthington's work plan involves:

- a detailed evaluation of the proposed extraction areas to identify any karst features;
- review new hydrology and hydrogeology results to determine whether there are any inconsistencies with the existing hydrogeological interpretation. This include streamflow data, well logs, well water levels, water chemistry data, pumping and packer test results;
- carry out tracer tests from observation wells in the West Extension to a pumping well during a long-term aquifer test and calculate apertures of enlarged fractures from results;
- use results from downhole flowmeter and video/televiewer to interpret extent of solutional enlargement of fractures and resultant preferential flow. If available, electrical conductivity, temperature, and gamma logs would assist this interpretation; and
- prepare a report on the extent and nature of karstic development in the aquifer at the site. This will utilize and expand on my previous report on karst at the site.

## 3 <u>STUDY OBJECTIVES</u>

The quarry assessment requires a technically defensible platform on which the interpretation, model development, and predictive simulations can be based. *Models are only as good as the data foundation*. The study team has been assembled to ensure a comprehensive database of groundwater and surface water information has been compiled to form this data foundation. Specifically, the field data collected as part of the quarry expansion will be relied upon to develop/characterize the local conditions in the conceptual and numerical models (including but not limited to: climatic conditions, surface water conditions [peak and low stream flows, surface water flow response to precipitation and snowmelt conditions, wetland hydro-periods], karst flow, geological conditions from drilling results, aquifer characterization from hydraulic testing and geophysics). The hydrogeological and hydrologic data will be used for model calibration.

The model will provide a unified framework for analysis of surface water and groundwater issues and will be a critical element of the site characterization report.

1. The integrated model will be used to evaluate and characterize the site function and model scenarios will be undertaken to assess different aspects of the plan. The model will provide detailed information on predicted flows and levels and will support wetland hydroperiod analysis, seasonality of response, and climate sensitivity.
2. The final phase of the analysis is the detailed impact analysis of the proposed quarry design for inclusion in the applications. In this phase long term (25 year) transient baseline and closure simulations will run to demonstrate that the effects of site development under the full range of natural climate conditions.

# 4 PROPOSED APPROACH

## *4.1 Model Selection*

We propose the development of a fully integrated SW/GW model based on U.S. Geological Survey GSFLOW code. This open source model fully integrates the well-recognized MODFLOW-NWT groundwater flow code and the USGS PRMS hydrologic model, both established models. We have used GSFLOW on more than 15 modelling projects in Ontario, including major Tier 3 Source Water Protection Studies for MNRF, MECP and Conservation Authorities. We have also used GSFLOW for models of Lafarge and Dufferin Aggregates quarries and major mines including Detour Gold Corporation and oil sand mining operations. GSFLOW is widely accepted as the premiere modelling assessment tool.

Most significantly, we used GSFLOW in the Greensville Tier 3 study, covering the municipal wellfield and the nearby Lafarge and Dufferin quarries of North Hamilton. The Greensville Tier 3 model builds on our extensive North Hamilton model. The Greensville GSFLOW model represents all aspects of quarry operations and has set a new standard for high resolution assessment of cumulative impact analysis. All aspects of the development and calibration of the Greensville GSFLOW model are presented in the Tier 3 Model Development and Calibration Report (Earthfx, 2014).

The main technical features and benefits of a GSFLOW model include:

- fully integrated simulation of all surface water and groundwater processes;
- fully transient (i.e., time-dependent) simulations and calibration to observed flows and levels;
- boundary conditions extended to natural flow divides;
- simulation of all hydrologic processes (rainfall, runoff, snowmelt, ET, overland runoff, and groundwater discharge to streams);
- full representation of wetlands and streams, with total flow stream routing;
- representation of internal quarry water management and reservoir operation;

- representation of all surface and groundwater takings using data from the MOE WTRS database; and
- improved representation of groundwater flow across the Niagara Escarpment.

# 5 WORK PLANS

## *5.1 Surface Water Management Assessment*

Tatham has developed the following work plan to define the components of the surface water assessment necessary to support the requisite approval applications for the Burlington quarry expansion. Specifically, the work plan has been developed to provide the necessary surface water and hydrologic input to the project team in support of the quarry expansion applications. We have divided the surface water assessment into four components as follows:

1. Surface water monitoring;
2. Water balance assessment (existing and proposed conditions);
3. Flood and erosion hazard study; and
4. Surface water management strategy (to be incorporated into the Final Adaptive Management Plan).

The specific terms of reference for each component of the surface water management assessment are presented in the following sections.

### 5.1.1 Surface Water Monitoring

To understand the surface water systems and surface water/groundwater interactions in the proposed expansion areas and the surrounding lands, a network of surface water monitoring stations has been established; including streamflow, wetland hydroperiod and shallow groundwater monitoring stations. In total, 21 streamflow, seven (7) wetland hydroperiod and seven (7) shallow groundwater continuously recording monitoring stations have been established on-site and in the surrounding area. Manual streamflow measurements are collected quarterly from an additional 35 surface water features surrounding the existing quarry and the proposed expansion lands.

Water quality samples are also collected four times per year from 13 select surface water monitoring locations to characterized existing surface water quality in the area. The parameters analyzed in each surface water sampled collected are presented in the following table:

**Table 1: Water Quality Parameter Summary**

| WATER QUALITY PARAMETER | |
|---|---|
| Dissolved Organic Carbon | Ammonia/Ammonium |
| Alkalinity | Biochemical Oxygen Demand |
| Chemical Oxygen Demand | Conductivity |
| Total Hardness | Metals |

| WATER QUALITY PARAMETER | |
|---|---|
| Turbidity | Total Dissolved Solids |
| Total Suspended Solids | pH |
| Carbonate and Bicarbonate | Temperature |

Monthly field visits are conducted to collect in-situ surface water measurements and to download data from the respective continuous recording monitoring devices. The in-situ field measurements are used to calibrate and validate the data collected by the continuous recording monitoring devices.

The surface water monitoring data will be used to calibrate and validate the existing condition water balances and the integrated surface water/groundwater model (being completed by others). The data will also be used to evaluate potential impacts and develop mitigation strategies that will address any potential impacts resulting from the expansion of the existing quarry.

The current surface water monitoring program will be undertaken throughout the duration of the approvals process of the proposed quarry expansion. It is anticipated that the surface water monitoring program will be adjusted (monitoring locations added and/or removed) during the approvals process through consultation with the requisite approval agencies. Also, it is anticipated that the surface water monitoring program will be refined for the operational lifespan of the quarry post approvals as part of the surface water assessment and approvals process to focus on the key receptors and waterbodies considering potential impacts.

### 5.1.2 Water Balance Assessment

Existing condition water balances are being developed for the various surface water catchment areas to understand how the existing surface water features function so we can predict wetland hydroperiod and streamflow under different climatic conditions. Detailed existing condition daily and monthly water balances are being prepared for each sub-catchment potentially impacted by the proposed quarry expansion and the areas include the existing quarry operations. Over a 20-year period of climate data is available for the area which will be analyzed to predict the range of streamflow and wetland hydroperiods expected under existing conditions.

The same climate data analyzed through the integrated surface water / groundwater model will be analyzed in the water balance assessment. The climate data will be an interpolation of climate data from the available Environment Canada climate stations surrounding Burlington Quarry. The climate data will cover a period of October 1997 to September 2019.

As discussed, the surface water monitoring data collected will be used to calibrate and verify the existing condition daily water balance. The results of the daily water balance will be compared against the available streamflow, wetland hydroperiod and shallow groundwater monitoring data. The daily water balance input parameters will be adjusted within acceptable ranges to calibrate the daily water balance to the surface water monitoring data for a specified period. The calibrated daily water balance results will then be compared against the surface water monitoring data for a different period to validate the results.

The monthly water balance will be updated to include the calibrated daily water balance input parameters.

After calibrating and validating the existing condition water balances, proposed condition water balances will be prepared to evaluate the potential impacts from the various phases of the proposed quarry expansions. The same climate data will be analyzed through the proposed condition water balances to predict the range of streamflow's and wetland hydroperiods that would be expected under proposed conditions. The results of the proposed condition water balances will then be compared against the results of the existing condition water balances to determine what, if any, impacts the proposed quarry expansions could have on the surface water features in the area.

The results of the proposed condition water balances will be used to develop mitigation strategies to address potential impacts, if any, from the proposed quarry expansions. The water balance assessment, both existing and proposed conditions, will be relied upon in the integrated surface water/groundwater model (being completed by Earthfx).

#### 5.1.3 Flood and Erosion Hazard Study

The West Tributary of the West Branch of the Mount Nemo Tributary runs southeast from No. 2 Sideroad downstream parallel to the proposed extraction limit of the south expansion. A flood and erosion hazard study is required to confirm the proposed extraction limits are located outside the natural hazards associates with the tributary. Flood and erosion thresholds are also required to establish the quarry discharge (both quantity and quality) targets to the tributary.

To complete the flood and erosion hazard study, a topographic survey of the tributary downstream of No. 2 Sideroad to the studies downstream limit is required. A detailed topographic survey of the tributary watercourse (cross-sections, sinuosity, longitudinal slope, etc.) and any structures (culverts, bridges, ponds) within the study limits is required. Based on the mapping available, we feel the study should extend approximately 750 m downstream of No. 2 Sideroad. As such, we will complete the detailed topographic survey of the tributary through this area.

A HEC-RAS hydraulic model of the watercourse through the study area will be created to delineate the flood hazard limit associated with the tributary. The topographic survey of the watercourse will be used to generate the geometry data for the watercourse. A hydrologic model of the tributaries contributing drainage area will be generated to establish the design storm and Regional Storm peak flows through the study reach. The calculated flow data plus the quarry discharge will be routed through the HEC-RAS hydraulic model to establish the tributaries flood hazard limit. The flood hazard limit will be delineated on a Natural Hazards Plan for inclusion in the Surface Water Assessment.

The erosion hazard limit for the tributary will be established following the erosion hazard guidelines defined in the MNRF Technical Guide – River and Stream Systems: Erosion Hazard Limit. Based on our knowledge of the tributary, we believe the watercourse is defined as an unconfined watercourse through the study area. As such, the erosion hazard limit is defined as the greater of 20 times the bankfull channel width centered over the meander belt axis (meander belt allowance) or the flood hazard limit plus a 6 m erosion access allowance. We will establish the bankfull channel width and meander belt axis from the topographic survey of the watercourse and delineate the meander belt allowance on the Natural Hazards

Plan previously discussed. A 6 m erosion access will be added to the greater of the meander belt allowance or flood hazard limit to establish the erosion hazard limit.

#### 5.1.4 Surface Water Management Strategy

At the conclusion of the water balance work a surface water management strategy will be developed for each expansion area and phase of extraction. The surface water management strategy will establish appropriate water quantity and quality targets for the off-site discharge from the existing quarry and future quarry expansions. The water quantity and quality targets will be developed to maintain existing streamflow, wetland hydroperiods and water quality in the areas surrounding surface water features. The surface water management strategy will specify discharge locations and the on-site storage requirements to satisfy the water quantity and quality targets while maintaining appropriate operating conditions for the quarry. The surface water management strategy will be integrated with the integrated surface/groundwater modeling work being completed by others.

The surface water management strategy will also establish appropriate long-term water quantity and quality targets for off-site discharge from the rehabilitated quarry after extraction has ceased. The surface water management strategy will specify the long-term discharge locations and the on-site storage requirements to satisfy the water quantity and quality targets for the rehabilitated site.

As part of the surface water management strategy, mitigative measures will be developed to address potential changes, if any, from the proposed quarry expansions. Long-term surface water monitoring stations that evaluate potential changes from the quarry expansions will be identified as part of the surface water management strategy. The existing surface water monitoring data and background baseline data will be evaluated to identify thresholds that can be used to signal potential changes during future extraction. When the thresholds are triggered, the surface water management strategy will outline the investigative measures to be undertaken to establish the cause of the trigger. Depending on the cause, (climate, quarry extraction, etc.) mitigation measures will be specified to address the change. The monitoring and proposed mitigation measures will be incorporated into the Adaptive Management Plan for the Burlington Quarry.

The surface water monitoring, water balance assessment, flood and erosion hazard study and surface water management strategy will be presented in a Surface Water Assessment Report distributed as part of the quarry expansion applications. The Surface Water Assessment Report will document the work undertaken, the results of the surface water monitoring, water balance assessment, and flood and erosion hazard study, the surface water management strategy for each extraction area and phase of extraction including rehabilitation of the site, any potential surface water changes resulting from extraction, and the mitigation measures recommended to address potential impacts.

### *5.2 GSFlow Model*

#### 5.2.1 Database Compilation

The Earthfx approach to all projects is founded on the development of a fully integrated database of groundwater, surface water, geology, and climate data to support the analysis phases of projects. The proposed approach for this project places a significant emphasis on data compilation and interpretation prior to the construction and calibration of the integrated model.

Considerable data has been collected at the Nelson site and based on our experience in the area we have an excellent understanding the regional information that is available. For example, cross sections through the eastern portion of the North Hamilton model, developed by Earthfx, will identify what data are available based on interrogating a number of sources including previous study reports, available mapping, data compilations created for earlier studies, and publicly accessible databases. The latter would include the MECP Water Well Information System (WWIS) for borehole data, the MOE Water Taking Reporting System (WTRS), the Permit to Take Water (PPTW) database, OGS borehole data, Provincial Water Quantity Geodatabase, and the Environment Canada climate and streamflow databases. A georeferenced digital library of all reports and investigations conducted in the study area will also be compiled.

**a. Hydrologic Data:**

- Climate data will be obtained from Environment Canada and MNRF.
- Streamflow data will be obtained from the WSC and Tatham on an hourly and daily time step for the stream gauges in and around the study area.

**b. Geologic Data:**

- Borehole data from a wide variety of sources including the Nelson's own drilling, WWIS borehole data and OGS boreholes will be assembled. Other sources may include municipal water well exploration studies, golf courses, landfill studies, and MTO geotechnical data.
- More importantly, we will include our insights and understanding from the three-dimensional geologic model that we created for the City of Hamilton.

**c. Hydrogeologic Data:**

- Hydrogeologic data sets will incorporate static water levels from the MOE Water Well Records database, as well as transient groundwater monitoring data from the Provincial Groundwater Monitoring Network (PGMN), municipal monitoring wells, and from the comprehensive site monitoring. Nelson has over 100 monitoring wells in its network.
- Previous studies will be reviewed to extract information on the hydraulic properties (i.e., hydraulic conductivity, anisotropy, and storage coefficients) of the aquifers and aquitards in the study area. These will include aquifer testing data, hydrogeological investigations, and modelling studies. This data will be compared to similar data collected by Azimuth to ensure consistency and completeness.
- Earthfx staff will use a combination of visual and statistical tools to spot errors in the time-series and geologic data. Our experience in the other studies showed that investigating discrepancies between observations and model results often helped spot outliers and data shifts and, in some cases, forced a re-examination of our understanding of the local hydrogeology.

**d. Conceptual Groundwater Model Surface Update:**

- The conceptual hydrostratigraphic model is a three-dimensional representation of the complex geologic and hydrogeologic setting in the subsurface. The conceptual hydrostratigraphic model describes the stratigraphy, hydrostratigraphy, and aquifer and aquitard properties.
- Regional conceptual hydrogeologic model will be updated with local data. When converting to a fully integrated SW/GW model, however, there are frequently changes needed to better represent the shallow subsurface. GSFLOW is very robust at simulating shallow subsurface aquifers that only transmit water during the spring wet period, and refinement of this critical layer is necessary to simulate SW interaction and impacts. Updated model surfaces, including the upper layers, will be generated. Quarry drains, sumps, pipe network systems, quarry lakes and other water storage systems will also be represented in the model.

**e. Conceptual Surface Water Model Development**

- A soil zone (and shallow unsaturated zone) model will be constructed to represent all the surface hydrology processes. Vegetation, land cover, soil properties, wetland attributes, and climate data will be compiled and represented in the model. Key data and processes will be evaluated to develop an understanding of the local SW processes that are significant to the impact assessment. For example, the role of shallow wetlands in the vicinity of the proposed expansion will be evaluated, along with other issues such as regional discharge patterns to the Provincially Significant Wetlands in the Medad valley. Golf course water use and the collaborative water management between the quarry and adjacent courses will be reviewed and prepared for simulation.
- Other aspects of the conceptual surface water model include:
  - the soil water balance (i.e., precipitation, overland runoff, infiltration, evapotranspiration and groundwater recharge) and the underlying processes that affect these rates including groundwater feedback mechanisms (e.g., Dunnian runoff);
  - properties of the surface-water system and factors controlling GW/SW interaction;
  - anthropogenic inputs and outputs from the surface water and groundwater system (pumping rates, return flows, water takings, diversions, and on/off-line storage); and
  - other significant features (e.g., soil properties, surficial geology, topographic features, and land use that may affect recharge and discharge).
- Hydrologic processes in the study area will be simulated using the Precipitation-Runoff Modeling System (PRMS) as implemented in GSFLOW. The PRMS model is fully distributed and soil water balances are calculated on a grid mesh which can be different than that used for the groundwater model. The use of multi-grid resolution is an innovation introduced by Earthfx in recent SWP studies. For example, the Kelso/Campbellville Tier 3 study used a uniform 20-m mesh to represent the spatial variability in topography, soil properties, vegetative cover, and land-use. The groundwater model used fine-resolution in the wellfields (10 m) and coarser resolution (80-m) outside. Climate data (NEXRAD) was interpolated over a 500-m mesh. This multi-grid approach allows us to add detail where necessary, providing high resolution modelling analysis within a larger sub-catchment basis. This approach was also used in the Greensville Tier 3 study to represent the Lafarge and Dufferin quarry operations.

### 5.2.2 Model Calibration

Our experience has shown that an integrated model is best developed in a staged approach in which we initially develop a preliminary calibration of the SW hydrologic and groundwater components and then link these components within the integrated model. Subtasks in the staged approach are outlined below.

#### a. Surface Water Model Development

- Model inputs for the PRMS hydrologic model include daily climate data (precipitation, temperature, and solar radiation). Model parameters will include soil properties, land use properties (e.g., vegetative cover and imperviousness), and topography. The preliminary model will be calibrated to match observed flow at the gauges, but refined during the integrated final calibration. Initial PRMS calibration will provide estimates of daily groundwater recharge over a 20-year period for use in as a recharge estimate for the groundwater model. The surface water model will rely on input and findings of Tatham's surface water monitoring and water balance results.

**b. Preliminary Steady-State Groundwater Calibration**

- Earthfx will construct, concurrently with the development of the PRMS hydrologic model, the groundwater component based on the MODFLOW-NWT sub-model in GSFLOW. The numerical model will utilize the hydrostratigraphic layers derived from the conceptual model update as described previously. Model boundaries and initial aquifer and aquitard properties will also be derived from results of Task 1. The purpose of the initial steady state GW development task is to set the stage for subsequent transient and integrated modelling.
- The initial model will be run for steady-state conditions using the estimates of long-term average recharge derived from PRMS model results and average annual pumping rates. These conditions will be assumed to be representative of "simplified current conditions", but subject to many of the limitation as previously discussed. Results will be compared against average observed water levels at monitoring wells and against MECP static water levels where monitoring data are lacking. Simulated baseflow to streams will be compared to estimated annual average baseflow values that will be determined by applying hydrograph separation technique to gauges with long-term record. In addition to absolute discharge values, the spatial distribution of groundwater discharge will be assessed, and this spatial distribution will be compared against spot flows as a qualitative calibration target.
- Model parameters, primarily hydraulic conductivity estimates for the aquifers and aquitards, will be adjusted in a consistent manner to improve the match between the simulated values and the calibration targets. Automated parameter estimation techniques may be applied to refine the calibration if warranted. Steady State calibration efforts will stop when it is felt that additional improvements can best be made with the fully integrated model.
- The end of this subtask is a good point to verify that the model conceptualization is reasonable. Water balance results from the steady-state model will be compared against water balance output generated from previous models and simplified calculations. Where significant differences in output are observed, likely reasons for the differences will be documented and resolved as needed.

**c. Integrated Transient Model Calibration**

- Once the two sub-models (PRMS and MODFLOW-NWT) are configured and reasonably well calibrated independently, we will use the GSFLOW code to run the integrated sub-models simultaneously. With an integrated model, feedback between the hydrologic and groundwater systems becomes instantaneous.
- Data sets needed to run the integrated model, including the cascading overland flow routing network, will be generated. Post-processing of model outputs and summations needed for the water budget analyses will be conducted using VIEWLOG.
- Daily and seasonal patterns in quarry water management will be compiled and represent in the transient model.
- Calibration will be done to match daily, seasonal, and year-to-year variation in water levels as seen in monitoring wells for the calibration period. The calibration period will be selected based on data availability. Matching historic groundwater response will be a good test of the integrated model's ability to predict the timing and magnitude of the groundwater response to elevated recharge in the fall, frozen ground and snowmelt events in the winter, the spring freshet, and summer low-recharge conditions.

### 5.2.3 Application Plan Assessment

The final phase of the project is to complete a full assessment of the proposed expansion plan. The assessment will follow a similar pattern to the Baseline Operations task, but with the incorporation of the proposed modifications to the GW and SW systems, as follows:

**Simulation of Baseline Conditions** - Once the design is finalized, a baseline time period will be selected for reference and subsequent impact assessment. For example, a 25-year baseline operation period will be simulated, and the daily results processed to present a complete picture of quarry operations under dry year (2007) wet year (2008) and average year conditions (2009). This will illustrate the overall behavior of the current operations and provide multiple seasonal points of reference for subsequent impact assessment.

**Integrated Simulation of Planned Expansion -** Changes to the stream network (diversions), wetlands and quarry drain configurations, as required by the proposed extension, will be incorporated into the model. Operational issues such as quarry water management, temporary storage ponds, spring dewatering rates and other surface water management issues will be identified and converted into a model representation of the operations plan.

Changes to the model layers will be incorporated into the model to represent the new excavation and sump details. Additional toe drains may be added to route groundwater seepage and runoff into new sump locations. The effects of blast damage to the geologic units may be incorporated if necessary. Operational details and closure plans in the existing quarry will also be represented in the model.

Once the changes to the model have been incorporated and tested, a multi-year integrated transient simulation will be completed. A simulation time frame consistent with the baseline operations scenario will be simulated to provide a consistent point of reference.

**Impact Assessment -** Finally, the impact assessment will be completed by comparing the baseline Scenario to the Planned Expansion Scenario. Seasonal changes in the surface water and groundwater system will be determined by comparing detailed outputs from each scenario. Impacts during dry years and wet years will also be evaluated.

### 5.2.4 Groundwater Management Strategy

Based on the findings of the Impact Assessment a groundwater management strategy will be developed for each expansion area and phase of extraction. The groundwater management strategy will establish an appropriate groundwater monitoring program to ensure that changes to the groundwater levels will have no adverse impact to domestic water wells, surface water and natural heritage features.

As part of the groundwater management strategy, mitigative measures will be developed to address potential changes, if any, from the proposed quarry expansions. Long-term groundwater monitoring stations that evaluate potential changes from the quarry expansions will be identified as part of the groundwater management strategy. The existing groundwater monitoring data and background baseline data will be evaluated to identify changes in water level trends that can be used to signal potential changes during future extraction. When the changes to groundwater level trends, the groundwater management strategy will outline the investigative measures to be undertaken to establish the cause of the change. Depending on the cause, (climate, quarry extraction, etc.) mitigation measures will be specified to address the change. The monitoring and proposed mitigation measures will be incorporated into the Adaptive Management Plan for the Burlington Quarry.

### *5.3 Reporting*

The reports that will be prepared to support the quarry applications will include:

1. Level 1 and 2 Hydrogeological and Hydrological Impact Assessment (Co-Authored Earthfx and Azimuth)
2. Surface Water and Groundwater Management Plan (Co-Authored: Earthfx and Tatham)

The monitoring and mitigation recommendations set out in the Surface Water and Groundwater Management Plan will be developed based on the identification of potential receptors (e.g., local domestic water wells and environmental features such as wetlands and fish habitat). These programs will form the basis of the Adaptive Management Plan, which will be prepared by Nelson Aggregates.

The Terms of Reference for the Adaptive Management Plan is provided under a separate cover.