Appendix G

Conceptual Design of the Springbank Off-Stream Flood Storage Site

Southern Alberta Flood Recovery Task Force
Volume 4 – Flood Mitigation Measures

Appendix G – Springbank Off-Stream Storage Project

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1.0 SPRINGBANK OFF-STREAM STORAGE PROJECT

1.1 Concept Description

The Springbank Off-stream storage (SR1) site was identified as a part of the current flood mitigation study. It is located just west of Calgary approximately 18.5 km upstream of the Glenmore Reservoir in a relatively undeveloped farmland and ranchland area valley.

This SR1 concept considers diverting extreme flood flow from the Elbow River into an off-stream storage reservoir where it would be temporarily contained and later released back into the Elbow River after the flood peak has passed. Project components include a diversion structure constructed across the Elbow River, and a diversion channel excavated through the adjacent uplands to transport flood water into an off-stream storage reservoir. The storage site includes an earthfill dam to temporarily contain the diverted flood water and a low level outlet structure incorporated into the dam to later release the stored water back into the Elbow River after the flood peak has passed. The diversion system, off-stream dam site and reservoir area are illustrated in **Drawing G1**.

The SR1 could be designed as a dry pond (i.e., no storage reservoir except during flood periods) or could include permanent multi-use water storage with much larger flood storage volume above the permanent multi-use storage full supply level (FSL). The multi-use water could be used for recreational/environmental purposes, and/or an additional water supply source for the City of Calgary, and/or for other uses during periods of low river flow or drought. This storage would also serve to dissipate energy when flood water first enters the reservoir. For the purpose of this conceptual assessment a multi-use storage containment of 9,000 dam^3 has been assumed providing a maximum pond depth of 10 m.

The potential use, FSL, volume, and regulation of the permanent multi-use storage component of the reservoir requires further investigation. Future climate change and sediment infilling of Glenmore Reservoir (loss of existing storage due to long-term sedimentation) should be key considerations. Bathymetric surveys indicate that Glenmore Reservoir may have lost 17% of its storage volume since 1933 as a result of river sediment transport.

Some portion of the above-noted multi-use storage could be considered for flood storage (e.g., reservoir lowered in spring in advance of incoming flood, then refilled after flood risk has passed). Multi-use storage has not been included as available flood storage in this conceptual design.

2.0 HYDROLOGICAL OVERVIEW

2.1 Median and Mean Monthly Flows

Median winter and median annual flows for the Elbow River are approximately 4 and 10 m^3/s, respectively, as recorded at ESRD gauging station 05BJ010 (Elbow River at Sarcee Bridge). Mean monthly flows as recorded at station 05BJ010 are provided in **Table G2.1**.

Table G2.1
Elbow River Mean Monthly Flows

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Flow (m^3/s)	3.5	3.6	4.1	5.3	14.8	27.6	15.2	9.6	8.3	6.6	5.2	4.1

The Springbank Road site is located approximately 16 km upstream of this gauging station, resulting in a 30% reduction in drainage area. The impact of this area's reduction on median and mean monthly flows has not been estimated as a part of this study, but will be much less than 30%.

2.2 Flood Flows

Frequency analysis of flood inflows into Glenmore Reservoir (i.e., 21 km downstream of the Springbank Road diversion site as discussed herein) which was completed for this study resulted in instantaneous flood peak flow and 7-day flood volume estimates as summarized in **Table G2.2**. These estimates are considered to be representative of the upstream Springbank diversion site (i.e., assumes minimal inflow between diversion site and Sarcee Bridge during extreme flood events generated in higher regions of the basin). Background information which provides the basis for these flood estimates is documented separately in **Appendix C** of the main report. Estimates of the June 2013 flood instantaneous peak flow and total flood volume entering Glenmore Reservoir are included for comparison in **Table G2.2**.

Table G2.2
Elbow River Instantaneous Flood Peak and Runoff Volume Estimates

Annual Flood Probability (Return Period)	Instantaneous Peak Flow (m^3/s)	7-day Volume dam^3
5% Annual Exceedence Probability (AEP; 1:20-year)	440	83,000
1% AEP (1:100-year)	930	130,000
June 2013 Flood	1,260	154,000
0.2% (1:500-year)	1,625	183,000

As indicated by **Table G2.2,** the June 2013 flood instantaneous peak flow and flood volumes were larger than the estimated 1% AEP flood but smaller than the 500-year flood. More detailed frequency analysis should be performed as part of future, more detailed design study.

2.3 Probable Maximum Flood

The Probable Maximum Flood (PMF) is defined as the most severe flood that may be reasonably expected to occur at a particular location. The PMF is normally evaluated by deterministic methods that maximize the various factors contributing to the generation of a flood. The probability of such a flood occurring is very rare (e.g., once in a million years).

A PMF hydrograph at Glenmore Reservoir was previously generated by ESRD and is included in the August 1986 *Elbow River Floodpain Management Study* by WER, IBI and ECOS. The PMF entering Glenmore Reservoir was estimated to have a flood peak value of 3,030 m^3/s and a 7-day volume of approximately 640,000 dam^3, which is approximately 4.2 times the volume of the 2013 flood. ESRD cautions:

> "…that these are preliminary estimates of PMF…subject to considerable error and that a detailed assessment….would be required prior to any detailed design."

3.0 GEOLOGICAL AND GEOTECHNICAL OVERVIEW

A preliminary subsurface field investigation was completed as a part of this study as documented in a separate report entitled *Preliminary Geotechnical Investigation Report, Springbank Off-stream Dam Project* (AMEC, 2014).

The SR1 site is located near the eastern edge of the foothills. The bedrock underlying the area transitions from the Paleocene/Upper Cretaceous Brazeau Formation in the vicinity of the diversion structure, to bedrock of the Paleocene Porcupine Hills Formation farther east and north toward the north end of the off-stream storage dam. Both formations are non-marine deposits generally consisting of cross-bedded and interbedded sandstone, mudstone, and siltstone. A bedrock exposure approximately 12 m high overlain with glacial till is evident in the left valley wall of the Elbow River at the site of the proposed diversion structure.

The findings of the above-noted preliminary geotechnical field investigation program indicate that subsurface soils in the area of the proposed diversion channel, off-stream dam, and reservoir generally consist of medium plastic clay and clay till soil underlain by bedrock consisting of interlayed mudstone, sandstone, and siltstone. Subsurface materials underlying the proposed diversion structure system are expected to consist primarily of fluvial sand and gravel deposits, while the subgrade underlying the dam is expected to consist of a mixture of clay, silt, sand, and gravel soils. The soils encountered during the field investigation are expected to be suitable as foundation materials for the embankments and structures associated with the proposed project development. The clay and clay till soils are also suitable for use in embankment construction for the floodplain berm, diversion channel fills, and the off-stream storage dam embankment.

Granular materials required for structure backfill, dam filters, and drains would need to be brought in from off-site sources. Rock riprap and cobble armour protection would similarly need to be brought in from off-site sources.

4.0 FLOOD STORAGE VOLUME

4.1 Background Considerations

Significant residential development located along the Elbow River floodplain downstream of Glenmore Reservoir is at risk during extreme flood events. Pathway closures are required when Glenmore Reservoir flood discharge reaches 40 m^3/s. Modest overbank flooding of undeveloped areas starts at 120 m^3/s discharge. Widespread basement seepage occurs for discharges of 140 m^3/s. First residents are impacted at discharges of 170 m^3/s. Evacuation of residents is initiated at a discharge of 192 m^3/s.

The most recent Glenmore Reservoir storage capacity and flooded area curves which were produced by Klohn Crippen Berger in 2013 are illustrated on **Figure G4.1**. The existing Glenmore Reservoir storage is used to attenuate flood peaks thereby protecting downstream developments. If an extreme flood is forecast, the City of Calgary opens the Glenmore Reservoir low level DOW valves thereby drawing the reservoir down to provide flood storage for the incoming flood. Maximum permissible drawdown is 5 m below FSL El. 1,076.85 m which equates to a flood storage volume of 15,400 dam^3 (KCB Glenmore Bathymetric Survey, 2013). This drawdown could be accomplished in 25 hours at the maximum discharge rate of 170 m^3/s (maximum discharge before significant downstream flood damages start to occur). In reality a portion of this storage should be drawn down well in advance of an actual flood event forecast (e.g., in the spring when significant snow pack exists in the watershed). The 15,400 dam^3 draw down was successfully achieved in anticipation of the June 2013 flood. The City of Calgary needs to use caution when drawing the reservoir down in that if they draw down the Glenmore Reservoir and the forecast flood does not develop they can be left with insufficient water supply.

Bathymetric surveys by Klohn Crippen Berger for the City of Calgary indicate that Glenmore Reservoir may have lost approximately 17% of its storage volume since 1933 as a result of sediment transport into the reservoir. This process is ongoing.

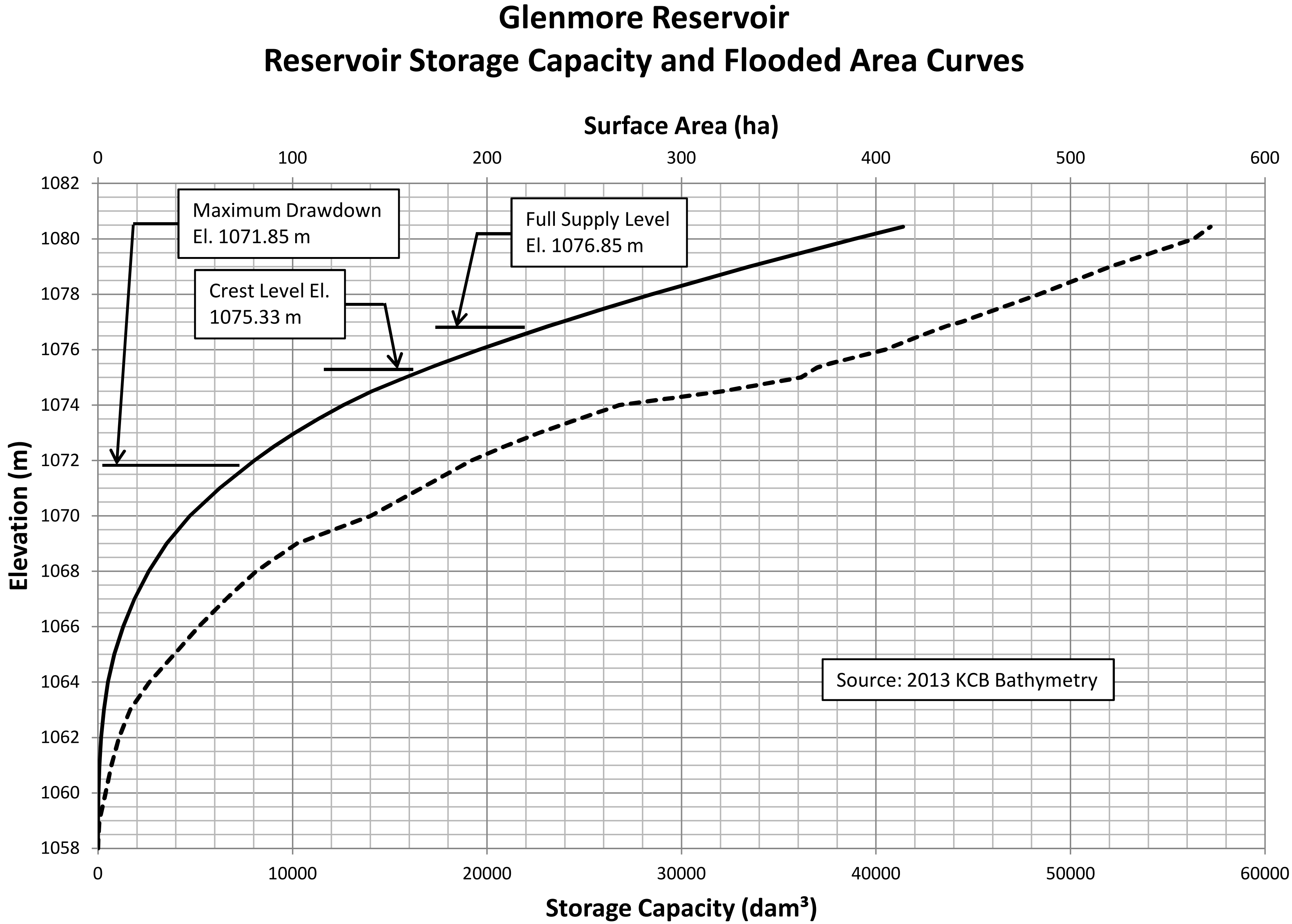
Table G4.1 provides estimates of the flood volume required to prevent significant damages along the Elbow River downstream of Glenmore Reservoir, considering a continuous discharge of 170 m^3/s from the reservoir for the duration of the flood (i.e., discharge before first downstream residents are impacted by flood water).

Table G4.1
Required Reservoir Flood Storage Volume to Prevent Damages

Return Period (Years)	Minimum Storage Requirement
5% AEP (1:20-year)	16,800
1% AEP (1:100-year)	56,600
June 2013 Flood	83,000
0.2% (1:500-year)	107,500

Based on the data presented in **Table G4.1,** one can conclude that the Glenmore Reservoir flood storage of 15,400 dam^3 is inadequate to prevent discharge from exceeding the 170 m^3/s value for floods events as small as the 20-year return period flood. The level of protection is even poorer if the City is not successful drawing Glenmore Reservoir down to its minimum El. 1,071.85 m prior to flood impact. It is therefore concluded that the existing level of protection to residences downstream of the Glenmore Reservoir is inadequate. That said, Glenmore Reservoir flood storage does provide significant flood peak attenuation and downstream development protection (e.g., as much as full protection for floods just smaller than 20-year return period, and successfully attenuated June 2013 flood inflow peak of 1,260 m^3/s to discharge of approximately 700 m^3/s).

Figure G4.1



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4.2 Flood Protection Design Basis

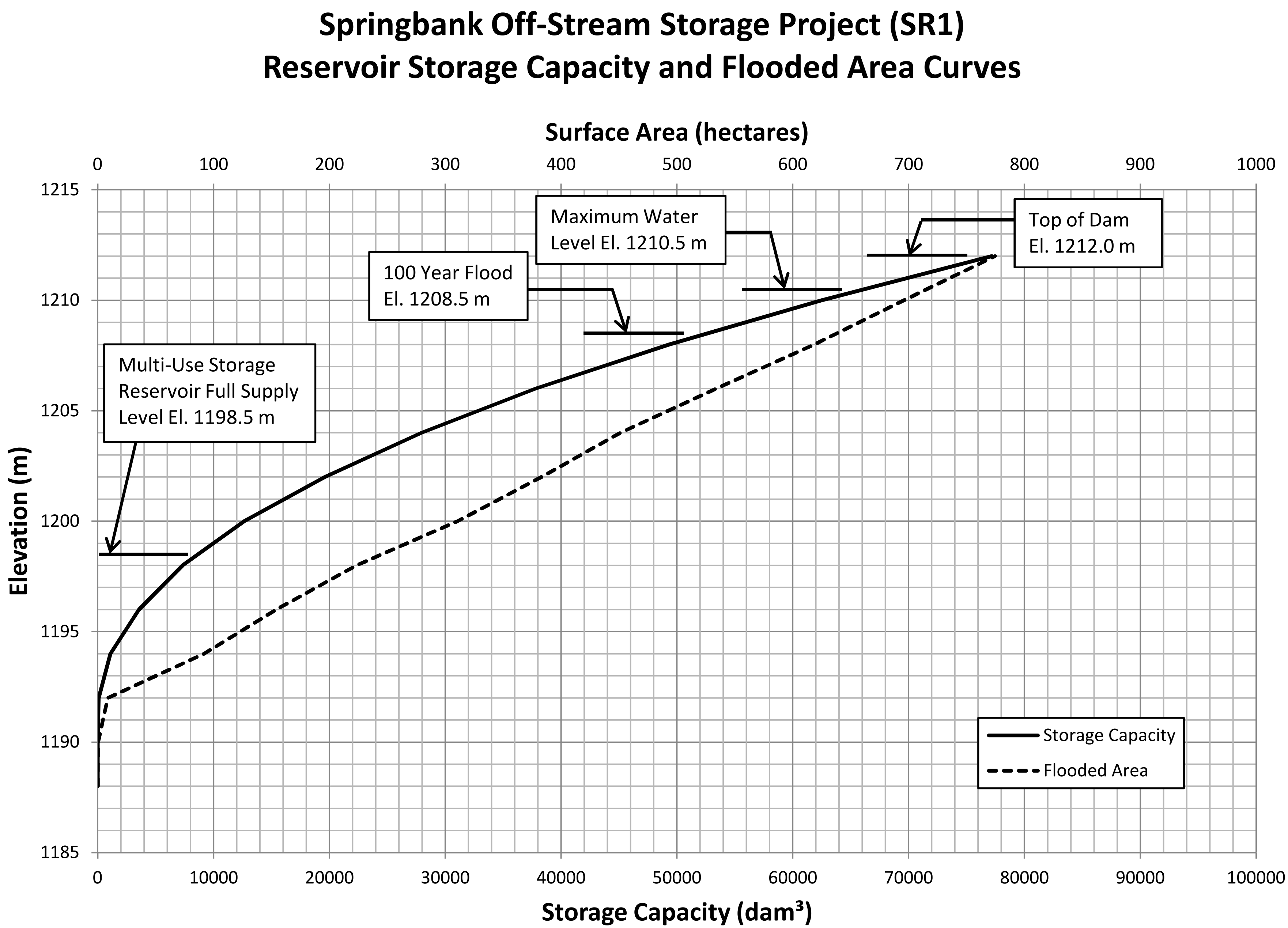
The current Alberta minimum flood protection design standard is the 1% AEP flood, or alternatively can be based on a historical flood event (e.g., June 2013 flood). Increased protection should be considered based on economic assessment and/or when such an event would result in severe societal impact. As an example, the Red River floodway was originally sized to protect Winnipeg from the 0.2% AEP (1:500-year) flood event. It was later enlarged to provide 0.14% AEP (1:700-year) flood protection. Even greater protection was considered but costs were proven to be prohibitive.

The SR1 concept as presented herein was developed considering the 1% AEP minimum design standard (i.e., total flood storage requirement of 56,600 dam^3). As previously mentioned, Glenmore Reservoir can provide 15,400 dam^3 of that amount. As indicated in **Figure G4.2,** the remaining 41,200 dam^3 flood storage could be provided with a Springbank off-stream storage reservoir water level of approximately El. 1,208.0 m. To account for operational inefficiencies a 1% AEP El. 1,208.5 m has been used. This conservatively assumes that none of the previously mentioned Springbank off-stream reservoir multi-use live storage was pre-released in anticipation of the flood. The conceptual design provides for a nominal 2 m additional storage above the 1% AEP El. 1,208.5 m (i.e., maximum allowable reservoir El. 1,210.5 m) resulting in a combined total flood storage capacity of 72,400 dam^3 (i.e., Glenmore and Springbank combined reservoir storage). Considering the project size presented in this conceptual design, a 2013 magnitude flood would still result in residential damages, but these damage would be greatly reduced as compared to what was experienced in 2013. The Springbank Road project could be built to a higher level than investigated herein to provide enhanced flood protection (e.g., full containment for 2013 magnitude flood or larger). Alternatively, additional projects could be constructed to provide enhanced flood protection above that provided herein.

Figure G4.2 area and capacity curves were developed based on contours developed from 15 m LiDAR, prior to obtaining the 1 m LiDAR illustrated on **Drawings G1** and **G8**. These area and capacity curves should be updated considering the 1 m LiDAR data in future design.

Figure G4.3 illustrates the potential flood flow reduction benefits of the Springbank and Glenmore Reservoir storage when managing the 1% AEP flood. The figure illustrates that a maximum 300 m^3/s flow would be diverted into the off-stream storage site reducing the river flow from 930 to 630 m^3/s at the diversion structure. This resulting 630 m^3/s flow rate is absorbed in Glenmore Reservoir storage. The resulting peak discharge from Glenmore Reservoir is 170 m^3/s; the maximum allowable discharge prior to residential damage. An Elbow River flow of 200 m^3/s has been set as a trigger condition to initiate diverting a portion of the Elbow River flood water into the off-stream storage site. Diversion would only be continued if a major flood develops.

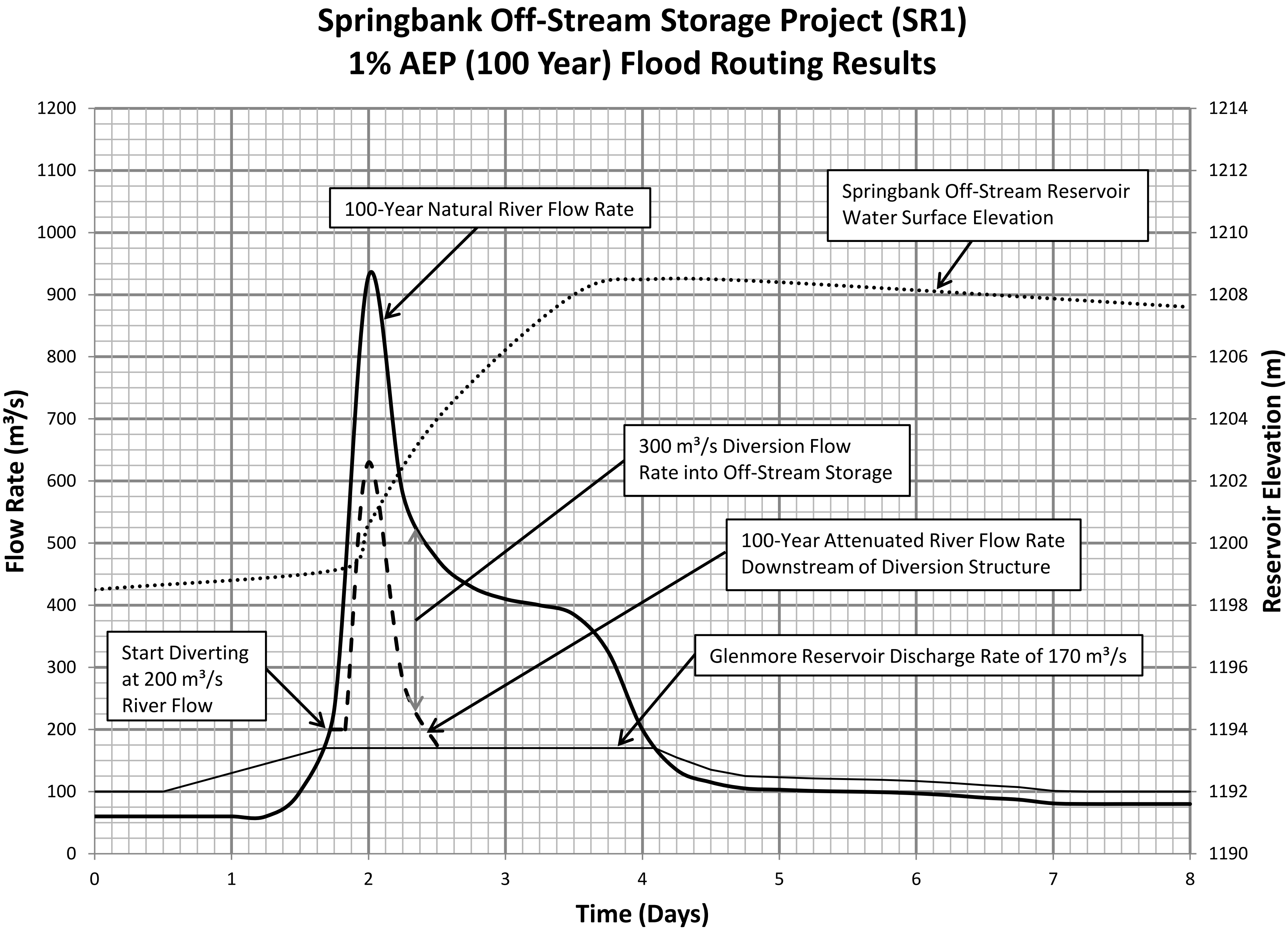
Figure G4.2


Springbank Off-Stream Storage Project (SR1)
Reservoir Storage Capacity and Flooded Area Curves
Surface Area (hectares)
0
100
200
300
400
500
600
700
800
900
1000
Elevation (m)
1215
1210
1205
1200
1195
1190
1185
Storage Capacity (dam³)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Top of Dam El. 1212.0 m
Maximum Water Level El. 1210.5 m
100 Year Flood El. 1208.5 m
Multi-Use Storage Reservoir Full Supply Level El. 1198.5 m
Storage Capacity
Flooded Area

The following additional observations are made with respect to **Figure G4.3**:

- The inflow hydrograph peaks vary rapidly emphasizing the need for improved flood forecasting methods.
- The operators must be quick to open the diversion gates on receipt of a flood warning otherwise the Glenmore Reservoir storage will be filled prematurely, and the Springbank off-stream storage flood protection benefit will be significantly reduced. The gates must be fully opened within the hour of its indicated 200 m^3/s trigger level. This could occur in the middle of the night.
- The Glenmore Reservoir storage component of the design is very important as it attenuates the peak inflow from 630 to 170 m^3/s. This again emphasizes the need for improved forecasting and the importance of drawing Glenmore Reservoir down in advance of the flood. A portion of this storage should be drawn down well in advance of a flood, based on the possibility of a major flood developing (e.g., high snowpack in basin).
- The 1% AEP inflow hydrograph is numerically generated. The benefit would be reduced for an event with a hydrograph having a steeper upstream limb or a flatter downstream limb, but having the same 1% AEP peak flow rate and volume.
- The above-noted operational considerations support building the project to greater than the 1% AEP return period protection level (i.e., increased volume and diversion rate) and/or constructing additional flood protection projects.

Figure G4.3



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5.0 PROJECT DESIGN

5.1 General

Pertinent structure data established for conceptual design and described in this report section are provided in **Table G5.1**.

5.2 River Diversion Structure System

A conceptual design layout for the diversion structure system is provided in **Drawing G2**. Additional structure details are provided in **Drawing G3** and **Drawing G4**. The design is similar in concept to the Carseland Weir diversion structure located on the Bow River near the town of Carseland, Alberta, except the diversion capacity for SR1 is significantly greater than at Carseland due to the function as a flood channel. The diversion structure system would consist of a concrete overflow weir section crossing the Elbow River, a gated concrete sluiceway/fishway located adjacent to the left side valley abutment with its invert at the river thalweg level, and a gated diversion outlet structure located in the left valley abutment immediately upstream of the sluiceway. The outlet structure invert level would be located approximately 1.5 m above the river thalweg in order to exclude larger bottom sediment from entering the diversion channel. A robust trash boom has also been considered spanning across the entrance of the diversion outlet structure to manage the risk of floating debris plugging the outlet gate openings.

Detailed hydraulic and sediment transport analysis is required to better establish key structure parameters and to estimate the performance of this structure within the Elbow River flood regime. This analysis should be considered a priority in establishing parameters including weir crest and diversion invert levels, and future operating procedures to ensure that excessive volumes of larger sediment are not diverted out of the river system into the diversion channel during extreme floods. Hydraulic and sediment transport modelling assessment may be required following preliminary office study assessment which would include input from a sediment transport specialist.

Fluvial sand and gravel deposits in the river channel will provide a stable subgrade both to support the diversion structure foundations, and to provide resistance to lateral loads during flood events. Local lacustrine clay and clay till deposits excavated from the adjacent diversion channel are generally of medium plasticity, and are suitable for use in constructing low permeability compacted backfill for headwalls and wing walls that extend into adjacent embankments or native soil abutments.

The diversion weir component of the diversion structure is a relatively massive 100 m long concrete structure with an ogee crest shape and a hydraulic jump stilling basin. This structure serves to reduce approach velocities and increase the river water level to facilitate diversion through the outlet structure into the diversion channel.

Table G5.1
Springbank Road Off-stream Storage Project (SR1) Pertinent Structure Data

Diversion Structure Weir	
River Bed Elevation	1,209.5 m
Weir Crest Elevation	1,213.5 m
Top of Structure Walls Elevation	1,218.0 m
Weir Crest Length	100 m
Basin Elevation	1,208.5 m
Maximum Structure Height	9.5 m
Floodplain Berm	
Top of Containment Embankment Elevation	1,217.9 m
Maximum Height	7 m
Sluiceway/Fishway	
Number and Size of Openings	2 @ 4.0 m high × 8.0 m wide
Type of Control	Radial Gates
Normal Water Level (Non-Flood Condition)	1,210.2 m
Upstream Bottom Invert Elevation	1,209.5 m
Gate Clearance During Normal Flow Condition	3.3 m
Basin Elevation	1,208.5 m
Maximum Structure Height	9.5 m
Diversion Outlet Structure	
Number and Size of Openings	4 @ 3.0 m high × 8.0 m wide
Type of Control	Radial Gates
Gate Invert Elevation	1,211.0 m
Basin Elevation	1,207.5 m
Maximum Structure Height	10.5 m
Diversion Channel	
Upstream Invert Elevation	1,208.5 m
Bottom Width	30 m
Side Slopes (H:V)	3:1
Bed Gradient	0.001
Design Water Velocity	2.5 m/s
Reservoir Inlet Structure	
Crest Elevation	1,205.0 m
Chute Width	24 m
Structure Length	60 m
Off-stream Storage Reservoir	
Multi-use Storage Volume	9,000 dam^3
Multi-use Storage FSL	1,198.5 m
100-year Flood Storage Volume required at SR1	41,200 dam^3
100-year Reservoir Flood Elevation	1,208.5 m
Maximum Flood Storage Volume	57,000 dam^3
Maximum Reservoir Flood Level	1,210.5 m
Off-stream Storage Dam	
Top of Dam Elevation	1,212.0 m
Maximum Dam Height	24 m
Maximum Flood Water Level	1,210.5 m
Freeboard Above Maximum Water Level	1.5 m
Storage Dam Outlet Structure	
Conduit System	1 conduit at 1.5 m wide × 1.8 m high
Gatewell Tower Height	20 m
Size of Gate	1 sluice gate at 1.2 m wide × 1.8 m high
Structure Design Flow	20 m^3/s

The sluiceway/fishway component of the diversion structure is equipped with two 8 m wide radial gates. The sluice gate number and width was selected to provide free passage of fish along the Elbow River without significantly impacting water velocity during normal flow conditions. The sluiceway gates would typically be kept in the wide open position during non-flood conditions allowing free passage of sediment, fish, etc. Partial gate closure would be required as a part of flood operations to provide for adequate flow rate diversion through the outlet structure into the diversion channel, while allowing bottom sediment to pass under the sluiceway structure gates thereby keeping the majority of bottom sediment in the main river system.

The outlet diversion structure is equipped with four 8 m wide radial gates. The outlet structure gates would typically be kept in the full closed position during non-flood conditions. This conceptual design considers opening these gates when extreme flood conditions are anticipated thereby diverting a portion of the flood flow into the off-stream storage site. As previously mentioned, an Elbow River flow of 200 m^3/s has been set as a trigger condition to initiate diverting a portion of the Elbow River flood water into the off-stream storage site. Diversion would only be continued if a major flood develops.

If the flood event is large, the outlet structure gates would be opened to divert a maximum 300 m^3/s out of the Elbow River into the off-stream storage reservoir. In the case of the 1% AEP flood event, the peak flow remaining in the Elbow River would be reduced from approximately 930 to 630 m^3/s, but this flow rate would occur for only a short period of time. Glenmore Reservoir storage would be used to further attenuate this short duration peak flow rate of 630 m^3/s to a maximum reservoir outflow of 170 m^3/s. These operations and flow rates are illustrated graphically on **Figure G4.3**.

Precast concrete access decks, gate system control buildings, instrumentation controls, and automation have been allowed for on both the sluiceway/fishway and diversion outlet structure components of the diversion structure systems illustrated on **Drawing G4,** and allowed for in the cost estimate.

An earthfill floodplain containment berm with crest El. 1,217.9 m will be required across the floodplain connecting the diversion structure system to the south land form to prevent flood water creating a new channel through the floodplain, and thereby prevent flood water from bypassing the diversion area/sluiceway system. This berm would not connect to the existing ground El. 1,217.9 m, but would rather stop short leaving a low gap area for extreme flood passage. The conceptual design considers that the concrete weir and sluiceway system would pass all floods up to the 0.1% AEP flood event, prior to more extreme flood water escaping through this southern gap area. The PMF would be conveyed through the system without overtopping the diversion structure crest. Fuse plugs would not be incorporated into the floodplain berm because of the associated sudden increase in discharge and resulting downstream safety risks in the City of Calgary.

Following stripping of surface organic soils, the exposed subgrade for the floodplain berm is expected to consist of a combination of fluvial sand and gravel deposits and clay/clay till soil. Removal of fine sand or silt overbank materials in the upper portion of the subgrade may be required in some areas prior to placing embankment fill to limit potential for piping below the embankment.

The floodplain berm is a zoned fill with an impervious zone 1A compacted clay core and random compacted 2A fill upstream and downstream shells. Available local medium plastic to low plastic clay and clay till soil will provide suitable borrow material for constructing the impervious 1A compacted core. Local clay soil, as well as reworked bedrock or other excavated materials from the embankment subgrade or diversion channel excavation, will provide suitable material for construction of the upstream and downstream random fill zone 2A shells.

5.3 Diversion Channel and Reservoir Inlet Structure

The proposed diversion channel profile and a typical channel section are illustrated in **Drawing G5**. The diversion channel is designed to convey a peak diversion flow of 300 m^3/s from the Elbow River into the off-stream storage reservoir. The channel has been designed to convey this flow at a relatively high channel velocity of 2.5 m/s in order to transport any sediment which enters from the reservoir and thereby reduce the risk of plugging the diversion channel. The channel is designed with a 24 m bottom width, three horizontal to one vertical side slopes and a 3.6 m water depth. Excavation for the diversion channel will range from approximately 25 m depth near the Elbow River diversion to less than a metre where the channel alignment crosses small creeks. Construction of banks will be required over short stretches of the channel alignment to provide adequate bank height to contain the flood water within the channel. The material excavated from the diversion channel will provide the primary borrow source for construction of the off-stream storage dam and the floodplain berm.
The material excavated from the diversion channel will consist mostly of lacustrine silty clay and clayey silt, silty clay till, and bedrock of the Brazeau and Porcupine Hills Formations. It is anticipated that occasional pockets of sand will also be encountered within the lacustrine and till units. Additional geotechnical drilling during future project phases will serve to better define the relative quantities of clay soil and bedrock that will be excavated from the diversion channel.

The lacustrine and till deposits predominately consist of medium plastic silty clays with occasional instances of either low plastic or high plastic clays. Atterberg limit tests conducted on samples of clay from the area have indicated liquid limits between 34% and 38%, and plastic limits between 18% and 20%. Soil moisture contents measured in the clay have ranged from 11% to 30%. It should be recognized that the number of boreholes drilled to date was limited to five locations due to restricted land access. The laboratory test results are generally consistent with the results of tests obtained on samples of similar clay from other nearby projects.

Bedrock in the project area generally consists of inter-bedded mudstone, siltstone and sandstone. The mudstone is generally extremely weak to weak rock with a consistency similar to very hard soil. The siltstone and sandstone layers are typically discontinuous, and can range from weathered very weak rock to moderately strong rock. Bedrock of the Brazeau and Porcupine Hills formations have been excavated on previous construction projects without use of blasting, by using large hydraulic excavators and large dozers equipped with rippers. Hydraulic breakers can be required to break up stronger siltstone and sandstone layers into pieces suitable for excavation. The weathered sandstone and siltstone, and the mudstone, deteriorates over time with exposure to air and water.

Use of the locally excavated bedrock as engineered fill requires that the blocky broken out pieces of bedrock be thoroughly broken down during compaction to a soil-like consistency. This is accomplished by using thin lifts of material for compaction, moisture conditioning as necessary including turning the soil with a disc or grader and using heavy compaction equipment capable of crushing the individual pieces of material. Large pieces of strong sandstone and siltstone should be stockpiled separately during the excavation process, and not be used for construction of engineered fill.

The clay lacustrine and till deposits are suitable for construction of either impervious zone 1A, or random zone 2 type embankment construction. Soil mixing to distribute pockets of siltier or sandier materials and moisture conditioning will be required during embankment construction. Embankments constructed of the local low to medium plastic clay soil with sideslope angles of 2.5H:1V (horizontal:vertical) or flatter, will provide a factor of safety against slope instability of 1.5 or greater, depending on slope height and with no groundwater present in the slope.

In general, within the lacustrine clay, clay till and bedrock materials expected to be encountered along the diversion channel alignment, slopes excavated to an angle of 3H:1V or flatter will provide a minimum 1.5 factor of safety against slope instability, assuming a 25 m high slope and considering that less than about 40% of slope height is below the groundwater table.

Remoulded bedrock is suitable material for use in constructing random zone 2A fill. Remoulded bedrock or mixtures containing remoulded bedrock may be suitable for use in constructing impervious zone 1A fill provided specific field procedures are implemented to ensure the bedrock is broken down to the consistency of soil during compaction. Sideslope angles of 3H:1V or flatter are recommended for embankments constructed of medium to high plastic remoulded bedrock, and will provide a factor of safety of 1.5 or greater for slope heights of up to 25 m and considering a groundwater level below about 40% of the slope height.

The diversion channel design is presented at a very conceptual level. Future design should consider:

- Sideslope benching to provide improved access for maintenance;
- Further evaluation of required diversion channel velocity to manage diverted sediment;
- Sediment deposition ponds at the existing depressions at stations 3+000 and 4+500;
- Gradient flattening to manage erosion on select reaches;
- Perhaps an intermediary drop structure at approximately station 3+400 to manage erosion at the upstream bridge; and
- Channel erosion protection including topsoiling, grassing, and cobble armour in select reaches.

A concrete reservoir inlet structure will be required at its downstream end where the water is discharged into the reservoir in order to manage the extent of channel erosion. **Drawing G7** illustrates the inlet chute structure concept. The proposed multi-use storage pond allows a reduction in required inlet chute length as compared to if the concept is designed without a pool. Following stripping of organic soil, the subgrade for the inlet structure foundation is expected to consist of clay till. The local clay soil will provide stable subgrade support for the structure foundation, and is suitable for construction of impervious backfill around headwalls, cutoff walls and side walls for the structure.

Ensuring that the larger river bottom sediment is excluded from this channel, and providing high channel velocities to transport any diverted sediment through the channel are extremely important features immediately downstream of the diversion outlet; otherwise, channel plugging could occur during diversion.

5.4 Off-stream Storage Dam and Reservoir

A 3 km long earthfill storage dam having a maximum height of 24 m is required to contain the diverted flood water. The conceptual design considers a zoned earthfill dam with a clay core and random earthfill shells as illustrated in **Drawing G6**. Embankment slopes of 3H:1V are provided, with 6 m wide berms at strategic levels resulting in average dam slopes of between 3H:1V and 4H:1V. The berms are included to provide stability, and to facilitate access for inspection, maintenance, and geotechnical instrument monitoring. The need, width, and spacing of such berms should be further evaluated as part of future design. An interior filter and drainage system and upstream riprap slope protection have been provided. Rock riprap protection has been provided in the active permanent multi-use reservoir zone from reservoir bottom to the lower berm El. 1,202.0 m. It is also provided in the dam crest zone (i.e., El. 1,207.0 to 1,212.0 m) to protect the dam from potential failure in the unlikely event of full flood containment to El. 1,210.5 m combined with a minimum 50% AEP wind event. This upper zone riprap can be covered with topsoil and seeded to provide a more desirable landscape appearance. Consideration should also be given to using a more erosion resistant impervious 1A zone material in the upstream shell/upstream dam surface to reduce the risk of wave damage. The extent of these features will be better established based on more detailed future design work.

Following stripping of surface organic soils, the exposed subgrade for the storage dam embankment is expected to consist of a combination of lacustrine clay and clay till. Previous experience with similar low to medium plastic soil subgrades indicates that subgrade deformations or increase in porewater pressure due to embankment construction are not limiting factors for typical rates of embankment construction.

The main embankment is a zoned fill with an impervious zone 1A compacted clay core and random compacted zone 2A fill upstream and downstream shells. Available local medium plastic to low plastic lacustrine clay and clay till soil will provide suitable borrow material for constructing the impervious zone 1A compacted core. Local clay soil, as well as reworked bedrock or other excavated materials from the embankment subgrade or diversion channel excavation, will provide suitable borrow for construction of the upstream and downstream random zone 2A shells. As discussed previously, it may also be possible to use remoulded bedrock to construct impervious zone 1A embankment subject to demonstration of adequate field procedures.

Embankment slope angles of 3H:1V for slopes formed of random zone 2A fill will provide adequate minimum factor of safety against slope instability for the approximately 24 m height of the main embankment – for an unsaturated slope condition. Assessment of a rapid drawdown condition for the multi-use reservoir full supply water elevation of 1,198.5 m, indicated a factor of safety against slope instability of approximately 1.4 for a 3H:1V upstream embankment angle. A rapid drawdown scenario was not investigated for the 1% AEP condition since even at the maximum 20 m^3/s rate of discharge for the low level outlet, a month or more would be required to lower the stored water level to the permanent pool elevation 1,198.5 m.

The dam system will include a gated low level outlet structure. This structure will include a 1.5 m wide by 1.8 m high concrete conduit through the dam including a gatewell tower located near the dam centerline as illustrated in **Drawing G6**. This structure will be used to release stored water back into the river after the flood has passed. Channel improvements will be required along the creek connecting this outlet to the Elbow River. As previously mentioned, the conceptual design considers a low level outlet system design discharge of 20 m^3/s which could release the contained 1% AEP flood water in a period of approximately 1 month. The design and cost estimate make allowances for a gate system control building, instrumentation controls, and automation.

It is expected that the subgrade soil supporting the low level outlet will consist of either lacustrine clay or clay till soil. Since the location proposed for the low level outlet is an existing natural drainage channel, there may be unconsolidated alluvial soil present along the alignment proposed for the low level outlet. Removal of such soils to a very stiff clay subgrade would be required to provide adequate support for the outlet conduit, otherwise consideration can be given to moving the structure to a location with a better foundation as determined by future drilling. The lacustrine clay soil or glacial clay till soil will provide adequate foundation support for the discharge structure at the end of the conduit.

6.0 EXISTING INFRASTRUCTURE IMPACTS

6.1 General

A number of pipelines, power lines, telephone lines, and road systems will be impacted by the proposed works as schematically illustrated on **Drawing G1**.

6.2 Pipelines, Power Lines and Telephone Lines

Numerous oil and gas pipelines cross the proposed diversion channel route and the off-stream storage dam alignment. These lines will need to be re-routed or lowered. Pipelines identified to date include ATCO Gas distribution lines, a 114 mm Pengrowth Energy Corporation HV line, a 168 mm Alberta Ethane Development Company HV line, a 914 mm Nova Gas Transmission NG line, and a 914 mm Foothills NG line. The Nova and Foothills lines are of particular concern because of their size. Several lines are also located within the proposed reservoir area. Dependent on existing burial depth these lines could be left in-place, or may require lowering, weighting, or rerouting. These include smaller ATCO Gas distribution lines and several Plains Midstream Canada S lines varying in size between 114 and 323 mm.

The extent of necessary oil and gas pipeline relocation has not been finitely established at this level of study. A nominal cost allowance has been included to account for these items.

6.3 Telephone Lines and Power Lines

Telus trench and Fortis power lines are located throughout the project areas. These lines would need to be rerouted or otherwise modified to suit project requirements.

6.4 Road Systems

Existing highways and local roads will be impacted by the proposed project.

A new bridge will be required where the diversion channel crosses Highway 22. The proposed flood storage reservoir would flood over existing Highway 22 at its upstream end, but only during extreme floods. The highway would need to be raised such that it is above the maximum flood level. It is conceivable that Highway 22 may be upgraded to a divided highway in the future; this would need to be considered in the proposed SR1 design.

The existing Springbank road will be submerged by reservoir flood water. Several solutions are feasible including relocation as illustrated on **Drawing G1**, or leaving it at its existing location but constructing a secondary road along the relocation route for use only when the existing road is submerged by flood water. A third option which considers raising the existing road above potential flood water level at its existing location would be a relatively more expensive option. This option may result in increased safety risk so is not recommended at this time.

Several local gravel roads will also be impacted by the proposed project. Rerouting of these roads will be required. Stakeholder engagement input is required as part of the next phase.

7.0 EXISTING LANDOWNERS

The proposed project is located within farmland and ranchland areas. A number of farm and/or ranch yards will be impacted along the diversion channel route and in the area of the off-stream storage dam and reservoir. Camp Kiwanis is located in the floodplain area south of the river and east of the diversion weir. The Tsuu T'ina Nation Indian Reserve, which is located upstream of the diversion structure would not be impacted by the project.

At least one residence located in the southeast quarter of Section 24-24-4 would be submerged by the reservoir and its relocation or purchase would be required. Several residences are located in northeast quarter of Section 24-24-4 as illustrated on **Drawing G8**. Two of the yards are well above the maximum reservoir flood water level and would not be directly impacted by the proposed project. Two of the yards are just above the estimated 1% AEP flood El. 1,208.5 m and could be directly impacted dependent on the maximum flood water level and top of dam levels selected for detailed design and construction (i.e., El. 1,210.5 m considered for conceptual design needs to be investigated further). Berms could be constructed on the west periphery of these yards to protect them from the reservoir flood water. A number of graineries, sheds and other buildings associated with the above four yards exist within the reservoir flood zone and would need to be removed, relocated, or rebuilt at a new location.

8.0 ENVIRONMENTAL AND REGULATORY OVERVIEW

The proposed project is located within the White Zone and is primarily on agricultural land. Project components would directly affect the Elbow River and its associated riparian land. Environmental concerns to be addressed in the project design include:

- Hydrogeology – effects of ponded water on groundwater resources.
- Water quality and quantity – effects of potential changes in stream flows, sediment load, and water quality parameters.

- Fisheries – potential for effects on fish and fish habitat, including possible populations of brook trout, brown trout, bull trout, burbot, longnose dace, longnose sucker, mountain whitefish, and rainbow trout. Bull trout are listed as species of special concern by Alberta's Endangered Species Conservation Committee.
- Soils – effects of changes in flows on soils and potential for soil erosion.
- Wildlife – Provincially designated Key Wildlife and Biodiversity zones are located along the Elbow River, which impose potential timing and construction constraints for the proposed project. Potential effects may occur to species using the zone, including cougar. Wildlife movement patterns may be altered in proximity to the project.
- Vegetation – potential effects on vegetation will be focused on agricultural lands, grazing land. There are no recorded locations for rare plants associated with the project.
- Traditional and non-traditional land use – potential effects include access, changes in traffic patterns and aesthetic concerns. In addition to private landowners, the project site may be located within the Stoney Nakoda and Tsuu T'ina First Nations traditional territories.

The proposed project would require a license to divert water under the *Water Act*, which is administered by ESRD. The project triggers Alberta Regulation 111/93 *Envrionmental Protection and Enhancement Act* (EPEA) Environmental Assessment (Mandatory and Exempted Activities) Regulation, which requires an environmental impact assessment (EIA) be completed for a dam greater than 15 m in height. A water management project that requires an EIA triggers a Natural Resources Conservation Board (NRCB) review. Typically environmental studies to support the EIA would include a minimum of 1- year of site-specific data.

The proponent would submit its project application with its supporting EIA to ESRD, which makes a determination of completeness. Once deemed complete, the NRCB review process would involve a public hearing as part of its review. The NRCB and ESRD have a history of working cooperatively on environmental reviews of this kind. The ESRD/NRCB process could take between 18 and 24 months to complete. At the completion of the process, the NRCB sends its determination to cabinet, who reviews the report and issues the final approval decision.

In addition to the ESRD and NRCB, several other provincial and federal departments will have regulatory roles for the proposed project. These processes can generally occur in parallel with the ESRD/NRCB review, as much of the information required for them supports the environmental review. For example, pre-development and post-development aquatic environmental assessments would be necessary as part of the application for approval under the *Water Act*. Specific authorizations and permits would be obtained subsequent to the ESRD/NRCB decision, if the project was approved.

An overview of the regulatory process is shown in **Table G8.1**.

Table G8.1
Regulatory Process Overview

Regulator	Legislation	Requirements/Process	Schedule
Provincial			
ESRD	EPEA Environmental Assessment Mandatory and Exempted Activities Regulation 111/93	Under EPEA an EIA is required for a dam greater than 15 m in height, as specified in the Mandatory and Exempted Activities Regulation.	18 to 24 months
NRCB	*Natural Resources Conservation Board Act*	The NRCB review process is triggered when a water management project requires an EIA.	
ESRD	*Alberta Water Act*	Authorization	Variable
	Alberta Water Act	Licence and approval	Variable
	Public Lands Act	Dispositions following the Environmental Field Report (EFR) process	5-8 months
Alberta Culture (AC)	*Historical Resources Act*	Application for clearance	Depends on requirements; for historic resources impact assessment, expect 4 to 6 months from initial application for clearance.
Federal			
Fisheries and Oceans Canada (DFO)		Authorization pursuant to the *Fisheries Act* (habitat and fish passage)	90 days post-filing, providing submission is complete.
Miscellaneous Federal Acts		*Migratory Birds Convention Act* (MBCA)	
		Species at Risk Act (SARA)	*n/a*

As currently designed, the proposed project is not listed in the *Regulations Designating Physical Activities*, under the *Canadian Environmental Assessment Act*. It does not result in a reservoir with a surface area that would exceed the annual mean surface area of a water body by 1,500 ha or more and it does not divert 10,000,000 m^3/year or more of water from a natural water body into another natural water body.

9.0 CONSTRUCTION COST ESTIMATE AND PROJECT SCHEDULE

9.1 Project Cost Estimate

A detailed cost estimate is provided in **Table G9.1**. The project cost is estimated to be $158,168,000. This price does not include the cost of land acquisition which will be determined by others. The estimate provided herein is based on 2012 construction price data. Year 2012 prices were used considering that 2013 construction prices are skewed as a result of abnormal activity which resulted from the June 2013 flood event. It is assumed that the construction of SR1 would take place in a more competitive environment for contractors and suppliers, and as such the 2012 prices are considered indicative of realistic project cost. The estimate was produced considering the conceptual designs presented herein. Additional subsurface soils investigations are required to better establish the concept details presented herein. More detailed hydrological assessment and topographic data are required to better establish the size of required works. A contingency allowance of 25% has been included in an effort to account for additional costs which could result from future additional information and the results of more detailed design work. No allowance is included for escalation until the time of construction.

To increase the flood protection above the 1% AEP, to the 2013 flood of record level would require the dam crest level raised by approximately 2.5m to Elevation 1214.5m and would also require a larger diversion outlet structure and channel. These adjustments would result in additional project cost of approximately $55 million. This amount includes contingency and engineering allowances.

Table G9.1
Off-stream Storage Project (SR1) Cost Estimate

Item	Unit	Quantity	Unit Price	Extension
General				
Mob./Demobilization	lump sum	lump sum	7,000,000.00	$7,000,000
Care of Water	lump sum	lump sum	3,000,000.00	$3,000,000
Clearing & Timber Salvage	hectares	10	12,000.00	$120,000
Raise Highway 22	lump sum	lump sum	2,000,000	2,000,000
Local Road Modifications	km	15	250,000.00	$3,750,000
Topsoil/Seeding etc.	m^2	1,200,000	1.50	$1,800,000
	Subtotal General			**$17,670,000**
River Diversion Structure System				
Stripping	m^3	5,000	6.00	$30,000
Common Excavation	m^3	20,000	10.00	$200,000
Structure Fill	m^3	10,000	30.00	$300,000
Diversion Weir Concrete	m^3	4,900	1,000.00	$4,900,000
Sluice/Fishway Concrete	m^3	990	1,000.00	$990,000
Outlet Structure Concrete	m^3	1,900	1,000.00	$1,900,000
Precast Decks	lump sum	lump sum	560,000.00	$560,000
Fine Filter	m^3	1,200	90.00	$108,000
Coarse Filter	m^3	1,200	90.00	$108,000
Piping System	lump sum	lump sum	200,000.00	$200,000
Rock Riprap	m^3	6,400	130.00	$832,000
Bedding Gravel	m^3	2,200	70.00	$154,000
Gate/Hoist Systems	each	6	500,000.00	$3,000,000
Controls/Instrumentation	lump sum	lump sum	300,000.00	$300,000
Electrical/Mechanical	lump sum	lump sum	500,000.00	$500,000
Superstructures	each	2	90,000.00	$180,000
	Subtotal Diversion Structure System			**$14,262,000**
Floodplain Berm				
Stripping	m^3	18,000	6.00	$108,000
Impervious Fill	m^3	90,000	1.50	$135,000
Random Fill	m^3	60,000	1.40	$84,000
Fine Filter	m^3	6,000	90.00	$540,000
Rock Riprap	m^3	8,000	130.00	$1,040,000
Bedding Gravel	m^3	4,000	60.00	$240,000
	Subtotal Floodplain Berm			**$2,147,000**

Item	Unit	Quantity	Unit Price	Extension
Diversion Channel & Reservoir Inlet Structure				
Stripping	m^3	180,000	6.00	$1,080,000
Common Excavation	m^3	1,800,000	5.50	$9,900,000
Rock Excavation	m^3	200,000	10.00	$2,000,000
Impervious Fill	m^3	10,000	20.00	$200,000
Inlet Chute Concrete	m^3	2,000	1,200.00	$2,400,000
Fine Filter	m^3	660	90.00	$59,000
Coarse Filter	m^3	1,760	90.00	$158,000
Piping System	lump sum	lump sum	200,000.00	$200,000
Bridge Crossings	each	1	4,000,000.00	$4,000,000
Pipeline Crossings	lump sum	lump sum	4,000,000.00	$4,000,000
Power Line Relocation	lump sum	lump sum	300,000.00	$300,000
	Subtotal Diversion Channel System			**$24,298,000**
Off-stream Storage Dam				
Stripping	m^3	180,000	6.00	$1,080,000
Borrow Excavation	m^3	1,700,000	5.00	$8,500,000
Overhaul	m^3km	2,500,000	1.50	$3,750,000
Impervious Fill	m^3	1,600,000	1.50	$2,400,000
Random Fill	m^3	1,200,000	1.40	$1,680,000
Fine Filter	m^3	140,000	60.00	$8,400,000
Coarse Filter	m^3	20,000	60.00	$1,200,000
Rock Riprap	m^3	62,000	130.00	$8,060,000
Bedding Gravel	m^3	31,000	60.00	$1,860,000
Geotechnical Instruments	lump sum	lump sum	400,000.00	$400,000
	Subtotal Off-stream Dam			**$37,330,000**
Dam Outlet Structure and Downstream Channel Improvements				
Structure Excavation	m^3	20,000	20.00	$400,000
Structure Fill	m^3	15,000	30.00	$450,000
Reinforced Concrete	m^3	1,600	1,200.00	$1,920,000
Rock Riprap	m^3	600	130.00	$78,000
Bedding Gravel	m^3	300	70.00	$21,000
Gate/Hoist Systems	each	lump sum	160,000.00	$320,000
Controls/Instrumentation	lump sum	lump sum	100,000.00	$100,000
Electrical/Mechanical	lump sum	lump sum	400,000.00	$400,000
Superstructure	lump sum	lump sum	50,000.00	$50,000
	Subtotal Structure & Channel Improvements			**$3,739,000**

Item	Unit	Quantity	Unit Price	Extension
Springbank Road Relocation				
Grading	km	5	550,000.00	$2,750,000
Base/Pavement	km	5	650,000.00	$3,250,000
Creek Crossings	lump sum	lump sum	1,000,000.00	$1,000,000
	Subtotal Springbank Road Relocation			**$7,000,000**
	SUBTOTAL CONSTRUCTION			**$106,446,000**
	Contingencies (25%)			$26,661,000
	Subtotal Construction and Contingencies			**$133,107,000**
	Engineering/Environmental (20%)			$26,661,000
	TOTAL CONSTRUCTION			**$159,768,000**

9.2 Project Schedule and Contracts

Studies to date indicate that the proposed project is feasible. A potential project schedule moving forward would consider both preliminary engineering and environmental impact assessment proceeding on parallel but linked paths, and followed by a detailed design–build or a detailed design-bid-build process.

A number of issues need to be resolved in order to proceed with preliminary design and environmental impact assessment. These include:

- Land access;
- Establishing the level of flood protection to be provided by the project (e.g. 1% AEP flood, 2013 record flood, or larger); and
- Establishing the need for and amount of multi-use storage, if any.

Land access is required in order to proceed with subsurface soil investigations for use in design and cost estimates, and for environmental field investigations. Similarly stakeholder involvement is required to better define project issues and potential solutions. Initiating stakeholder involvement and gaining land access need to be initial priorities.

Key stakeholder input is required to better define the preferred reservoir storage volume which would impact the locations of the diversion structure, diversion channel, off-stream storage dam and associated facilities. As an example a larger reservoir containment would require a larger diversion outlet and channel, a higher dam, the diversion structure to be moved as much as 200 m upstream, could consider the off-stream storage dam moved about 100 m south, and the diversion channel alignment moved up to 100 m north or south of its currently proposed location. Similarly a larger reservoir volume would result in increased impacts to the previously discussed four yard complex located in the northeast of Section 24-24-4. Resolving project size and associated layout needs to be an initial priority.

This conceptual design has provided for a portion of the reservoir to be used for purposes other than, or in addition to, flood storage (i.e. multi-use storage). This concept needs to be endorsed or rejected and the amount of such multi-purpose storage established.

Sediment transport has been identified as a major factor in diversion structure design and should be addressed at the onset of preliminary design, as the results of this assessment could significantly impact the diversion structure configuration. Preliminary design would include hydraulic and sediment transport modelling, if required, to produce detailed structure outline drawings and better establish project cost. Preliminary design should include more detailed subsurface soils investigations and stakeholder involvement. Land access will be required for the preliminary design and environmental field investigations.

Design-build or design-bid-build contracting procedures can be considered for project detailed design and construction. Design-build considers that the work is both designed and built by one project team. Design-bid-build considers that a team is selected to design the project, it then goes to public tender, and is constructed by the successful bidder. Design-build process can result in a reduced time schedule, but the design-bid-build process is considered to be more conventional and appropriate for this project type. The SR1 project could be tendered as one major construction contract, or alternatively divided into two or more contracts. At this time a minimum of three contracts is recommended. One contract would include the diversion structure, floodplain berm, and upstream end of the diversion channel. A second contract would include the remainder of the diversion channel, reservoir inlet chute, off-stream storage dam and associated outlet works. Bridge and road works would be included in the third contract. The contract areas do not overlap and could proceed simultaneously. The multiple contract concept would provide smaller local contractors opportunity to bid this work and could allow earlier initiation of some portions of project construction.

The project schedule is dependent on factors including cash flow, land access/purchase, environmental and regulatory processes, subsurface field investigations (drilling), engineering design and construction. As previously mentioned, engineering design can proceed parallel with environmental studies and regulatory processes which could require 30 to 36 months to complete.

Construction will require a minimum one calendar year, but a 2 or 3-year schedule is preferred considering the size of this project. Of course the government would need to weigh the risk of additional flood damage against the preferred longer construction period. Construction could proceed year-round, taking advantage of both summer and winter seasons. Most of the work would be performed in the spring through fall period; however, significant quantities of work could be completed in the winter. Special measures would be required for winter construction including heating and hoarding for concrete and continuous 24-hour per day earthfill operations. A project schedule can be developed but requires additional owner input.

10.0 CLOSURE

This report is based on, and limited by, the interpretation of data, circumstances, and conditions available at the time of completion of the work as referenced throughout the report. It has been prepared in accordance with generally accepted engineering practices. No other warranty, express or implied, is made.

Yours truly,

AMEC Environment & Infrastructure

Reviewed by:

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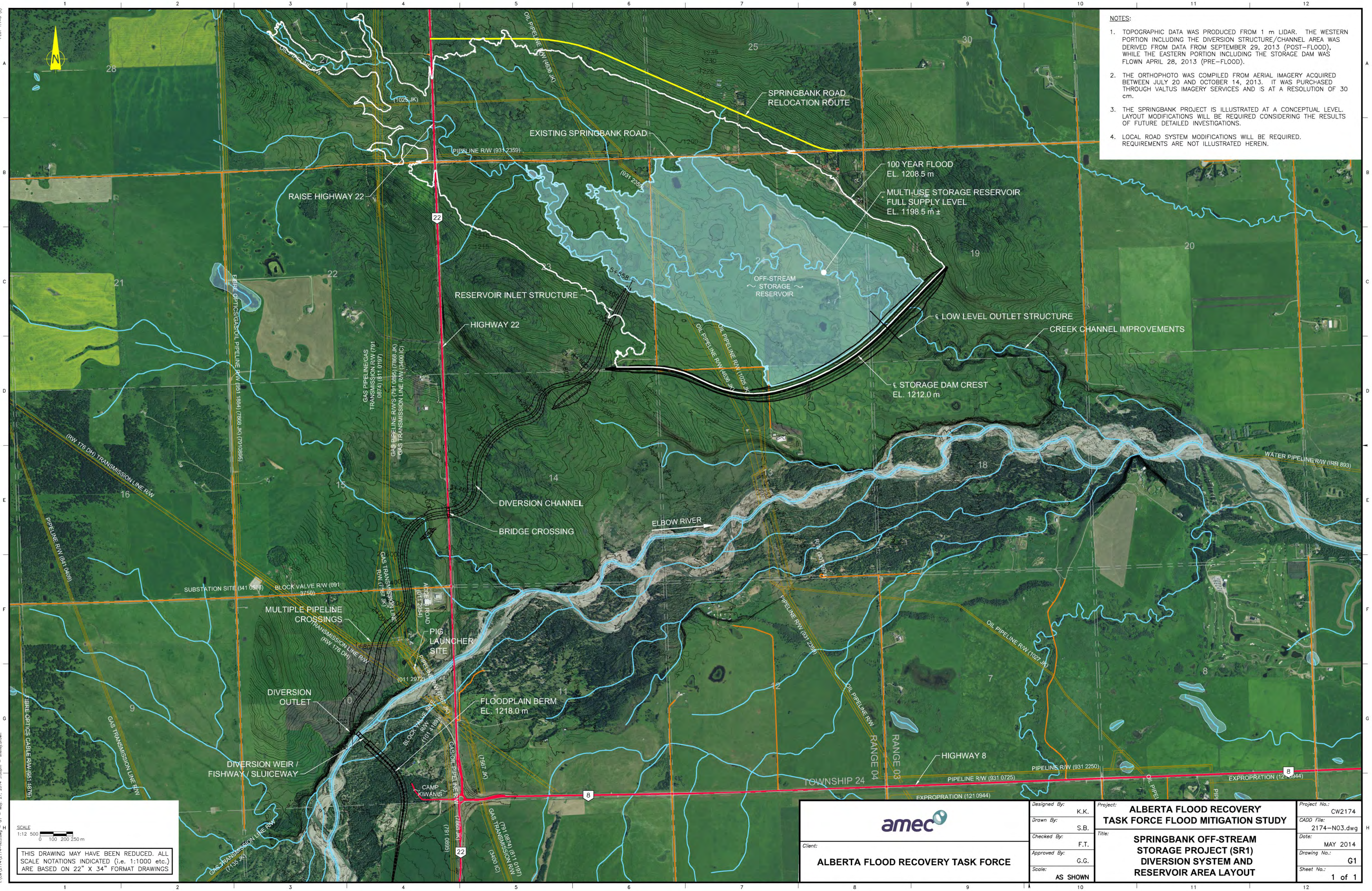
KK/elf

Permit to Practice No. P-4546



NOTES:

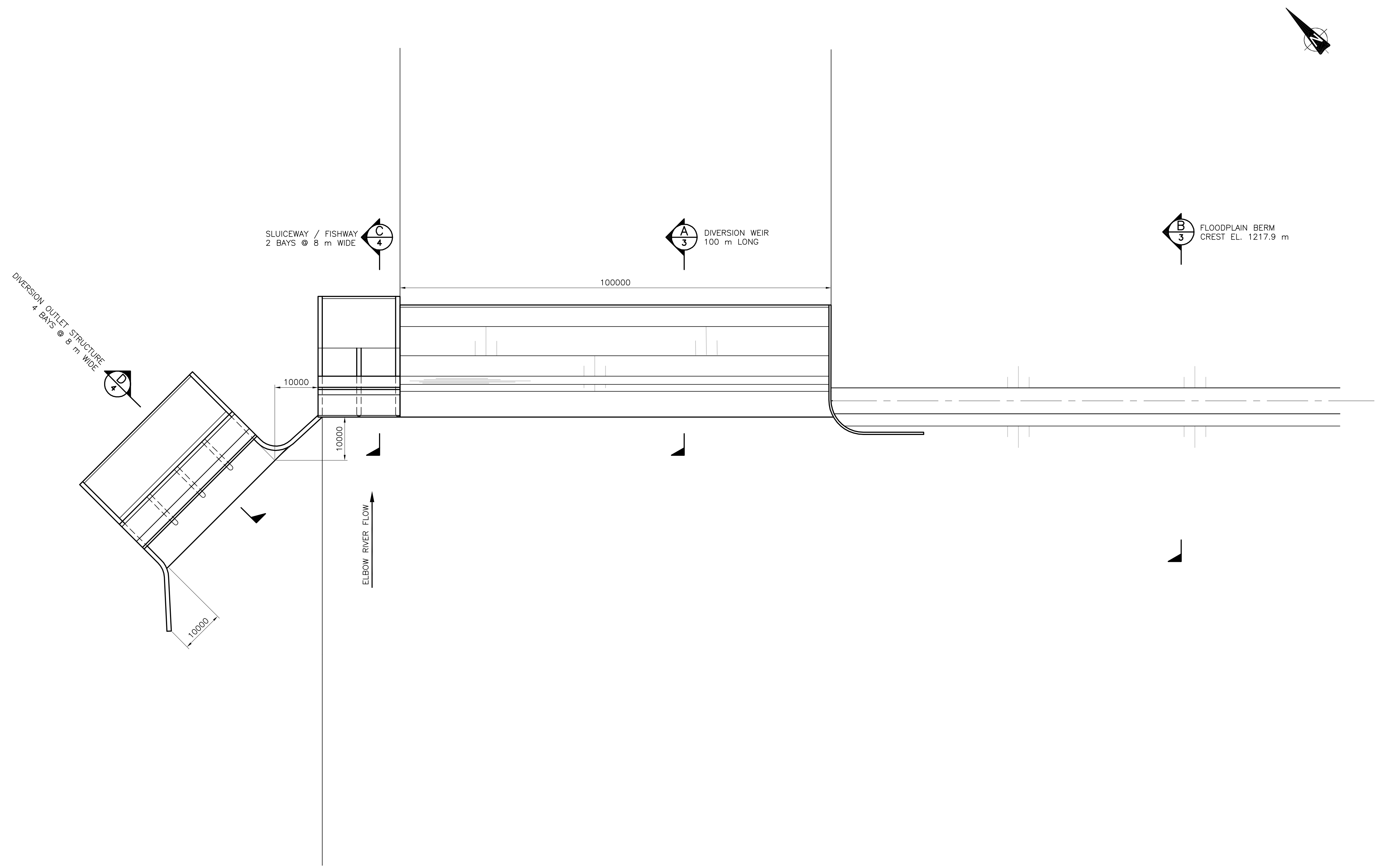
1. TOPOGRAPHIC DATA WAS PRODUCED FROM 1 m LIDAR. THE WESTERN PORTION INCLUDING THE DIVERSION STRUCTURE/CHANNEL AREA WAS DERIVED FROM DATA FROM SEPTEMBER 29, 2013 (POST-FLOOD), WHILE THE EASTERN PORTION INCLUDING THE STORAGE DAM WAS FLOWN APRIL 28, 2013 (PRE-FLOOD).
2. THE ORTHOPHOTO WAS COMPILED FROM AERIAL IMAGERY ACQUIRED BETWEEN JULY 20 AND OCTOBER 14, 2013. IT WAS PURCHASED THROUGH VALTUS IMAGERY SERVICES AND IS AT A RESOLUTION OF 30 cm.
3. THE SPRINGBANK PROJECT IS ILLUSTRATED AT A CONCEPTUAL LEVEL. LAYOUT MODIFICATIONS WILL BE REQUIRED CONSIDERING THE RESULTS OF FUTURE DETAILED INVESTIGATIONS.
4. LOCAL ROAD SYSTEM MODIFICATIONS WILL BE REQUIRED. REQUIREMENTS ARE NOT ILLUSTRATED HEREIN.

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

amec	Designed By: K.K.	Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY	Project No.: CW2174
	Drawn By: S.B.		CADD File: 2174–N03.dwg
Client: ALBERTA FLOOD RECOVERY TASK FORCE	Checked By: F.T.	Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) DIVERSION SYSTEM AND RESERVOIR AREA LAYOUT	Date: MAY 2014
	Approved By: G.G.		Drawing No.: G1
	Scale: AS SHOWN		Sheet No.: 1 of 1

NOTES:

1. ELEVATIONS ARE IN METRES AND DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.



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THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

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G						
F						
E						
D						
C						
B						
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) DIVERSION WEIR / SLUICEWAY / FISHWAY / OUTLET STRUCTURE SYSTEM

Project No.: CW2174
CADD File: 2174-B08.dwg
Date: MAY 2014
Drawing No.: G2
Sheet No.: 1 of 1

NOTES:

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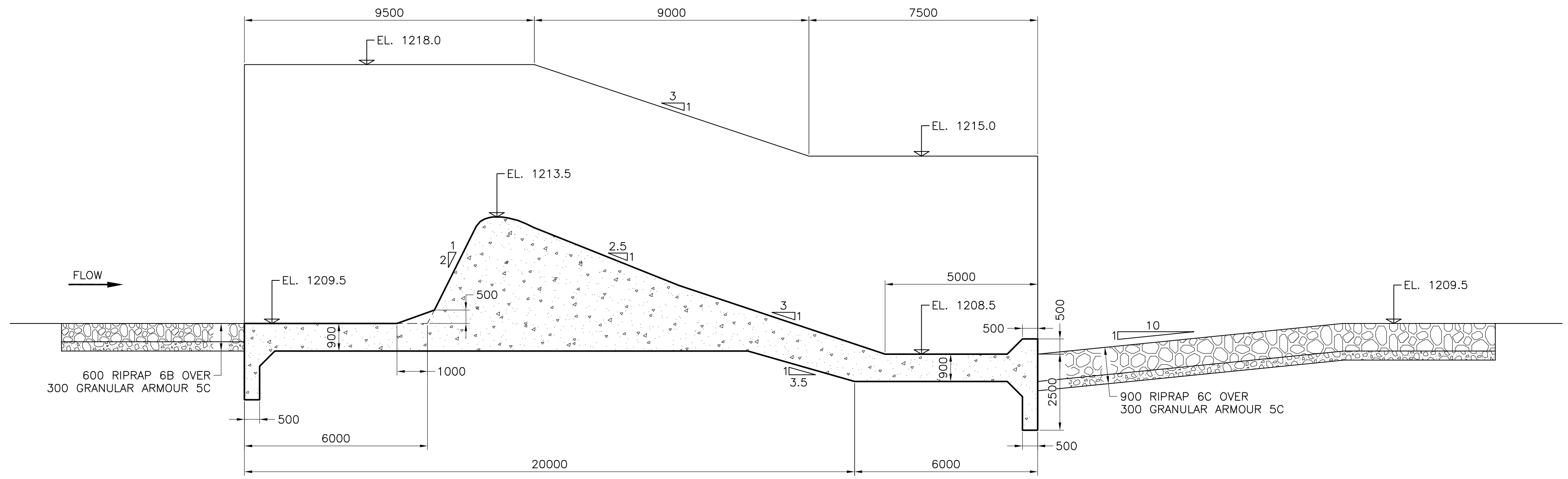
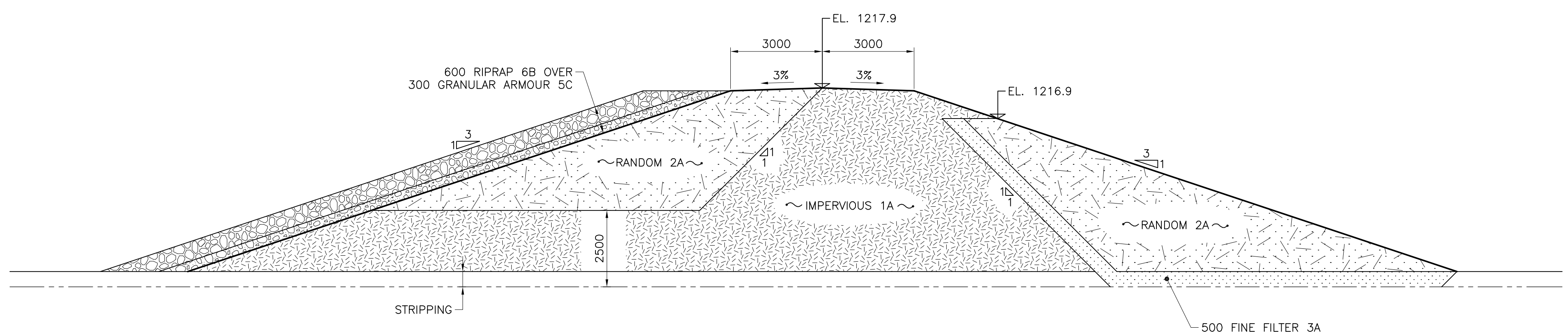


A/2 SECTION – DIVERSION WEIR

N.T.S.



B/2 SECTION – FLOODPLAIN BERM

SCALE 1:100

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1:100 0 1 2m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

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amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

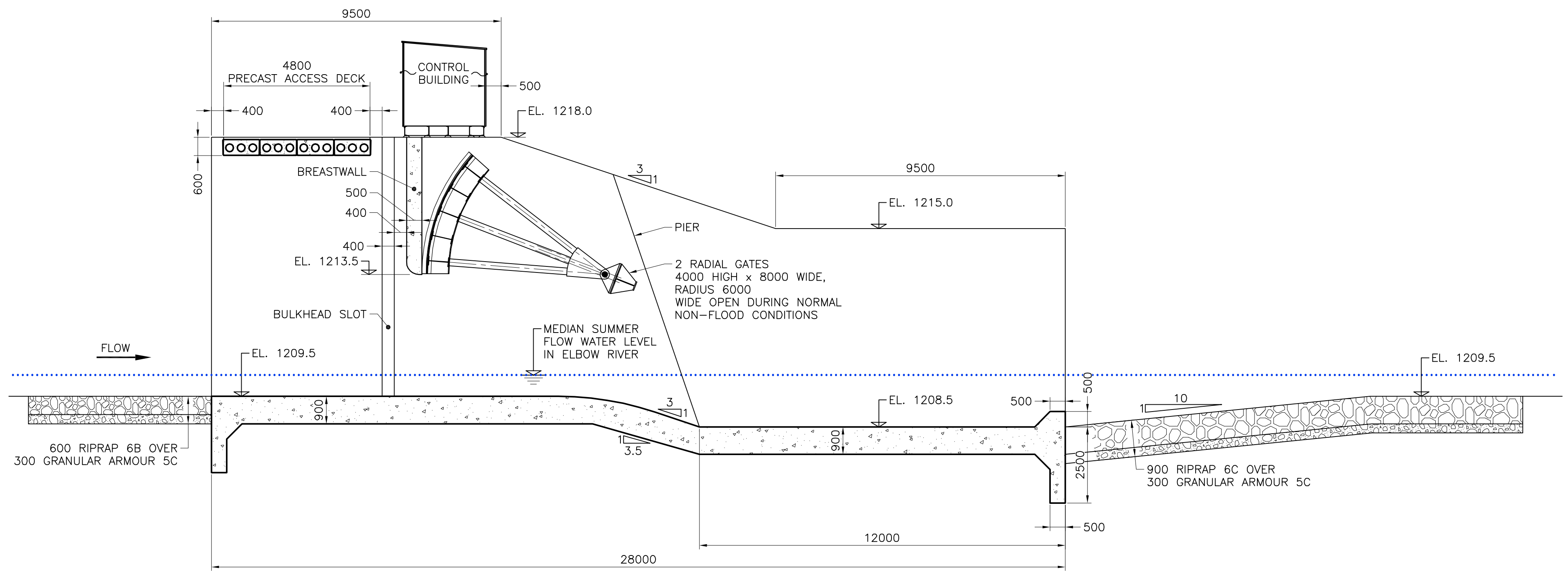
Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) DIVERSION STRUCTURE SYSTEM SECTIONS (SHEET 1 of 2)

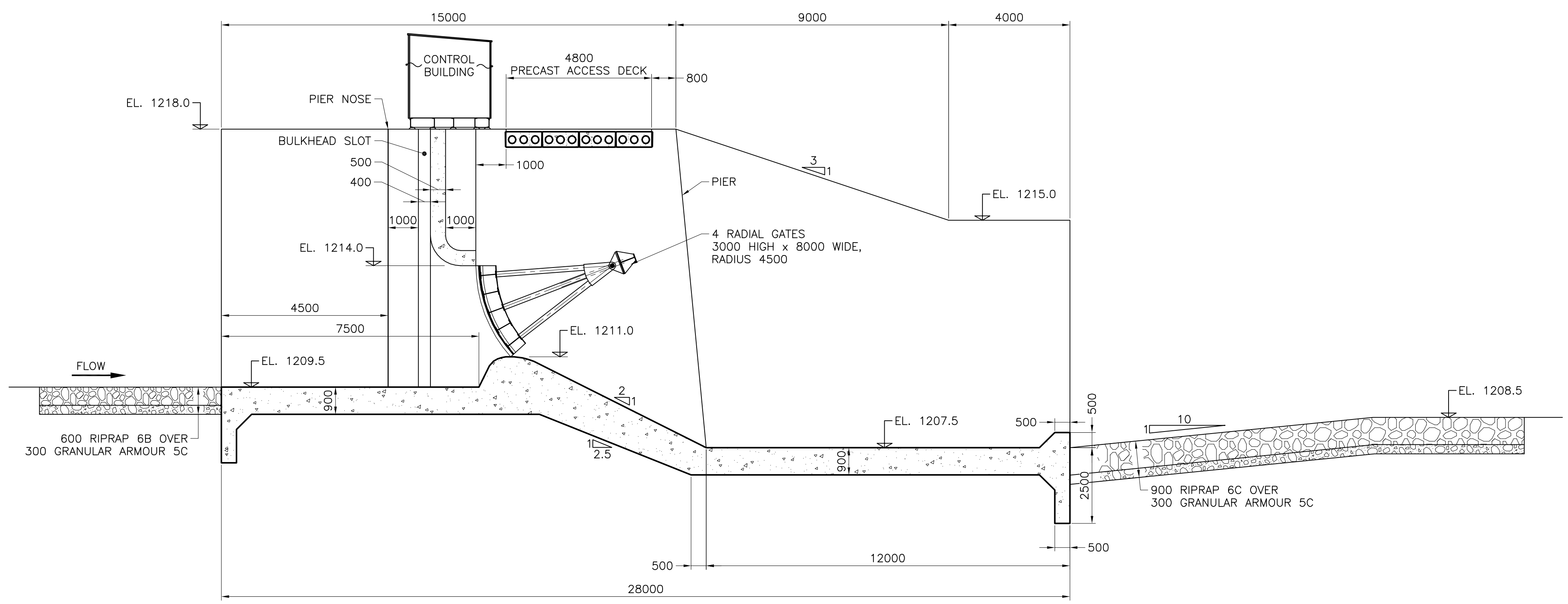
Project No.: CW2174
CADD File: 2174–B03.dwg
Date: MAY 2014
Drawing No.: G3
Sheet No.: 1 of 1

NOTES:

1. ELEVATIONS ARE IN METRES AND DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.



C/2 SECTION – SLUICEWAY / FISHWAY
SCALE 1:100



D/2 SECTION – DIVERSION OUTLET STRUCTURE
N.T.S.

SCALE
1:100 0 1 2m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
G						
F						
E						
D						
C						
B						
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client:
ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

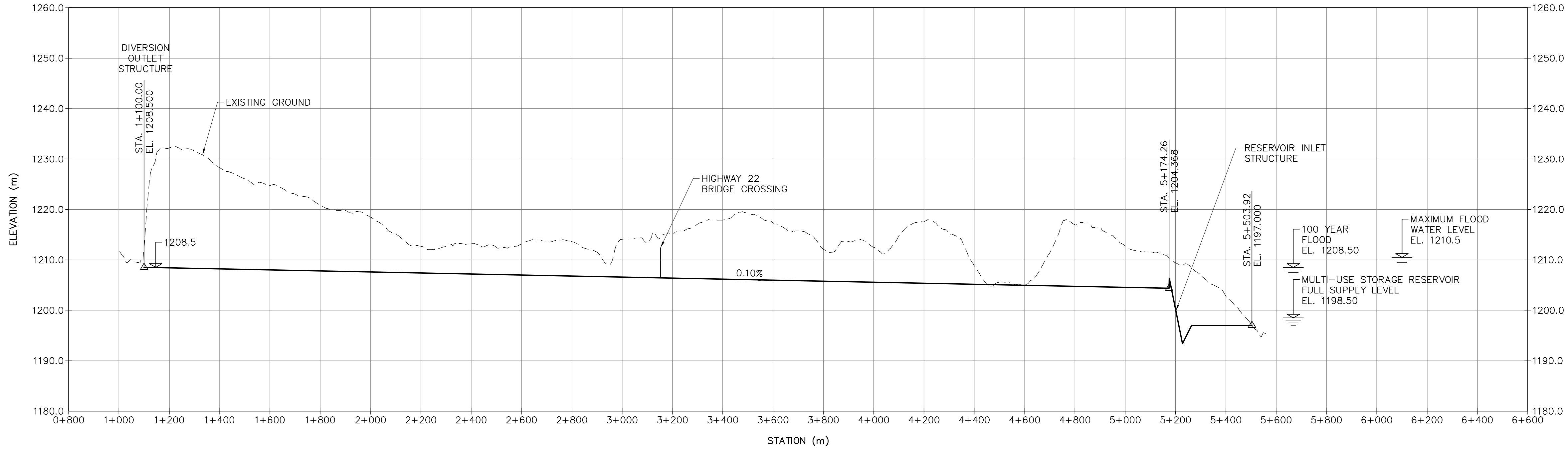
Project:
ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title:
SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) DIVERSION STRUCTURE SYSTEM SECTIONS (SHEET 2 of 2)

Project No.: CW2174
CADD File: 2174–B05.dwg
Date: MAY 2014
Drawing No.: G4
Sheet No.: 1 of 1

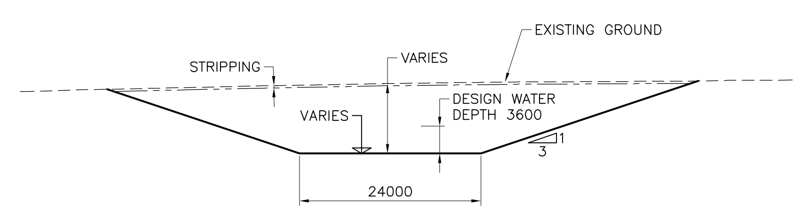
NOTES:

1. ELEVATIONS ARE IN METRES AND DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.



DIVERSION CHANNEL PROFILE

SCALE HOR. 1:10000
VER. 1:500



DIVERSION CHANNEL TYPICAL CROSS SECTION

SCALE 1:500

SCALES
1:10 000 0 100 200m
1:500 0 5 10m

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REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

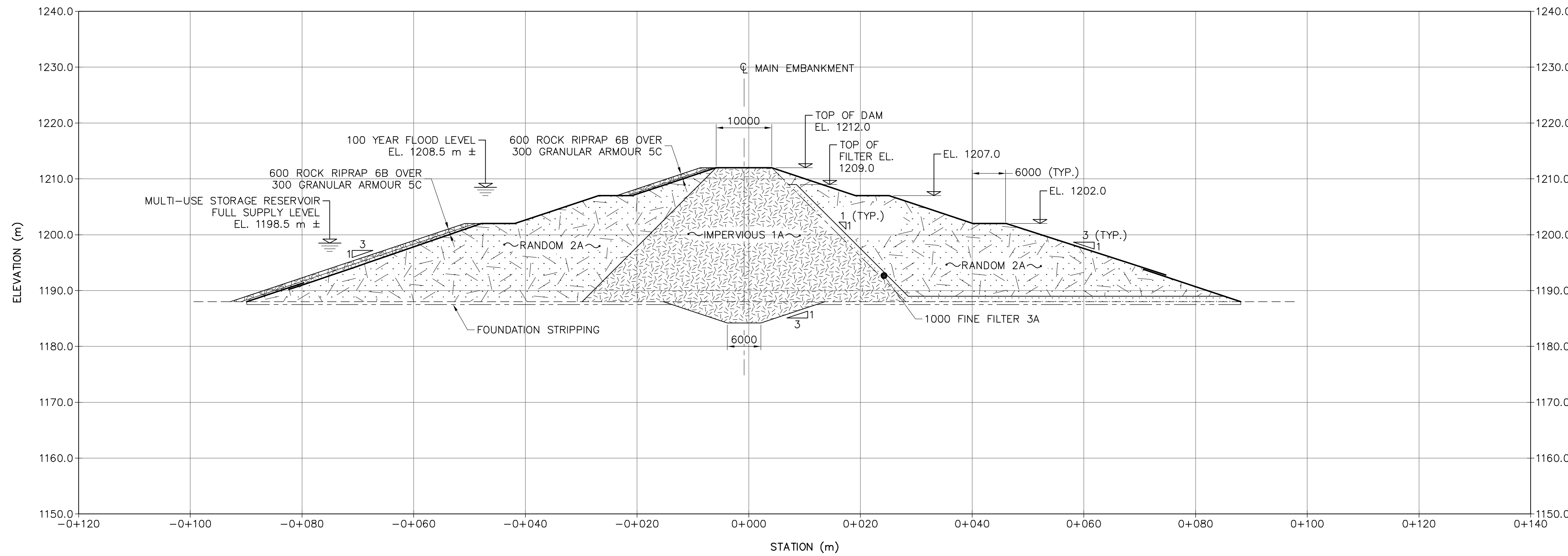
Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) DIVERSION CHANNEL

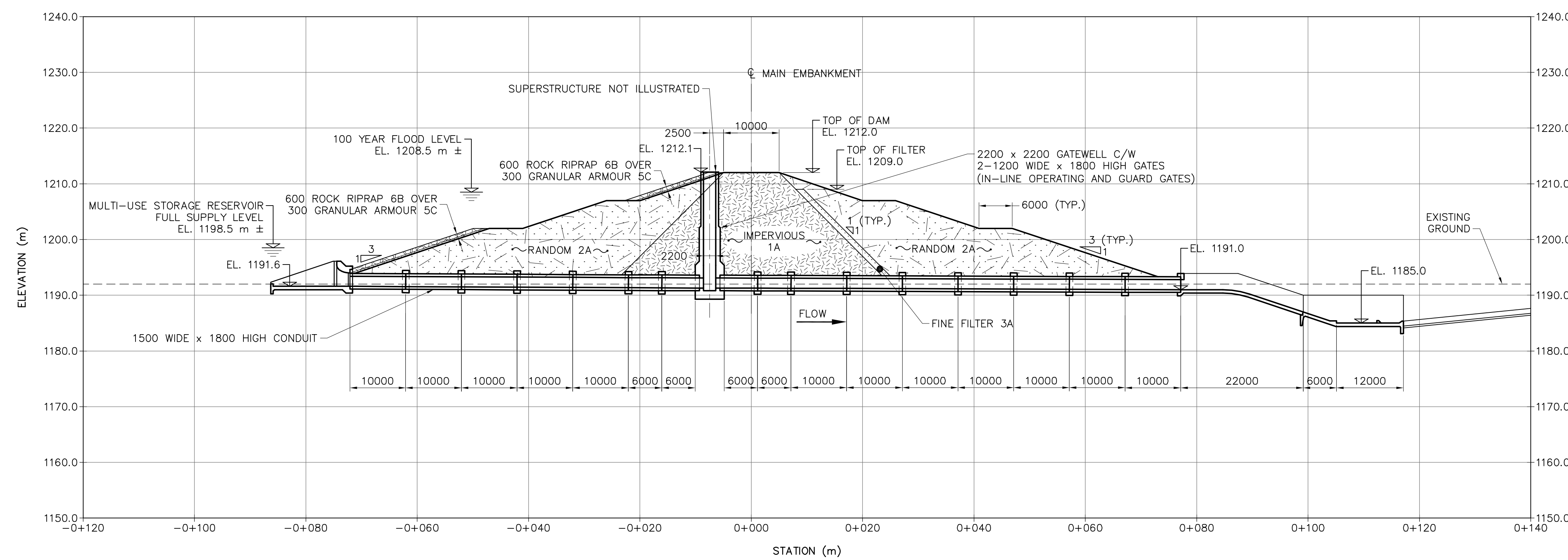
Project No.: CW2174
CADD File: 2174–N03.dwg
Date: MAY 2014
Drawing No.: G5
Sheet No.: 1 of 1

NOTES:

1. ELEVATIONS ARE IN METRES AND DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.



OFF-STREAM STORAGE DAM
SCALE 1:500



LOW LEVEL OUTLET STRUCTURE
SCALE 1:500

SCALE 1:500 0 5 10 m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

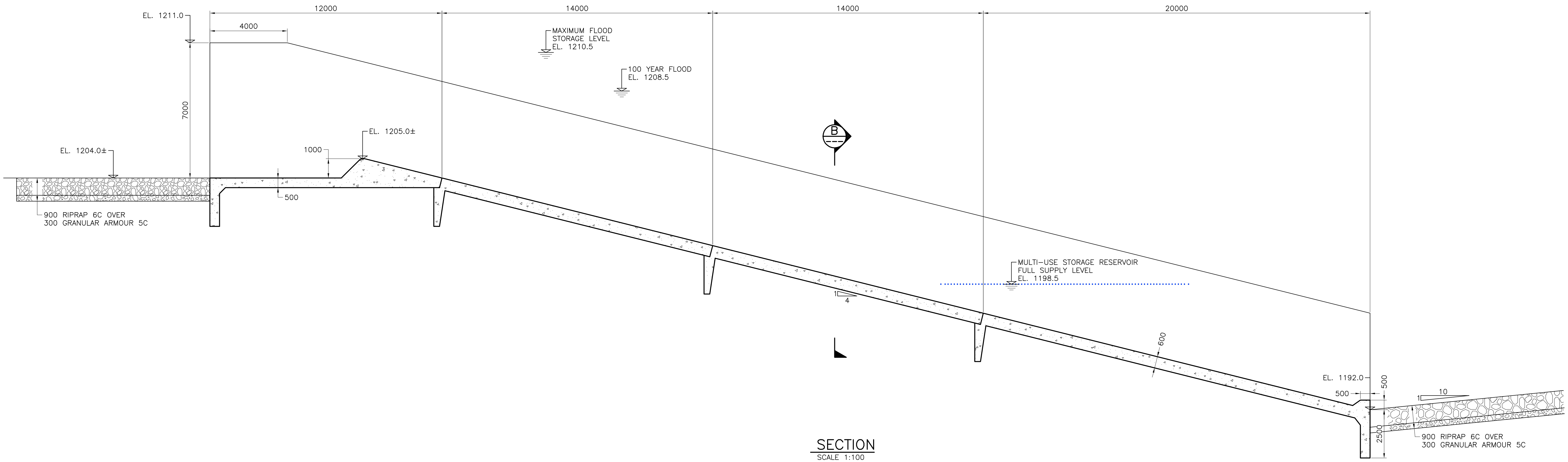
Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) OFF-STREAM STORAGE DAM & LOW LEVEL OUTLET

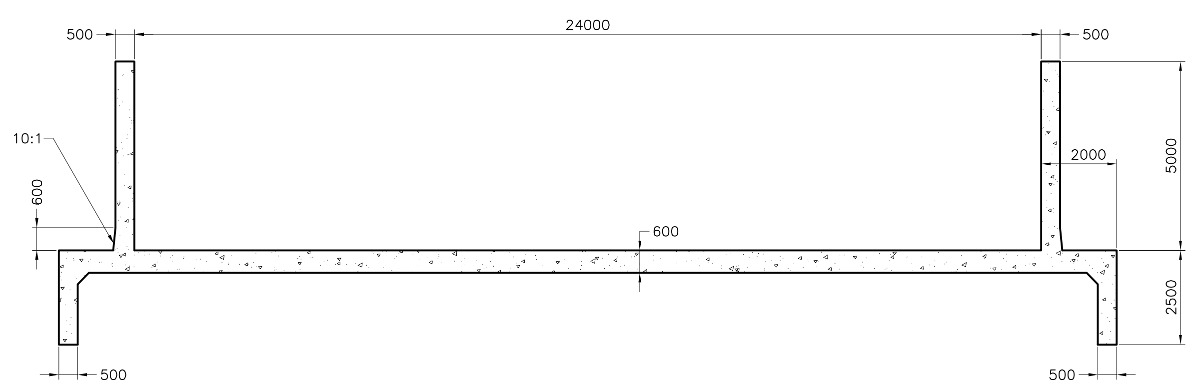
Project No.: CW2174
CADD File: 2174-N03.dwg
Date: MAY 2014
Drawing No.: G6
Sheet No.: 1 of 1

NOTES:

1. ELEVATIONS ARE IN METRES AND DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.



SECTION
SCALE 1:100



B SECTION
SCALE 1:100

SCALE 1:100
0 1 2m

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc.) ARE BASED ON 22" X 34" FORMAT DRAWINGS

REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By:	K.K.
Drawn By:	S.B.
Checked By:	F.T.
Approved By:	G.G.
Scale:	AS SHOWN

Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFF-STREAM STORAGE PROJECT (SR1) RESERVOIR INLET STRUCTURE

Project No.:	CW2174
CADD File:	2174–B06.dwg
Date:	MAY 2014
Drawing No.:	G7
Sheet No.:	1 of 1

NOTES:

1. TOPOGRAPHIC DATA WAS PRODUCED FROM 1 m LIDAR. THE WESTERN PORTION INCLUDING THE DIVERSION STRUCTURE/CHANNEL AREA WAS DERIVED FROM DATA FROM SEPTEMBER 29, 2013 (POST-FLOOD), WHILE THE EASTERN PORTION INCLUDING THE STORAGE DAM WAS FLOWN APRIL 28, 2013 (PRE-FLOOD).
2. THE ORTHOPHOTO WAS COMPILED FROM AERIAL IMAGERY ACQUIRED BETWEEN JULY 20 AND OCTOBER 14, 2013. IT WAS PURCHASED THROUGH VALTUS IMAGERY SERVICES AND IS AT A RESOLUTION OF 30 cm.
3. THE SPRINGBANK PROJECT IS ILLUSTRATED AT A CONCEPTUAL LEVEL. LAYOUT MODIFICATIONS WILL BE REQUIRED CONSIDERING THE RESULTS OF FUTURE DETAILED INVESTIGATIONS.
4. LOCAL ROAD SYSTEM MODIFICATIONS WILL BE REQUIRED. REQUIREMENTS ARE NOT ILLUSTRATED HEREIN.

SCALE
1:1000 0 10 20m

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REV	D	M	Y	ISSUE/REVISION DESCRIPTION	ENG.	APPR.
A	00	00	00	ISSUED FOR CLIENT REVIEW	X.X.	X.X.

amec

Client: ALBERTA FLOOD RECOVERY TASK FORCE

Designed By: K.K.
Drawn By: S.B.
Checked By: F.T.
Approved By: G.G.
Scale: AS SHOWN

Project: ALBERTA FLOOD RECOVERY TASK FORCE FLOOD MITIGATION STUDY

Title: SPRINGBANK OFFSTREAM STORAGE PROJECT (SR1) FLOODED AREA DETAIL IN NE¼-24-24-4

Project No.: CW2174
CADD File: 2174-J03.dwg
Date: MAY 2014
Drawing No.: G8
Sheet No.: 1 of 1