Table 5.14: Summary of Potential Impacts to Aquatic Resources

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
<u>Subject Property</u> • West Fourteen Mile Creek tributaries flow through the subject property including Reach 14W-11, Reach 14W-11A, Reach 14W-12, Reach 14W-12A, Reach 14W-13, Reach 14W-14, Reach 14W-14A and Reach 14W-16. • Reach 14W-13 is considered *Low Constraint* with the possibility of elimination/incorporation into SWM plan/surface drainage systems. • Reaches 14W-11A, 14W-14, 14W-14A and 14W-16 are considered *Medium Constraint* for retention in current location or can be relocated with enhancement of the existing conditions. • Reach 14W-11 is considered *High Constraint Requiring Rehabilitation* for retention in its current location with enhancement opportunities for effective protection while maintaining function. • Reach 14W-12 is considered *High Constraint* and is to remain in its present condition with development occurring outside of the stream corridor. Alternatively, if the watercourse is anticipated to be affected, the recommendation is that the reach is to be maintained in the present location and undertake enhancement of the geomorphic and aquatic habitat conditions within the affected watercourse. Rehabilitation options for the concrete retaining wall at the Dundas Street crossing of Reach of 14W-12 will be considered during a later stage of design. Consideration will include replacement options (i.e., bioengineered application to reinforce the existing	**<u>Subject Property</u>** • **Road crossings.** The construction of the Burnhamthorpe Road Extension and Avenue 1 will result in crossings of existing reaches. Burnhamthorpe Road Extension will cross over the existing Reach 14W-16 and realigned Reach 14W-14 (new Reach 14W-22). Avenue 1 will cross over the realigned Reach 14W-14 (new Reach 14W-22). Impacts will be to the aquatic habitat associated with the channel under the structure and loss of riparian habitat under the road footprint. The use of an open bottom culvert will potentially result in fewer impacts and impacts of lesser severity when compared to a box culvert. As such, open bottom culverts will be proposed for all reach crossings. Potential impacts of road crossings included the transport of deleterious substances (i.e. sediment, fuel, etc.) associated with construction activity, elimination of floodplain vegetation that could result in reduced productivity and shading of the reach at the crossing location, and loss/alteration of habitat during construction due to in-water work. • **Burnhamthorpe Road Extension adjacent to Reach 14W-12A stream corridor.** The construction of the Burnhamthorpe Road Extension has been realigned to the north of the alignment proposed in the Secondary Plan in order to minimize adverse effects to a downstream section of Reach 14W-12 which is Redside Dace Occupied Habitat. This has resulted in the alignment being located adjacent to the stream corridor associated with Reach 14W-12A. Reach 14W-12A has marginal function as fish habitat. • **Buried services watercourse crossings.** Potential impacts and their severity are directly related to the type of construction method used and the location of installation. In the absence of proper mitigation, impacts associated with service installation have the potential to contravene the *Fisheries Act* through the introduction of deleterious substances and/or result in "serious harm to fish".	**<u>Subject Property</u>** • **Road crossing/alignment.** Road crossings/alignments will be designed in a manner that minimizes encroachment into the stream corridors (i.e., grading/fill). • The preferred option for the road crossing consists of an open bottom structure to minimize impacts to the reach by minimizing the potential for in-water works. In the event that this type of crossing cannot be constructed (i.e., unsuitable soils), a box culvert will be used that will be designed to minimize the footprint within the valley and provide fish passage (i.e., low flow channel lined with appropriately sized riverstone). Road alignments have been further investigated and revised in order to mitigate potential adverse effects to the stream corridors. The road alignments have been revised sufficiently to avoid encroachment into the Reaches 14W-12 and 14W-12A stream corridor as was previously the case with the former concept plan; thereby, minimizing potential adverse effects to the reaches and associated riparian habitats. • **Watermain construction.** The preferred construction method will be to install the watermains within the footprint of the roadbed; thereby, consolidating the servicing corridor and minimizing encroachments into the valley. In the event that there is insufficient cover between the road and the culvert to permit this, the	• **Road Crossing.** It is anticipated that with the construction of an open bottom precast structure that avoids in-water work (i.e., footing excavation, realignment, etc.) and the development and implementation of suitable mitigation measures (i.e., construction methods), serious harm to fish will not occur. In the event that open bottom culverts cannot be used and a box culvert is required, it is anticipated that impacts to fish habitat may not be entirely mitigated and, as a result, the construction of this type of crossing may result in serious harm to fish; thereby, requiring Authorization under the Fisheries Act (1985) and the need for fish habitat enhancement measures to offset the outstanding impacts. • **Buried Services Crossing.** It is anticipated that impacts to aquatic habitat associated with construction of the reach crossings can largely be mitigated. The use of a trenchless construction method is anticipated to potentially have less adverse effects than open cut construction. The effects of a standard open cut construction method in the reaches can also likely be mitigated due to the relatively small size of the reaches and the intermittent flow regime. A review of the service crossing under the Fisheries Act (1985) indicate that a crossing can likely be addressed through standard construction methods and adhering to DFO guidance documents provided the proposed works meet specific conditions. In the event that the proposed construction

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
banks of this reach.) • Reach 14W-12A is also considered High Constraint; however, due to its form, function and origin as drainage from a constructed bypass pond its function as fish habitat is marginal. • Reach 14W-12 and Reach 14W-16 are Occupied Redside Dace habitat. • Reach 14W-11A, Reach 14W-12A, Reach 14W-13, Reach 14W-14 and Reach 14W-14A are considered Contributing Redside Dace habitat.	• Installing buried services using an open cut construction method will have the potential to result in impacts to the aquatic habitat through the alteration of the reach bed and banks, temporary access for construction, removal/compaction of vegetation/soils, transport of deleterious substances to the reach. • The use of a trenchless method (i.e., directional drilling) will minimize the potential for impacts to the aquatic habitat as it is anticipated that the area of disturbance will be confined to the margins of the floodplain/valley walls. The trenchless construction method will minimize the extent of activity immediately adjacent to the reach that has the potential to impact the aquatic habitat (i.e., in-water intrusions by equipment and personnel, sediment transport, etc.); provided construction activity is restricted to a delineated work area. Furthermore, the disturbance to the floodplain vegetation is minimized and the potential for sediment transport and erosion is reduced. • **SWM facilities adjacent to Reach 14W-12 development setback.** The proposed locations of the SWM facilities have been located beyond the limits of Reach 14W-12 stream corridor. There will be a minor encroachment into the stream corridor associated with the SWM facilities outlets. The encroachment into Redside Dace (riparian) habitat will continue to be discussed with Ministry of Environment Conservation and Parks (MECP) as it relates to an ESA (2007) approval. • **Incorporation of Reach 14W-14A (Farm Pond) into the SWM facility.** The removal of the pond and its incorporation into the SWM facility will result in a benefit to the fisheries. This is because the Farm Pond (14W-14A) currently provides warmwater contributions to Reach 14W-12 that supports coolwater species including Redside Dace. Removing this pond, will remove that warm water contribution. Typically the removal of pond habitat (i.e., bypass, online), specifically that outflows to cool/coldwater habitats, is considered an enhancement to fish and fish habitat due to the associated adverse effects to water quality (i.e., water temperature, dissolved oxygen). It is also suggested	watermain will be constructed within the road right-of-way using a trenchless method to minimize the potential for physical disturbance to aquatic habitat and associated stream corridor. If trenchless construction is not feasible (i.e., bedrock) an open cut construction methods will be used to install the watermain. • **Sewer construction.** A sewer crossing to service the Subject Property will be installed along Avenue 1. The preferred method of construction will be constructed within the road right-of-way using a trenchless method (i.e., jack and bore) to minimize the potential for physical disturbance to aquatic habitat and associated stream corridor. If trenchless construction is not feasible (i.e., bedrock) an open cut construction methods will be used to install the watermain. • **Encroachments into watercourse setbacks.** The areas where there will be encroachment consist largely of active agricultural lands or disturbed riparian habitat. These areas where reach setbacks will be encroached (i.e., SWM facilities outlets into Reach 14W-12, road and service reach crossings), will be restored using native plantings and seeding with the goal to restore the same area that was disturbed by the road. • **Timing of in-water construction (if required).** In the event that in-water works are required (i.e., footings, open cut) works will adhere to the in-water timing window including permissible works from July 1 to September 15 for Reach 14W-12, Reach 14W-11 and Reach 14W-16 with all	methods do not meet the conditions of these guidance documents and/or the effects cannot be entirely mitigated this construction method has a greater likelihood of resulting in a serious harm to fish and may require Authorization under the Fisheries Act (1985). This assessment is dependent upon site specific impacts; the type of habitat affected and will be determined through a self-assessment and/or review of the project by DFO to determine whether an Authorization is required. The self-assessment and/or DFO consultation will occur once the construction method has been determined at the detail design stage. However, it is anticipated that serious harm to fish will not occur as a result of the construction of buried services. • **Encroachments into watercourse setbacks.** Residual effects associated with these encroachments are anticipated to be minor due to the limited encroachment (i.e., SWM facilities outlets to Reach 14W-12) of natural habitat and the disturbed nature of the natural habitat that will be affected. Furthermore, as the areas will be restored using native plantings and seeding of the areas, there is a potential to enhance these locations from their current form. • **Surface and groundwater quality.** The residual effects are anticipated to be minor given: improved treatment of surface water discharging from the Subject Property (via the SWM system); enhanced/larger buffer for nutrient filtering; and implementation

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
	as a potential overall benefit action in the DRAFT Guidance for Development Activities in Redside Dace Protected Habitat (MNR, 2011). • **Removal of Reach 14W-13.** This Low Constraint reach will be eliminated: with flow originating from north of Highway 407 directed by the new Reach 14W-21 to the realigned Reach 14W-14 (new Reach 14W-22). • **Realignment of Reach 14W-14 and Reach 14W-11A.** In the absence of other measures these works are anticipated to contravene the *Fisheries Act* (1985) and may result in serious harm to fish requiring an Authorization. Consultation with DFO during detail design will be undertaken to confirm. • **Alteration of flow to Reach 14W-12A.** The alteration of flow to this reach is anticipated to have minimal adverse effects to fish habitat due to its limited function on flows. • **Water quality impacts (long-term).** Potential for increased sedimentation / erosion, contamination. • **Water quality impacts (temporary).** Potential water quality impacts during construction activities (e.g., sedimentation, spills, etc.). • **Hydrology.** Potential changes to the hydrological regime resulting from increases in impervious surface and elevated flows or as the result of SWM discharge. The majority of flow is made up of surface water contributions that will continue to be directed to the reaches. On site surface runoff will be directed to the proposed SWM facilities resulting in a localized redirection of surface runoff in the Reach 14W-14 catchment area. Reach 14W-13 will be eliminated with flow directed by new Reach 14W-21 to realigned Reach 14W-14 (new Reach 14W-22). These changes will result in a slight shift in the amount of surface water directed to Reach 14W-14 (new Reach 14W-22) between Highway 407	remaining watercourses subject to the period from July 1 to March 31. Any works within Redside Dace habitat associated with Reach 14W-12 and Reach 14W-16 (meanderbelt plus 30 m) will only be permitted from July 1 to September 15. • **In-water construction method (if required):** If in-water works are required, in-water construction measures will consist of isolating the work area and redirecting flow (i.e., dam and pump, dam and flume, diversion channel) downstream to minimize potential adverse effects. Standard mitigation measures including sediment and erosion control measures (i.e., sediment filter bag) and fish screens on pump intakes will be incorporated into the design to minimize potential adverse effects. Adherence to the permissible in-water timing window will not be required for the proposed Avenue 1 crossing over the realigned channel provided the realigned channel is not connected to the existing channel. This will permit the construction to occur throughout the year with low potential for adverse effects to fish habitat. • **Fish relocation (if required).** In the event that in-water works are required and the work area must be isolated, fish relocation will be undertaken to remove fish from the isolated work area and relocate the fish downstream. This will be undertaken by qualified aquatic biologists with a Scientific Collectors Permit from the MNRF. • **Surface water quality (long-term).** The SWM facility will provide Enhanced level of treatment of stormwater runoff prior to discharge to Reach 14W-12. The conversion of agricultural land to	construction mitigation measures (i.e., S&E Plan, Spills Plan and BMPs). Potential changes to water quality (i.e., water temperature and dissolved oxygen) will be monitored during construction and post-construction as indicated in the OMB decision with Ontario Municipal Board (OMB) *Mediation Item: Stormwater Management – Temperature and Dissolved Oxygen Targets* (July 12, 2007). • **Sediment and erosion.** No adverse effects from construction generated sediment runoff are expected with the implementation and maintenance of an approved S&E Plan. • **Groundwater flow / volume.** Residual effects are anticipated to be minor – groundwater recharge is very limited on the site. The drainage design recommends passive infiltration (and at-source infiltration measures where local soils permit) and implementation of infiltration trenches along the boundary of the Open Space Area (Natural Heritage System). • **Incorporation of Reach 14W-14A (Farm Pond) into the SWM facility.** The removal of this warmwater contribution to downstream coolwater habitat will improve fish habitat. Although the footprint of this feature will be incorporated into the proposed SWM facility (another open water feature), the mitigation measures proposed (bottom draw, rock channel outlet) will assist in mitigating potential adverse effects to temperature from the existing condition and improve water quality.

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
	and the SWM facilities. The potential impact is minimal as the remaining catchment area north of Highway 407 will remain undisturbed and flow will be redirected from Reach 14W-13. As a result, this short section of Reach 14W-14 upstream of the SWM ponds to the limits of the site will continue to receive approximately 95% of the existing surface water contributions; thereby, minimizing potential adverse effects to fish habitat in downstream reaches. In general, the results of the hydrologic flow regime comparison shows that under the proposed condition for all reaches, except for Reach 14W-12A, the mean flow values have increased, the peak flows have marginally reduced, and the standard deviation (dispersion of the flow data with respect to the mean) of the flow values has reduced. This means that in all the channels within the Subject Property, there will higher uniform and sustained levels of flows with reduced peaks. • **Groundwater contributions.** Potential impacts to the groundwater regime and subsequent impacts to base flow in receiving reaches is associated primarily with the removal/compaction of the upper weathered till layer. The weathered soil layer will be altered/removed by grading activities thereby reducing the amount of shallow groundwater moving laterally that comprises the majority of the groundwater inputs into the reaches. Although this constitutes the majority of groundwater inputs into the reaches on the Subject Property, the flow regime will continue to be influenced largely by surface water. It is anticipated that the deeper groundwater inputs will remain largely unaffected by the proposed development and will continue to provide similar inputs to the lower sections of the reaches where refuge pools supporting fish including Redside Dace have been observed.	developed commercial and industrial uses is anticipated to reduce bacterial, nutrient, and total suspended sediment contamination due to cessation of tilling and fertilizing practices. Significant reductions to phosphorus loadings due to the switch from more heavily applied agriculture related fertilizers to maintenance related fertilizers are anticipated. While not of similar importance as phosphorus, other soluble and insoluble pollutants will see overall reductions in concentrations, subject to the treatment capacities of the water quality improvement features. The SWM facilities will also mitigate potential temperature increases from pond water through its design (i.e., planting native shrubs around the pond perimeter, bottom-draw outlet structure, discharge through a rock lined trench shaded by plantings). • **Groundwater.** Groundwater quality protection will generally be addressed by the same measures in place for surface water quality protection (i.e., E&S Plan, SWM system). The potential for minor changes to localized groundwater recharge/discharge areas and corresponding base flow contribution to the reaches is inferred to be minor given the low permeability of soils and remaining undisturbed catchment areas upstream. Mitigation measures consisting of the installation of infiltration galleries along the proposed stream corridors are anticipated to mitigate potential adverse effects. Clean water (i.e., roof runoff) will be directed to the galleries located along the edge of the corridor where the shallow weathered till remains intact promoting the existing lateral movement of shallow groundwater.	• **Realignment of Reach 14W-14, Reach 14W-11A and Alteration of flow to Reach 14W-12A.** The realignment of these reaches provides the opportunity to enhance the existing conditions of these altered reaches. As identified in NOCSS, the concept plan has been developed to enhance existing habitat form and function. The proposed concept will result in an enhancement over the existing channels by including morphologically diverse habitat (i.e., riffles and pools), as well as, floodplain wetlands. Floodplain wetlands will consist of both meadow marsh habitat and small offline open water wetland-pond features. These will recreate habitat loss in Reach 14W-13 and Reach 14W-14 and replicate existing open water features and provide additional opportunities for infiltration. DFO has indicated that Fisheries Act (1985) Authorization will not be required for the removal of Reach 14W-14A, realignment of Reach 14W-11A and consolidation of Reach 14W-14 and Reach 14W-13 into a realigned reach. The proposed approach to address the change in surface water contributions to Reach 14W-12A consists of maintaining a portion of surface runoff (directed via surface flows and an infiltration swale), as well as, the direction of roof top runoff to this reach.

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
		• **Water quality (temporary).** ESC Plan, Spills Management Plan, Best Management Practices (BMPs) for heavy equipment use. • **Hydrology.** SWM/drainage design to retain, treat and control discharge to Reach 14W-12. • Clean water (i.e., roof runoff) will be directed to the galleries located along the edge of the open space corridor and then will be directed through Reach 14W-12A to Reach 14W-12 in order to maintain surface water contributions to flow. • **Monitoring**. Potential impacts within the reaches will be assessed using the monitoring program discussed in Section 5.10 of this report. Requirements for monitoring of water temperatures and dissolved oxygen will be incorporated into the program in accordance with Ontario Municipal Board (OMB) *Mediation Item: Stormwater Management – Temperature and Dissolved Oxygen Targets* (July 12, 2007).	
Adjacent Lands • Reach 14W-12 flows downstream of Dundas Street in a meandering defined channel that is considered Redside Dace habitat. .	**Adjacent Lands** Potential impacts to aquatic habitat on adjacent lands are similar to those identified on the subject property with varying levels of severity. Below is a list of potential impacts that would likely occur as a result of the development of those lands however site specific impacts will be addressed during future studies undertaken in support of the EIR/FSS pertaining to those subcatchments areas and the Draft Plan Level of Detail. Potential impacts include • **Road and service crossings.** Fourteen Mile Creek will be crossed in three locations including Reaches 14W-11, 14W-2 and 14W-1A to the east and one location; Reach 14W-16 to the west. Potential impacts are similar to those identified above including type of road crossings,	**Adjacent Lands** Mitigation measures will be developed through a greater detailed examination of potential impacts during future EIR/FSS studies specific to the draft plan areas.	**Adjacent Lands** Residual effects will be identified during future EIR/FSS studies specific to the draft plan areas

Aquatic Resources			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
	methods of construction and location of servicing installation. • **Groundwater contributions.** Impacts are anticipated to be similar potentially with differing levels of severity based on the type of development proposed, mitigation measures and the amount of undisturbed open space remaining. • **Water quality impacts to (temporary and permanent)**. These impacts are anticipated to be similar to those discussed above. • **Hydrology**. The changes in surface water contributions that make up the majority of the flow contributions due to increased imperviousness are based upon the development proposed. It is anticipated that it will be similar in nature to the potential impacts identified for the Subject Property, with majority of these contributions maintained to the watercourses with minor redirection of surface runoff associated with SWM systems.		

Table 5.15: Summary of Potential Impacts to Vegetation

Vegetation			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
Subject Property • The Subject Property is dominated by active agricultural land uses with a network of drainage swales (reaches) supporting cultural meadow/meadow marsh vegetation. • A small deciduous woodland within the proposed Highway 407 transitway, abuts the existing Highway 407 ROW at the north end of the property. • A Farm Pond (Reach 14W-14A) with a fringe of wetland vegetation is located approximately 200 m north of Dundas Street. • A small provincially uncommon deciduous forest community [Dry-Fresh Oak-Hickory Deciduous Forest (FOD2-2, S3S4] is located on the banks of Reach 14W-11 along the east property boundary. This feature will be retained in its entirety within the proposed development. • Occasional hedgerows are present; hedgerow trees are in variable condition (poor, fair, good). • Overall, vegetation is dominated by disturbance tolerant and non-native species and has a low to moderate ecological significance and sensitivity. • Twelve (12) regionally rare/uncommon species were identified on the Subject Property. Eight (8) are located within the drainage swale network, three (3) are associated with hedgerows, and one (1) is located in vegetation unit 4i. **Adjacent Lands** • Adjacent lands to the east include Core #1 and the Linkage to Core #2 as defined in the NOCSS. • Adjacent lands to the north, east and west include the Candidate Oakville-Milton Wetlands and Uplands Life Science ANSI, the Candidate Trafalgar Moraine Earth Science ANSI, Greenbelt Plan "Protected Countryside", and portions of the North Oakville-Milton West	**Direct impacts.** Direct impacts to vegetation on the Subject Property are: • The removal of portions of Vegetation Unit 2 (a, d, & g) to accommodate the relocation of Reach 14W-14, Reach 14W-13 and Reach 14W-11A. It is important to note that works within the stream corridor downstream of the proposed realigned Reach 14W-11A consisting of Dry Oak-Hickory Forrest Type (FOD2-2) will not be affected. In the event that there are works proposed within this vegetation community, consultation with the Town and CH will be undertaken. • Removal of Vegetation Unit 1 and portions of Vegetation Unit 2A to accommodate construction of a SWM facility. • Removal of Hedgerows HR2, HR3, HR7 and portions of HR4, and removal of Tree Clusters TC1, TC2, and TC3 to accommodate site grading and road construction. • Removal of vegetation from within Vegetation Unit 2A to accommodate construction of the trail system along the south side of Reach 14W-12 and Reach 14W-16. The trail system (Off-Road Major Trail) has been located within close proximity of the limit of the NHS in order to minimize encroachment into established habitats (Figure 5.8). **Direct impacts.** Direct impacts to vegetation[1] adjacent to the subject property are: • Removal of cultural meadow, cultural thicket and oak dominated deciduous forest to accommodate two new road crossings of the Fourteen Mile Creek valley (part of Core #1). • Removal of hedgerows to accommodate new road	• **Vegetation protection fencing (temporary).** Will be installed prior to any site grading to delineate the work zone and prevent direct damage to adjacent retained vegetation (i.e., mechanical damage, root damage, soil compaction). This fencing will remain until construction is complete. • **Permanent fencing.** To be installed along lot limits abutting retained/realigned watercourse features. This prevents intrusion and uncontrolled dumping into these features. • **Watercourse buffer management.** The NOCSS identifies buffer requirements for all Medium and High Constraint Reaches. The buffers identified for protection of retained reaches on the Subject Property are considered sufficient to protect associated vegetation features including forested areas [Vegetation Unit 5A (Valley Forest) and Vegetation Unit 3A]. • **Sediment/Erosion Control Plan.** To prevent sedimentation of off-site retained vegetation; sediment and erosion fencing will be installed prior to any site grading. Steep slopes may be created as a result of grading requirements. In these cases, erosion control blankets are recommended. • **Hydrology.** Surface and groundwater water inputs to drainage features to be maintained. • **Stewardship.** An integrated stewardship approach is proposed, including: signage at the Natural Heritage System limit; and property owner/tenant brochures. • **Monitoring.** A vegetation monitoring program will be developed in accordance with applicable directions in the NOCSS as a condition of Draft Plan approval. • **Restoration/rehabilitation.** A landscape planting plan/restoration plan will be developed to guide restoration of meadow marsh and shallow marsh vegetation within realigned reach corridors on the Subject Property. The plan will include measures to re-establish regionally rare/uncommon species in addition to common and tolerant	Residual impacts to vegetation are assumed to be relatively minor, with proper implementation of recommended mitigation, stewardship and monitoring measures. • The edge of Vegetation Units 3A and 5A and on-site hedgerows have been 'pre-stressed' by a long history of plowing adjacent to or within the dripline. The recommended reach buffers identified in the NOCSS will provide good dripline and root zone protection for Units 3A and 5A. • Edge effects are already present in the natural features on-site due to the anthropogenic land use history and small size and high edge ratio. Exotic and invasive species are prevalent at the cultivated field edge, and widespread but typically not abundant within Vegetation Units 3A and 5A and B. Given the increased development in the broader landscape, some increase in exotic and invasive species is likely. The intent is to reduce this to the extent possible. • With the restoration/rehabilitation of meadow marsh/shallow marsh within realigned stream corridors, and the drainage design measures to maintain hydrology, no substantive changes in wetland vegetation diversity or function are anticipated. The restored meadow marsh/shallow marsh communities will likely undergo natural succession towards a greater percentage cover of woody species (trees and shrubs) over time, unless actively managed to prevent succession. • Residual impacts from construction are anticipated to be very minor, with implementation of recommended vegetation protection fencing, sediment and erosion fencing and spills management plan.

[1] Existing conditions information based on NOCSS, off-site vegetation was not classified during the present study.

Vegetation			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
Provincially Significant Wetland complex. • Adjacent lands to the south include Bronte Creek Provincial Park. • Other designated features are present in the general area, including the Bronte Creek provincially significant life science ANSI.	construction. • Removal from the edge of a Sugar Maple dominated deciduous forest (part of Core #1) to accommodate road crossing of the Linkage between Core #1 and Core #2. • **Edge effects.** Vegetation removal and dieback at the forest edge is not desirable because this edge helps to moderate microclimate changes between the bordering open field and the more shaded forest interior. This can result in exposure of the less disturbed forest zone to additional sunlight and invasive plant species which can lead to trunk damage (sunscald), desiccation, and localized changes in ground flora (e.g., increase in exotic and invasive species). Potential edge effects are restricted to portions of Core #1 where new crossings are proposed. • **Indirect impacts.** There is potential for indirect impacts to vegetation as the result of construction, changes to hydrology and occupancy related activities. • **Construction-related impacts.** These include: damage to vegetation outside the work zone; sedimentation; spills of contaminants or fuels; root pruning; damage to limbs; and soil compaction. • **Hydrology.** Retained vegetation (including off-site habitats) might be impacted by changes to hydrology on the Subject Property. For example, wetland vegetation that receives hydrological inputs from the Subject Property can be stressed if those inputs are significantly changed (e.g., change to surface water volume/flow direction; reduced infiltration or changes to groundwater flow direction). • **Occupancy-related impacts.** These may include: woodland edge effects (e.g., invasive species proliferation); trail creation; vandalism; refuse/vegetation dumping; and, effects of salt spray from road maintenance.	species that dominate the existing communities. These measures may include seedbank salvage and/or salvage of sedge 'turf' from densely vegetated portions of relocated reaches. The restored meadow marsh/shallow marsh communities will likely undergo natural succession towards a greater percentage cover of woody species (trees and shrubs) over time, unless actively managed to prevent succession. • **Core and linkage crossings.** The proponent(s) responsible for design and construction of roads/services that will cross Core #1 and the Linkage to Core #2 will be required to address the study requirements identified in the North Oakville EIR/FSS Terms of Reference. In addition, the following recommendations identified in the NOCSS should be incorporated into the design of Core and Linkage Crossings; • Use of plantings and wing-walls to direct wildlife using the linkage to culvert/bridge crossings; • Consideration of alternative road designs to minimize the width of the gap created by the roadway (in either Linkages or other natural areas); • Locating services under the roadway to minimize roadway right-of-way; and, • Road alignments through Core Areas should be selected to avoid woodland and wetland features.	

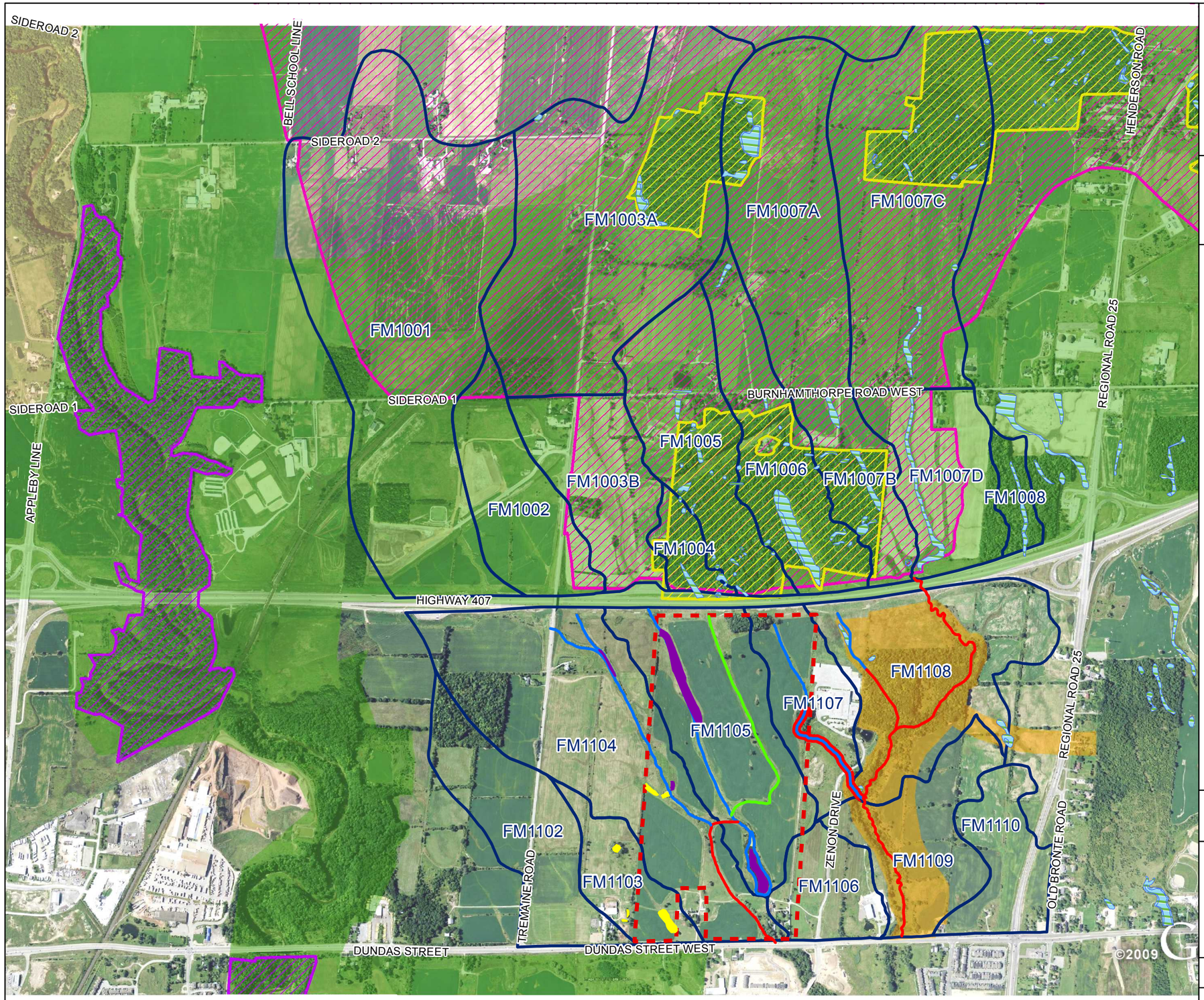
Table 5.16 – Summary of Potential Impacts to Wildlife

Wildlife			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
<u>Subject Property</u> • The cultivated fields, small woodlands and drainage swales (reaches) network supporting cultural meadow/meadow marsh vegetation provide habitat for common, urban-adapted, open-country, edge, and generalist species and habitat for wetland & woodland associated species. • Some specialized wildlife habitat is present – amphibian breeding habitat in the Farm Pond (Reach 14W-14A). • Four (4) SAR species were recorded (Bobolink, Barn Swallow, Snapping Turtle, and Redside Dace). Implications for Redside Dace are discussed in Table 5.12 Summary of Potential Impacts to Aquatic Resources. • One (1) provincially significant species was recorded (Black-crowned Night-heron) but was recorded outside of the breeding season and is not thought to be breeding on the Subject Property. • Ten (10) regionally significant species were recorded (9 avifaunal spp. and 1 herpetofaunal sp. - Bullfrog). American Bullfrog was not recorded in 2010 and may be extirpated from the Subject Property. • Two (2) bird species observed are considered area sensitive (Savannah Sparrow, and Northern Harrier). • No woodland amphibian breeding habitat is present **<u>Adjacent Lands</u>** • Lands within EIR subcatchments that overlap with the Subject Property include much larger, more ecologically significant and sensitive wildlife habitat blocks. • Adjacent lands to the east include Core #1 and the Linkage to Core #2 as defined in the NOCSS. • The NOCSS states that; "the forested portion of (Core #1) was found to provide potential nesting habitat for a number of forest bird species of conservation concern. Most of these bird species are also considered to be	Potential impacts on wildlife habitat are similar to those discussed for vegetation (i.e., direct/indirect impacts to habitat – removals, fragmentation, occupancy related effects, etc.). Some additional occupancy-related effects are specific to wildlife (e.g., influence of increased pedestrian activity adjacent to wildlife habitats). • **Direct impacts,** Loss of wildlife habitat is restricted to cultivated fields, meadow marsh/shallow marsh vegetation within realigned portions of the drainage swale network (Vegetation Unit 2) and the large pond (Vegetation Unit 1). Direct impacts to the Farm Pond and reaches are considered temporary as these features will be recreated within the proposed SWM facilities and realigned reaches within a wider riparian stream corridor, respectively. • **Movement opportunities.** Wildlife passage will be maintained via the retained/realigned stream corridor(s). • **Habitat for Bobolink may be impacted.** Consultation with MECP will be undertaken during detail design to determine potential ESA (2007) permitting requirements. • **Habitat for species of regional conservation concern will not be impacted over the long-term.** There will be a temporary disturbance to riparian meadow during relocation and restoration. The regionally significant bird species recorded are tolerant of cultural habitats. • **Anuran breeding habitat associated with the Farm Pond (Vegetation Unit 1) will be removed.** Anuran species may re-colonize the SWM facilities habitat following construction. Ephemeral pool/pond habitat will be recreated within realigned reaches, and will provide potential amphibian breeding habitat in the post-development landscape. • **Indirect Impacts.** There is potential for indirect impacts to wildlife habitats on adjacent lands as the result of construction, changes to hydrology and	Retention and recreation of vegetation communities (as discussed above) will also protect wildlife habitat. Specific mitigation measures are as follows: • **Movement opportunities.** Open country movement opportunities will be maintained via the retained/realigned stream corridors. • **Habitat for SAR bird species.** As noted, consultation with MECP will be undertaken with regards to Bobolink and Barn Swallow; however, impacts to Barn Swallow can be registered under the Notice of Activity under the ESA (2007) for the removal of nest and nesting structures as long as new nesting habitat is provided. The proposed development will conform to the requirements of the ESA (2007) legislation with regards to both of these species. • Habitat for wildlife species of conservation concern will be retained in situ, relocated or recreated. Additional measures are proposed to protect this habitat, including: ESC measures, maintenance of hydrological inputs, fencing/restricted access and stewardship initiatives (e.g., signage, property owner/tenant brochures). • **Sediment and erosion controls and SWM facilities.** Will be designed to reduce the potential for sedimentation or contamination of receiving habitats. • **Maintenance of hydrology.** Direction and volume of surface flows to be maintained post-development. • **Occupancy-related impacts.** Occupancy related impacts to wildlife and wildlife habitat will be mitigated by a combination of measures: **<u>fencing</u>** along retained/realigned stream corridors to restrict access; and **<u>stewardship</u>** initiatives (Natural Heritage System signage, property owner/tenant brochure). The intent is to restrict access to sensitive areas and inform local residents about the sensitivity of adjacent natural areas. • **Monitoring.** An avifaunal and anuran monitoring program will be developed in accordance with applicable directions in the NOCSS as a condition of Draft Plan approval. • **Restoration/rehabilitation.** As noted above, restoration	Residual impacts to wildlife and wildlife habitat resulting from land development on the Subject Property are anticipated to be minor: • The proposed development is primarily restricted to cultivated fields that provide habitat for common, tolerant wildlife species. • While there are direct impacts to anuran breeding habitat, ephemeral pool/pond habitat suitable for anurans breeding will be recreated within the buffers of realigned stream reaches. Anurans may also re-colonize SWM facilities following construction. • Additional measures are proposed to reduce potential for indirect impacts to off-site wildlife habitat (i.e., erosion and sediment controls, SWM treatment of contaminants, maintenance of hydrological inputs to dependent features, buffering of sensitive areas). • Stewardship measures are proposed to raise awareness of the sensitivity of adjacent natural areas and further reduce potential for indirect (occupancy-related) impacts. This can include, the Town of Oakville publication "*Living the Green Life – Oakville's Guide to Environmental Stewardship*" However, it is acknowledged that in any populated area there is potential for unauthorized intrusion and damage to natural areas, and less tangible but inferred effects of occupancy on breeding bird activity. Population changes in breeding birds are inevitably related to the approved transformation of the broader landscape in the Region. Changes can also be affected by factors outside the Region (such as alteration/loss of wintering habitat, severe climatic conditions during migration activity, and changes in migratory stopover habitat). Hence, it must be recognized that shifts in wildlife species composition may be inevitable in this area over time, and in fact have probably already occurred with changes in the regional landscape.

Wildlife			
Feature Significance and Sensitivity	**Potential Natural Environment Impacts**	**Mitigation Measures**	**Residual Effects**
area sensitive species, despite the limited amount of interior habitat beyond 100 m of the edge (<1ha). • Other natural environment features that provide wildlife habitat on adjacent lands to the north, south, east and west include the Candidate Oakville-Milton Wetlands and Uplands Life Science ANSI, the Candidate Trafalgar Moraine Earth Science ANSI, Greenbelt Plan "Protected Countryside", portions of the North Oakville-Milton West Provincially Significant Wetland complex, Bronte Creek Provincial Park, and Bronte Creek provincially significant life science ANSI.	occupancy related activities. • **Construction-related impacts.** These are generally limited to temporary disturbances to the Farm Pond (Vegetation Unit 1) and portions of Vegetation Unit 2 habitats during construction. Potential for sedimentation and contamination are addressed by sediment and erosion controls and SWM measures. • **Hydrology.** As above, retained off-site habitats may be impacted by changes to hydrological inputs. • **Occupancy-related impacts.** These may include: woodland edge effects; and other degradation of wildlife habitat. In addition, there will be an increased pedestrian presence adjacent to retained/recreated habitats.	measures will be implemented to recreate the form and function of meadow marsh/shallow marsh and ephemeral Farm Pond habitats within the realigned portions of stream reaches (14W-22). These habitats are anticipated to be suitable to the anurans displaced from the Farm Pond. The re-vegetation plant list will include *Asclepias* species and nectar producing plants to enhance habitat suitability for Monarch Butterfly.	

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Natural Environment Features:
407 West Employment Area and
Overlapping NOCSS EIR Subcatchments



LEGEND

- Subject Property
- Subcatchment Area Boundary
- Provincially Significant Wetlands
- ANSI, Life Science
- Candidate Oakville-Milton Wetlands & Uplands Life Science ANSI
- Candidate Trafalgar Moraine Earth Science ANSI
- NOCSS Core #1 and Linkage to Core #2
- Protected Countryside (Greenbelt Plan)
- Niagara Escarpment Plan Area
- Hydrologic Feature "A"
- Hydrologic Feature "B"

Watercourse Constraints

- High Constraint Stream Corridor
- High Constraint Stream Corridor - Requiring Rehabilitation
- Medium Constraint Stream Corridor
- Low Constraint Stream Corridor

Scale
0 120 240 480 720 960 m

Client: QuadReal

Prepared by: wsp

Date: June 2017

Project No.: 1409222001

Aerial Photo
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Figure: 5.1

M:\Jobs\2009\14.09222.001.P01 - 407 West Employment Area\mapping\mxd\2013 04\Figure 5-1 - Natural Environment Features - 407 West Employment Area and Overlapping NOCSS EIR Subcatchments.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Vegetation Communities

LEGEND

- Subject Property
- Vegetation Communities
- Wetland Communities
- Transitway
- Soil Auger Locations

AG Agricultural Field
HR Hedgerow
TC Tree Cluster

Unit ELC Community

1A Cattail Mineral Shallow Marsh (MAS2-1)
1B Duckweed Floating-leaved Shallow Aquatic (SAF1-3)
1C Open Aquatic (OAO)
1D Pondweed Submerged Aquatic (SAS1-1)
2A Dry-Moist Old Field Meadow (CUM1-1)
2B Reed-canary Grass Mineral Meadow Marsh (MAM2-2)
2C Willow Mineral Thicket Swamp (SWT2-2)
2D Cattail Mineral Shallow Marsh (MAS2-1)
2E Red-top Mineral Meadow Marsh (MAM2-3)
2F Broad-leaved Sedge Mineral Meadow Marsh (MAM2-6)
2G Forb Mineral Meadow Marsh (MAM2-10)
3A Fresh-Moist Willow Lowland Deciduous Forest (FOD7-3)
3B Mosaic of Mineral Cultural Meadow (CUM1) and Forb Mineral Meadow Marsh (MAM2-10)
4 Dry-Fresh Sugar Maple-Oak Deciduous Forest (FOD5-3)
4I Mineral Thicket Swamp (SWT2) inclusion
5A Dry-Fresh Oak-Hickory Deciduous Forest (FOD2-2)
5B Jewelweed Mineral Meadow Marsh (MAM2-9)

Scale
0 50 100 200 300 400 m

Client
QuadReal

Prepared by
wsp

Date
June 2017

Project No.
1409222001

Aerial Photo
© DigitalGlobe, 2010, Google, 2009

Figure: 5.2

M:\Jobs\2009\14.09222.001.P01 - 407 West Employment Area\mapping\mxd\2017 06\Figure 5-2 - Vegetation Communities.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Wildlife Sampling Locations

LEGEND

- Subject Property
- 407 Transitway
- Bird Sampling Stations
- Anuran Sampling Locations
- Bobolink Observation Locations
- Transect Lines
- BOBO-EAME Survey Point Count (2012)
- BOBO-EAME Survey Point Count (2013)

Scale: 0 50 100 200 300 400 m

Client: QuadReal

Prepared by: wsp

Date: June 2017

Project No.: 1409222001

Aerial Photo: © DigitalGlobe, 2010, Google, 2009

Figure: 5.3

M:\Jobs\2009\14 09222 001 P01 - 407 West Employment Area\mapping\mxd\2014 07\Figure 5-3 - Wildlife Sampling Locations R2.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Aquatic Ecology: Field Investigations and Watercourse Constraints

HIGHWAY 407

Truck Inspection Station

TREMAINE ROAD

14W-17

14W-11A

14W-13

14W-14

14W-11

Site 2

Site 1

POND 1

14W-16

14W-12A

SEE INSET

POND 2

Site 2

14W-12

Site 1

ZENON DRIVE

REGIONAL ROAD 25

DUNDAS STREET WEST

VALLEYRIDGE DRIVE

BRONTE ROAD

OLD BRONTE ROAD

SKIPTON LANE

INSET

LEGEND

- Subject Property
- Temp Logger Locations (2009)
- Temp Logger Locations (2011)
- Benthic / OSAP (2009)
- Electroshocking Locations (2009)
- Benthic / OSAP and Electroshocking Location (2009)
- Minnow Trap Locations (2002)
- Pot Trap Location (2011)
- Minnow Trap Location (2011)
- 407 Transitway

Watercourse Constraints

- High Constraint Stream Corridor
- High Constraint Stream Corridor - Requiring Rehabilitation
- Medium Constraint Stream Corridor
- Low Constraint Stream Corridor

Scale

0 65 130 260 390 520 m

N

Client: QuadReal

Prepared by: wsp

Date: June 2017

Project No.: 1409222001

Aerial Photo: © DigitalGlobe, 2010, Google, 2009

Figure: 5.4

M:\Jobs\2009\14.09222.001.P01 - 407 West Employment Area\mapping\mxd\2012 12\Figure 5.4 - Aquatic Ecology - Field Investigations and Watercourse Constraints.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Vegetation Communities: Proposed Development Impact Review

LEGEND

- Subject Property
- Vegetation Communities
- Wetland Communities
- Open Space Area
- 407 Transitway
- Soil Auger Locations

AG Agricultural Field
HR Hedgerow
TC Tree Cluster

Unit ELC Community

1A Cattail Mineral Shallow Marsh (MAS2-1)
1B Duckweed Floating-leaved Shallow Aquatic (SAF1-3)
1C Open Aquatic (OAO)
1D Pondweed Submerged Aquatic (SAS1-1)
2A Dry-Moist Old Field Meadow (CUM1-1)
2B Reed-canary Grass Mineral Meadow Marsh (MAM2-2)
2C Willow Mineral Thicket Swamp (SWT2-2)
2D Cattail Mineral Shallow Marsh (MAS2-1)
2E Red-top Mineral Meadow Marsh (MAM2-3)
2F Broad-leaved Sedge Mineral Meadow Marsh (MAM2-6)
2G Forb Mineral Meadow Marsh (MAM2-10)
3A Fresh-Moist Willow Lowland Deciduous Forest (FOD7-3)
3B Mosaic of Mineral Cultural Meadow (CUM1) and Forb Mineral Meadow Marsh (MAM2-10)
4 Dry-Fresh Sugar Maple-Oak Deciduous Forest (FOD5-3)
4I Mineral Thicket Swamp (SWT2) inclusion
5A Dry-Fresh Oak-Hickory Deciduous Forest (FOD2-2)
5B Jewelweed Mineral Meadow Marsh (MAM2-9)

Scale: 0 50 100 200 300 400 m

Client: QuadReal

Prepared by: wsp

Date: April 2019

Project No.: 1409222001

Aerial Photo: © DigitalGlobe, 2010, Google, 2009

Figure: 5.5

M:\Jobs\2009\14 09222.001.P01 - 407 West Employment Arealmapping\mxd\2019 04\Figure 5-5 - Vegetation Communities - Proposed Development Impact Review R2.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Aquatic Ecology: Proposed Development Impact Review

LEGEND

- Subject Property
- Open Space Area
- 407 Transitway

Watercourse Constraints

- High Constraint Stream Corridor
- High Constraint Stream Corridor - Requiring Rehabilitation
- Medium Constraint Stream Corridor
- Low Constraint Stream Corridor

Scale: 0 50 100 200 300 400 m

Client: QuadReal

Prepared by: wsp

Date: April 2019

Project No.: 1409222001

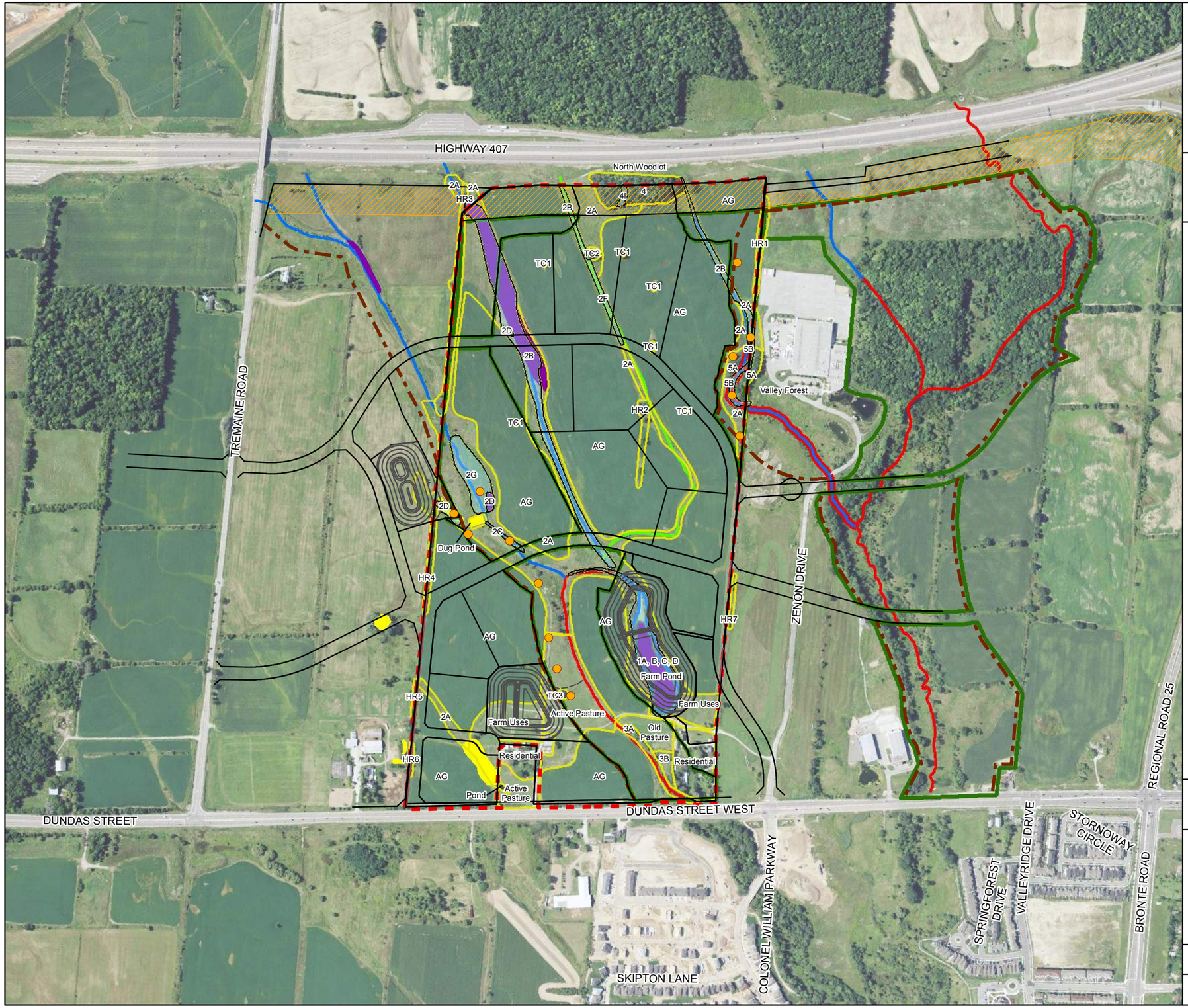
Aerial Photo: © DigitalGlobe, 2010, Google, 2009

Figure: 5.6

M:\Jobs\2009\14 09222 001.P01 - 407 West Employment Area\mapping\mxd\2014 07\Figure 5-6 - Aquatic Ecology - Proposed Development Impact Review R2.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Natural Heritage Features: Proposed Development Impact Review



LEGEND

- Subject Property
- Vegetation Communities
- Wetland Communities
- Open Space Area
- 407 Transitway
- Hydrologic Feature "A"
- Hydrologic Feature "B"
- Major Trails
- Ditch
- Soil Auger Locations

Watercourse Constraints

- High Constraint Stream Corridor
- High Constraint Stream Corridor - Requiring Rehabilitation
- Medium Constraint Stream Corridor
- Low Constraint Stream Corridor

AG	Agricultural Field
HR	Hedgerow
TC	Tree Cluster

Unit	ELC Community
1A	Cattail Mineral Shallow Marsh (MAS2-1)
1B	Duckweed Floating-leaved Shallow Aquatic (SAF1-3)
1C	Open Aquatic (OAO)
1D	Pondweed Submerged Aquatic (SAS1-1)
2A	Dry-Moist Old Field Meadow (CUM1-1)
2B	Reed-canary Grass Mineral Meadow Marsh (MAM2-2)
2C	Willow Mineral Thicket Swamp (SWT2-2)
2D	Cattail Mineral Shallow Marsh (MAS2-1)
2E	Red-top Mineral Meadow Marsh (MAM2-3)
2F	Broad-leaved Sedge Mineral Meadow Marsh (MAM2-6)
2G	Forb Mineral Meadow Marsh (MAM2-10)
3A	Fresh-Moist Willow Lowland Deciduous Forest (FOD7-3)
3B	Mosaic of Mineral Cultural Meadow (CUM1) and Forb Mineral Meadow Marsh (MAM2-10)
4	Dry-Fresh Sugar Maple-Oak Deciduous Forest (FOD5-3)
4I	Mineral Thicket Swamp (SWT2) inclusion
5A	Dry-Fresh Oak-Hickory Deciduous Forest (FOD2-2)
5B	Jewelweed Mineral Meadow Marsh (MAM2-9)

Scale: 0 65 130 260 390 520 m

Client: QuadReal

Prepared by: wsp

Date: April 2019

Project No.: 1409222001

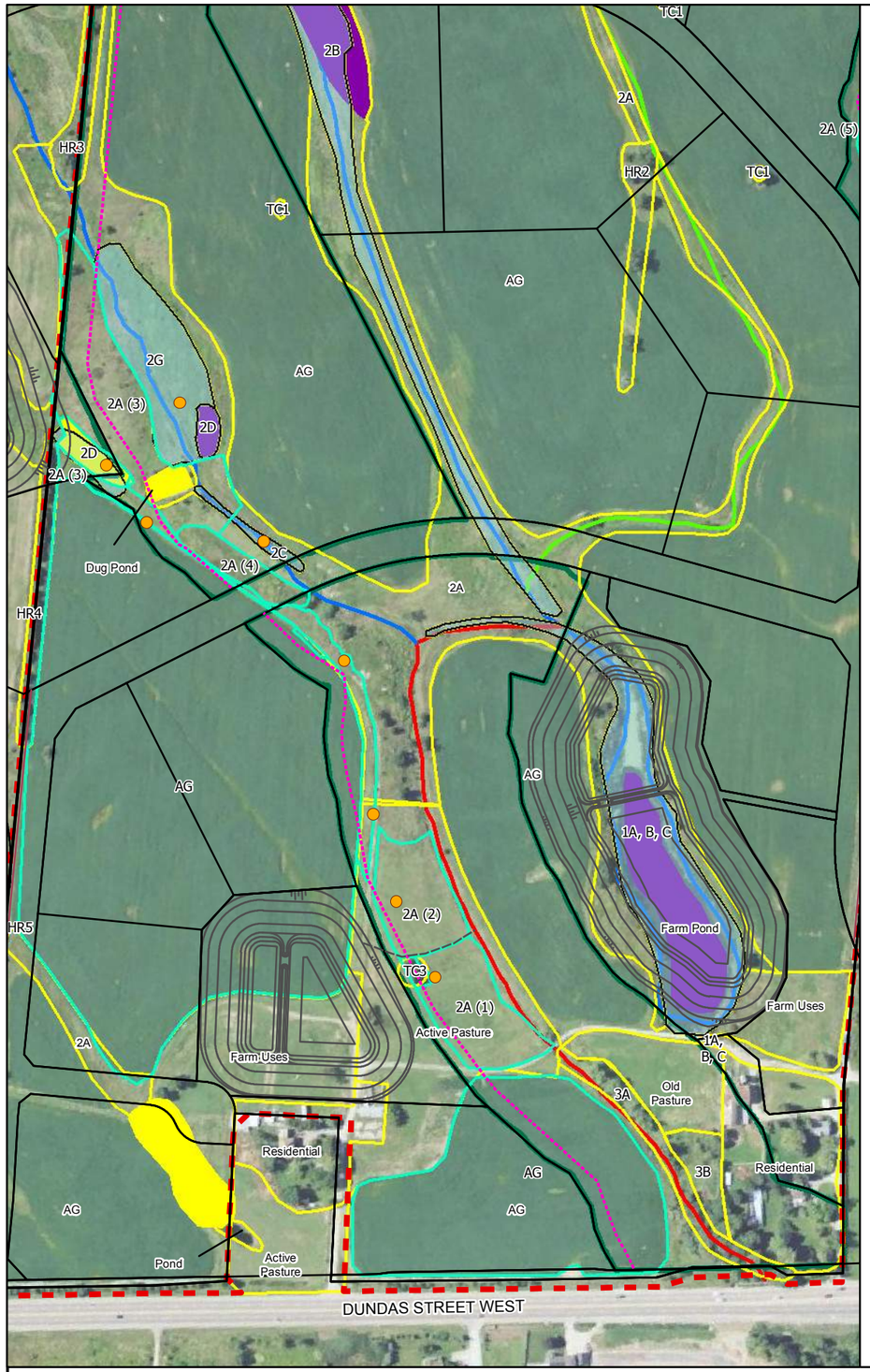
Aerial Photo: © DigitalGlobe, 2010, Google, 2009

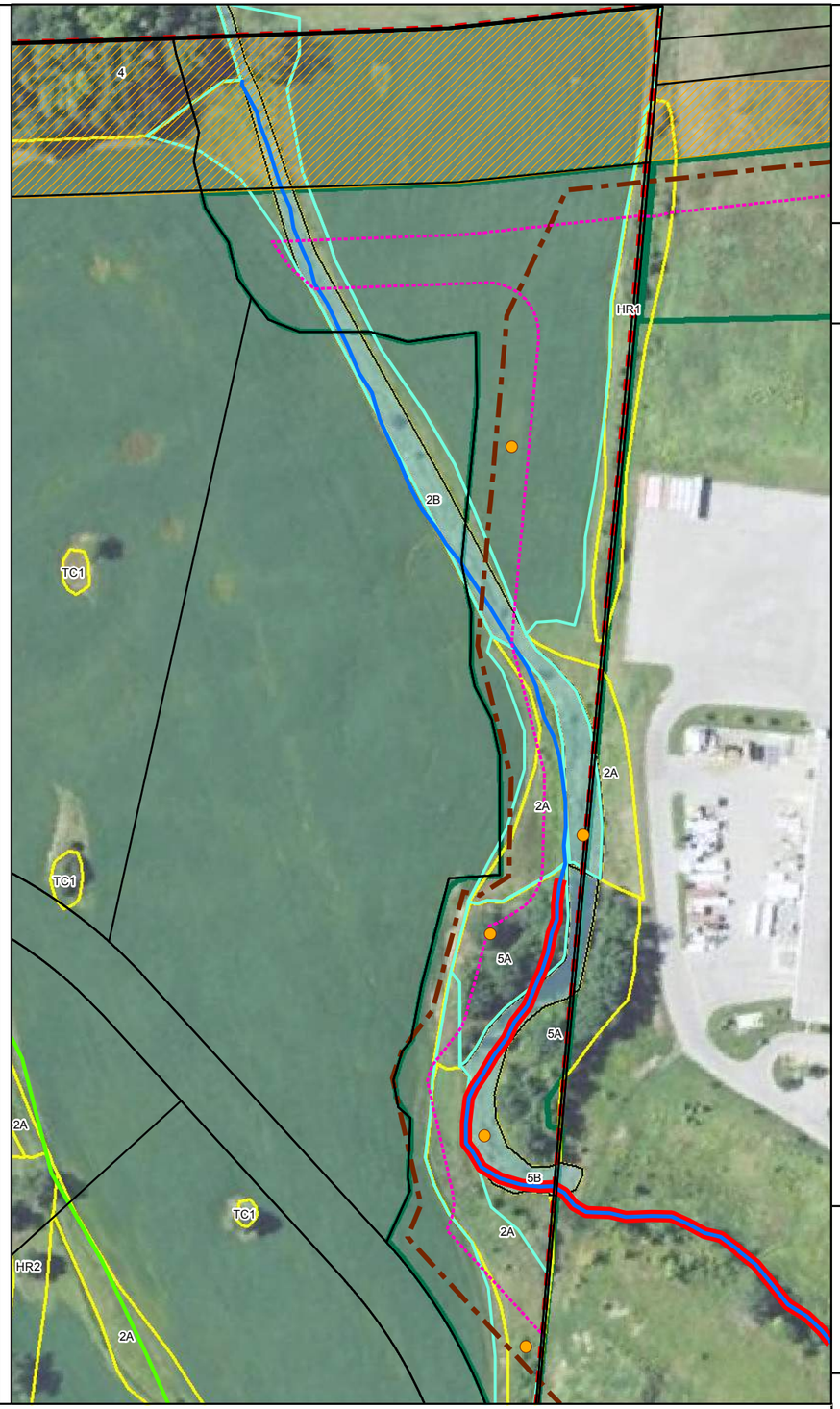
Figure: 5.7

M:\Jobs\2009\14.09222.001.P01 - 407 West Employment Area\mapping\mxd\2019 04\Figure 5-7 - Vegetation Communities - Proposed Development Impact Review.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Natural Heritage Features: Proposed Trail Impact Review





LEGEND

- Subject Property
- 20m Study Corridor Boundary
- Vegetation Communities
- Vegetation Communities in Trail Corridor
- Wetland Communities
- Open Space Area
- 407 Transitway
- Hydrologic Feature "A"
- Hydrologic Feature "B"
- Major Trails
- Ditch
- Soil Auger Locations

Watercourse Constraints

- High Constraint Stream Corridor
- High Constraint Stream Corridor - Requiring Rehabilitation
- Medium Constraint Stream Corridor
- Low Constraint Stream Corridor

AG Agricultural Field
HR Hedgerow
TC Tree Cluster

Unit	ELC Community
1A	Cattail Mineral Shallow Marsh (MAS2-1)
1B	Duckweed Floating-leaved Shallow Aquatic (SAF1-3)
1C	Open Aquatic (OAO)
1D	Pondweed Submerged Aquatic (SAS1-1)
2A	Dry-Moist Old Field Meadow (CUM1-1)
2B	Reed-canary Grass Mineral Meadow Marsh (MAM2-2)
2C	Willow Mineral Thicket Swamp (SWT2-2)
2D	Cattail Mineral Shallow Marsh (MAS2-1)
2E	Red-top Mineral Meadow Marsh (MAM2-3)
2F	Broad-leaved Sedge Mineral Meadow Marsh (MAM2-6)
2G	Forb Mineral Meadow Marsh (MAM2-10)
3A	Fresh-Moist Willow Lowland Deciduous Forest (FOD7-3)
3B	Mosaic of Mineral Cultural Meadow (CUM1) and Forb Mineral Meadow Marsh (MAM2-10)
4	Dry-Fresh Sugar Maple-Oak Deciduous Forest (FOD5-3)
4I	Mineral Thicket Swamp (SWT2) inclusion
5A	Dry-Fresh Oak-Hickory Deciduous Forest (FOD2-2)
5B	Jewelweed Mineral Meadow Marsh (MAM2-9)

0 30 60 120 180 240 m

0 15 30 60 90 120 m

Client: QuadReal

Prepared by: wsp

Date: April 2019

Project No.: 1409222001

Aerial Photo: © DigitalGlobe, 2010, Google, 2009

Figure: 5.8

M:\Jobs\2009\14.09222.001.P01 - 407 West Employment Area\mapping\mxd\2019 04\Figure 5-8 - Vegetation Communities - Proposed Trail Impact Review.mxd

6.0 Water Resources

6.0 Water Resources

6.1 Introduction

The proposed development area contains the headwater tributaries of the West Branch of Fourteen Mile Creek which flow generally from west to east. The headwaters enter the development area via 5 culverts (FM1, FM2, FM3, FM4 and FM5) located under Highway 407 and exit the subject property through two culverts (FM-D4 and FM-D5) located under Dundas Street West as shown in **Figure 6.1**. Two tributaries of West Branch of Fourteen Mile Creek (Reaches 14W-13 and 14W-14) will be diverted upstream of confluence with 14W-16, and an east Reach 14W-11A will be realigned to accommodate the proposed development.

The 14W-12A reach contains a well-defined trapezoidal cross-section and was constructed to allow outflows from the pond to flow back out into Reach 14W-12. The 'A' designation for this sub-reach is intended to illustrate that this area requires altered management recommendations from the remainder of Reach 14W-12. No intent to re-designate NOCSS reaches is implied. In the pre-development condition, Reach 14W-12A receives flow from reaches 14W-13, 14W-14 and from water flowing out of the existing pond. Under post-development conditions, with the consolidation of Reaches 14W-13 and 14W-14 into Reach 14W-22, Reach 14W-12A will continue to receive controlled discharge from the developed upstream catchment (see **Section 7**), and the forces promoting the current channel form will be altered. Therefore, the distinction for Reach 14W-12A has been carried through the EIR/FSS when addressing issues related to this area.

Changes on the hydrologic features and functions within the Subject Property has been analyzed based on the following phasing plan (Refer to **Section 7** for hydrologic modelling results):

1. Existing (i.e. pre-development)
2. Interim Conditions Phase 1A
3. Interim Conditions Phase 1B
4. Interim Conditions Phase 2
5. Ultimate Conditions

According to the Terms of Reference (TOR) of the Environmental Implementation Report (EIR)/Functional Servicing Study (FSS) for North Oakville, the following requirements are to be satisfied:

- Refine corridor widths of medium and high constraint streams within the study area; and,
- Develop preliminary design concepts based on the principles of "Natural Channel Design" for streams to be relocated and/or rehabilitated.

Therefore, the following tasks were completed to satisfy the requirements of the TOR of EIR/FSS and are presented in this report:

- Corridor width estimation; and,
- Preliminary natural channel design for the proposed channel diversions.

Details are provided in the following appendices:

- **Appendix 6.1**: HEC RAS Results

- **Appendix 6.2**: Proposed Cross Sections
- **Appendix 6.3**: Proposed Crossings
- **Appendix 6.4**: Corridor Width Delineation
- **Appendix 6.5**: EXP Slope Stability Report
- **Appendix 6.6**: Stream Stability and Drainage Density
- **Appendix 6.7**: Water Surface Profiles at Tie in of 14W-22 and 14W-12A
- **Appendix 6.8**: Top of Bank 14W-12A South of Farm Pond

6.2 Background

The following studies, technical guidelines and references were reviewed and used in the preparation of this study:

- North Oakville Creeks Subwatershed Study (NOCSS), 2006
- North Oakville Creeks Subwatershed Study Addendum, 2007
- Morphologic Relationships of Rural Watercourses in Southern Ontario and Selected Field Methods in Fluvial Geomorphology, Annable, 1996
- River & Systems: Flooding Hazard Limit, Technical Guide, Ontario Ministry of Natural Resources, 2002
- Belt Width Delineation Procedures, PARISH geomorphic, 2004

The study criteria are multidisciplinary and follow technical direction from the North Oakville EIR and FSS Terms of Reference, 2007, in addition to policy direction and guidance from Town of Oakville, Conservation Halton, MECP, MNRF, and other agencies. Specific references include:

- Corridor Width Delineation (**Section 6**): ToR Section 3.3.3.1a & b.
- Top of Bank Delineation (**Section 6**): ToR Section 3.3.3.1c.
- Hydraulic Modelling and Floodplain Mapping (**Section 6**)
- Hydrologic Model (**Section 7**):
    - ToR Section 3.3.3.3:
        - Identify the form and function of Hydrologic Feature 'A' and document its ecological and hydrologic relationship to the watercourse; and
        - Identify how the ecological and hydrological relationships of the Hydrologic Feature 'A' is considered in the present stream modification.
    - ToR Section 3.4.4:
        - The modelling approach is to follow commonly accepted practices;
        - Stormwater management targets include control of the peak flow to predevelopment levels for the 2-year to 100-year return period events and the Regional Storm; and
        - Future land use development applicants may carry out an investigation of the potential increase to flood risk to confirm if Regional Storm controls are necessary.
- Flow Regime (**Section 7**):
    - Instream Flow Assessment Method (April 1st 2016 email from Conservation Halton);
    - ToR Section 3.3.3.2: Fish and Fish Habitats; and
    - ToR Section 3.4.3: Preliminary Grading and Drainage Plan.
- Erosion Thresholds (**Section 7**):

    - The frequency and duration of time (expressed as hours) that the erosive threshold flow is exceeded, in the pre-development condition, is to be matched in the post-development condition (i.e. results are within approximately 5% of the pre-development conditions.)
- Stormwater Management (**Section 7**): ToR Section 3.4.

6.3 Corridor Width Delineation

The NOCSS and its related addendum set out the approach for the delineation of stream corridor widths. The corridor widths of the high and medium constraint streams and the end points of the reach delineations are required to be refined as part of the EIR/FSS study. High constraint streams are required to preserve their form and function, while medium constraint streams are required to preserve their current functions. Low constraint streams can be replaced through infrastructure or stormwater management (SWM) practices. The factors to be considered in the refinement of the corridor widths include:

- Fluvial geomorphologic requirements;
- Regulatory floodplain;
- Stable slope top of bank;
- Fish and fish habitat protection requirements;
- NOCSS Setback and buffer requirements.
- Hydrologic features "A".

The following sub-sections include the definition of each component of the Corridor Width Delineation. A summary table is incorporated at the end of Section 6.3, with total corridor width summarized at the end.

6.3.1 Fluvial Geomorphic Requirements

A historical evaluation of changes of channel alignment was conducted using air photos from 1934, 1960, 1969, 1988 and 2009 (**Figure 6.2**). It was determined that all watercourses within the study limit have been significantly altered, most likely to accommodate agricultural practices. The drainage channels have been repeatedly straightened, and a relatively short reach (Reach 14W-12) just upstream of Dundas Street remains in a natural condition.

Reach 14W-12 was observed to have a defined channel. This definition occurs immediately upstream of Dundas Street and evolves into a poorly defined swale at the upstream end of the reach. Channel disturbances consist of the Dundas Street crossing, concrete revetments and farm crossings. The primary geomorphic process influencing this reach is aggradation and widening. Fallen and leaning trees, exposed tree roots, poorly formed bars, siltation in pools and riffles and accretion on point bars were noted at the Subject Property.

Approximately 400 m of Reach 14W-16 enters the project site from the west side. Reach 14W-16 was observed to be a poorly defined swale, before its convergence with Reach 14W-12.

The remaining reaches on West Branch of Fourteen Mile Creek are poorly defined vegetated swales. The majority of the reaches show signs of straightening and agricultural influences. Therefore, the fluvial geomorphic analysis is not applicable to these reaches since they are not in a natural condition.

6.3.1.1 Meander Belt Width

Since the meander belt widths of the existing streams cannot be determined from the historical movement, they were calculated using the following two empirical methods:

- PARISH Geomorphic Ltd., 2004; and,
- Annable, 1996

6.3.1.2 100 Year Erosion Rate

According to the NOCSS (**Figures 6.3.15a** and **6.3.15b**), the 100 Year erosion rate or 10% of the meander belt width to each side of the belt width is applied as a factor of safety. The 100 Year erosion rate cannot be estimated using historic air photos as all water courses within study area have been altered to accommodate agricultural practices. Therefore, 10% of the meander belt width or 6 m, whichever is higher, is added to each side of meander belt width instead of 100 Year erosion rate.

6.3.2 Top of Bank Requirements

For the Subject Property, field staking was initially performed by MMM staff in 2009 according to professional experience based on similar watercourse forms. The staking was subsequently reviewed by Conservation Halton and Town of Oakville staff to arrive at a final position as shown in **Figure 6.3A**, along with the required setbacks.

Following comprehensive discussions with Conservation Halton and the Town of Oakville concerning the delineation of top of bank for 14W-11, the following findings are noted:

1. The EXP Slope Stability Report recommendations, including location of the stable slope line, erosion allowance offset, and long term stable top of bank, have been incorporated in **Figure 6.3A**;

2. The physical top of bank limits that were staked as part of the original fieldwork component for previous submissions of the EIR/FSS were plotted in **Figure 6.3A** with the EXP report recommendations; and

3. As all development limits have been established well beyond the slope areas recommended by the EXP report and protected by the relevant buffers as shown in **Figure 6.3A**, we feel the comments related to the EXP slope stability analysis have been adequately addressed.

Reach 14W-12 Figure for cross section south of the farm pond is included in **Figure 6.3B** and **Appendix 6.8**

6.3.3 Regulatory Floodplain Delineation Requirements

In accordance with NOCSS, a regulatory floodplain delineation is required for all high and medium constraint streams as identified in the Secondary Plan. The floodplain is to be delineated for the larger of the Regional Flood or the 100 year flood.

As noted in NOCSS and discussed with Conservation Halton, a Hazard Allowance of 7.5 m for minor stream , and Hazard Allowance of 15 m for major stream are applied to flood plain, meander belt, or top of bank, whichever is the greatest. In this study, floodplain mapping is shown via two sets of figures:

- As part of corridor width delineation for the interim and ultimate development phases: **Figures 6.5.1, 6.5.2, 6.5.3, and 6.5.4**
- As part of floodplain mapping for the interim and ultimate development phases: **Figures 6.6.1, 6.6.2, 6.6.3, and 6.6.4**

6.3.4 Fisheries Setback and NOCSS Setback Requirements

The determination of fisheries setbacks for the associated reaches within the Subject Property was undertaken to address the objectives listed above while adhering to the requirements associated with two documents, NOCSS and the Recovery Strategy for Redside Dace (*Clinostomus elongatus*) in Ontario (2010) in association with the ESA (2007) Ontario Regulation 242/08. Based on that consultation with Conservation Halton, the following was confirmed under the NOCSS Management Report, Section 6.3.4.2, Environmental/Fisheries.

- For Reach 14W-16, Reach 14W-12, Reach 14W-12A(hook)
    - NOCSS Management Report Section 6.3.4.2
        - For the Redside Dace streams, the buffer requirements of the draft Redside Dace Recovery Strategy (Dextrase et al., 2005) are recommended. This would result in buffer widths, for survival habitat, of 30m from top of bank for incised channels and 30m on either side of meander belt width if no defined valley is present."
    - Reach 14W-16, 14-12 and 14W-12A are considered Redside Dace Stream, thus the Fisheries Setback is 30m measured from the meander belt on either side.

- For Reach 14W-11A, Reach 14W-13, 14W-14, Reach 14W-21, Reach 14W-22 and Reach 14W-23
    - NOCSS Management Report Section 6.3.4.2
        "For non-Redside Dace streams, a minimum buffer width is recommended that would provide some level of protection for the stream. Review of the literature and of current practice in southern Ontario suggests that a minimum width of 15m would be appropriate and this width is recommended."
        - NOCSS states that the fisheries setback is measured as 15m on either side of the watercourse from the edge of the bankfull channel.
        - However, the location of the ultimate constructed channel including bankfull width of the study area has not been determined. Based on the consultation with Conservation Halton, the 15m fisheries setback should be measure from the meander belt allowance on the site-specific section plan and profiles.
    - Reach 14W-11A, 14W-13, 14W-14, 14W-21, 14W-22 and 14W-23 are considered Non-Redside Dace Stream, thus the Fisheries Setback is 15m measured from the meander belt on either side.

6.3.5 Hydrologic Feature 'A'

Hydrological features associated with the Natural Heritage System and located inside the high and medium constraint stream are identified as Hydrologic features "A". Hydrological features not associated with the Natural Heritage System are identified as Hydrologic features "B". There are three Hydrologic Features 'A' in the West Branch of Fourteen Mile Creek within the Subject Property; Reaches 14W-14, 14W-16 and 14W-14A, identified on **Figure 7.3.1 of NOCSS.** Additional Hydrologic Features 'A' also located along Reach 14W-16, 14W-14, 14W-14A and 14W-11A during field survey, as described in Section 5.2.1.5 and shown on **Figure 5.1**. Reach 14W-14 will be eliminated and replaced by a realigned channel, Reach 14W-22. Hydrologic Feature 'A' in this area will be replaced by online wetlands and floodplain ponds along the proposed diversion Reach 14W-22 as shown in **Figure 6.4.1**. Hydrologic Feature 'A' in Reach 14W-16 within the Subject Property will not be disturbed by the development. Therefore, the two Hydrologic Features 'A' will have various setbacks as discussed above. Hydrologic Feature 'A' in Reach 14W-14A associated with the human-made pond in this area functions as an off-line storage area during periods of high flow in the watercourse system, as flow enters the pond during high flows and retreats as the water levels in the watercourse system recede. Hydrologic features "B" and topographic depressions do not contribute to the definition of corridor widths.

Recommendations in terms of maintaining and sustaining Hydrologic Feature 'A' is addressed via the following:

- **Section 6.4**: Conceptual Natural Channel Design (refer to **Figures 6.4.1 to 6.4.4**)
- **Section 6.5**: Riparian Storage Analysis.

6.3.6 Total Corridor Widths

Table 6.2 presents key numbers used in the determination of total corridor width. Specifically:

- Meander Belt Width
- Meander Belt + Factor of Safety
    - Minimum 6m or 10% of Meander Belt on each side, whichever is greater.
- 3:1 Slope Line for Confined Channel
    - Minimum 6m setback on each side measured from Meander Belt + Factor of Safety.
- Regional Floodplain Width.
- 7.5m Hazard Allowance
    - For Constructed Confined Channel (Reach 14W-21 and 14W-22)
        - 7.5m setback on each side measured from the flood plain width or 3:1 Slope Line, whichever is the greatest.
    - For Natural Unconfined Channel and Constructed Unconfined Channel (Reach 14W-23)
        - 7.5m setback on each side measure from flood plain width or Meander Belt + Factor of Safety, whichever is the greatest
- Woodland Setback
- Fisheries Setback
    - Redside Dace Stream – 30m setback on each side measured from Meander Belt
    - Non Redside Dace Stream – 15m setback on each side measured from Meander Belt

As such, the outside limit of the widest setback will be referred to as the "Development Limit" within the EIF/FSS document.

Figures 6.4.1 to 6.4.4 depict these key setbacks and the development limit, in addition to the Regulatory Floodlines.

Table 6.2 – Total Corridor Width

Development Phasing	Reach	Meander Belt Width (m)	Meander Belt + Factor of Safety Width (m)	3:1 Slope Line Width (m)	Hazard Allowance Width (m)	Fisheries Setback Width (m)	Total Corridor Width (m)
Interim P1A	14W-12	60	72	n/a	87	120	120
Interim P1B	14W-12	59	71	n/a	86	119	119
	14W-12A	18	30	n/a	45	78	78
	14W-16	44	56	n/a	71	104	104
	14W-21	6	18	30	45	36	45
	14W-22	39	51	63	78	69	78
Interim P2	14W-11	23	35	n/a	50	53	53
	14W-12	66	79.2	n/a	94.2	126	126
	14W-12A	14	26	n/a	41	74	74
	14W-16	44	56	n/a	71	104	104
	14W-21	6	18	30	45	36	45
	14W-22	39	51	63	78	69	78
	14W-23	19	31	n/a	46	49	49
Ultimate	14W-11	23	35	n/a	50	53	53
	14W-12	71	85.2	n/a	100.2	131	131
	14W-12A	14	26	n/a	41	74	74
	14W-16	47	59	n/a	74	107	107
	14W-21	6	18	30	45	36	45
	14W-22	39	51	63	78	69	78
	14W-23	19	31	n/a	46	49	49

6.4 Conceptual Natural Channel Design

Stream rehabilitation opportunities have been identified in the Management Strategy of the NOCSS, which recommends that:

- High Constraint Streams (e.g., Reaches 14W-12, 14W-12A and 14W-16) must be protected in their locations. The only modifications permitted would be through local enhancement or rehabilitation works. No channel modifications are proposed in these reaches.
- High Constraint Streams with Rehabilitation must be maintained in their current location but provide enhancement opportunity to provide for effective protection and their functional role.
- Medium Constraint Streams can be either relocated or deepened to improve the overall resiliency of the stream network and subwatershed.
- Low Constraint Streams can be replaced through infrastructure or SWM facilities.

A medium constraint stream (Reach 14W-14) and a low constraint stream (Reach 14W-13) of the West Branch of Fourteen Mile Creek within the development area are proposed to be combined and realigned. New channels are therefore needed to intercept the flows from Reaches 14W-13 and 14W-14 just downstream of the transit corridor and to divert via 14W-21 and 14-W-23 to Reach 14W-12A, approximately 20 m from the confluence with Reach 14W-16. Another medium constraint stream (**Figure 6.1**), Reach 14W-11A, will be realigned along the transit corridor and northeast limits of the property limits (Reach 14W-23).

6.4.1 Design Criteria

The design criteria for the natural channel design of diversions Reaches 14W-21, 14W-22 and 14W-23 are summarized as follows:

- Provide bankfull channel dimensions based on stream morphology;
- Convey the larger of 100-Year and Regional Storm floods with a minimum freeboard of 0.3 m;
- Keep the maximum channel velocity less than 1.7 m/s for the bankfull condition and 2.0 m/s for storms up to a 100-Year flood, to enable the use of vegetation for channel protection;
- Provide adequate hydraulic capacity through road crossings;
- Enable the passage of fish up to the culvert at Highway 407; and
- A riffle/pool meandering sequence along the flatter channel reaches.

6.4.2 Proposed Channel Morphology

The natural channel design method aims at creating a functional, self-sustaining stream system that provides valuable hydraulic, geomorphic and ecological functions. Streams restored or designed based on the natural channel design principles relies on the fluvial geomorphic characteristics of the river system, which in turn is dependent on the relationships between the disciplines of geology, hydrology and hydraulics. In this study, the concept of natural channel design was used for determining the proposed channel morphology.

For consistency between morphological design, hydrologic analysis, and hydraulic modelling, bankfull flows were estimated based on the 2-year return period.

It should be noted that for the purpose of hydraulic modelling, the channel design parameters, including bankfull depth, width, and riffle length and slope were applied as much as possible, as appropriate to the level and scale of this study. It is understood that the Detailed Design stage will provide input and analysis that is more specific and concise.

6.4.2.1 Reach 14W-16

No alterations will be made to the channel Reach 14W-16, except at the confluence point with the realigned Reach 14W-22

6.4.2.2 Reach 14W-22 Diversion (Realignment of Reaches 14W-13 and 14W-14)

The proposed morphology of the Reach 14W-22 diversion is a meandering watercourse with riffle/pool sequence. The proposed cross-section is that of a moderately entrenched stream with an entrenchment ratio less than 2.2. The bankfull discharge of 0.79 m^3/s was estimated based on a 2 year return period flow. The proposed Reach 14W-22 connects to an existing Reach 14W-12A. Hence, the longitudinal slope of the proposed Reach 14W-22 is restricted by the upstream and downstream inverts of the existing channel (**Appendix 6.7** shows water surface profiles for the tie in). As part of the Detailed Design stage, this will be addressed.

A bankfull width of 1.5 m with a bankfull depth of 0.35 m was selected to provide a bankfull velocity less than 1.7 m/s (to permit vegetative erosion protection of the channel embankments) and a bankfull width to depth ratio greater than 10. The proposed alignment and plan form of Reach 14W-22 is shown in **Figures 6.4.1**, **6.4.2 and 6.4.3**. Typical riffle/pool cross sections for the Reach 14W-22 channel are provided in **Figure 6.4.5**.

The proposed riffle slope is approximately twice the average slope of the reach, and the pool depth at low flow is equal to bankfull riffle depth, with twice the bankfull riffle depth at bankfull discharge. The morphological parameters for diversion Reach 14W-22 are presented in **Table 6.3**.

6.4.2.3 Reach 14W-21 Diversion

The proposed morphology of the Reach 14W-21 diversion is a relatively straight watercourse. Estimated bankfull discharge is 0.04 m^3/s which corresponds to the 2 year return period flow. A bankfull width of 0.8 m with a bankfull depth of 0.20 m was selected. These dimensions will provide bankfull discharge greater than 0.04 m^3/s and were selected to accommodate construction. The morphological parameters for diversion Reach 14W-21 are presented in **Table 6.3**. The proposed alignment and plan form of Reach 14W-21 is shown in **Figures 6.4.1 and 6.4.2**.

6.4.2.4 Reach 14W-23 (Realignment of Reach 14W-11A)

The proposed morphology of the Reach 14W-11A realignment is a relatively straight watercourse with a meandering section. Estimated bankfull discharge based on the 2-year return period is 0.42 m^3/s.

A bankfull width of 0.5 m and a bankfull depth of 0.30 m was selected to provide a bankfull velocity less than 1.7 m/s (to permit vegetative erosion protection). Typical riffle/pool cross sections for the Reach 14W-23 channel are provided in **Figure 6.4.5**.

The proposed riffle slope is approximately twice the average slope of the reach, and the pool depth at low flow is equal to the bankfull riffle depth and twice the bankfull riffle depth at bankfull discharge. The morphological parameters for diversion Reach 14W-23 are presented in **Table 6.3**. The proposed alignment and plan form of Reach 14W-23 is shown in **Figures 6.4.1 and 6.4.4**.

Table 6.3 – Morphological Parameters for Proposed Channel Diversion and Rehabilitation

	14W-22	14W-21	14W-23
Drainage area	141.99 ha	11.6 ha	49.75 ha
Flow Node	2B	8	9
Bankfull Discharge (2-year flow)	0.79 m^3/s	0.04 m^3/s	0.42 m^3/s
Bankfull Width	1.5 m	0.8 m	0.5 m
Bankfull Depth	0.34 m	0.20 m	0.3 m
Bankfull Width/Depth (Average)	4	4	2
Average Channel Slope	0.46%	0.62%	0.38%
Riffle Slope	0.94%	0.64%	0.92%
Meander Length	35 m	-	18m
Meander Belt Width	39 m	6 m	19 m
Riffle Length	9 m	6 m	6 m
Sinuosity	1.2	1.0	1.1
Entrenchment	1.4 – 2.2	1.4 - 2.2	1.4 – 2.2

6.4.3 Road Crossings

From a functional perspective, a key requirement for the design of the crossings is to protect the existing stream conditions, and minimise any impact on fish passage and fish habitat.

In terms of hydraulic design however, the primary consideration was to satisfy the requirements of the Ministry of Transportation (MTO) Drainage Design Standards (2008) – in particular, the design flows and freeboard/clearance requirements set out in sections WC-1 and WC-2. The requirements of these two sections are summarised below in **Table 6.4**. The hydraulic modelling results were checked against these criteria, and the final sizing of the crossings was completed in an iterative fashion to verify compliance.

Table 6.4 – Summary of MTO Drainage Design Criteria

Crossing Name	Road Classification	Return Period of Design Flows (years)[1]		Minimum Freeboard (m)[2]	Minimum Clearance (m)[3]
		Span 6.0 m or less	Span greater than 6.0 m		
14W-16A / Burnhamthorpe	Minor Arterial	50	100	1.0	1.0
14W-16 / Avenue One	Collector	25	50	1.0	1.0
14W-22 / Avenue One	Collector	25	50	1.0	1.0

[1] From MTO Drainage Design Standards, section WC-1, clause 1.1.
[2] From MTO Drainage Design Standards, section WC-2, clause 3.2.1.
[3] From MTO Drainage Design Standards, section WC-2, clause 3.2.2.

It should be noted that freeboard is measured vertically from the high water level for the design event, to the edge of the travelled lane. Clearance is measured vertically from the high water level for the design event to the lowest point of the soffit (considered to be the central point of the arch for these structures).

Another important consideration in the design of the crossings was their impact on the Regulatory flood lines. The proposed development limits, and layout of the lots was based, in part, on the Regional flood lines mapped as part of the previous Regional Floodplain Analysis exercise. Significant changes to these lines were therefore not desirable. It should be noted that through compliance with the MTO minimum freeboard/clearance criteria, sufficient flow capacity is typically provided to ensure that changes to floodline elevations in the immediate vicinity of the proposed structures are not significant.

6.5 Hydraulic Analysis

The proposed development area contains the headwater tributaries of the West Branch of Fourteen Mile Creek which generally flows from west to east. As shown in **Figure 6.1**, the creeks within the subject property boundary are identified as 14W-16, 14W-14, 14W-13 and 14W-11A from west to east; the creek section at the downstream of the confluence of 14W-16, 14W-14 and 14W-13 is called 14W-12. Except the creek reach 14W-13 is a low constraint stream, the others are medium constraint streams.

In accordance with North Oakville Creek Watershed Study (NOCSS), a regulatory floodplain delineation is required for all high and medium constraint streams as identified in the Secondary Plan. The floodplain is to be delineated for the larger of the Regional Flood or the 100 year flood. The hydrologic analysis revealed that the Regional Flood is the larger one (see Section 7.0). Therefore, the floodplain limits were delineated based on the surface water elevations of Regional Flood (i.e. Hurricane Hazel).

6.5.1 Previous Studies

The regulatory floodplain was delineated for Fourteen Mile Creek by Philips Planning and Engineering, in a study titled “Flood Damage Reduction Study on the Fourteen Mile Creek, 1984” and by Triton Engineering Services Ltd. (1992) in a study titled “Fourteen Mile Creek – McCraney Creek Watershed Planning Study”. The HEC-2 model along with Flood Risk Map (Fourteen Mile Creek and McCraney Creek Watershed Study) were obtained from Conservation Halton (CH). The reaches of the Fourteen Mile Creek in the model, which are relevant to the subject site, extended north up to Dundas Street and south to Lake Ontario.

More recently, floodline mapping for Fourteen Mile Creek was completed for the North Oakville Creek Watershed Study (NOCSS) in 2006 and updated in 2007. The HEC-RAS model only extended up to approximately 70 m downstream of Dundas Street.

WSP (former MMM Group Limited) combined the two models (HEC-RAS model prepared for NOCSS and the HEC-RAS model converted from the HEC-2 format), while making necessary updates of the cross-sections with up-to-date survey data.

6.5.2 Existing Conditions

The combined HEC-RAS model was used to investigate the current floodplain limits.

The floodplain map (Sheet "upper_14m_mc15" of 1992 Fourteen Mile Creek and McCraney Creek Watershed Study) was overlaid on the subject area and shown in **Figure 6.1**. It shows the identifications of creeks used in the EIR/FSSR and in HEC-RAS model. The original cross section 165 of HEC-2 model was removed and replaced with cross sections 171 & 169 to represent the Colonel William Parkway Crossing. **Table 6.5** provides brief information of the combined HEC-RAS model. As per the identification of river/reach of the HEC-2 model, the majority of the subject site is tributary to River 2 Reach 1; and the remaining area drains to River 1 Reach 1; River 2 Reach 1 joins River 1 Reach 1 at junction "A" (the combined HEC-RAS model) to become River 1 Reach 2. The confluence of the two creeks is location at north of Richview Blvd and west of Bronte Road.

Table 6.5 Information of Combined HEC-RAS Model

River	Reach	Tributary (EIS/FSS Report)	Cross Sections	Note
2	2A	14W-14	XS 3081-221	Combined HEC-RAS model
2	2B	14W-12A	XS240-231	Combined HEC-RAS model
Confluence – Junction "1-4"				Combined HEC-RAS model
2	2C	14W-12A	XS 220.3-220	Combined HEC-RAS model
2	1A	14W-16	XS 210.5-206.1	Combined HEC-RAS model
Confluence - Junction "1-3"				Combined HEC-RAS model
2	1	14W-12	XS 205-169	Combined HEC-RAS model included three existing crossings
2	1		XS 164-160	CH HEC-2 model; XS 165 was removed to represent the current Colonel William Pkwy Crossing
1	1		XS 79-75	CH HEC-2 model
Confluence - Junction "A"				CH HEC-2 model
1	2		XS 74-60	CH HEC-2 model

A new independent HEC-RAS model was developed for the creek 14W-11A/14W-11, which were identified as River 1 Reach 1B. The cross sections were extended from south of Highway 407 to east side of Zenon Drive. The model results were used for the floodplain of creek 14W-11A/14W-11. In addition to this, cross-sections within site area were modified to represent bankfull channel locations based on available topographic information. Additional cross-sections (XS 232-240) on the existing farm pond were included on Reach 14W-12A. As a conservative modelling practice, a permanent pool volume of an existing farm pond is excluded from hydraulic analysis and as summarized below, a higher flow rate of 8.23 m3/s is applied (From Node 2).

6.5.3 Flow Rates

A hydrologic analysis (details included in Section 7.0) was carried out to investigate the flow rates of Regional Flood at various locations under the existing conditions. The flow nodes are shown in **Figures 7.4.2 to 7.4.5** under Section 7. The flow rates used in the updated CH model and the new HEC-RAS model were tabulated in **Table 6.6**.

Table 6.6 Regional Flow Rates used in the Existing Condition Models

Updated CH Model			EIS/FSSR Identifications	Flow Node in Hydrologic Analysis	Regional Flow Rate (m3/s)	Source of Flow Data
River	Reach	XS				
River-2	Reach 2A	3081	14W-14	2	8.23	WSP hydrology analysis
River-2	Reach 2B	240	14W-12A	2	8.23	
River-2	Reach 2C	220.3	14W-12A	2	8.23	
River-2	Reach 1A	210.5	14W-16	1B	8.22	
River-2	Reach 1A	206.3		1	10.29	
River-2	Reach 1	205.1	14W-12	3/3B	19.22	
River-2	Reach 1	203		4	20.34	
River-2	Reach 1	171	South of Dundas Street		28.9	CH hydraulic model
River-1	Reach 1	79			22.9	CH hydraulic model
River-1	Reach 2	74			64.8	
New HEC-RAS Model						
River-1	Reach 1B	14	14W-11A	9	3.06	WSP hydrology analysis
River-1	Reach 1B	10	14W-11	5	3.79	

6.5.4 Existing Crossings and Parameters

A detailed topographic survey of the Bentall lands was undertaken by the WSP Geomatics in January 2012. The DEM provided by the survey data was used to generate an existing ground surface in Civil 3D software. Coordinates for the HEC-RAS cross sections were then defined by cutting sections through the ground surface at the appropriate locations. The locations of these cross-sections are displayed on **Figures 6.6.1**. The bankfull locations for each cross-section based on the topographic survey information. Three crossings over creek 14W-12 and one crossing over creek 14-11 were incorporated in the model. The culverts' information was obtained from the survey. The crossing data are shown in **Table 6.7.**

Table 6.7 Information of the Existing Crossings

HEC-RAS Model			EIS/FSSR	Location	Dimension		Type
Crossing ID	River	Reach			Rise (m)	Span (m)	
XS 204.6	2	1	14W-12	Farm access road	1.5	3.6	Conc. Box Culvert
XS 202.5	2	1	14W-12	Dundas Street West	2.5	3.85	Conc. Box Culvert
XS 170	2	1	South of Dundas	Colonel Willian Parkway	3.8	42	Bridge
XS 8.5	1	1B	14W-11/11A	Zenon Drive	0.91 diameter		CPS Pipe

In the model, the values for the expansion and contraction coefficients adopted for expansion and contraction coefficients were 0.3 and 0.1, respectively. The expansion coefficient of 0.5 and contraction coefficient of 0.3 were used in the cross sections at the upstream and downstream of roadway crossings.

Proper calibration of the HEC-RAS model is highly dependent upon the accurate estimation of values for Manning's Roughness Coefficient. No measured water levels were available for model calibration. Based on the Table 3-1 Manning's n Value included in the HEC-RAS Hydraulic Reference Manual, n=0.1 were selected to represent medium to dense bushes at the creek floodplain within the subject site. The roughness values of 0.03 for channel was adopted in the HEC-RAS model.

The flow rates of design floods (2-year up to 100-year) and Regional Flood were obtained from the hydrologic analysis (see Section 7). Simulation of the full range of design floods were conducted with the HEC-RAS model for creeks 14W-16, 14W-14&14W-12 and the HEC-RAS model for creek 14W-11/11A. The Regional Flood water levels resulted from the model are summarized in **Table 6.8**. They were used for floodplain delineation. The floodplain limit is shown in **Figure 6.6.1**.

Table 6.8 Regional Flood Water Levels under the Existing Conditions

River	Reach	Cross Section ID	EIS/FSSR Identifications	Existing Regional Water Surface Elevation (m)
River-2	Reach 2A	3081	14W-14	154.76
River-2	Reach 2A	228	14W-14	154.32
River-2	Reach 2A	227	14W-14	153.42
River-2	Reach 2A	226	14W-14	152.87
River-2	Reach 2A	225	14W-14	152.32
River-2	Reach 2A	224	14W-14	151.8
River-2	Reach 2A	223	14W-14	150.96
River-2	Reach 2A	222	14W-14	150.43
River-2	Reach 2A	221	14W-14	149.72
River-2	Reach 2B	240	14W-12A	149.91
River-2	Reach 2B	239	14W-12A	149.85

River	Reach	Cross Section ID	EIS/FSSR Identifications	Existing Regional Water Surface Elevation (m)
River-2	Reach 2B	238	14W-12A	149.84
River-2	Reach 2B	237	14W-12A	149.84
River-2	Reach 2B	236	14W-12A	149.83
River-2	Reach 2B	235	14W-12A	149.81
River-2	Reach 2B	234	14W-12A	149.8
River-2	Reach 2B	233	14W-12A	149.79
River-2	Reach 2B	232	14W-12A	149.77
River-2	Reach 2B	231	14W-12A	149.75
River-2	Reach 2C	220.3	14W-12A	149.75
River-2	Reach 2C	220.2	14W-12A	149.59
River-2	Reach 2C	220.1	14W-12A	149.47
River-2	Reach 2C	220	14W-12A	149.47
River-2	Reach 1A	210.5	14W-16	155.74
River-2	Reach 1A	210	14W-16	155.47
River-2	Reach 1A	209	14W-16	154.89
River-2	Reach 1A	208.3	14W-16	153.57
River-2	Reach 1A	208.2	14W-16	153.2
River-2	Reach 1A	208.1	14W-16	153.09
River-2	Reach 1A	208	14W-16	152.5
River-2	Reach 1A	207	14W-16	151.13
River-2	Reach 1A	206.3	14W-16	150.59
River-2	Reach 1A	206.2	14W-16	150.48
River-2	Reach 1A	206.1	14W-16	149.97
River-2	Reach 1	205.1	14W-12	149.36
River-2	Reach 1	205	14W-12	148.85
River-2	Reach 1	204.75	14W-12	148.38
River-2	Reach 1	204.7	14W-12	148.33
River-2	Reach 1	204.55	14W-12	146.96
River-2	Reach 1	204.5	14W-12	146.81
River-2	Reach 1	204.25	14W-12	146.44
River-2	Reach 1	204	14W-12	145.14
River-2	Reach 1	203	14W-12	145.05
River-2	Reach 1	202.75	14W-12	144.67
River-2	Reach 1	202.25	14W-12	143.69
River-2	Reach 1	202	14W-12	143.33
River-2	Reach 1	201	14W-12	143.27
River-2	Reach 1	171	14W-12	142.97
River-2	Reach 1	169	14W-12	142.7
River-2	Reach 1	164	14W-12	139.25
River-2	Reach 1	163	14W-12	138.47
River-2	Reach 1	162	14W-12	136.76
River-2	Reach 1	161	14W-12	135.3
River-2	Reach 1	160	14W-12	134.02

River	Reach	Cross Section ID	EIS/FSSR Identifications	Existing Regional Water Surface Elevation (m)
River-1	Reach 1B	14	14W-11A	155.34
River-1	Reach 1B	13	14W-11A	155.27
River-1	Reach 1B	12.1	14W-11A	154.71
River-1	Reach 1B	12	14W-11A	154.25
River-1	Reach 1B	11.1	14W-11	153.1
River-1	Reach 1B	11	14W-11	152.76
River-1	Reach 1B	10	14W-11	152.76
River-1	Reach 1B	9	14W-11	152.74
River-1	Reach 1B	8	14W-11	150.51
River-1	Reach 1B	7	14W-11	147.97

6.5.6 Proposed Conditions

The floodplain limits under the post-development conditions are required to restrict development into the regulatory areas. Although the development plan will provide Regional Flood control (i.e. post-development flow will be less than the existing flow level), the uncontrolled regional flood flows were used to delineate floodplain mapping in accordance with the Ministry of Natural Resources and Forest guidelines. However, controlled flow rates were used for conveyance analysis. Therefore, tabulated results will provide summary for both uncontrolled and controlled flow scenarios to ensure that the proposed development will not result in additional impacts.

The site development was phased into Phase 1A, Phase 1B, Phase 2 and Ultimate Condition. Each development phase has different development components till the ultimate conditions. Hence, the existing conditions HEC-RAS models were revised accordingly to reflect the proposed development impacts. The scenarios of the HEC-RAS models representing proposed conditions included the individual development phase. Comparing to the model base (i.e. the existing condition), the revisions of HEC-RAS model in each scenario were tabulated in **Table 6.9**. The following alterations were incorporated in the model scenarios:

- Channel Realignment

It was proposed that the upstream section of low constraint creek 14W-13 will be realigned to join creek 14W-14 south of the site boundary; this new channel section was named as 14W-21. The alignment of the existing 14W-14 will be close to the west boundary of the site, therefore the realigned creek was identified as 14W-22. The proposed channel 14W-23 will replace creek 14W-11A to join 14W-11.

- New Crossings

The development plan proposes two new roads, Burnhamthorpe Road Extension and Avenue One from south to north, to overpass creeks 14W-16 and the new realigned creek 14W-22. Four crossings will be constructed. The preliminary size of the new crossings was proposed based on following factors:

- MTO hydraulic design criteria

- CH requirements: all new roads must be designed to provide full access and egress under Regional Storm conditions, and preferably flood free access. In addition, no backwater effects at the river sections; the span of a crossing to be at least 3 times of bankfull width were considered in the crossing sizing.

- Flow Rates

The stormwater management plan was developed to mitigate development impacts. The post-development flows will be restricted to the existing flow levels for 2-year up to a Regional Flood. As discussed previously, flow controls were not considered in the floodplain delineation. In other words, the uncontrolled Regional flood rates (i.e. without flow attenuations in SWM ponds) were used in the HEC-RAS models to obtain water levels for floodplain mapping.

- Geometric Data and Parameters

New cross sections to represent the new aligned creeks were added in the model; the geometric data were obtained from the channel design and the existing topography or the proposed grading plan where applicable. A two tiers cross section was proposed. The expansion/contraction coefficients and Manning's n values are consistent with the HEC-RAS models of existing conditions.

Table 6.9 Model Scenarios of the HEC-RAS Model of Proposed Conditions

Scenario (Development Phase)	River	Reach	EIS/FSSR ID	Revisions in the Base Model				
				Flow Rates	Realignment	Geometric Data of Cross Section	Confluence Move	Crossing
1A	River-2	Reach 1A	14W-16			X		
	River -2	Reach 2A	14W-14					
	River -2	Reach 2B	14W-12A					
	River -2	Reach 1A	14W-12	X		X		Remove local roadway crossing
	River -1	Reach 1B	14W-11A					
1B	River-2	Reach 1A	14W-16	X		X		Add in Burnhamthorpe Road Crossing
	River -2	Reach 2A	14W-22, 14W-21	X	X	X		Add in Burnhamthorpe Road Crossing
	River -2	Reach 2B	14W-12A				X	
	River -2	Reach 1A	14W-12	X		X		
	River -1	Reach 1B	14W-11A					
2	River-2	Reach 1A	14W-16	X		X		Add in Avenue One Crossing
	River -2	Reach 2A	14W-22, 14W-21	X	X	X		Add in Avenue One Crossing
	River -2	Reach 2B	14W-12A				X	
	River -2	Reach 1A	14W-12	X		X		
	River -1	Reach 1B	14W-23	X	X	X		
Ultimate	River-2	Reach 1A	14W-16	X		X		All new crossings
	River -2	Reach 2A	14W-22, 14W-21	X	X	X		All new crossings
	River -2	Reach 2B	14W-12A				X	
	River -2	Reach 1A	14W-12	X		X		
	River -1	Reach 1B	14W-23	X	X	X		

Phase 1A

Based on the existing conditions, the following revisions were carried out to represent the grading plan of Phase 1A. The revisions include:

- Revision of the right bank of cross sections 204 to 205 of creek 14W-12; and cross-section 206.1 to 206.3 of creek 14W-16 base on the grading plan at this phase
- Removal of the existing Farm Access road crossing (Crossing 204.6 of HEC-RAS model)
- The flow rates were revised based on the hydrologic modelling results of this development phase

The comparison of flow rates between the existing and Phase 1A (uncontrolled & controlled) is shown in **Table 6.10**. The HEC-RAS model of creek 14W-11/11A remained unchanged; and flood elevations are consistent with the existing conditions.

Table 6.10 Flow Rates of Phase 1A

Creek ID in HEC-RAS	Creek ID in EIS/FSSR	Existing			Phase 1A			
		Flow Node	XS	Regional Flow Rate (m3/s)	Flow Node	XS	Regional Flow Rate (m3/s)	
							Uncontrolled Flow	Controlled Flow
River2, Reach2A	14W-14	2	3081	8.23	2	228	8.23	8.23
River2, Reach2B	14W-12A	2	240	8.23	2	231.1	8.23	8.23
River2, Reach2C	14W-12A	2	220.3	8.23	2	220.3	8.23	8.23
River2, Reach1A	14W-16	1B	210.5	8.22	1B	210.5	8.22	8.22
		1	206.3	10.29	1	206.3	10.21	10.21
River2, Reach 1	14W-12	3/3B	205.1	19.22	3B	205.1	18.7	18.7
					3	204	20.47	18.99
		4	203	20.34	4	203	20.61	19.14
			171	28.9		171	28.9	28.9
River1, Reach1	14W-11	9	14	3.06	9	14	3.06	3.06
		5	10	3.79	5	10	3.79	3.79

The modelling results in comparison to the existing conditions are included in **Table 6.11.** Floodplain limits are shown in **Figures 6.6.2**. This development phase will have negligible alterations of flood elevations.

Table 6.11 Phase 1A- Regional Flood Elevations of 14W-16, 14W21/22, 14W-12, and 14W-12A

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 1A	difference	Phase 1A	difference
River-2	Reach 2A	3081	14W-14	154.76	154.76	0	154.76	0
River-2	Reach 2A	228	14W-14	154.32	154.32	0	154.32	0
River-2	Reach 2A	227	14W-14	153.42	153.42	0	153.42	0
River-2	Reach 2A	226	14W-14	152.87	152.87	0	152.87	0
River-2	Reach 2A	225	14W-14	152.32	152.32	0	152.32	0
River-2	Reach 2A	224	14W-14	151.8	151.8	0	151.8	0
River-2	Reach 2A	223	14W-14	150.96	150.96	0	150.96	0
River-2	Reach 2A	222	14W-14	150.43	150.43	0	150.43	0
River-2	Reach 2A	221	14W-14	149.72	149.72	0	149.72	0
River-2	Reach 2B	240	14W-12A	149.91				
River-2	Reach 2B	239	14W-12A	149.85				
River-2	Reach 2B	238	14W-12A	149.84				
River-2	Reach 2B	237	14W-12A	149.84				
River-2	Reach 2B	236	14W-12A	149.83				
River-2	Reach 2B	235	14W-12A	149.81				
River-2	Reach 2B	234	14W-12A	149.8				
River-2	Reach 2B	233	14W-12A	149.79				
River-2	Reach 2B	232	14W-12A	149.77				
River-2	Reach 2B	231.1	14W-12A		149.75		149.75	
River-2	Reach 2B	231	14W-12A	149.75	149.75	0	149.75	0
River-2	Reach 2C	220.3	14W-12A	149.75	149.75	0	149.75	0
River-2	Reach 2C	220.2	14W-12A	149.59	149.59	0	149.59	0
River-2	Reach 2C	220.1	14W-12A	149.47	149.46	-0.01	149.46	-0.01
River-2	Reach 2C	220	14W-12A	149.47	149.46	-0.01	149.46	-0.01
River-2	Reach 1A	210.5	14W-16	155.74	155.74	0	155.74	0
River-2	Reach 1A	210	14W-16	155.47	155.47	0	155.47	0
River-2	Reach 1A	209	14W-16	154.89	154.89	0	154.89	0
River-2	Reach 1A	208.3	14W-16	153.57	153.57	0	153.57	0
River-2	Reach 1A	208.2	14W-16	153.2	153.2	0	153.2	0
River-2	Reach 1A	208.1	14W-16	153.09	153.09	0	153.09	0
River-2	Reach 1A	208	14W-16	152.5	152.5	0	152.5	0
River-2	Reach 1A	207	14W-16	151.13	151.13	0	151.13	0
River-2	Reach 1A	206.3	14W-16	150.59	150.59	0	150.59	0

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 1A	difference	Phase 1A	difference
River-2	Reach 1A	206.2	14W-16	150.48	150.48	0	150.48	0
River-2	Reach 1A	206.1	14W-16	149.97	149.96	-0.01	149.96	-0.01
River-2	Reach 1	205.1	14W-12	149.36	149.34	-0.02	149.34	-0.02
River-2	Reach 1	205	14W-12	148.85	148.81	-0.04	148.81	-0.04
River-2	Reach 1	204.75	14W-12	148.38	147.84	-0.54	147.84	-0.54
River-2	Reach 1	204.7	14W-12	148.33	147	-1.33	147	-1.33
River-2	Reach 1	204.55	14W-12	146.96	146.94	-0.02	146.94	-0.02
River-2	Reach 1	204.5	14W-12	146.81	146.8	-0.01	146.8	-0.01
River-2	Reach 1	204.25	14W-12	146.44	146.43	-0.01	146.43	-0.01
River-2	Reach 1	204	14W-12	145.14	145.16	0.02	145.05	-0.09
River-2	Reach 1	203	14W-12	145.05	145.07	0.02	144.95	-0.1
River-2	Reach 1	202.75	14W-12	144.67	144.69	0.02	144.58	-0.09
River-2	Reach 1	202.25	14W-12	143.69	143.71	0.02	143.64	-0.05
River-2	Reach 1	202	14W-12	143.33	143.33	0	143.32	-0.01
River-2	Reach 1	201	14W-12	143.27	143.27	0	143.27	0
River-2	Reach 1	171	14W-12	142.97	142.97	0	142.97	0
River-2	Reach 1	169	14W-12	142.7	142.7	0	142.7	0
River-2	Reach 1	164	14W-12	139.25	139.25	0	139.25	0
River-2	Reach 1	163	14W-12	138.47	138.47	0	138.47	0
River-2	Reach 1	162	14W-12	136.76	136.76	0	136.76	0
River-2	Reach 1	161	14W-12	135.3	135.3	0	135.3	0
River-2	Reach 1	160	14W-12	134.02	134.02	0	134.02	0

Phase 1B

Based on the model of Phase 1A, the following revisions were incorporated in the model to represent Phase 1B development:

- Additional cross sections to reflect channel realignments for creeks 14W-21 and 14W-22. The geometric data of these cross sections were obtained from the channel design and the existing topography or the proposed grading plan where applicable,
- A two-tier cross section with low flow channel of 1.5 m width and 0.3 m depth to maximize low flow conditions within channel,
- To meet sinuosity requirement of 1.2 for reach 14W-22, channel length increment from 770 m to 924 m (between XS 296 to XS 305) to sequence riffle/pool meandering sequence,
- Addition of new Burnhamthorpe Road Crossings (as proposed in **Table 6.12**) over 14W-22 and 14W-16

Table 6.12 New Burnhamthorpe Road Crossings

Crossing ID	River	Reach	EIS/FSSR	Location	Rise (m)	Span (m)	Bankfull Width (m)
XS 206.15	2	1A	14W-16	Burnhamthorpe Rd Extension	2.5	18	5.15
XS 296.5	2	2A	14W-22	Burnhamthorpe Rd Extension	2.5	12.25	1.5

Table 6.13 Flow Rates of Phase 1B

Creek ID in HEC-RAS	Existing				Phase 1B				
	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	
								Uncontrolled Flow	Controlled Flow
River2, Reach2A	14W-14	2	3081	8.23	14W-21/ 14W-22	2B	3081/ 309	6.68	6.68
River2, Reach2B	14W-12A	2	240	8.23	14W-12A	2	231.1	1.03	0.86
River2, Reach2C	14W-12A	2	220.3	8.23	14W-12A	2A	220.1	7.38	7.29
River2, Reach1A	14W-16	1B	210.5	8.22	14W-16	1B	210.5	8.11	8.11
		1	206.3	10.29		1	206.3	10.06	10.06
River2, Reach 1	14W-12	3/3B	205.1	19.22	14W-12	3B	205.1	18.51	18.06
						3	204	20.32	18.35
		4	203	20.34		4	203	20.46	18.50
			171	28.9			171	28.90	28.90
River1, Reach1	14W-11	9	14	3.06	14W-11	9	14	3.06	3.06
		5	10	3.79		5	10	3.79	3.79

The HEC-RAS model of creek 14W-11/11A remained unchanged; and flood elevations are consistent with the existing conditions.

The Regional Flood elevations of creeks 14W-21&22, 14W-16, 14W-12 obtained from the revised HEC-RAS model are included in **Table 6.14**. Floodplain limits are shown in **Figure 6.6.3.** Comparing to the existing conditions, the new Burnhamthorpe Road Extension crossing proposed over creek 14W-16 did not cause any increase of water level at the upstream of the crossing under the controlled flow condition. The floodplain limits should be considered in the development limits. It was confirmed that the proposed new crossings can meet the design criteria. The roadway will not be overtopped during the Regional Flood.

Table 6.14 Phase 1B - Regional Flood Elevations of 14W-16, 14W21/22, 14W-12, and 14W-12A

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 1B	difference	Phase 1B	difference
River-2	Reach 2A2	309	14W-21		154.85		154.85	
River-2	Reach 2A2	308	14W-21		154.49		154.49	
River-2	Reach 2A2	307	14W-21		154.04		154.04	
River-2	Reach 2A2	306	14W-21		153.39		153.39	
River-2	Reach 2A1	3081	14W-22		154.72		154.72	
River-2	Reach 2A1	3071	14W-22		154.2		154.2	
River-2	Reach 2A1	3061	14W-22		153.61		153.61	
River-2	Reach 2A	305	14W-22		153.01		153.01	
River-2	Reach 2A	304	14W-22		152.51		152.51	
River-2	Reach 2A	303	14W-22		152.35		152.35	
River-2	Reach 2A	302	14W-22		152.18		152.18	
River-2	Reach 2A	301	14W-22		151.68		151.68	
River-2	Reach 2A	300	14W-22		151.27		151.27	
River-2	Reach 2A	299	14W-22		150.96		150.96	
River-2	Reach 2A	298	14W-22		150.67		150.67	
River-2	Reach 2A	297	14W-22		150.35		150.35	
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 2A	296	14W-22		150.15		150.15	
River-2	Reach2A	3081	14W-14	154.76				
River-2	Reach 2A	228	14W-14	154.32				
River-2	Reach 2A	227	14W-14	153.42				
River-2	Reach 2A	226	14W-14	152.87				
River-2	Reach 2A	225	14W-14	152.32				
River-2	Reach 2A	224	14W-14	151.8				
River-2	Reach 2A	223	14W-14	150.96				

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 1B	difference	Phase 1B	difference
River-2	Reach 2A	222	14W-14	150.43				
River-2	Reach 2A	221	14W-14	149.72				
River-2	Reach 2B	240	14W-12A	149.91				
River-2	Reach 2B	239	14W-12A	149.85				
River-2	Reach 2B	238	14W-12A	149.84				
River-2	Reach 2B	237	14W-12A	149.84				
River-2	Reach 2B	236	14W-12A	149.83				
River-2	Reach 2B	235	14W-12A	149.81				
River-2	Reach 2B	234	14W-12A	149.8				
River-2	Reach 2B	233	14W-12A	149.79				
River-2	Reach 2B	232	14W-12A	149.77				
River-2	Reach 2B	231.1	14W-12A		149.48		149.47	
River-2	Reach 2B	231	14W-12A	149.75	149.48	-0.27	149.47	-0.28
River-2	Reach 2B	220.3	14W-12A	149.75	149.48	-0.27	149.47	-0.28
River-2	Reach 2B	220.2	14W-12A	149.59	149.48	-0.11	149.47	-0.12
River-2	Reach 2C	220.15	14W-12A		149.47		149.46	
River-2	Reach 2C	220.1	14W-12A	149.47	149.46	-0.01	149.45	-0.02
River-2	Reach 2C	220	14W-12A	149.47	149.46	-0.01	149.45	-0.02
River-2	Reach 1A	210.5	14W-16	155.74	155.74	0	155.74	0
River-2	Reach 1A	210	14W-16	155.47	155.46	-0.01	155.46	-0.01
River-2	Reach 1A	209	14W-16	154.89	154.88	-0.01	154.88	-0.01
River-2	Reach 1A	208.3	14W-16	153.57	153.57	0	153.57	0
River-2	Reach 1A	208.2	14W-16	153.2	153.2	0	153.2	0
River-2	Reach 1A	208.1	14W-16	153.09	153.09	0	153.09	0
River-2	Reach 1A	208	14W-16	152.5	152.49	-0.01	152.49	-0.01
River-2	Reach 1A	207	14W-16	151.13	151.12	-0.01	151.12	-0.01
River-2	Reach 1A	206.3	14W-16	150.59	150.59	0	150.59	0
River-2	Reach 1A	206.2	14W-16	150.48	150.19	-0.29	150.19	-0.29
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 1A	206.1	14W-16	149.97	149.96	-0.01	149.96	-0.01
River-2	Reach 1	205.1	14W-12	149.36	149.34	-0.02	149.33	-0.03
River-2	Reach 1	205	14W-12	148.85	148.8	-0.05	148.78	-0.07
River-2	Reach 1	204.75	14W-12	148.38	147.83	-0.55	147.82	-0.56
River-2	Reach 1	204.7	14W-12	148.33	147	-1.33	146.99	-1.34
River-2	Reach 1	204.55	14W-12	146.96	146.93	-0.03	146.92	-0.04

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 1B	difference	Phase 1B	difference
River-2	Reach 1	204.5	14W-12	146.81	146.8	-0.01	146.78	-0.03
River-2	Reach 1	204.25	14W-12	146.44	146.43	-0.01	146.42	-0.02
River-2	Reach 1	204	14W-12	145.14	145.15	0.01	145	-0.14
River-2	Reach 1	203	14W-12	145.05	145.06	0.01	144.89	-0.16
River-2	Reach 1	202.75	14W-12	144.67	144.68	0.01	144.53	-0.14
River-2	Reach 1	202.25	14W-12	143.69	143.7	0.01	143.61	-0.08
River-2	Reach 1	202	14W-12	143.33	143.33	0	143.32	-0.01
River-2	Reach 1	201	14W-12	143.27	143.27	0	143.27	0
River-2	Reach 1	171	14W-12	142.97	142.97	0	142.97	0
River-2	Reach 1	169	14W-12	142.7	142.7	0	142.7	0
River-2	Reach 1	164	14W-12	139.25	139.25	0	139.25	0
River-2	Reach 1	163	14W-12	138.47	138.47	0	138.47	0
River-2	Reach 1	162	14W-12	136.76	136.76	0	136.76	0
River-2	Reach 1	161	14W-12	135.3	135.3	0	135.3	0
River-2	Reach 1	160	14W-12	134.02	134.02	0	134.02	0

Phase 2

Based on the model of Phase 1B, the following revisions were incorporated in the model to represent Phase 2 development:

- Add two more new Avenue One Crossings (as proposed in **Table 6.15**) over 14W-22 and 14W-16
- A two-tier cross section with low flow channel of 0.50 m width and 0.22 m depth to maximize low flow conditions within channel for reach 14W-23.
- To meet sinuosity requirement for reach 14W-23, channel length increment from 323 m to 355 m (between XS 11.1 to XS 12.9) to sequence riffle/pool meandering sequence.
- Revision to channel slope for tie in to the existing ground elevation at cross-section 12.9.

Table 6.15 New Avenue One Crossings

Crossing ID	River	Reach	EIS/FSSR	Location	Rise (m)	Span (m)	Bankfull Width (m)
XS 208.15	2	1A	14W-16	Avenue One	2.5	18	5.15
XS 302.5	2	2A	14W-22	Avenue One	2.5	12.25	1.5

- Update flow rates (as shown in **Table 6.16**) in the model

Table 6.16 Flow Rates of Phase 2

Creek ID in HEC-RAS	Existing				Phase 2				
	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	
								Uncontrolled Flow	Controlled Flow
River2, Reach2A	14W-14	2	3081	8.23	14W-21/ 14W-22	8	309	0.52	0.52
						6	3081	6.52	6.52
						2B	303	6.67	6.67
River2, Reach2B	14W-12A	2	240	8.23	14W-12A	2	231.1	0.52	0.22
River2, Reach2C	14W-12A	2	220.3	8.23	14W-12A	2A	220.1	7.03	6.89
River2, Reach1A	14W-16	1B	210.5	8.22	14W-16	1B	210.5	8.1	7.95
						7	208.2	8.1	8.1
		1	206.3	10.29		1	206.3	10.04	10.04
River2, Reach 1	14W-12	3/3B	205.1	19.22	14W-12	3B	205.1	20.11	17.72
						3	204	22	18.01
		4	203	20.34		4	203	22.15	18.16
			171	28.9			171	28.9	28.9
River1, Reach1	14W-11	9	14	3.06	14W-11	9	14	2.69	2.69
		5	10	3.79		5	10	3.38	3.38

The HEC-RAS model of creek 14W-11and 11A was revised. The proposed channel 14W-23 replace 14W-11A to join 14W-11. The Regional flood elevations are shown in **Table 6.17**. Floodplain limits are shown in **Figure 6.6.4.** Comparing to the existing conditions, the Regional Flow will be slightly decreased. The proposed realignment of the channel will not cause adverse flood impacts to the downstream reach.

Table 6.17 Phase 2- Regional Flood Elevation of Creek 14W-23/14W-11A

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)		
				Existing/1A/1B	Phase 2/ Ultimate	difference
River-1	Reach 1B	14	14W-11A\23	155.34	155.3	-0.04
River-1	Reach 1B	13	14W-11A\23	155.27	155.16	-0.11
River-1	Reach 1B	12.9	14W-23		154.93	
River-1	Reach 1B	12.8	14W-23		154.72	
River-1	Reach 1B	12.7	14W-23		154.51	
River-1	Reach 1B	12.6	14W-23		154.28	
River-1	Reach 1B	12.5	14W-11A\23		154.05	
River-1	Reach 1B	12.4	14W-23		153.82	

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)		
				Existing/1A/1B	Phase 2/ Ultimate	difference
River-1	Reach 1B	12.1	14W-11	154.71		
River-1	Reach 1B	12	14W-11	154.25		
River-1	Reach 1B	11.1	14W-11	153.1	153.09	-0.01
River-1	Reach 1B	11	14W-11	152.76	152.73	-0.03
River-1	Reach 1B	10	14W-11	152.76	152.73	-0.03
River-1	Reach 1B	9	14W-11	152.74	152.71	-0.03
River-1	Reach 1B	8	14W-11	150.51	150.42	-0.09
River-1	Reach 1B	7	14W-11	147.97	147.95	-0.02

The Regional Flood elevations of creeks 14W-21&22, 14W-16, 14W-12 obtained from the revised HEC-RAS model are included in **Table 6.18**. Floodplain limits are shown in **Figure 6.6.4.** Comparing to the existing conditions, the new Avenue One Crossing over creek 14W-16 did not caused any increase of water level at the upstream of the crossing under controlled flow condition. It was confirmed that the proposed new crossings can meet the design criteria.

Table 6.18 Phase 2- Regional Flood Elevation of Creek 14W-16, 14W21/22, 14W-12, and 14W-12A

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 2	difference	Phase 2	difference
River-2	Reach 2A2	309	14W-21		154.36		154.36	
River-2	Reach 2A2	308	14W-21		153.92		153.92	
River-2	Reach 2A2	307	14W-21		153.37		153.37	
River-2	Reach 2A2	306	14W-21		153.2		153.2	
River-2	Reach 2A1	3081	14W-22		154.71		154.71	
River-2	Reach 2A1	3071	14W-22		154.19		154.19	
River-2	Reach 2A1	3061	14W-22		153.6		153.6	
River-2	Reach 2A	305	14W-22		152.97		152.97	
River-2	Reach 2A	304	14W-22		152.6		152.6	
River-2	Reach 2A	303	14W-22		152.32		152.32	
New Avenue One Extension Crossing								
River-2	Reach 2A	302	14W-22		152.34		152.34	
River-2	Reach 2A	301	14W-22		151.68		151.68	
River-2	Reach 2A	300	14W-22		151.27		151.27	
River-2	Reach 2A	299	14W-22		150.96		150.96	
River-2	Reach 2A	298	14W-22		150.67		150.67	
River-2	Reach 2A	297	14W-22		150.35		150.35	

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 2	difference	Phase 2	difference
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 2A	296	14W-22		150.15		150.15	
River-2	Reach 2A	3081	14W-14	154.76				
River-2	Reach 2A	228	14W-14	154.32				
River-2	Reach 2A	227	14W-14	153.42				
River-2	Reach 2A	226	14W-14	152.87				
River-2	Reach 2A	225	14W-14	152.32				
River-2	Reach 2A	224	14W-14	151.8				
River-2	Reach 2A	223	14W-14	150.96				
River-2	Reach 2A	222	14W-14	150.43				
River-2	Reach 2A	221	14W-14	149.72				
River-2	Reach 2B	240	14W-12A	149.91				
River-2	Reach 2B	239	14W-12A	149.85				
River-2	Reach 2B	238	14W-12A	149.84				
River-2	Reach 2B	237	14W-12A	149.84				
River-2	Reach 2B	236	14W-12A	149.83				
River-2	Reach 2B	235	14W-12A	149.81				
River-2	Reach 2B	234	14W-12A	149.8				
River-2	Reach 2B	233	14W-12A	149.79				
River-2	Reach 2B	232	14W-12A	149.77				
River-2	Reach 2B	231.1	14W-12A		149.51		149.46	
River-2	Reach 2B	231	14W-12A	149.75	149.51	-0.24	149.46	-0.29
River-2	Reach 2B	220.3	14W-12A	149.75	149.51	-0.24	149.46	-0.29
River-2	Reach 2B	220.2	14W-12A	149.59	149.51	-0.08	149.46	-0.13
River-2	Reach 2C	220.15	14W-12A		149.5		149.45	
River-2	Reach 2C	220.1	14W-12A	149.47	149.49	0.02	149.44	-0.03
River-2	Reach 2C	220	14W-12A	149.47	149.49	0.02	149.44	-0.03
River-2	Reach 1A	210.5	14W-16	155.74	155.74	0	155.73	0
River-2	Reach 1A	210	14W-16	155.47	155.47	0	155.46	0
River-2	Reach 1A	209	14W-16	154.89	154.88	-0.01	154.88	-0.01
River-2	Reach 1A	208.3	14W-16	153.57	153.58	0.01	153.57	0
River-2	Reach 1A	208.2	14W-16	153.2	153.14	-0.06	153.14	-0.06
New Avenue One Extension Crossing								
River-2	Reach 1A	208.1	14W-16	153.09	153.09	0	153.09	0
River-2	Reach 1A	208	14W-16	152.5	152.49	-0.01	152.49	-0.01
River-2	Reach 1A	207	14W-16	151.13	151.12	-0.01	151.12	-0.01

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Phase 2	difference	Phase 2	difference
River-2	Reach 1A	206.3	14W-16	150.59	150.59	0	150.59	0
River-2	Reach 1A	206.2	14W-16	150.48	150.19	-0.29	150.19	-0.29
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 1A	206.1	14W-16	149.97	149.96	-0.01	149.96	-0.01
River-2	Reach 1	205.1	14W-12	149.36	149.39	0.03	149.32	-0.04
River-2	Reach 1	205	14W-12	148.85	148.86	0.01	148.77	-0.08
River-2	Reach 1	204.75	14W-12	148.38	147.89	-0.49	147.8	-0.58
River-2	Reach 1	204.7	14W-12	148.33	147.03	-1.3	146.98	-1.35
River-2	Reach 1	204.55	14W-12	146.96	146.97	0.01	146.91	-0.05
River-2	Reach 1	204.5	14W-12	146.81	146.84	0.03	146.77	-0.04
River-2	Reach 1	204.25	14W-12	146.44	146.46	0.02	146.41	-0.03
River-2	Reach 1	204	14W-12	145.14	145.27	0.13	144.98	-0.16
River-2	Reach 1	203	14W-12	145.05	145.2	0.15	144.86	-0.19
River-2	Reach 1	202.75	14W-12	144.67	144.8	0.13	144.51	-0.16
River-2	Reach 1	202.25	14W-12	143.69	143.78	0.09	143.59	-0.1
River-2	Reach 1	202	14W-12	143.33	143.35	0.02	143.31	-0.02
River-2	Reach 1	201	14W-12	143.27	143.28	0.01	143.26	-0.01
River-2	Reach 1	171	14W-12	142.97	142.97	0	142.97	0
River-2	Reach 1	169	14W-12	142.7	142.7	0	142.7	0
River-2	Reach 1	164	14W-12	139.25	139.25	0	139.25	0
River-2	Reach 1	163	14W-12	138.47	138.47	0	138.47	0
River-2	Reach 1	162	14W-12	136.76	136.76	0	136.76	0
River-2	Reach 1	161	14W-12	135.3	135.3	0	135.3	0
River-2	Reach 1	160	14W-12	134.02	134.02	0	134.02	0

Ultimate Conditions

The preliminary grading plan and development plan for the development land west of the subject site were developed. Correspondingly, the HEC-RAS models for the Ultimate Conditions were revised to incorporate the following changes:

- Geometric data of cross sections 207 to 210.5 were revised to reflect the proposed grading plan at the right bank for this creek section.
- Flow rates (as shown in **Table 6.19**) were revised.

Table 6.19 Flow Rates of Ultimate Conditions

Creek ID in HEC-RAS	Existing				Ultimate				
	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	Creek ID in EIS/FSSR	Flow Node	XS	Regional Flow Rate (m3/s)	
								Uncontrolled Flow	Controlled Flow
River2, Reach2A	14W-14	2	3081	8.23	14W-21/ 14W-22	8	309	0.52	0.52
						6	3081	6.35	6.35
						2B	303	6.5	6.5
River2, Reach2B	14W-12A	2	240	8.23	14W-12A	2	231.1	0.52	0.22
River2, Reach2C	14W-12A	2	220.3	8.23	14W-12A	2A	220.1	6.86	6.72
River2, Reach1A	14W-16	1B	210.5	8.22	14W-16	1B	210.5	8.02	7.87
						7	208.2		8.02
		1	206.3	10.29		1	206.3	11.06	9.44
River2, Reach 1	14W-12	3/3B	205.1	19.22	14W-12	3B	205.1	21.19	16.97
						3	204	23.03	17.26
		4	203	20.34		4	203	23.2	17.41
			171	28.9			171	28.9	28.9
River1, Reach1	14W-11	9	14	3.06	14W-11	9	14	2.69	2.69
		5	10	3.79		5	10	3.38	3.38

In the ultimate conditions, development will not impact the creek 14W-21/14W-11A. The modelling results and floodplain delineation of Phase 2 remain unchanged.

The Regional Flood elevations of creeks 14W-21&22, 14W-16, 14W-12 obtained from the revised HEC-RAS model are included in **Table 6.20**. Floodplain limits are shown in **Figure 6.6.5.** Comparing to the existing conditions, there are no increase in water level under controlled flow condition.

Table 6.20 Ultimate Conditions - Regional Flood Elevation of Creek 14W-16, 14W21/22, 14W-12, and 14W-12A

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Ultimate	difference	Ultimate	difference
River-2	Reach 2A2	309	14W-21		154.36		154.36	
River-2	Reach 2A2	308	14W-21		153.92		153.92	
River-2	Reach 2A2	307	14W-21		153.38		153.38	
River-2	Reach 2A2	306	14W-21		153.19		153.19	
River-2	Reach 2A1	3081	14W-22		154.71		154.71	
River-2	Reach 2A1	3071	14W-22		154.19		154.19	

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Ultimate	difference	Ultimate	difference
River-2	Reach 2A1	3061	14W-22		153.59		153.59	
River-2	Reach 2A	305	14W-22		152.97		152.97	
River-2	Reach 2A	304	14W-22		152.6		152.6	
River-2	Reach 2A	303	14W-22		152.31		152.31	
New Avenue One Extension Crossing								
River-2	Reach 2A	302	14W-22		152.33		152.33	
River-2	Reach 2A	301	14W-22		151.67		151.67	
River-2	Reach 2A	300	14W-22		151.26		151.26	
River-2	Reach 2A	299	14W-22		150.96		150.96	
River-2	Reach 2A	298	14W-22		150.66		150.66	
River-2	Reach 2A	297	14W-22		150.34		150.34	
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 2A	296	14W-22		150.14		150.14	
River-2	Reach 2A	3081	14W-14	154.76				
River-2	Reach 2A	228	14W-14	154.32				
River-2	Reach 2A	227	14W-14	153.42				
River-2	Reach 2A	226	14W-14	152.87				
River-2	Reach 2A	225	14W-14	152.32				
River-2	Reach 2A	224	14W-14	151.8				
River-2	Reach 2A	223	14W-14	150.96				
River-2	Reach 2A	222	14W-14	150.43				
River-2	Reach 2A	221	14W-14	149.72				
River-2	Reach 2B	240	14W-12A	149.91				
River-2	Reach 2B	239	14W-12A	149.85				
River-2	Reach 2B	238	14W-12A	149.84				
River-2	Reach 2B	237	14W-12A	149.84				
River-2	Reach 2B	236	14W-12A	149.83				
River-2	Reach 2B	235	14W-12A	149.81				
River-2	Reach 2B	234	14W-12A	149.8				
River-2	Reach 2B	233	14W-12A	149.79				
River-2	Reach 2B	232	14W-12A	149.77				
River-2	Reach 2B	231.1	14W-12A		149.53		149.45	
River-2	Reach 2B	231	14W-12A	149.75	149.53	-0.22	149.45	-0.3
River-2	Reach 2B	220.3	14W-12A	149.75	149.53	-0.22	149.45	-0.3
River-2	Reach 2B	220.2	14W-12A	149.59	149.53	-0.06	149.45	-0.14

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Ultimate	difference	Ultimate	difference
River-2	Reach 2C	220.15	14W-12A		149.52		149.44	
River-2	Reach 2C	220.1	14W-12A	149.47	149.51	0.04	149.42	-0.05
River-2	Reach 2C	220	14W-12A	149.47	149.51	0.04	149.42	-0.05
River-2	Reach 1A	210.5	14W-16	155.74	155.74	0	155.73	-0.01
River-2	Reach 1A	210	14W-16	155.47	155.47	0	155.46	-0.01
River-2	Reach 1A	209	14W-16	154.89	154.88	-0.01	154.87	-0.02
River-2	Reach 1A	208.3	14W-16	153.57	153.58	0.01	153.57	0
River-2	Reach 1A	208.2	14W-16	153.2	153.15	-0.05	153.15	-0.05
New Avenue One Extension Crossing								
River-2	Reach 1A	208.1	14W-16	153.09	153.09	0	153.09	0
River-2	Reach 1A	208	14W-16	152.5	152.49	-0.01	152.49	-0.01
River-2	Reach 1A	207	14W-16	151.13	151.15	0.02	151.11	-0.02
River-2	Reach 1A	206.3	14W-16	150.59	150.63	0.04	150.57	-0.02
River-2	Reach 1A	206.2	14W-16	150.48	150.22	-0.26	150.17	-0.31
New Burnhamthorpe Road Extension Crossing								
River-2	Reach 1A	206.1	14W-16	149.97	149.98	0.01	149.94	-0.03
River-2	Reach 1	205.1	14W-12	149.36	149.41	0.05	149.3	-0.06
River-2	Reach 1	205	14W-12	148.85	148.89	0.04	148.75	-0.1
River-2	Reach 1	204.75	14W-12	148.38	147.92	-0.46	147.78	-0.6
River-2	Reach 1	204.7	14W-12	148.33	147.05	-1.28	146.96	-1.37
River-2	Reach 1	204.55	14W-12	146.96	147	0.04	146.89	-0.07
River-2	Reach 1	204.5	14W-12	146.81	146.86	0.05	146.75	-0.06
River-2	Reach 1	204.25	14W-12	146.44	146.48	0.04	146.39	-0.05
River-2	Reach 1	204	14W-12	145.14	145.35	0.21	144.96	-0.18
River-2	Reach 1	203	14W-12	145.05	145.28	0.23	144.8	-0.25
River-2	Reach 1	202.75	14W-12	144.67	144.88	0.21	144.45	-0.22
River-2	Reach 1	202.25	14W-12	143.69	143.83	0.14	143.56	-0.13
River-2	Reach 1	202	14W-12	143.33	143.36	0.03	143.31	-0.02
River-2	Reach 1	201	14W-12	143.27	143.28	0.01	143.26	-0.01
River-2	Reach 1	171	14W-12	142.97	142.97	0	142.97	0
River-2	Reach 1	169	14W-12	142.7	142.7	0	142.7	0
River-2	Reach 1	164	14W-12	139.25	139.25	0	139.25	0
River-2	Reach 1	163	14W-12	138.47	138.47	0	138.47	0
River-2	Reach 1	162	14W-12	136.76	136.76	0	136.76	0
River-2	Reach 1	161	14W-12	135.3	135.3	0	135.3	0

River	Reach	XS	EIS/FSSR Identifications	Regional Water Surface Elevation (m)				
				Existing	Uncontrolled Flow		Controlled Flow	
					Ultimate	difference	Ultimate	difference
River-2	Reach 1	160	14W-12	134.02	134.02	0	134.02	0

In summary, adding new crossings or the revisions of geometric data will have impacts on the creek sections at the upstream of the alternation rather than the downstream, as the flow regime of the creeks is subcritical. Additionally, the development will have Regional Flood control, the full range of floods will be less or equal to the current flow levels. Therefore, the proposed developments in the site will not impact the flood elevations in the Fourteen Miles Creek downstream of the site.

6.5.7 Riparian Storage Assessment

The NOCSS and its related Addendum outline requirements to be addressed when proposing to relocate a medium constraint stream. One such requirement includes maintenance of riparian storage for regulatory floodplains. In particular, any modifications to a stream or floodplain should address the maintenance of riparian storage characteristics to prevent increases in peak flows in downstream areas. The NOCSS Addendum states that discharge-storage characteristics must be addressed for a range of design events including the 2 to 100-year and Regional Storm events.

To address this requirement and confirm channel realignment was designed appropriately, a riparian storage analysis of each creek reach was undertaken with the HEC-RAS model. The design events flow rates of the subject site under the existing and ultimate controlled flow rates were used in HEC-RAS models to obtain the cumulative riparian storages. In addition, the road crossings were removed from both existing and ultimate condition HEC-RAS models.

Reach 14W-16 and 14W-12

For creeks 14W-16 and 14W-12, there are no channel modification under the proposed grading plan.

Table 6.21 shows the flow rates of the existing conditions and ultimate conditions. Since proposed stormwater management ponds will control the flow, flow rates in ultimate conditions will be less than existing conditions.

Table 6.21 Flow Rates for Reach 14W-16 and 14W-12

Reach	Phases	Design Flow (m^3/s)						
		Regional	100yr	50yr	25yr	10yr	5yr	2yr
14W-16	Existing flow	8.22	3.34	2.95	2.59	2.04	1.69	1.08
	Ultimate flow	7.87	3.19	2.83	2.48	1.96	1.62	1.03
	Difference	*-4%*	*-4%*	*-4%*	*-4%*	*-4%*	*-4%*	*-5%*

14W-12	Existing flow	8.23	3.2	2.83	2.48	1.94	1.59	1
	Ultimate flow	6.35	2.45	2.16	1.89	1.47	1.2	0.75
	Difference	*-23%*	*-23%*	*-24%*	*-24%*	*-24%*	*-25%*	*-25%*

The comparison of riparian storages between the existing and the ultimate development condition is tabulated in **Table 6.22**.

Table 6.22 Riparian Storage Analysis for Design Flow Rates

Reach	Phases	Riparian Storage Volume (m3)						
		Regional	**100yr**	**50yr**	**25yr**	**10yr**	**5yr**	**2yr**
14W-16	Existing	16680	7740	6980	6250	5130	4370	2920
	Ultimate	15950	7420	6730	6040	4960	4220	2820
	Difference	-4%	-4%	-4%	-3%	-3%	-3%	-3%
14W-12	Existing	10530	4210	3770	3380	2650	2230	1560
	Ultimate	9030	3790	3430	3040	2430	2040	1440
	Difference	-14%	-10%	-9%	-10%	-8%	-9%	-8%

To assist the assessment of the impact on the riparian storage, the standardized flow rates were also utilized in the analysis. A spectrum of standardized flow rates covering the full range design flows were used in HEC-RAS models for both existing and ultimate conditions to obtain the cumulative riparian storages.

For Reach 14W-16 and 14W-12, the design flows were range from 8.23 m^3/s to 0.75 m^3/s. Therefore, the standardized flow rates were set between 8.3 m^3/s to 0.5 m^3/s.

The comparison of riparian storages between the existing and the ultimate development conditions using Standardized flow is tabulated in **Table 6.23.** The table below concludes that the riparian storage for 14W-16 and 14W-12 will remain unchanged.

Table 6.23 Riparian Storage Analysis for Standardized Flow Rates

Reach	Phases	Riparian Storage Volume (m3)						
		8.3 m^3/s	**8 m^3/s**	**6.5 m^3/s**	**5 m^3/s**	**2.5 m^3/s**	**1 m^3/s**	**0.5 m^3/s**
14W-16	Existing	15110	14680	12310	9870	5670	2630	1560
	Ultimate	15220	14680	12330	9910	5700	2640	1560
	Difference	0.7%	0.0%	0.2%	0.4%	0.5%	0.4%	0.0%
14W-12	Existing	4510	4410	3630	2810	1560	750	420
	Ultimate	4580	4330	3650	2830	1590	770	440

	Difference	2%	-2%	1%	1%	2%	3%	5%

Reach 14W-11A / 14W-23

Under the proposed grading plan, the proposed channel 14W-23 will replace creek 14W-11A to join 14W-11. The **Table 6.24** shows the flow rates of the existing conditions and ultimate conditions.

Table 6.24 Flow Rates for Reach 14W-11A and 14W-23

Reach	Phases	Design Flow (m^3/s)						
		Regional	100yr	50yr	25yr	10yr	5yr	2yr
14W-11A	Existing flow	3.06	1.53	1.35	1.17	0.91	0.73	0.42
14W-23	Ultimate flow	2.69	1.27	1.12	0.97	0.75	0.6	0.34
	Difference	*-12%*	*-17%*	*-17%*	*-17%*	*-18%*	*-18%*	*-19%*

The comparison of riparian storages between the existing and the ultimate development condition is tabulated in **Table 6.25.** The riparian storage of the new creek 14W-23 will be larger than the current 14W-11A.

Table 6.25 Riparian Storages base on Design Flow Rates

Reach	Phases	Riparian Storage Volume (m3)						
		Regional	100yr	50yr	25yr	10yr	5yr	2yr
14W-11A	Existing	4010	2540	1730	1570	1330	1150	810
14W-23	Ultimate	5720	2690	2420	2160	1760	1280	930
	Different	43%	6%	40%	38%	32%	11%	15%

For Reach 14W-11A/14W-23, the design flows were range from 3.06 m^3/s to 0.34 m^3/s. Therefore, the standardized flow rates were set between 3.1 m^3/s to 0.2 m^3/s to cover the full range design flow.

The comparison of riparian storages between the existing and the ultimate development conditions using Standardized flow is tabulated in **Table 6.26.** The riparian storage of the new creek 14W-23 will be larger than the current 14W-11A.

Table 6.26 Riparian Storages base on Standardized Flows

Reach	Phases	Riparian Storage Volume (m3)						
		3.1 m^3/s	2.5 m^3/s	2 m^3/s	1.5 m^3/s	1 m^3/s	0.5 m^3/s	0.2 m^3/s
14W-11A	Existing	3850	3410	2620	1850	1420	910	500
14W-23	Ultimate	6070	5290	4190	3020	2210	1260	590
	Different	58%	55%	60%	63%	56%	38%	18%

Reach 14W-14 / 14W-22

Under existing condition, reach 14W-14 associated with the human-made pond (farm pond) that functions as an off-line storage area during periods of high flow. The high flow from reach 14W-14 will enters the pond and release these flow into the downstream reach 14W-12A.

Under the proposed grading plan, Reach 14W-14 will be replaced by a realigned channel, Reach 14W-22. The confluence of reach 14W-14 and reach 14W-12A will be relocated about 60m downstream. The human-made pond will be replaced by a proposed SWM Pond 3 and divert the flow away from reach 14W-12A.

The **Table 6.27** shows the flow rates of the existing conditions and ultimate conditions. As a conservative approach, the flow rates from node 2 were applied to reach 14W-14 instead of using node 2c. Node 2 represent the total outflow from Reach 14W-12, including the flow from reach 14W-14 and the human-made pond. The Ultimate control flow was less than the existing condition flow rates.

Table 6.27 Flow Rates for Reach 14W-14, 14W-12A and 14W-22

Reach	Phases	Design Flow (m^3/s)						
		Regional	100yr	50yr	25yr	10yr	5yr	2yr
14W-14	Existing	8.23	3.2	2.83	2.48	1.94	1.59	1
14W-22	Ultimate	6.35	2.45	2.16	1.89	1.47	1.2	0.75
	Different	*-23%*	*-23%*	*-24%*	*-24%*	*-24%*	*-25%*	*-25%*
14W-12A	Existing	8.23	3.2	2.83	2.48	1.94	1.59	1
14W-12A (reach length that located downstream of new confluence)	Ultimate	6.72	2.59	2.29	2	1.56	1.28	0.8
	Different	*-18%*	*-19%*	*-19%*	*-19%*	*-20%*	*-19%*	*-20%*

The existing condition riparian storage include the following:

- Riparian storage for Reach 14W-14
- The flood storage above the permanent pool in the human-made pond
- Riparian storage for Reach 14W-12A

The cross sections in existing condition HEC-RAS model were revised. Reach 14W-12A and the flood storage about the permanent pool in the human-made pond were combined with Reach 14W-14, representing only single reach due to confluence located on the downstream side. **Figure 6.7** shown the HEC-RAS model cross section locations for human-made pond and Reach 14W-12 that combined with Reach 14W-14. Cross section 220.7 to 220.4 were added in the model.

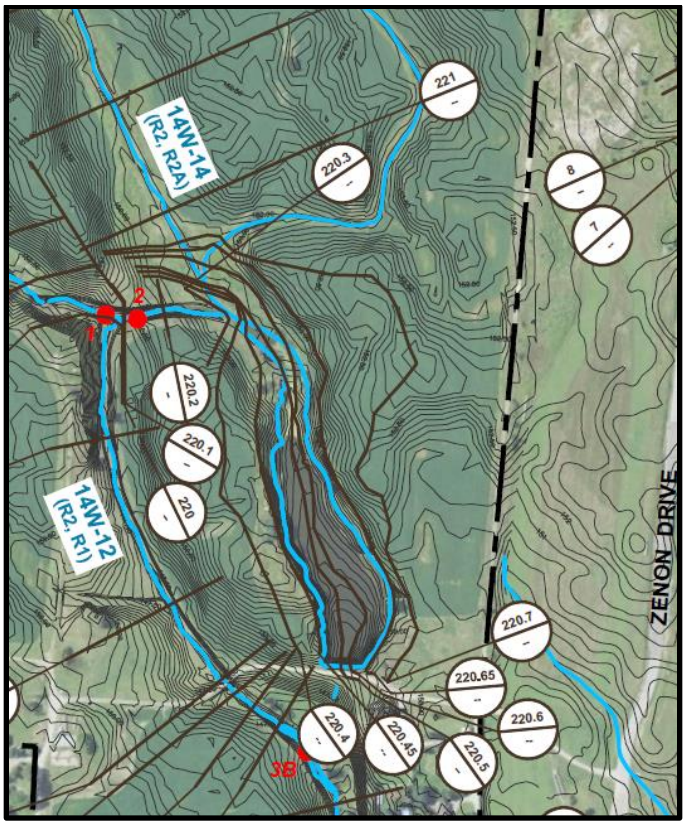


Figure 6.7 - Hec-RAS cross-section location for Riparian Storage existing condition model

The Ultimate development condition riparian storage include the following:

- Riparian storage for Reach 14W-22
- Riparian storage for reach length that cover the downstream of new confluence for Reach 14W-12A

Riparian storage for Proposed SWM Pond 3 did not included in the analysis because it is not part of the riparian system.

Riparian storage for reach length that cover the upstream of new confluence for Reach 14W-12A also not included in the analysis due to the minimal flow rate under Ultimate development condition.

The comparison of riparian storages between the existing and the ultimate development condition is tabulated in **Table 6.28**. Comparing to the riparian storage of the current creek 14W-14, the realigned creek 14W-22 will have increased riparian storages for all design flow, except for regional flow.

However, the flow reduction for regional flow is -23%, while the storage reduction is only 11%. Therefore, with reduce flow, more storage is provided.

Table 6.28 Riparian Storages base on Design Flow Rates

Reach	Phases	Riparian Storage Volume (m3)						
		Regional	100yr	50yr	25yr	10yr	5yr	2yr
14W-14 (including 14W-12A and human-made pond)	Existing	19540	8850	7870	6880	5410	4600	3220
14W-22	Ultimate	18550	8790	7830	7060	5820	4980	3430
14W-12A (reach length that located downstream of new confluence)		750	310	260	210	130	90	40
Total		19300	9100	8090	7270	5950	5070	3470
	Different	-1%	3%	3%	6%	10%	10%	8%

Using the standardized flow rate will eliminate the flow impact on water level elevation along creeks and compare the storage based on consistent basis.

For Reach 14W-14/14W-22, the design flows were range from 8.23 m^3/s to 0.8 m^3/s. Therefore, the standardized flow rates were set between 8.3 m^3/s to 0.5 m^3/s to cover the full range design flow.

The comparison of riparian storages between the existing and the ultimate development conditions using Standardized flow is tabulated in **Table 6.29.** The riparian storage of the new creek 14W-22 will be larger than the current reach 14W-14 (including reach 14W-12A and human-made pond).

Table 6.29 Riparian Storages base on Standardized Flows

Reach	Phases	Riparian Storage Volume (m3)						
		8.3 m^3/s	8 m^3/s	6.5 m^3/s	5 m^3/s	2.5 m^3/s	1 m^3/s	0.5 m^3/s
14W-14 (including 14W-12A and human-made pond)	Existing	19280	18720	15830	12630	6640	3200	1880
14W-22	Ultimate	21260	20770	18160	15340	8560	4230	2330
14W-12A (Downstream of new confluence)		440	440	330	250	120	40	20
Total		21700	21210	18490	15590	8680	4270	2350
	Different	13%	13%	17%	23%	31%	33%	25%

In summary, the riparian storage for Reach 14W-16, 14W-12 and 14W-11A/14W-23 were maintained under the ultimate condition.

For Reach 14W-14/14W-22, the decrease in riparian storage of 11% estimated under regional storm is reasonable, especially considering the 23% flow reduction. Moreover, the standardized flow storage estimates shown that the riparian storage for existing condition were maintained under ultimate condition.

6.6 Stream Length Requirements

Medium constraint stream Reaches 14W-14 and 14W-11A and a low constraint stream Reach 14W-13 will be eliminated and replaced by proposed channel Reaches 14W-21, 14W-22 and 14W-23. No alterations will be made to the existing Reaches 14W-16 and 14W-12 channels. The existing Reach 14W-16 channel is considered as Redside Dace occupied habitat; hence the channel reach is unaltered and a meander belt plus 30 m setback is applied. The realigned channel Reach 14W-22 is designated a contributing habitat. Based on direction from MNRF, an additional 30 m buffer is maintained between the existing Reach 14W-16 and the proposed realigned Reach 14W-22 channels. The existing Reach 14W-16 channel will continue to flow parallel to the proposed Reach 14W-22 channel to maintain Regional Drainage Densities and preserve the overall length of medium and high constraint watercourses according to NOCSS recommendations. The realigned Reach 14W-22 channel will confluence with Reach 14W-12A, immediately upstream of the confluence with 14W-12.

Table 6.24 shows the existing stream lengths and the proposed stream lengths for the high, medium and low constraint streams. The proposed realignment and rehabilitation of medium constraint streams have almost equal channel lengths as the existing conditions through realignment and meandering of these channels. The existing medium constraint stream length of 1830 m will be replaced with 1389 m length of more defined channel with increased habitat diversity (i.e. riffles, pools, etc.) improving the habitat, especially for Redside Dace. The realignment provides an opportunity to improve fish habitat over the existing system that is periodically subject to disturbance associated with agricultural practices.

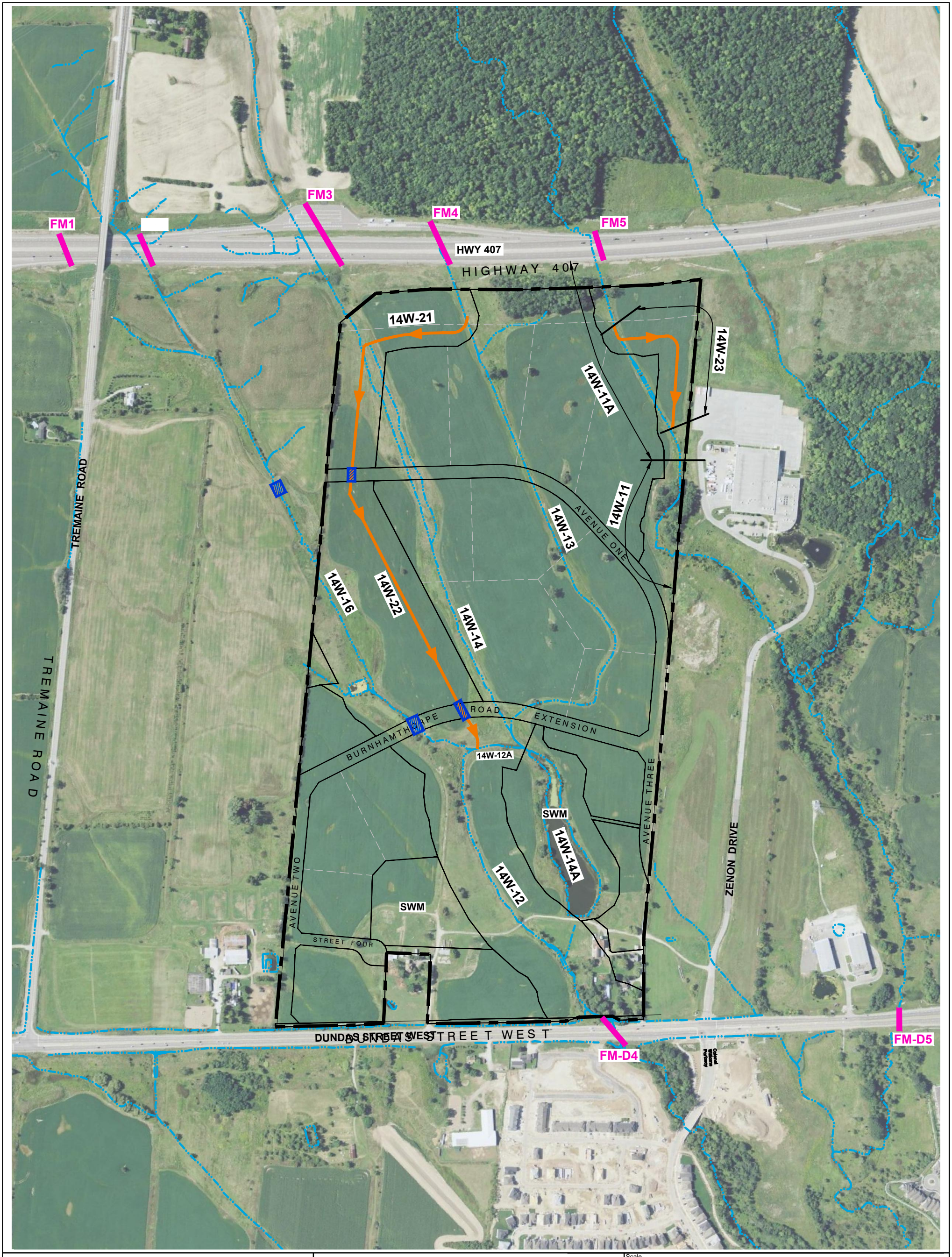
Table 6.24 Existing and Proposed Stream Lengths for High, Medium and Low Constraint Streams

Channel ID	Channel Length (m)						Reference
	Existing			Proposed			
	High	Medium	Low	High	Medium	Low	
14W-12	619			619			River 2, Reach 1, XS 205.1 To XS 202.25
14W-12A	85			17			River2, Reach 2C, XS 220.3 to XS 220
14W-11	157			157			River1, Reach 1B, XS 11.1 to XS 11
14W-11A		348					River1, Reach 1B, XS 14 to XS 11.1
14W-14		787					River2, Reach 2A, XS 3081 to XS 221
14W-14A		300					Human-made pond
14W-16		395		395			River2, Reach 1A, XS 208 to XS 206.1
14W-13			960			94	
14W-21						202	River2, Reach 2A2, XS 309 to XS 306
14W-22					953		River 2, Reach 2A1 & 2A, XS 3081 to XS 296
14W-23					427		River 1, Reach 1B, XS 14 to XS 11.1

Channel ID	Channel Length (m)						Reference
	Existing			Proposed			
	High	Medium	Low	High	Medium	Low	
Total	862	1830	960	1188	1380	296	
Total (High+Medium)	2692			2568			

6.7 Summary

Refinement of corridor width for high and medium constraint streams have been completed based on the guidance provided in the NOCSS. Under the proposed condition, the total channel length of the high and medium constraint streams is reduced by 120 m compared to the existing condition. However, it should be noted that under the existing condition, 300 m of Reach 14W-14A, which is an artificial pond has been incorporated in the drainage density assessment (Drainage density estimates can be found under **Appendix 6.6**). Furthermore, there is also additional opportunity to compensate for the reduction in length, by incorporating SWM Pond 3 in the drainage density assessment (as indicated by direction from John Parish at the November 13, 2013 Meeting at the Town of Oakville). As indicated in the November 13, 2013 meeting, in this scenario, there may be consideration to allow the SWM Pond 3 length to count as drainage density length from a hydraulic point of view, as the SWM facility is essentially replacing the existing pond in the same location. Conservatively, the proposed SWM Pond 3 length has not been incorporated in our assessment. Two medium constraint tributaries of West Branch of Fourteen Mile Creek in the Subject Property are realigned and a low constraint tributary is eliminated to accommodate the proposed development. At the Detailed Design stage, the principles of “Natural Channel Design” and NOCSS requirements will be pursued further.



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Existing Channel System, And Proposed Channel Diversion and Rehabilitation

LEGEND

- SUBJECT PROPERTY
- PROPOSED WATER CROSSING
- EXISTING CULVERT
- PROPOSED CHANNEL DIVERSION

Scale: 0 100 200 300m

Client: QuadReal

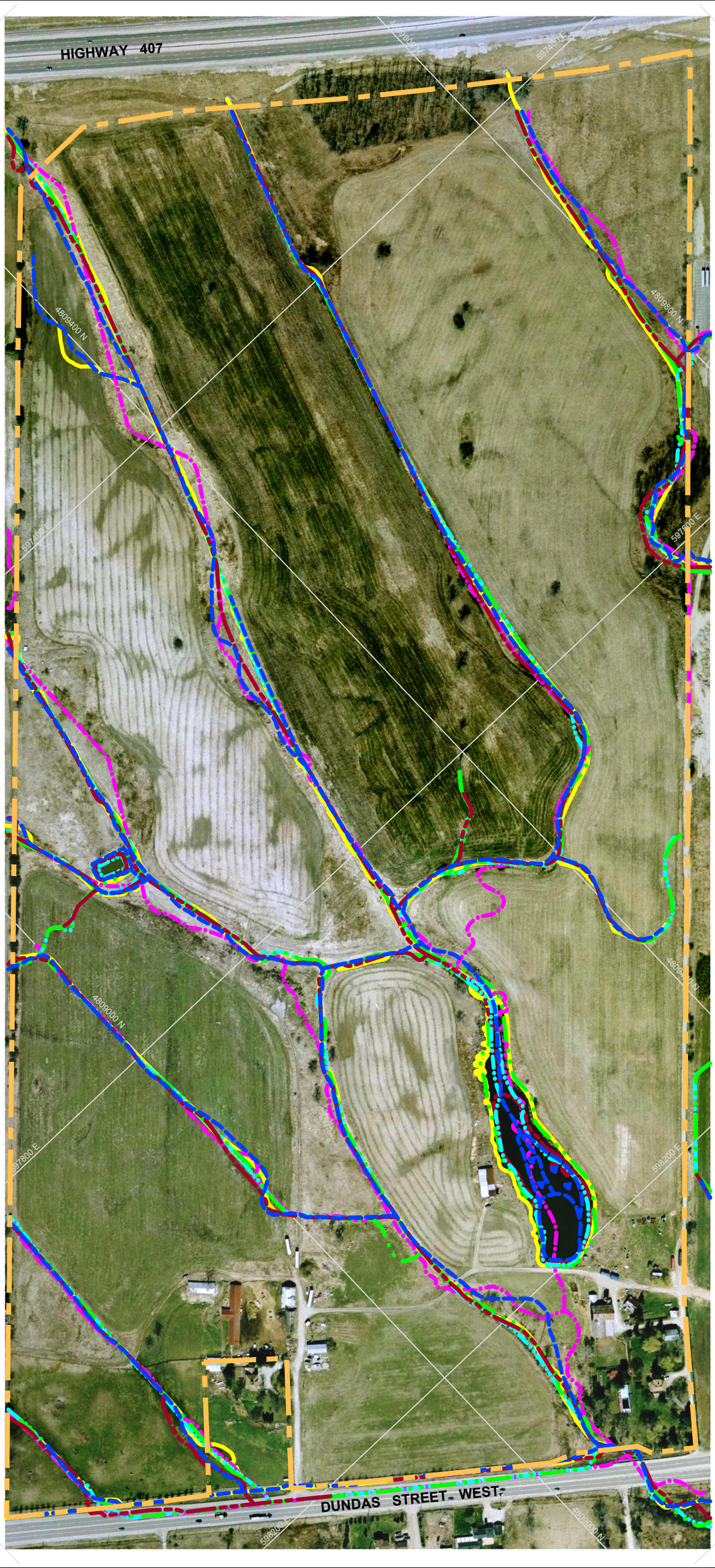
Prepared by: WSP

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.1



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Historical Channel Planform

LEGEND

- SUBJECT PROPERTY
- 1934
- 1960
- 1969
- 1979
- 1988
- 2009

Scale: 0 50 100 150 200m

Client: QuadReal

Prepared by: wsp

Date: April 2018

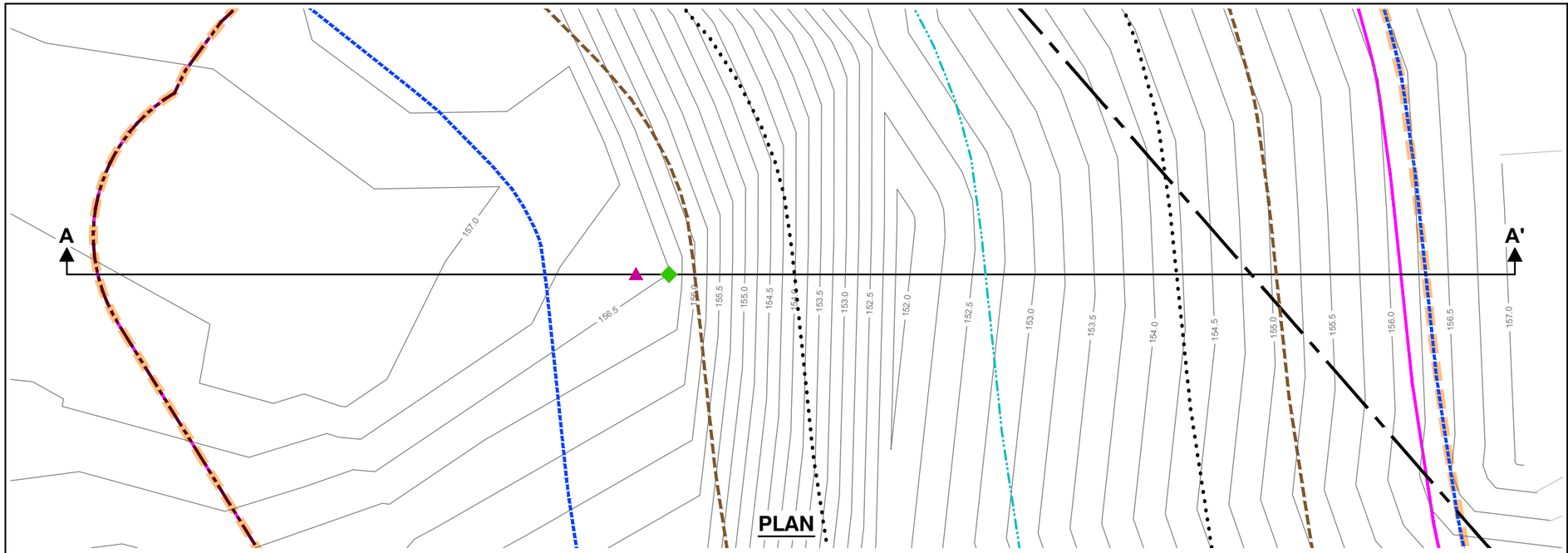
Project No.: 09M-00013-01-WR1

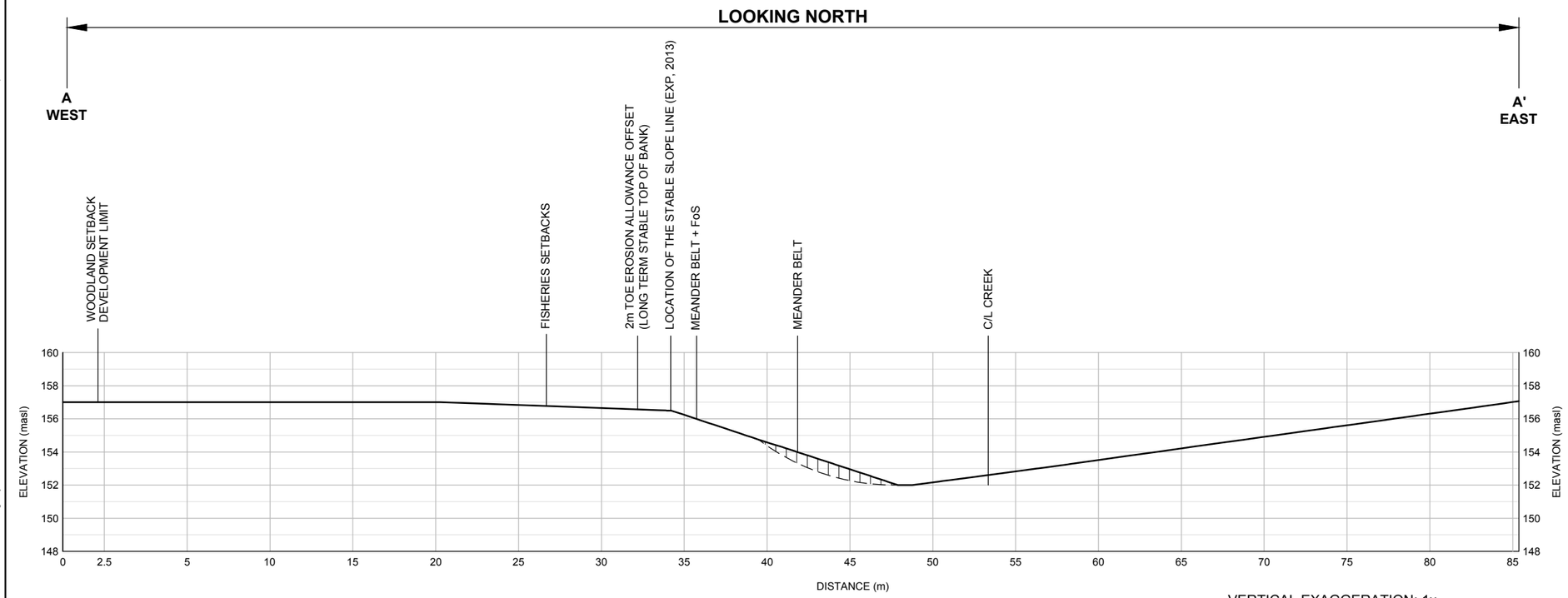
Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.2

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

TOP OF BANK DELINEATION - 14W-11





CROSS-SECTION A-A'

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- MEANDER BELT WIDTH
- MEANDER BELT WIDTH + FoS
- FISHERIES SETBACKS
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- DEVELOPMENT LIMIT
- 2m TOE EROSION ALLOWANCE OFFSET (LONG TERM STABLE TOP OF BANK)
- STABLE SLOPE LINE (EXP, 2013)

Scale: 0 5 10 15m

N

Client: QuadReal

Prepared by: wsp

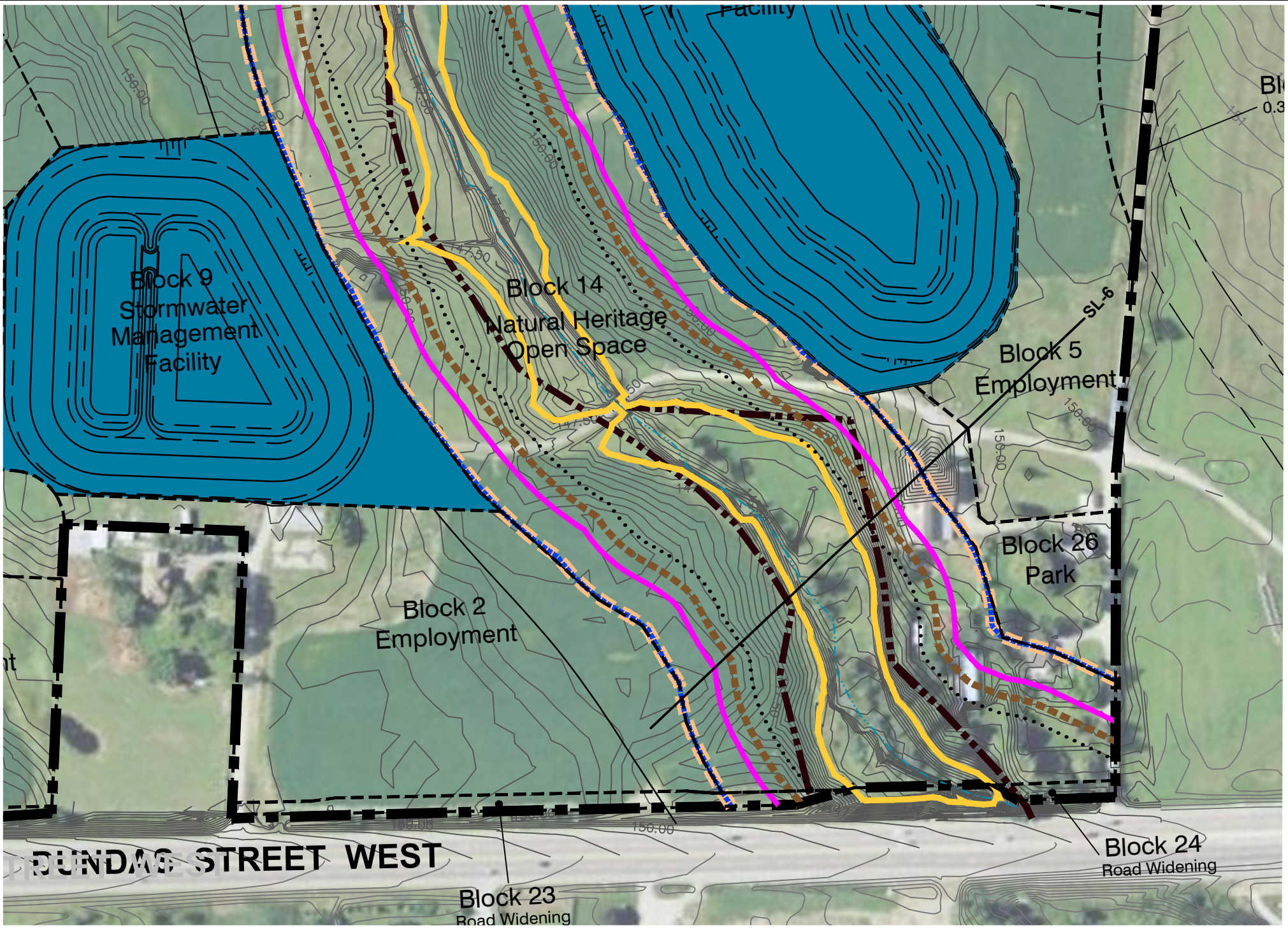
Date: April 2019

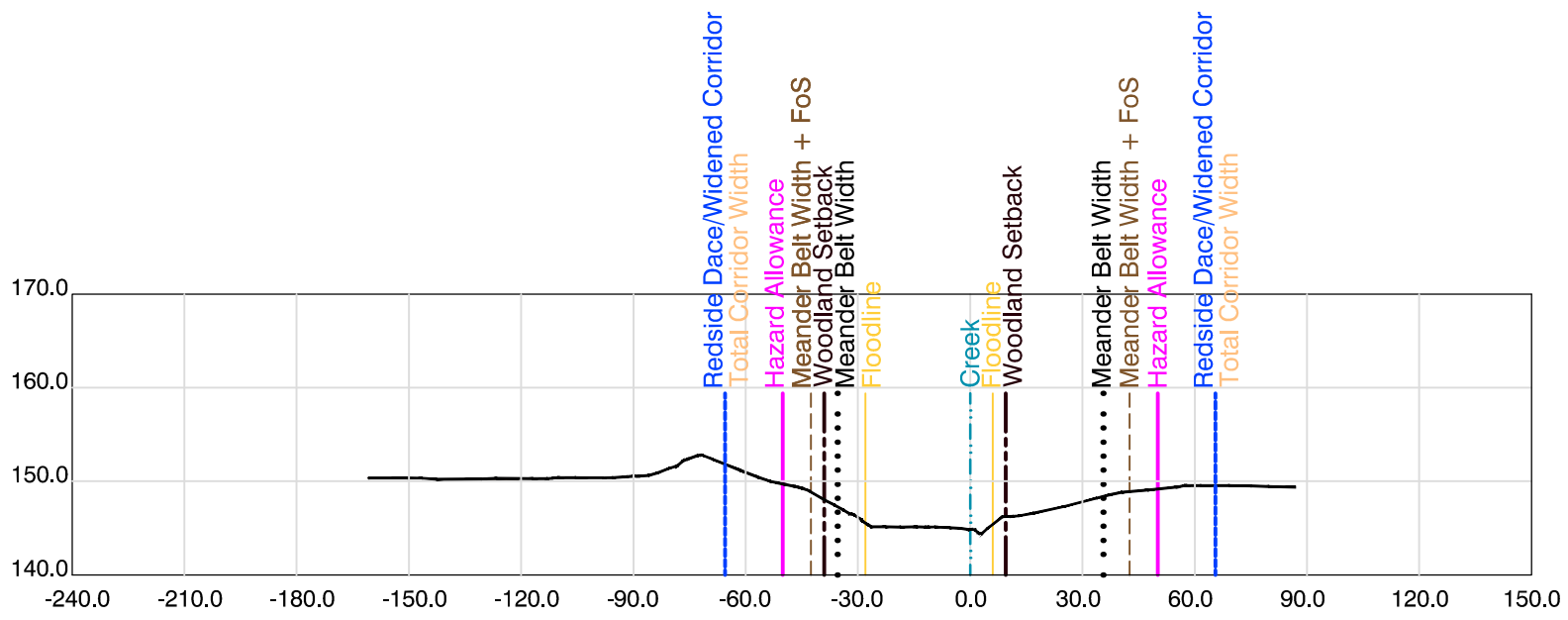
Project No.: 14-09222-001-WR1

Aerial Photo

Figure 6.3A

FIGURE 6.3A - Top of Bank Delineation - 14W-11.dwg Layout 1 \\thfler1.mmm.ca\cad$\14-41\14\09222-001-WR1\REPORT 15 FEB 2019\FIGURES SERIES 6\ Apr 05, 2019 - 11:18am





Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Cross- Section Downstream of SWM Pond3 (Ultimate Phase)

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- REDSIDE DACE/WIDENED CORRIDOR
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale
1:2000 0 25 50 75 100m

Client
QuadReal

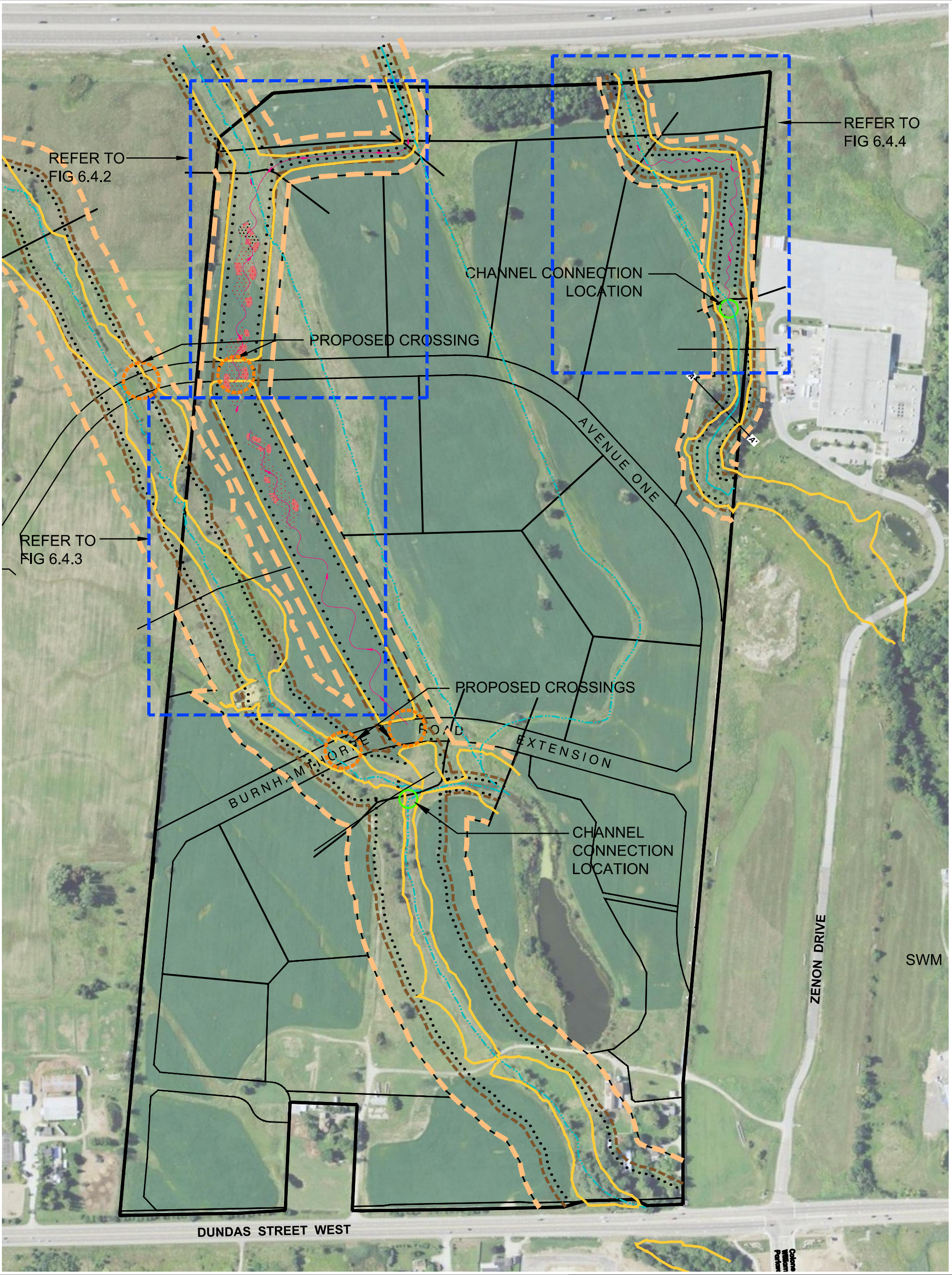
Prepared by
wsp

Date
April 2019

Project No.
14-09222-001-WR1

Aerial Photo

Figure 6.3B



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

14 Mile Creek Natural Channel Design Alignment And Planform -Key Plan (Ultimate Phase)

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- CHANNEL DIVERSION / REHABILITATION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 50 100 150 200 250m

Client: QuadReal

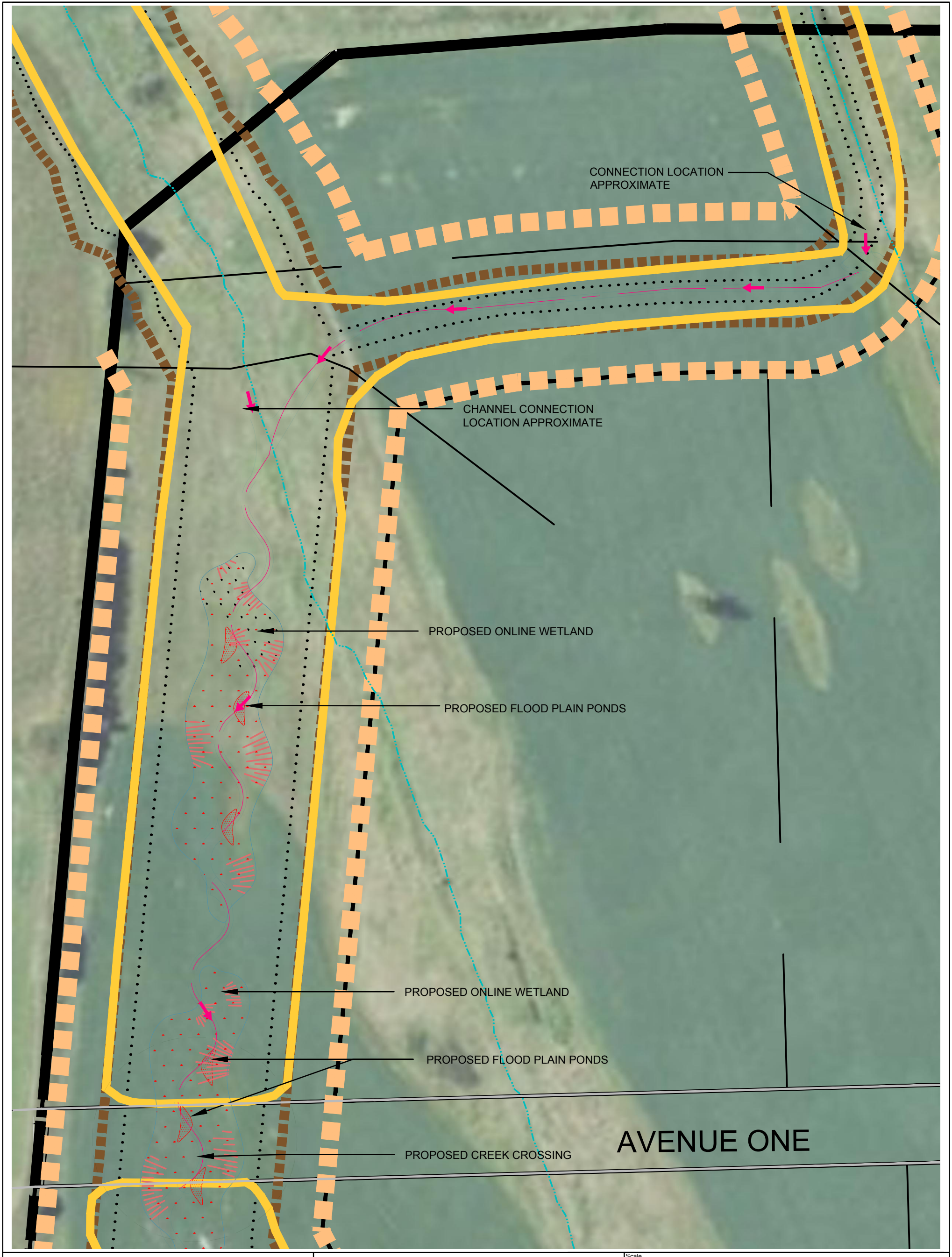
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.4.1



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Diversion Channels 14W-21 And 14W-22 Alignment And Planform

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- CHANNEL DIVERSION / REHABILITATION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 10 20 30 40 50m

Client: QuadReal

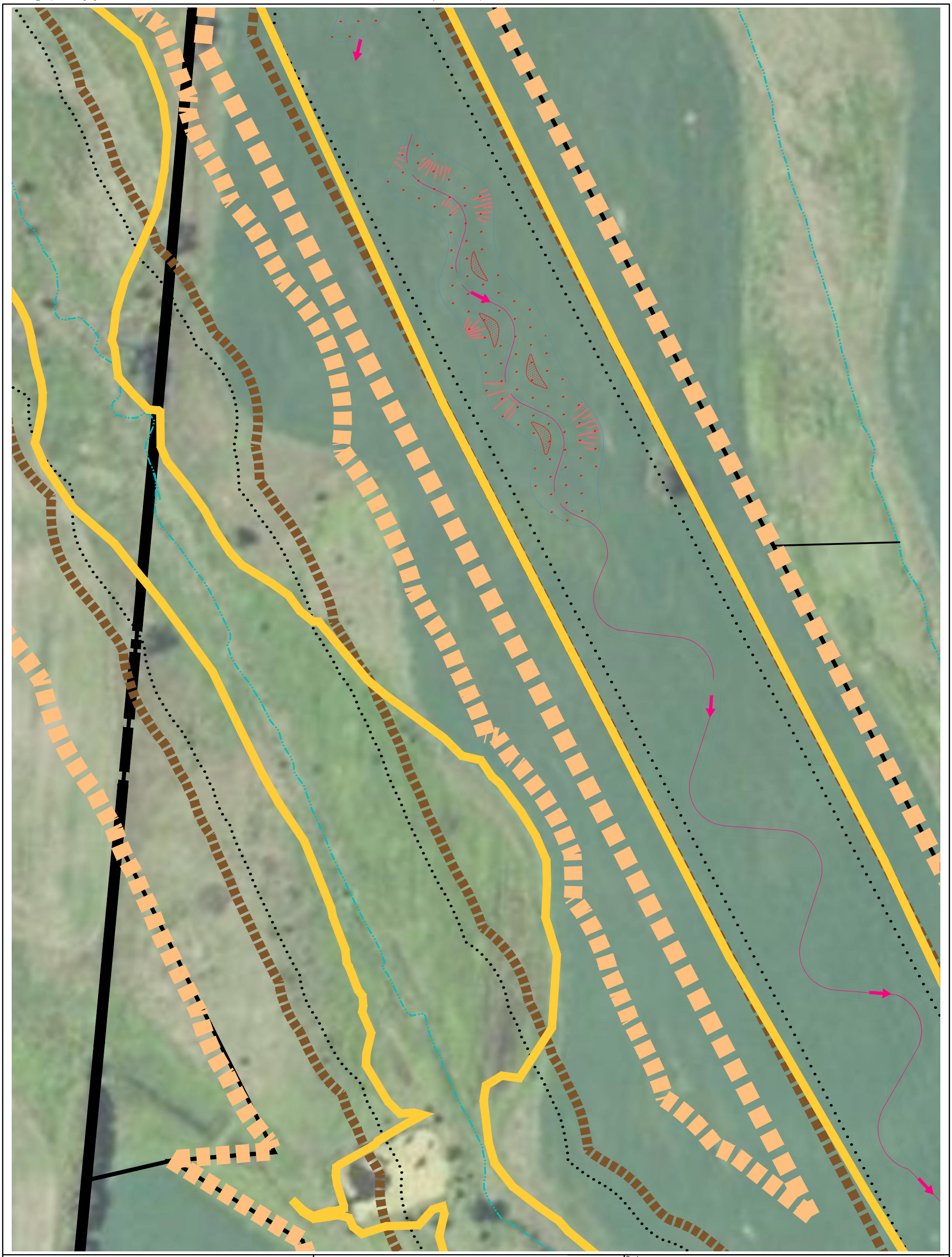
Prepared by: wsp

Date: April 2019

Project No.: 09M- 00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.4.2



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Diversion Channels 14W-22 And reach 14W-16 Rehabilitation Alignment And Planform

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- CHANNEL DIVERSION / REHABILITATION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 10 20 30 40 50m

Client: QuadReal

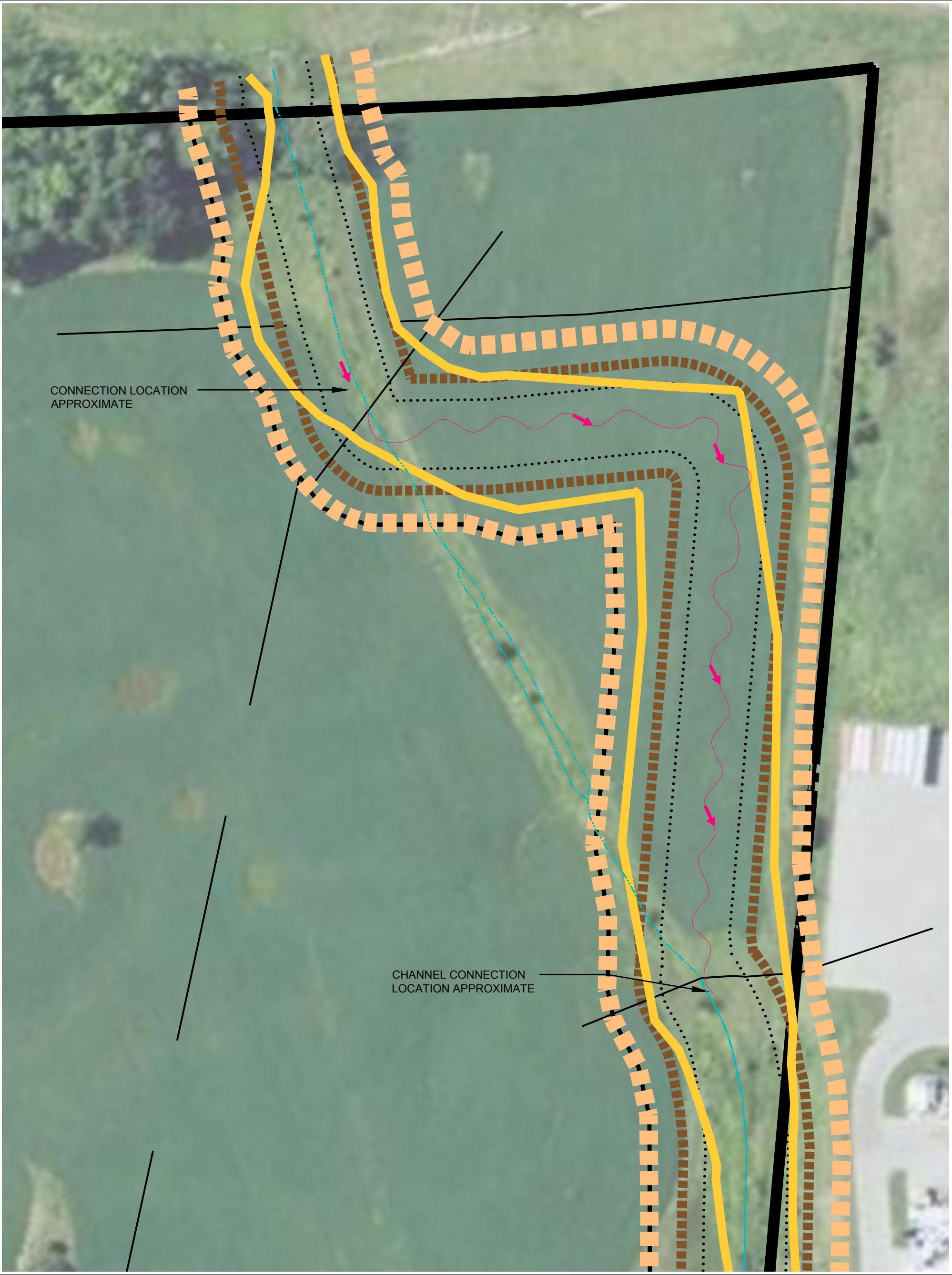
Prepared by: wsp

Date: April 2019

Project No.: 09M- 00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.4.3



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Diversion Channels 14W-23 and 14W-11 Alignment And Planform

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- CHANNEL DIVERSION / REHABILITATION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 10 20 30 40 50m

Client: QuadReal

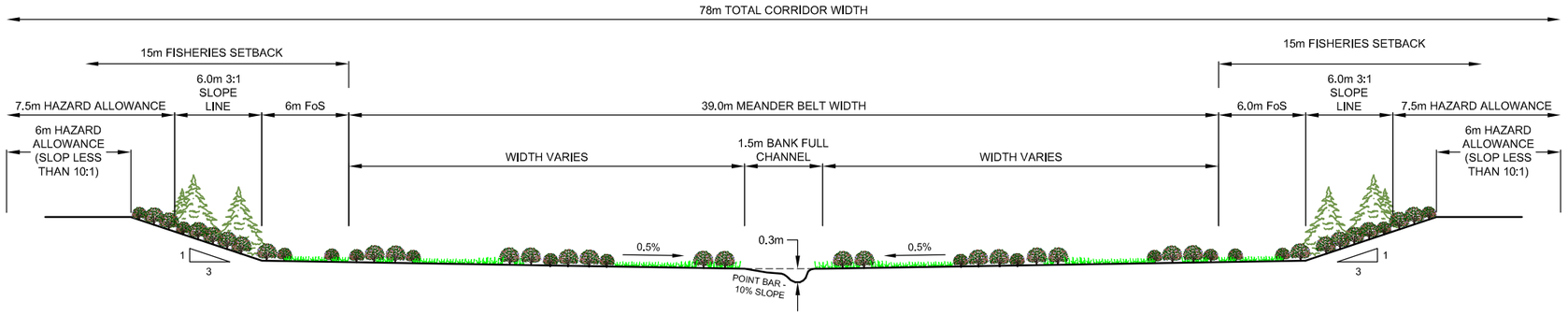
Prepared by: wsp

Date: April 2019

Project No.: 09M- 00013-01-WR1

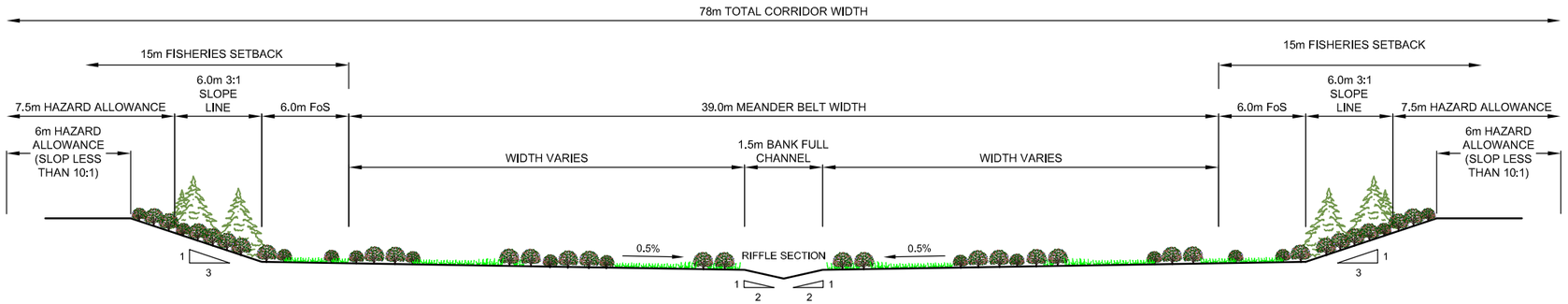
Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.4.4



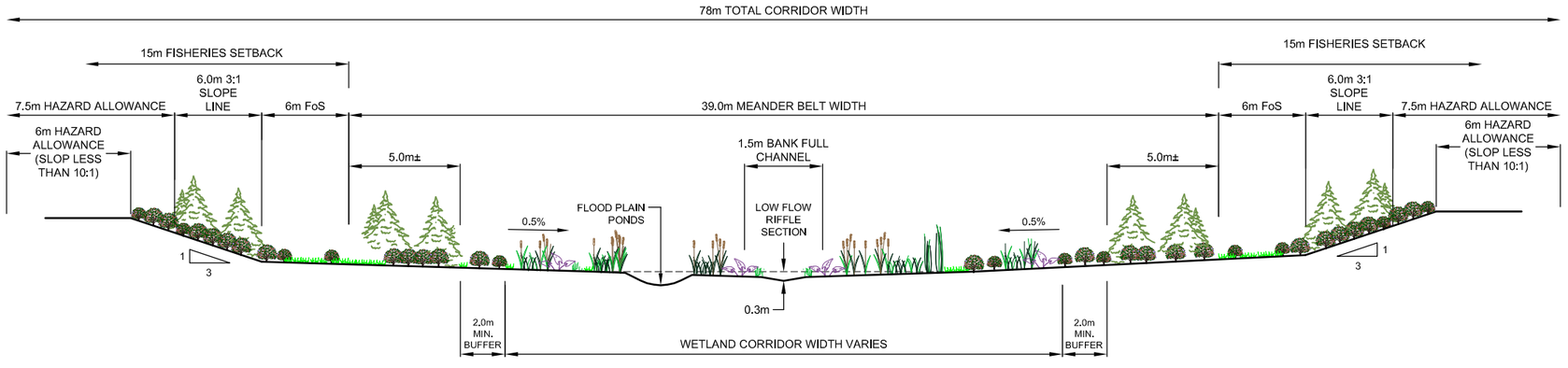
CHANNEL CORRIDOR - CHANNEL OUTSIDE BEND

N.T.S.



CHANNEL CORRIDOR - CHANNEL RIFFLE SECTION BEND

N.T.S.



CHANNEL CORRIDOR - WETLAND LOCATION

N.T.S.

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Channel Corridor Sections Typical For 14W-22

Scale: AS NOTED

Client: QuadReal

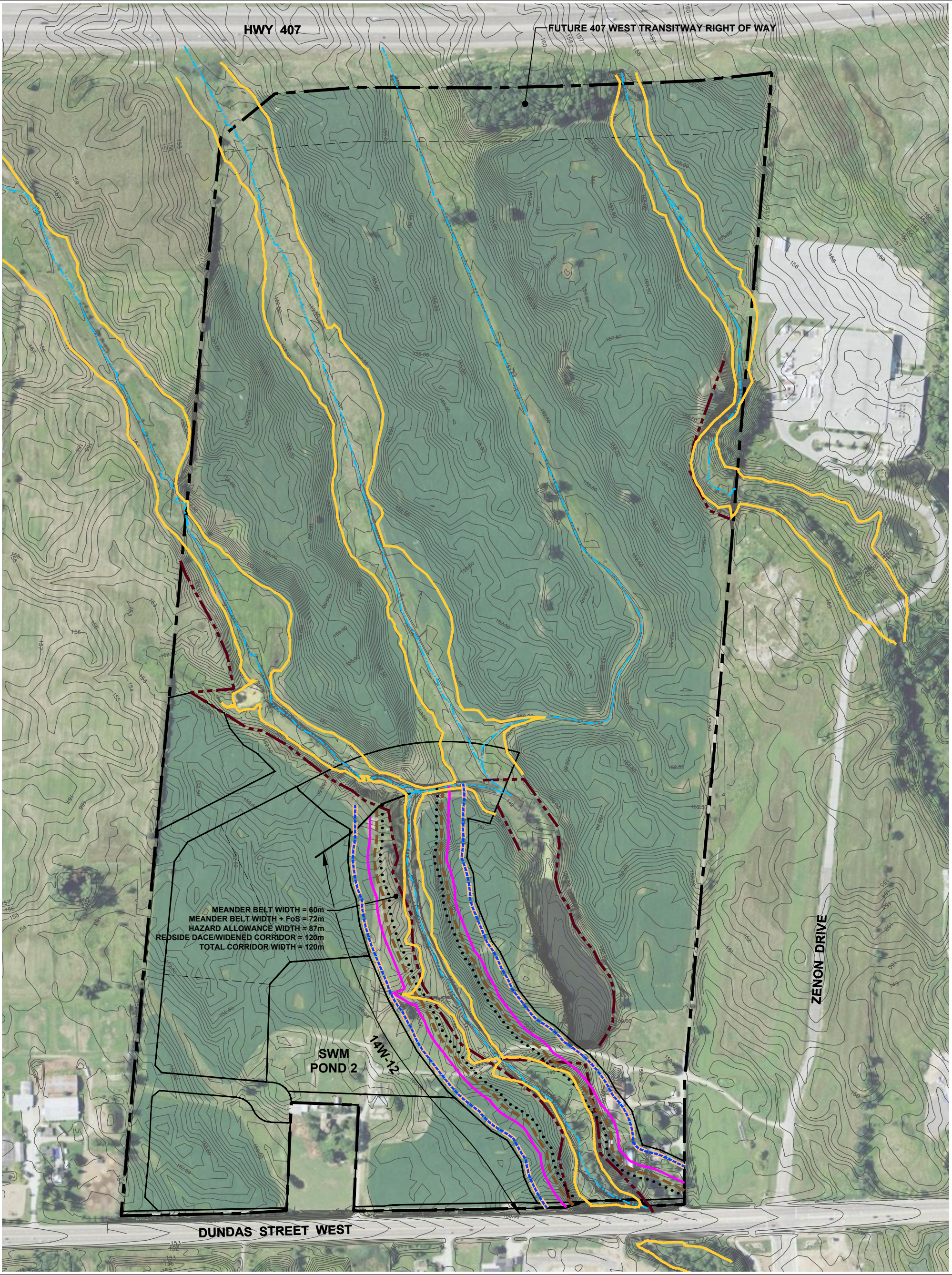
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo

Figure 6.4.5



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Corridor Delineation - Interim Phase 1A Conditions

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- PROPOSED DIVERSION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- REDSIDE DACE/WIDENED CORRIDOR
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 50 100 150 200m

Client: QuadReal

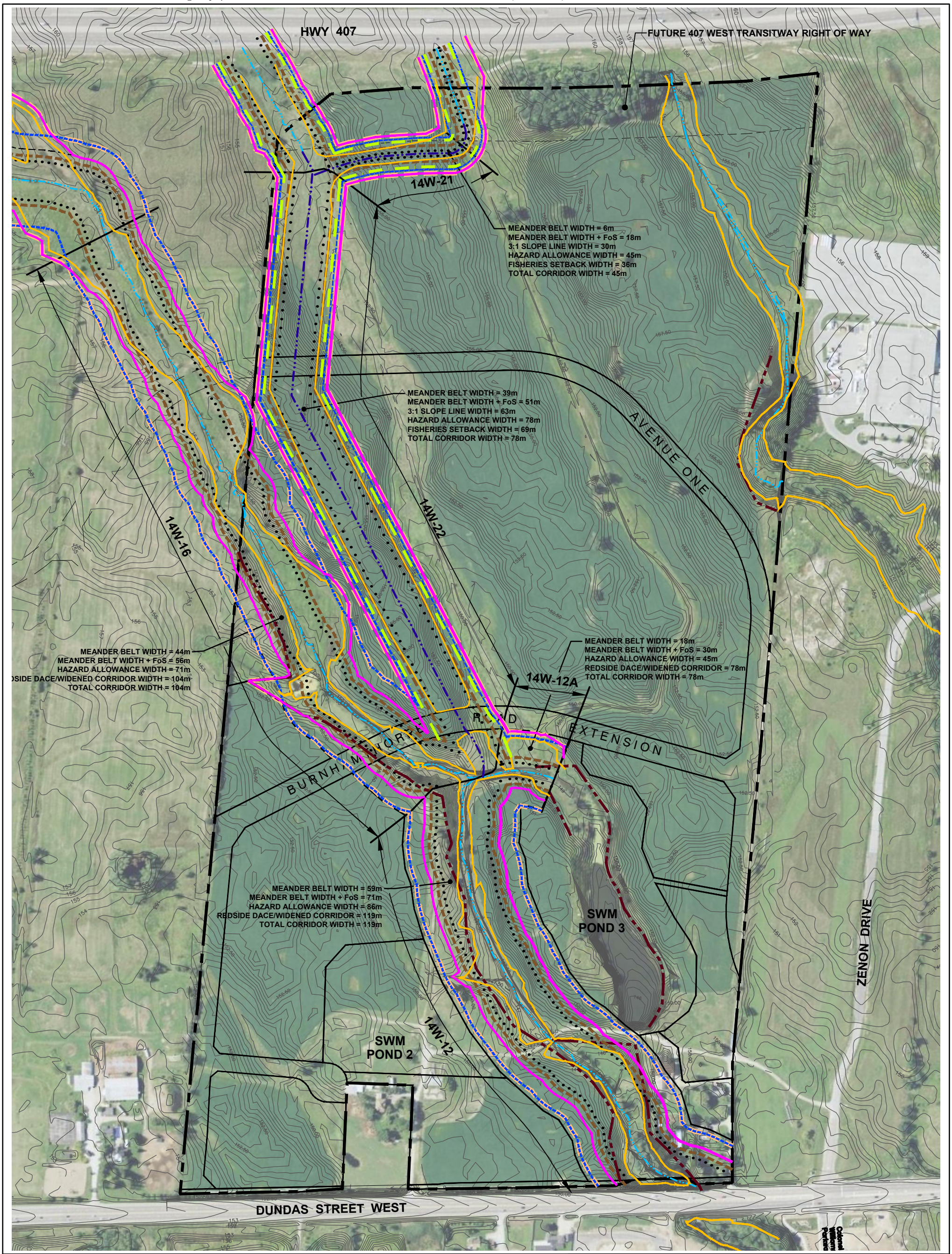
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.5.1



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Corridor Delineation - Interim Phase 1B Conditions

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- PROPOSED DIVERSION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- 3:1 SLOPE LINES FOR PROPOSED CONFINED CHANNEL
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- FISHERIES SETBACKS (30m FOR REDSIDE DACE STREAM) (15m FOR NON-REDSIDE DACE STREAM)
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 50 100 150 200m

Client: QuadReal

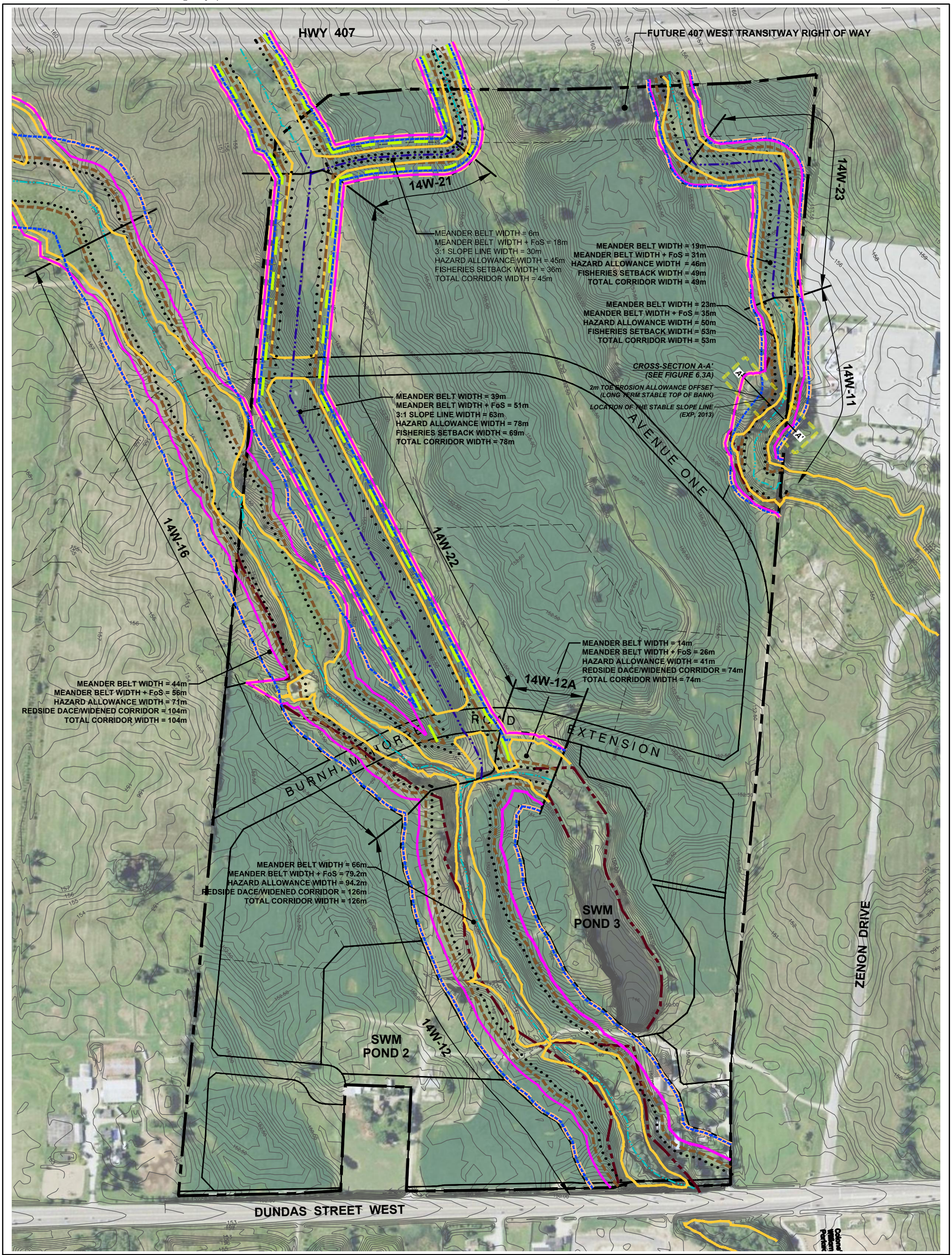
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.5.2



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Corridor Delineation - Interim Phase 2 Conditions

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- PROPOSED DIVERSION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- 3:1 SLOPE LINES FOR CONFINED CHANNEL
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- FISHERIES SETBACKS (30m FOR REDSIDE DACE STREAM) (15m FOR NON-REDSIDE DACE STREAM)
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 50 100 150 200m

Client: QuadReal

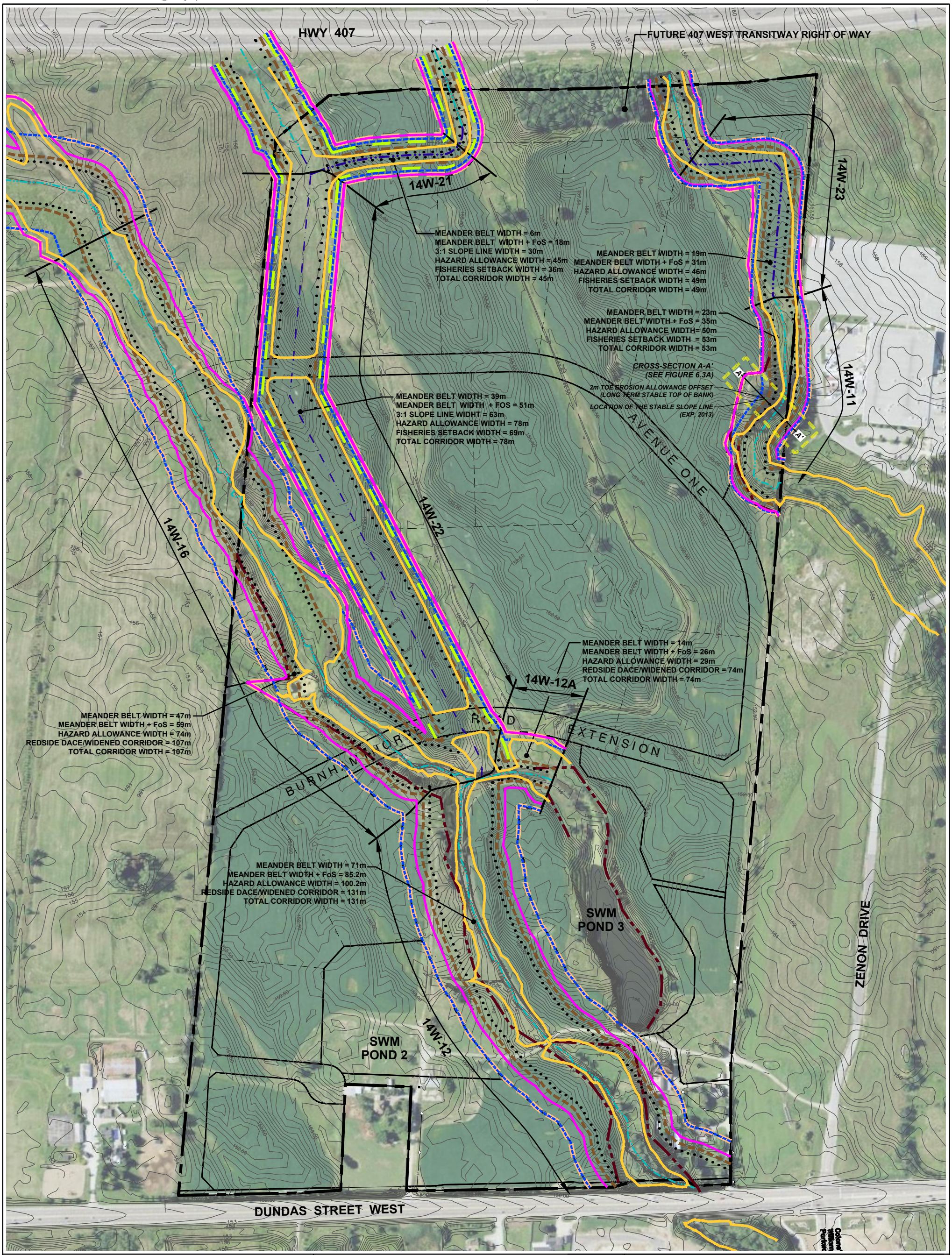
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.5.3



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Corridor Delineation - Ultimate Conditions

LEGEND

- SUBJECT PROPERTY
- EXISTING CREEK
- PROPOSED DIVERSION
- MEANDER BELT WIDTH
- MEANDER BELT + FoS
- 3:1 SLOPE LINES FOR PROPOSED CONFINED CHANNEL
- HAZARD ALLOWANCE
- WOODLAND SETBACK
- FISHERIES SETBACKS (30m FOR REDSIDE DACE STREAM) (15m FOR NON-REDSIDE DACE STREAM)
- REGULATORY FLOODPLAIN
- TOTAL CORRIDOR WIDTH

Scale: 0 50 100 150 200m

Client: QuadReal

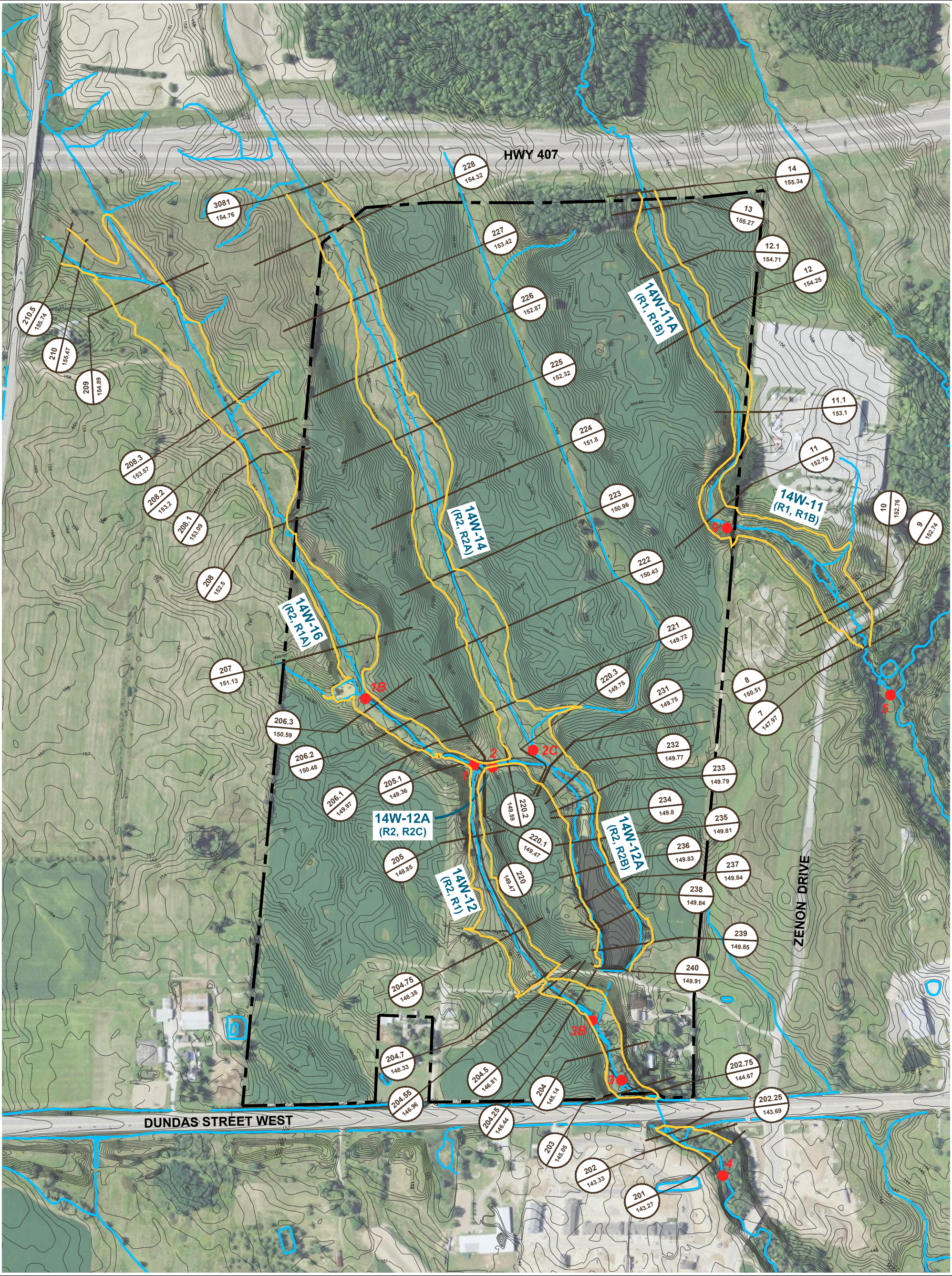
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.5.4



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

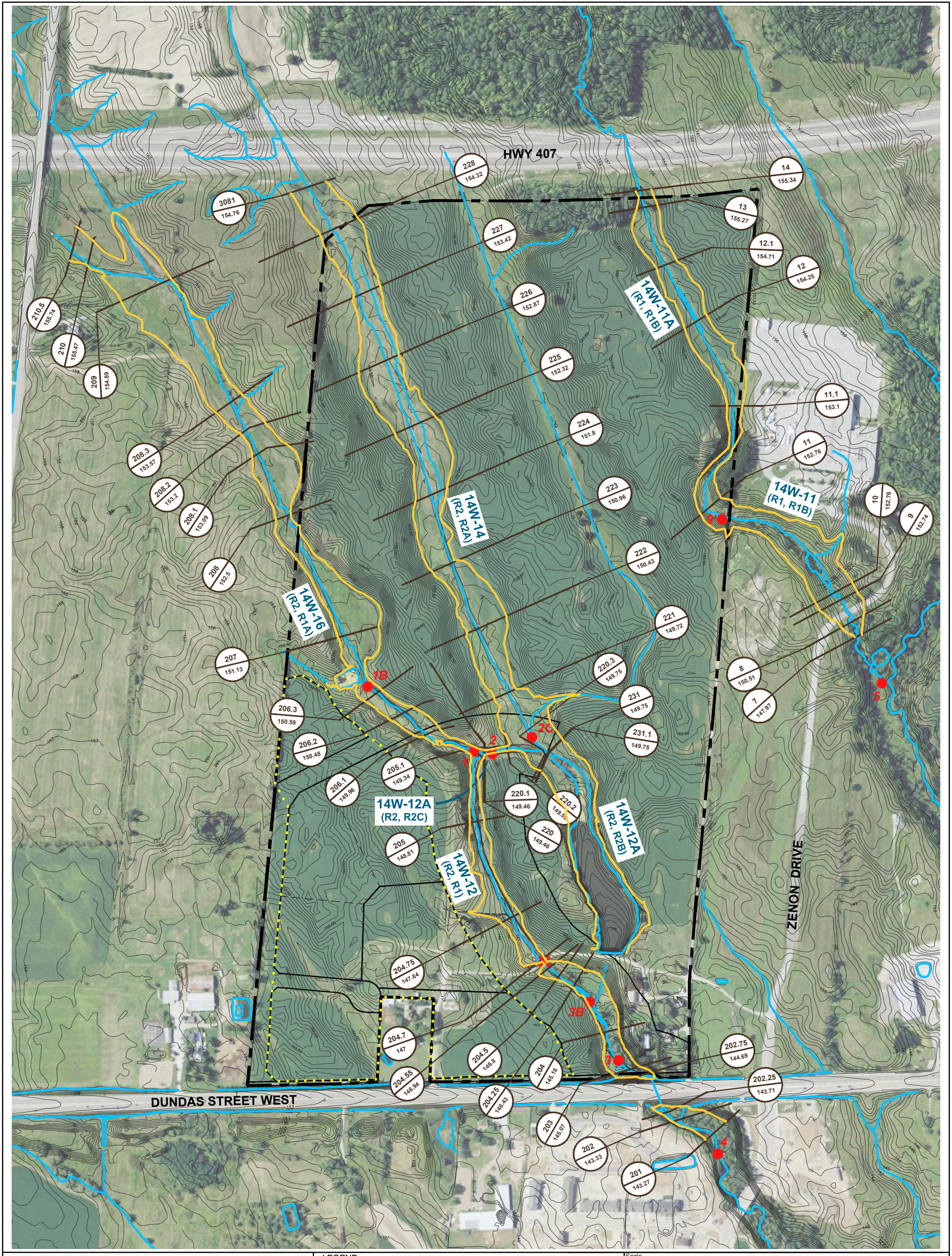
Hec-Ras Cross-Sections Existing Conditions

LEGEND

- SUBJECT PROPERTY
- EXISTING REGIONAL FLOODLINE
- HEC-RAS CROSS-SECTION
- 201 / 143.21 — WSP HEC-RAS CROSS-SECTION ID. / REGIONAL FLOOD ELEVATION (masl)
- 3B — HYDROLOGY MODEL FLOW NODES
- 14W-12 (R2, R1) — REACH (EIS/FSS) / REACH ID. / RIVER ID.

Scale: 0 50 100 150 200 250m

Client: QuadReal	Prepared by: wsp
Date: April 2019	Project No.: 09M-00013-01-WR1
Aerial Photo: © DigitalGlobe 2010, Google 2009	**Figure 6.6.1**



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Hec-Ras Cross-Sections Interim Phase 1A Conditions

LEGEND

- SUBJECT PROPERTY
- DEVELOPMENT BOUNDARY
- INTERIM PHASE 1A REGIONAL FLOODLINE
- HEC-RAS CROSS-SECTION
- 201 / 143.21 — WSP HEC-RAS CROSS-SECTION ID. / REGIONAL FLOOD ELEVATION (masl)
- 3B — HYDROLOGY MODEL FLOW NODES
- FARM ACCESS ROAD CULVERT REMOVED
- 14W-12 (R2, R1) — REACH (EIS/FSS) / REACH ID. / RIVER ID.

Scale: 0 50 100 150 200 250m

Client: QuadReal

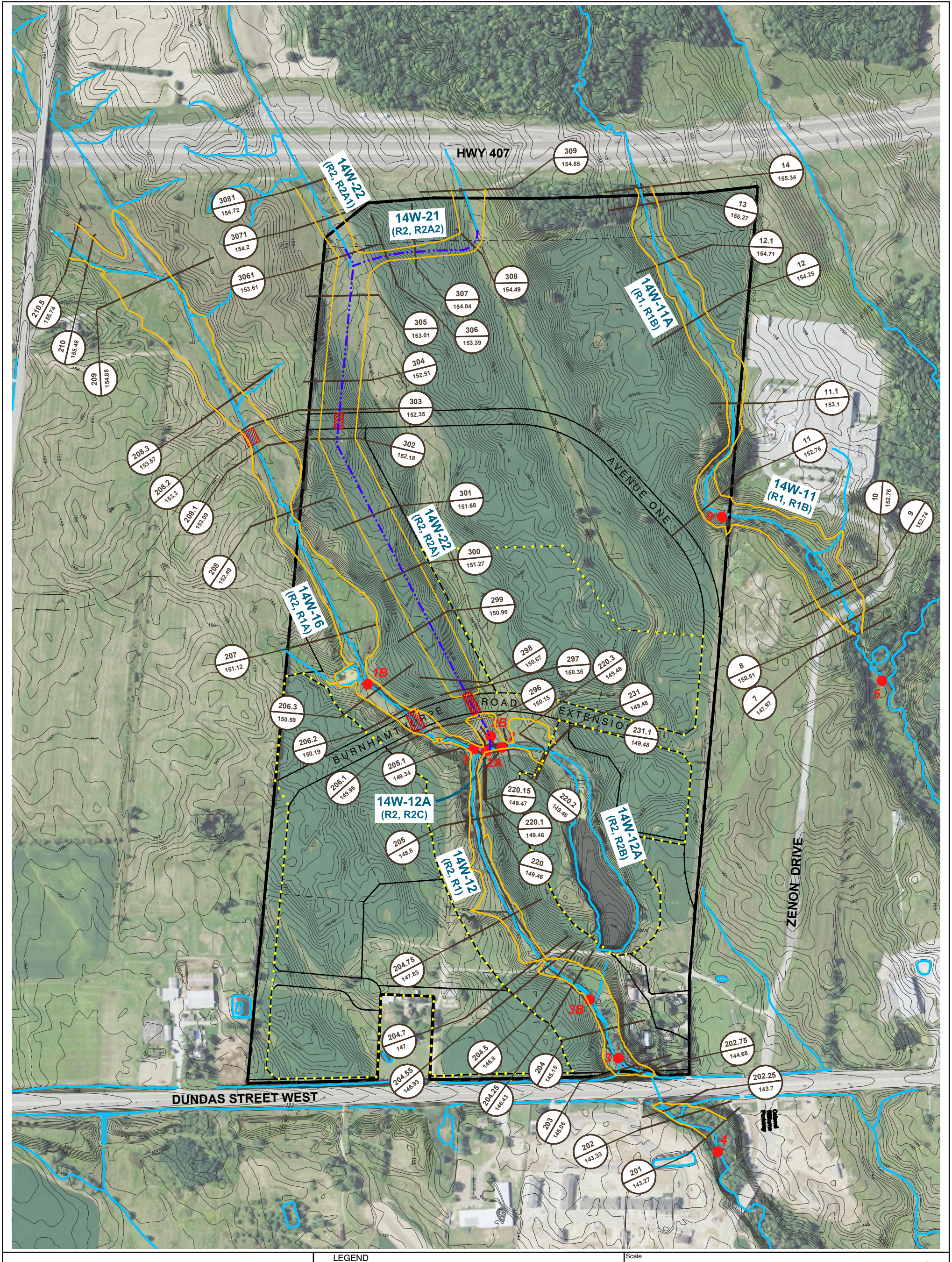
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.6.2



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Hec-Ras Cross-Sections Interim Phase 1B Conditions

LEGEND

- SUBJECT PROPERTY
- DEVELOPMENT BOUNDARY
- INTERIM PHASE 1B REGIONAL FLOODLINE
- HEC-RAS CROSS-SECTION
- 201 / 143.21 — WSP HEC-RAS CROSS-SECTION ID. / REGIONAL FLOOD ELEVATION (masl)
- 3B — HYDROLOGY MODEL FLOW NODES
- PROPOSED ROAD CROSSING
- 14W-12 (R2, R1) — REACH (EIS/FSS) / REACH ID. / RIVER ID.

Scale: 0 50 100 150 200 250m

Client: QuadReal

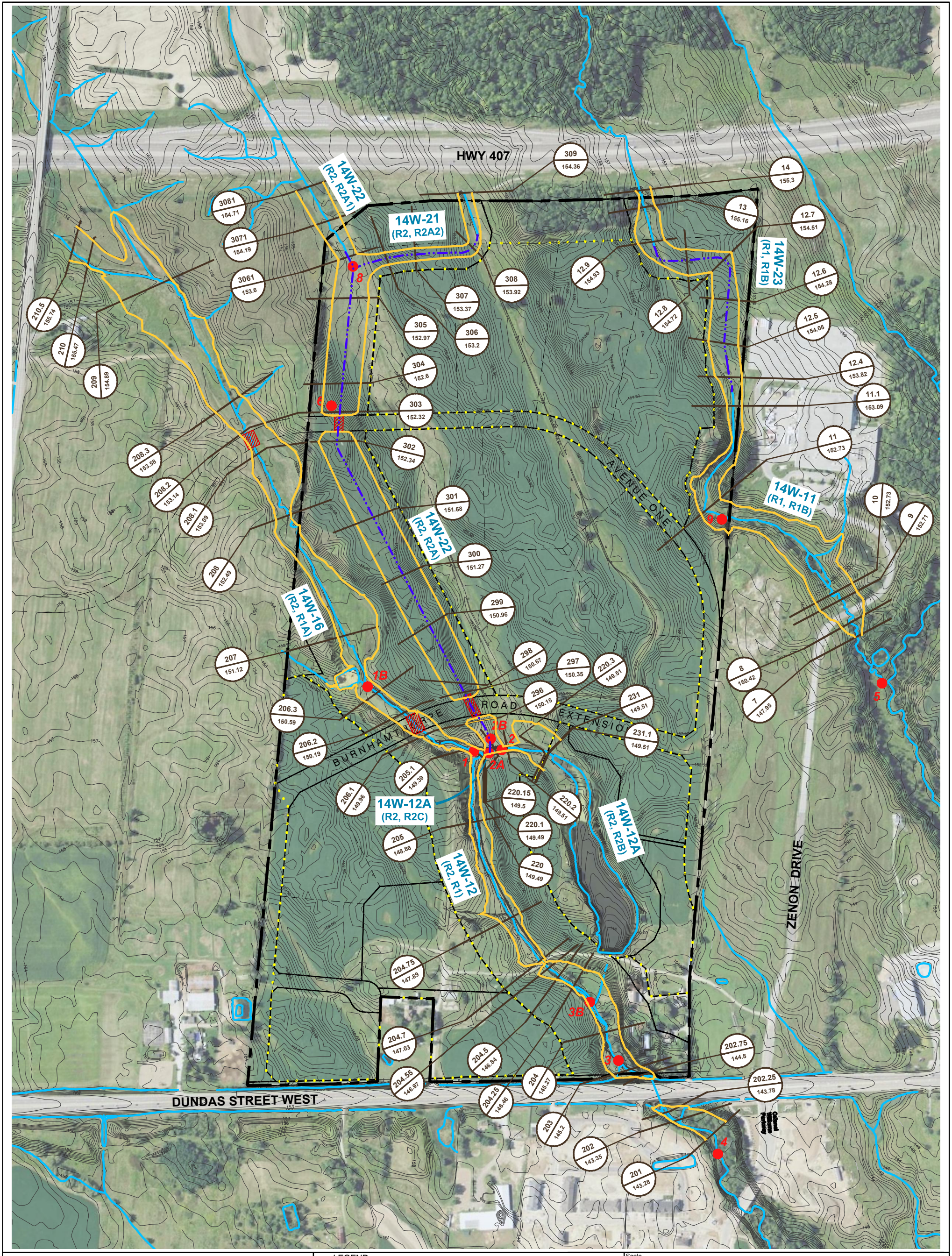
Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.6.3



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

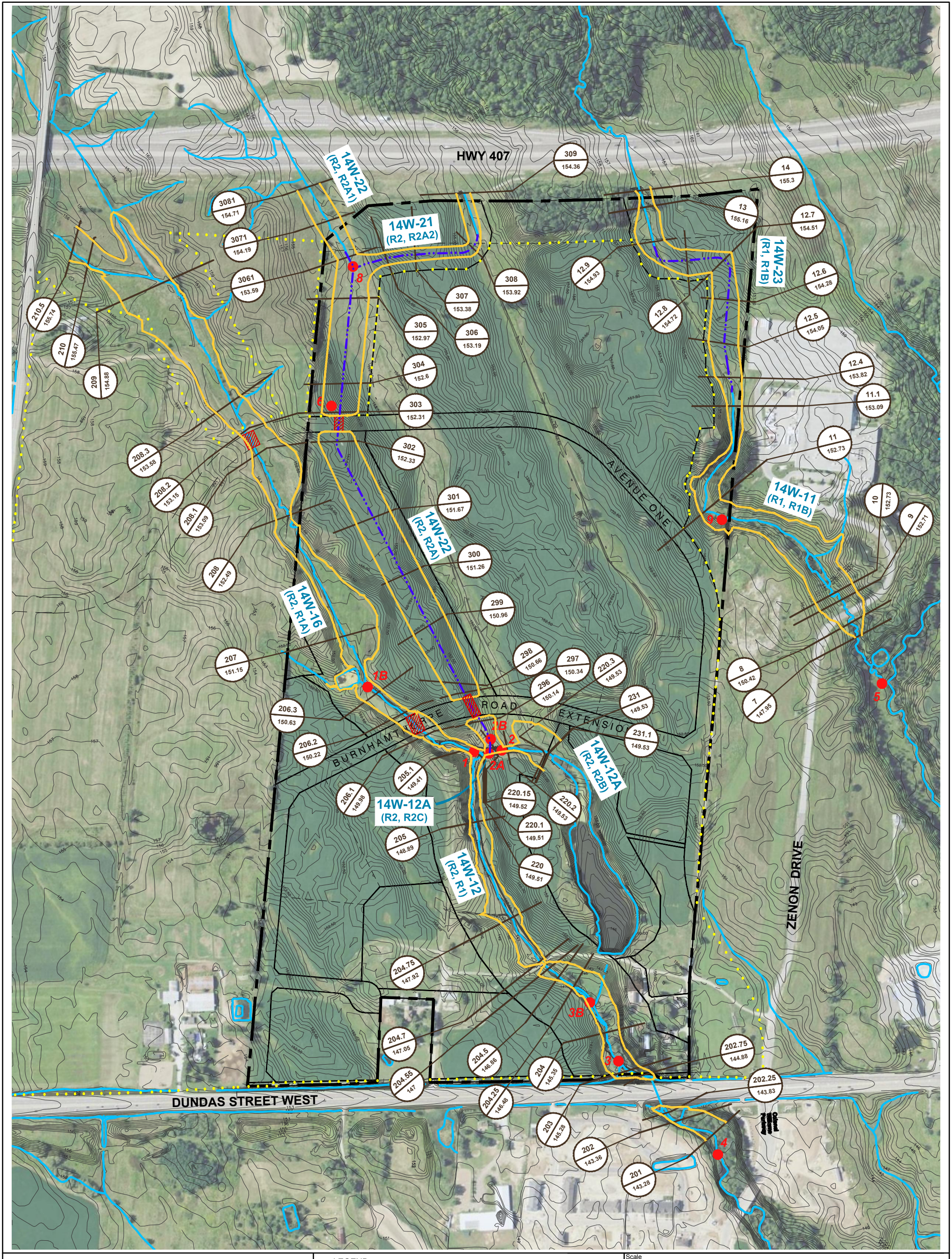
Hec-Ras Cross-Sections Interim Phase 2 Conditions

LEGEND

- SUBJECT PROPERTY
- DEVELOPMENT BOUNDARY
- INTERIM PHASE 2 REGIONAL FLOODLINE
- HEC-RAS CROSS-SECTION
- 201 / 143.21 — WSP HEC-RAS CROSS-SECTION ID. / REGIONAL FLOOD ELEVATION (masl)
- 3B — HYDROLOGY MODEL FLOW NODES
- PROPOSED ROAD CROSSING
- 14W-12 (R2, R1) — REACH (EIS/FSS) / REACH ID. / RIVER ID.

Scale: 0 50 100 150 200 250m

Client: QuadReal	Prepared by: wsp
Date: April 2019	Project No.: 09M-00013-01-WR1
Aerial Photo: © DigitalGlobe 2010, Google 2009	**Figure 6.6.4**



Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Hec-Ras Cross-Sections Ultimate Conditions

LEGEND

- SUBJECT PROPERTY
- DEVELOPMENT BOUNDARY
- ULTIMATE REGIONAL FLOODLINE
- HEC-RAS CROSS-SECTION
- 201 / 143.21 — WSP HEC-RAS CROSS-SECTION ID. / REGIONAL FLOOD ELEVATION (masl)
- 3B — HYDROLOGY MODEL FLOW NODES
- PROPOSED ROAD CROSSING
- 14W-12 (R2, R1) — REACH (EIS/FSS) / REACH ID. / RIVER ID.

Scale: 0 50 100 150 200 250m

Client: QuadReal

Prepared by: wsp

Date: April 2019

Project No.: 09M-00013-01-WR1

Aerial Photo: © DigitalGlobe 2010, Google 2009

Figure 6.6.5