

**POTTER CREEK MASTER DRAINAGE PLAN
IMPLEMENTATION REPORT**

LOYALIST SECONDARY PLAN AREA

Final Report

October 1, 2008



Prepared by Quinte Conservation
For City of Belleville

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I. INTRODUCTION

This report is a companion to the Potter Creek Master Drainage Plan (MDP) prepared by XCG Consultants (March 2007) and outlines potential locations for centralized drainage facility (pond) locations and provides guidance on implementation. These facilities are for both quality and quantity control. A brief synopsis of the XCG report is contained in the second section of this report. The reader is also referred to the original subwatershed plan - Potter Creek Subwatershed Plan – Ecos-Garatech (1994).

Pond locations were refined in this report through the use of very accurate elevation information obtained from a LIDAR survey of the Potter Creek basin carried out in late 2006. The topographic data accumulated during this study has been delivered to the City of Belleville in digital format and will reside with the City. In addition, aerial photographs of the Loyalist Secondary Plan area were obtained in digital format and also reside with the City.

Figure 1 shows the watershed and the location of the recommended facilities. Included are the lands immediately south and east of the watershed, which are slated for development. Figure 2 shows the municipal boundaries and the area covered by the City of Belleville Loyalist Secondary Plan (LSP). It should be noted that this report pertains to the entire Potter Creek watershed; additionally a facility (S1) deals with a development area immediately south of the watershed boundary which drains directly to the Bay of Quinte.

The overall intent of the MDP exercise is to ensure:

- Post development flows do not exceed predevelopment levels.
- Development of tributary lands draining to Potter Creek does not degrade the quality of Potter Creek.
- Facilities are sited in the most advantageous locations from a land use and operational viewpoint.
- Fewer and larger facilities are planned.

While the emphasis of this report is on ponds (which are expensive to build and maintain), other stormwater controls are encouraged:

- Source control – measures such as rooftop storage in commercial situations and discharge of impervious onto pervious surfaces all reduce the peak discharge and facilitate groundwater (GW) recharge.
- Conveyance measures such as ‘leaky’ storm sewers reduce peak flows and promote GW recharge.

Another matter of critical importance is the strategy to implement the SWM Plan. Discussed in greater detail in Section V, implementation has several critical components:

- Identification and protection of pond locations.
- Ensuring development plans can tie in all lands to ponds via minor (storm sewer) and major systems.

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- Development and maintenance of a capital fund to collect revenue as land develops and build facilities as needed.
- Provision of a (timing) schedule linking sub basin development and the construction of the pertinent facility.

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Figure 1: Potter Creek Watershed Boundary

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Figure 2: Proposed Land Use

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This report is not intended to be ‘stand alone’ or an absolute guide to facility design. Reference is made to the following reports:

- Potter Creek Subwatershed Plan – Ecos-Garatech (1994) contains detail on physiography, biology, soils and fisheries in the watershed. A hydrologic model was developed for the entire watershed, pre and post development flows calculated and a series of twelve SWM facilities were proposed. Floodline mapping of Potter Creek was also produced.
- Marshall Macklin Monaghan (MMM) (2006) prepared a MDP for the lands drained by Tributaries 1 & 2 known as the Neighbourhoods of Avonshire (NOA). Flows were calculated and SWM facilities recommended.
- Potter Creek MDP, XCG (2007) discussed in further detail in Section II of this report.
- Stormwater Management Planning and Design Manual, MOE (2003).

II. BACKGROUND

The Loyalist Secondary Plan area is largely within the Potter Creek drainage basin. The Potter Creek basin is predominantly rural agricultural with some urban drainage from the western limits of development in the City of Belleville. It drains into the Bay of Quinte a few kilometres west of the Moira River outlet.

Floodline mapping for Potter Creek was prepared in 1994 that shows the extent of lands that would be flooded in the one in one hundred year (regional) flood event. As development proceeds in LSP area, increased urban runoff, if permitted to happen unchecked, would increase the risk of flooding in the basin and decrease water quality of the creek and Bay of Quinte.

Standard stormwater mitigation would be employed to reduce these impacts. Currently, water quality mitigation is directed by both the Stormwater Management Planning and Design Manual, MOE (2003) and the Bay of Quinte Remedial Action Plan, Implementation Area Stormwater Management Guidelines, March 2006. Water quantity control is governed by provincial policies respecting both riparian rights of upstream and downstream landowners as well as public safety concerns.

The City of Belleville employs a Cash-in-Lieu of stormwater management policy developed by the conservation authority over ten years ago. This policy is used in areas of infill or redevelopment and was not intended to be used for newly developing areas. The contributions from redeveloping areas would be pooled and used for construction of remedial stormwater management facilities that would improve water quality discharging from existing storm outfalls. The current Cash-in-Lieu policy would not be adequate for new developments and should not be applied in Loyalist Secondary Plan area.

The approach of constructing central stormwater management facilities that would be shared by several developments is encouraged. The facility costs can be substantially estimated using comparisons with experiences in other communities and by determining

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where facilities may be constructed in advance of development and how large they would need to be to meet the objectives stated earlier. These costs may then be apportioned to contributing developments on a cost share basis considering land area and impervious cover.

III. SYNOPSIS OF XCG MASTER DRAINAGE PLAN (2007)

This Report was commissioned by Quinte Conservation for the City of Belleville. It was prepared as an update of the hydrology of the entire Potter Creek watershed 1994 Eco-Garatech study). It also puts the MMM NOA study into the context of the entire watershed. A hydrologic model was developed of the entire watershed including lands which drain onto the NOA lands but not included in the MMM report.

The XCG study had the following objectives:

1. For existing conditions, determine peak flows generated by the 12-h, 100-year storm rainfall at the outlets of all major sub-basins and at all junctions in the stream network.
2. For post-development conditions (as defined by official plans), determine peak flows at the same locations and for the same storm rainfall as set out in (1) above.
3. At the outlets of all major sub basins, determine the storage required to reduce post-development peaks to existing condition peak flows.
4. At the outlet of all major sub basins, determine values for water quality storage according to MOE and Bay of Quinte Remedial Action Plan Guidelines.
5. Provide guidance on basin-wide stormwater management measures.
6. Provide a generic design of a typical stormwater management facility that will accomplish the water quantity and water quality objectives set out in (3) and (4).
7. Provide guidance on the apportionment of capital cost of a stormwater management facility that will serve a number of consecutive and/or concurrent developments.
8. Provide guidance on operation and maintenance and associated costs.

Hydrologic Model

XCG selected HEC-HMS which is well known in the public domain and easily replicated for future study in the event that current plans change.

A 12-h design storm was chosen for various return periods including 100 years. This was compared to the September 2004 event.

The basin was discretized into 20 subwatersheds as shown in Figure 1. Basins included areas of existing development, lands slated for development and areas where little change is anticipated.

Peak flows for the 100-year event were obtained from the model, both at sub basin outlet and at points along the stream, including the outlet at Highway 2. These flows were calculated for the existing and post-development condition.

General Stormwater Strategy

The plan for SWM was prepared using the major-minor system approach:

- minor system including roof gutters, driveways, street gutters and storm sewers. This conveys a design storm event (typical 5-yr) without surcharge.
- major system includes overland elements designed to convey the larger storm, typically 100-yr.

Quality design follows the Bay of Quinte Remedial Action Plan Implementation Area Stormwater Management Guidelines for Enhanced protection.

Facility Design

Facilities were sized to maintain existing flows at the outlets of all sub basins. Additionally, stormwater quality was managed by provision of facilities meeting current standard of Enhanced protection based on a wet pond design. The required facilities are shown in the XCG report (Table 3.4). As explained in Sections IV and V of this (Implementation) report, subsequent facility locations differ from XCG but meet the quantity and quality requirements as set out by the XCG report. The reason for this variance is that the pond locations are determined basin wide within the XCG report and do not account for situations such as flow contribution from two sides of the channel. The XCG work provided the hydrologic and hydraulic targets for the outflows of each catchment area. The implementation report brings the facility design one step further taking into consideration how drainage will be conveyed to and from the ponds.

A generic design for SWM facilities is provided in the XCG report based on the MOE design manual (2003) and other pertinent literature (XCG Figures 9, 10, 11, Table 3.3).

Implementation

The XCG report offers guidance on the following:

- Capital costs are in the range of \$40-\$60 per cubic meter of design storage volume for ponds of the size recommended for Potter Creek. Local experience suggests these estimates may be high. Other factors may influence Potter Creek facilities, including the opportunity to utilize excavated materials nearby as part of a 'cut and fill' process (discussed in Section V). Land costs have not been estimated but must be accounted for during development. Cost apportionment is recommended based on impervious areas.
- Maintenance strategies are outlined, including budgets and responsibilities.

IV. OVERVIEW OF POND LOCATIONS

As previously discussed the availability of finely detailed topographic mapping allowed for accurate placement of SWM (pond) locations. This was particularly important in the Potter Creek watershed where areas of little topographic relief limit pond locations. If the pond is located too low a suitable outlet elevation may not be available. If the pond is located at a higher elevation the level of active storage may inundate adjacent properties.

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Figure 1 shows approximate location of ponds in Potter Creek watershed. Another series of figures (Figures F1-F9, S1) show recommended size and location in greater detail. Also shown is the approximate boundary of the area tributary to the pond. This is not the actual boundary of the catchment area; it will be determined by road and lot grading at the time of development. The maximum boundary is intended as a guide to the municipality in plan review to ensure no areas are accidentally omitted or stranded. The criterion for the boundary is an average slope in the minor system of 0.5 %. This was chosen to ensure adequate cleansing velocity (>0.75 m/sec) and provision for losses in the system.

One pond within the NOA lands falls outside the Potter Creek watershed; it is shown on Figure S1.

It is important to note that these locations are not absolute. Other configurations may be chosen at the time of land development; however the locations shown should not be abandoned until functional alternatives are provided. Also, in the interest of maintenance and cost the configuration is for the minimum number of ponds; several smaller ponds could replace the function of any pond shown if necessary.

Table 1 lists the eleven recommended SWM ponds within the Loyalist Secondary Plan area and the associated land area requirements. Also shown are the possible elevations for the top of the permanent pool storage and the top of the active pool. The permanent pool elevation is constrained by the elevation of the available outlet. In all cases the SWM facilities are located as low as possible. The top of the active storage is constrained by upstream land elevations. In flat terrain the active storage level may inundate large areas upstream. In these cases active storage depth may be limited to one metre. Further pond details are included in the appendix in Table 2.

The contributing areas shown in Table 1 were determined by estimation of the area captured by the major and minor systems that will be put in place at the time of development. The post-development drainage boundaries will not in most cases coincide with the existing (XCG sub basin) boundaries. As developed boundaries will likely differ from those shown on the table new storage volumes can be calculated using a unit flow per (ha) area as provided in the XCG report.

V. FACILITY LOCATION BY SUBWATERSHED

Starting from the south, a series of figures show individual subwatersheds (see Figures F1 through 9 and S1). Each figure also shows potential pond locations and, most importantly, elevation differences available. In order to function, ponds must be located low enough to receive both the major and minor flows and have access to the lower elevation to facilitate discharge of the active storage after storm events. Other location criteria considered were: avoiding placement within the regulatory flood risk and environmental protection areas, placement in undeveloped areas and ideally at the exit of the sub-area.

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The actual pond elevations on each figure are only intended as an illustration of how the pond could function at the selected location. In most cases the active storage depth is the maximum allowable, limited by design criteria or upstream land elevation. A lack of relief limits the depth in order to not inundate upstream areas. Where this is unavoidable, filling will be necessary to provide minimum cover over the storm sewer system.

Additionally, ponds serving a subwatershed are shown as a single facility where possible. This will not be possible in situations of EP designation or stream considerations (e.g., fish habitat). In these cases, off-line ponds must be located on either side of the stream (see subwatershed 18, Figure F2 for example).

The figures discussed below show ponds at locations which are optimal from the standpoint of operation and ability to intercept runoff from the greatest amount of lands. A dashed line shows the maximum distance 'reach' of the minor (storm sewer) system from the SWM facility. It should be noted that this reach or boundary often overlaps adjacent SWM facility boundaries. In these cases water can be taken to either facility.

Other considerations, such as the availability of the lands, may rule against these locations, in which case alternate locations and designs will be necessary. The overall policy thrust of flood attenuation and water quality preservation must still be maintained.

Lastly, small amounts of development lands cannot easily be brought into SWM facilities due to a lack of gradient. Section V offers policies to deal with these areas.

Facility 1, sub-basin 19 (Figure F1). The facility is recommended to be located at the western limit of sub-basin 19 where a low area provides suitable outlet elevation to accommodate most of sub-basin 19 and a southern portion of sub-basin 17 which would otherwise be difficult to capture. The lands required are less desirable since they border on the RR right of way. The facility is an online wetpond and could be naturally vegetated and utilized as a recreation/trail feature. (Note: This pond replaces F3 shown in the NOA Master Drainage Plan study).

Facility 2, sub-basin 18 (Figure F2). This pond is essentially the F2 facility in the NOA MDP. It is off-line (from Tributary 2) and captures the southern portion of sub-basin 18. F2 has the potential to capture a greater area to the south in which case flows to F1 would be reduced.

Facility 3, sub-basin 18 (Figure F3). This facility, again from the NOA MDP (called facility F1 in that report), captures the northern portion of sub-basin 18 and can also bring in the extreme western area of sub-basin 14 and the portion of sub-basin 13 east of Avonlough Road. The rationale for this boundary is the constraint imposed by roads and the opportunity to eliminate an additional facility serving sub-basin 14. Because of size limitations F3 cannot receive all stormwater south of Moira street from subbasins 13 and 14. Another intermediate facility F3a is shown.

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Facility 4, sub-basin 16 (Figure F4). In order to find an outlet elevation low enough to capture the subwatershed and not locating on lands covered by draft plan of subdivision, only two locations are feasible (shown as F4 and F4alt). An opportunity exists to treat the runoff from the existing residential area to the west in this facility and to bring in adjacent lands planned for redevelopment. There are sizing and cost/benefit implications for the City to consider. Location F4 is on the east side of Marshall Road and is the minimum area to site the required facility. F4alt on the west side of Marshall Road is on lands owned by the developer of the adjacent Neighbourhoods of Avonshire (NOA) and is outside the boundary of subwatershed 16. Both locations will meet the need and in either case negotiations regarding acquisition and compensation will be necessary.

Facility 5, sub-basin 14 (Figure F5). Because of the extremely flat terrain, it is difficult to site a SWM facility in this sub basin. If an online facility could be permitted, Facility 5 could be located east of Marshall Road and have outlet across the road to the west. Material excavated from the pond could be utilized in adjacent areas to bring lots up to the required grade (and out of the flood plain). Drainage at this location is constrained by culverts under Marshall Road forcing a large floodplain east of the road. An additional benefit to this plan is that the drainage improvements here would also remove homes on the east side of Marshall Road from the current floodplain extents.

Dependent on the culvert capacity under the CN line (at Moira), a portion of sub-basin 14 north of Moira could be treated in this facility. As discussed in Section VI, there are few options to accommodate development in the area immediately north of Moira due to the flat terrain.

Facility 6, sub-basin 6 and sub-basin 4 (Figure F6). The flat terrain and lack of outlet from Tributary 3 creates a large flood plain north of Moira Street and makes SWM difficult. Facility 6 can capture lands to the north but with an outlet limited by the flood line of approximately elevation 93m, it is not possible to capture low areas – even the existing subdivision to the east is only a metre above this elevation.

Facility 7, sub-basin 8 and sub-basin 10 (Figure F7). This facility has the same limitations as Facility 6; lands which are above elevation 95m can easily be captured. It is assumed that lands north of Bell Boulevard have onsite facilities.

Facility 8, sub-basin 8 and sub-basin 12 (Figure F8). This facility has the same limitations as noted above; the available outlet is the flood line – approximately elevation 93m, thus limiting the capture of low lands lying (approx. 95m).

Facility 9, sub-basin 12 (Figure F9). This facility can service the lands immediately north of Moira provided outlet is available at elevation 92m or lower (discussed in Section VI).

Facility S1, (Figure S1). The facility is located at a low elevation in order to capture the flow from NOA lands lying outside the Potter Creek watershed. Topography limits the

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area of the major flow but an opportunity exists to bring in minor flow from part of sub basin 19 if needed.

Table 1: Facility Summary

Facility	Developable Area (ha)	% Impervious	Active Detention		Permanent Pool		Total Volume (ha.m)	Pond Area (ha)	Vol./Imp. Ha (m ³)	Cost/Imp. Ha (\$1000)
			Volume (ha.m)	Depth (m)	Volume (ha.m)	Depth (m)				
1	57.1	40.8	1.40	1.5	0.55	1.0	1.95	2.15	981	39
2	34.7	42.4	1.00	1.75	0.26	1.0	1.26	1.26	1352	54
3	34.7	15.4	1.75	2.0	0.41	1.0	2.17	1.50	1448	58
3a	29.5	47.8	1.07	2.0	0.26	1.0	1.32	1.20	1391	56
4	33.4	41.3	1.55	2.0	0.38	1.0	1.93	1.30	1404	56
5	60.9	40.0	0.70	1.0	0.14	1.0	0.84	1.74	1702	68
6	74.8	38.5	4.89	2.0	1.53	1.0	6.41	4.26	1083	43
7	144.2	64.2	1.30	1.5	0.39	1.0	1.69	1.88	1114	45
8	94.6	52.6	2.75	2.0	1.01	1.0	3.76	2.72	954	38
9	94.6	40.0	0.95	2.0	0.21	1.0	1.16	1.40	1270	51
S1	23.4	42.4	0.27	2.0	0.27	1.0	1.35	1.28	1363	55

Cost / m³ of storage
(based on local
average)

\$40

Avg.

1,278

\$51,133

VI. IMPLEMENTATION STRATEGIES AND POLICIES

- 1. Locations for Ponds.** As stated previously, the locations shown are ones that can function properly and meet the intent of the MDP. Further study involving geotechnical conditions and land ownership is required to either confirm these locations or identify alternatives. If the locations provided are confirmed as feasible and the most desirable, steps should be taken to obtain the lands in those locations soon to be developed. It may be necessary for the City to ‘front end’ the purchase until the development charges generate sufficient funds for land acquisition and facility construction. In the case of facilities located in areas with long development horizons, it is sufficient to have them designated on the Secondary Plan.

Once locations have been confirmed, efforts should be made to turn them into assets through integration with pond and trail areas. With low bank slopes and heavy vegetation cover, there would be no need to fence the facilities.

Access for maintenance was considered in pond sizing by assuming a 4.0 metre wide gravel access road atop a perimeter berm. Side slopes allowing for 5:1 slope and 0.3 metre freeboard for interior of pond berm and 3:1 back slopes for outer perimeter were assumed.

- 2. Land Acquisition.** Most if not all the pond locations are on private land and in some cases may involve multiple ownership. As well the owner may not also own the other land within the sub basin thus would not benefit from the facility. For these reasons a strategy is required for acquisition. This could be as simple as outright purchase at fair market value or land swapping amongst owner/developers. Once the site is known to the affected owners the City should assist in the foregoing process by identifying owners and bringing them together to explore options. If there is no satisfactory outcome from negotiations the City does have the right of expropriation.
- 3. Planning Considerations.** The ponds should be viewed as a community facility akin to a water plant, school or park and so designated on an appropriate plan. This ensures that the ponds are properly integrated into development plans for roads, parks and storm sewers.
- 4. Financing.** Each facility has an estimated cost and the development area contributing to the facility is shown (Table 1) in order to calculate a cost per hectare development charges. The City should determine the estimated cost of land acquisition and update the construction cost figures from time to time. Table 1 has been prepared to show estimated facility costs and provide a tool for estimation of cost sharing for each. The cost for each has been based on an estimated value of storage of \$40/m³. This is based on construction cost only and is comparable to the estimated construction cost of the Foster Avenue pond at

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\$37/m³ and final construction costs of Canniff Mills pond \$34/m³ and No-Name Creek pond at 401 \$36/m³.

Stormwater management cost allocation for each development is suggested to be assigned by the City at \$51,000 per impervious hectare.

5. **Areas not connected to ponds.** A careful examination of the watershed mapping will show that small pockets of development lands cannot easily be connected to facilities. In most instances, the storm sewer system can capture the minor system, even if the street grades toward the watercourse (away from the pond location). In these instances, it may be sufficient to slightly over control to accommodate any increase in flood peak and provide a greater vegetated buffer to the watercourse (for example, 30m instead of 15m). Stormwater management costs would be determined based on an impervious area contribution to the facility in the same predevelopment catchment area. If greater buffering is provided the cost of the additional land could be considered.
6. **Tributary 3, north of Moira.** (Special Policy Area 1, Figure SP1). As discussed previously, this is a problem area due to the flat terrain and lack of outlet capacity at Moira Street and under the CN rail line. There are few options:
 - a) Do nothing and restrict development to areas more than a metre above the flood plain in order to bring the lands (mainly north of Tributary 3) into SWM facilities. This would make large areas of sub-basins 12, 10, 14 and 6 undevelopable.
 - b) Create online storage on tributary 3 north of Moira and on the main branch by cutting to elevation 90m and using the material generated to fill adjacent lands and raise them out of the flood plain. If the flood elevation could be lowered even by 0.5m large areas of the above noted lands could be developed. This option has major cost and environmental implications.

Because these lands are not likely to be developed in the near future an opportunity exists to study these options and recommend a plan of action.

VII. LANDS SOUTH OF POTTER CREEK

Contained within the Loyalist Secondary Plan are lands which drain directly to the Bay of Quinte through a network of open ditches, culverts and pipes. These are lands south and east of the Potter Creek watershed boundary. Figure 3 shows the land use designation for these lands. Although partially developed, there is a potential for increased density, hence increased stormwater runoff. The potential development includes low and medium density residential as well as commercial. No single drainage feature connects these lands.

Lands shown as Area A are those that would drain to Facility S1. These are more clearly presented earlier in section V. Area B lands may be diverted to Facility F1. At the time

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F1 is considered a review of the southern fringe lands should be completed to determine the merit of their inclusion into F1.

The remaining lands shown as Area C cannot feasibly be directed to large central facilities. This is due to constraints such as the Old Highway 2 and the CP Railway corridors and the generally low relief. Redevelopment upstream of these would increase runoff volume and peak flows and may lead to surcharging of culvert crossings. Good stormwater management design would be to plan facility locations upstream of the constraints. However, much of the lands are separated by the two corridors which traverse the area from east to west. Therefore central facilities are not recommended for area C.

For development in the remaining area two issues arise;

1. What are the water quality impacts on the Bay of Quinte?
2. What quantity control measures are necessary to ensure the existing drainage structures are not overloaded.

It is recommended that the City of Belleville put the following policies in place:

Water Quantity

1. Runoff from lands developed within the Neighbourhoods of Avonshire (NOA) south of the Potter Creek watershed boundary be directed to facilities S1 and F1, where possible.
2. Prior to development/redevelopment of residential lands outside NOA downstream drainage facilities be investigated for capacity. If adequate capacity does not exist either on-site control or a plan to expand capacity will be necessary.
3. Significant new commercial development should maintain predevelopment flows by way of on-site storage.

Water Quality

1. Development should meet Enhanced water quality objectives.
2. Residential development outside that serviced by facility S1 should emphasize source control measures such as back yard swales and roof leader discharge onto permeable areas.

VIII. CONCLUSIONS

The facilities that are conceptually designed and located herein have considered the best information available at the time and are technically feasible if constructed at the proposed locations. For other reasons facility locations may be altered and numbers of facilities may be expanded. Since the guiding principle has been to keep the number of facilities at a minimum in consideration of long-term maintenance costs, alternate proposals must be acceptable to the City of Belleville who will be the final owners and operators of the facilities.

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An approach for cost sharing is suggested and may be applied based on developable land area and % imperviousness. Before finalizing the formula and incorporating it into the schedule of development charges it will be necessary to obtain better facility cost estimates including land costs. The City may wish to draw upon the experience of other municipalities with a longer history with stormwater management facilities.

It is recommended the City apply a stormwater management contribution calculation of **\$51,000 per impervious hectare** for each development in the LSP area for construction of central facilities.

It is also recommended that land costs be apportioned in the same way between developments by using the impervious area of each development as their share of land costs.

APPENDIX A

Figures

*Potter Creek Master Drainage Plan Implementation Report
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Figure 3 **Figure F1: Facility 1 – Sub-basin 19**

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Figure 4Figure F2: Facility 2 – Sub-basin 18

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Figure 5 Figure F3: Facility 3 – Sub-basin 18

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Figure 6Figure F4: Facility 4 – Sub-basin 16

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Figure 7Figure F5: Facility 5 – Sub-basin 14

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Figure 8 Figure F6: Facility 6 – Sub-basins 4 and 6

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Figure 9Figure F7: Facility 7 – Sub-basins 8 and 10

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Figure 10 Figure F8: Facility 8 – Sub-basins 8 and 10

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Figure 11Figure F9: Facility 9 – Sub-basin 12

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Figure 12 Figure S1: Facility S1

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Figure 13 Figure SP1: Special Policy Area

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Figure 14 Figure 3: Southern LSP lands

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Table 2: Pond Sizing Calculations

**Potter Creek Master Drainage Plan
Pond Volume calculations**

Prepared by: BCK
Date: May 14, 2008

Facility	F1	F2	F3	F3a	F4	F5	F6	F7	F8	F9	S1	Total	XCG total
Land Area (ha)	2.15	1.26	1.50	1.20	1.30	1.74	4.26	1.88	2.72	1.40	1.28		
Pond Length to Width Ratio Full $_:$ 1	3	3	3	4	1.75	3	1	2.4	1.5	1.5	1.2		
Pond Side Slope $_:$ 1	5	5	5	5	3	5	5	5	5	5	5		
Storage Required													
Active Volume Required (cu.m)	14,016	10,017	17,531	10,658	15,500	6,988	48,867	12,962	27,482	9,505	10,775	184,302	363000
Dead Storage Required (cu.m)	5,490	2,585	4,128	2,587	3,841	1,384	15,268	3,912	10,089	2,126	2,750	54,159	154200
Total Storage Required (cu.m)	19,506	12,602	21,660	13,245	19,341	8,372	64,135	16,874	37,571	11,631	13,525		
Active Storage Calculations													
Depth of Active Storage (m)	1.5	1.75	2	2	2	1	2	1.5	2	2	2		
Length at Full Storage (m)	200	150	185	180	125	160	180	160	165	100	95		
Width at Full Storage (m)	66.7	50.0	61.7	45.0	71.4	53.3	180.0	66.7	110.0	66.7	79.2		
Surface Area at Full Storage (sq.m)	13333.3	7500.0	11408.3	8100.0	8928.6	8533.3	32400.0	10666.7	18150.0	6666.7	7520.8		
Active Volume (cu.m)	17,008	10,073	17,897	11,713	15,508	7,470	57,613	13,458	30,813	10,013	11,572		
Volume of Active Storage is	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		
Dead Storage Calculations													
Depth of Dead Storage (m)	1	1	1	1	1	1	1	1	1	1	1		
Length at top of Dead Storage (m)	185	132.5	165	160	113	150	160	145	145	80	75		
Width at Top of Dead Storage (m)	51.7	32.5	41.7	25.0	59.4	43.3	160.0	51.7	90.0	46.7	59.2		
Surface Area of Top of Dead Storage (sq.m)	9558.3	4306.3	6875.0	4000.0	6715.4	6500.0	25600.0	7491.7	13050.0	3733.3	4437.5		
Dead Volume (cu.m)	8,378	3,485	5,845	3,078	6,200	5,537	24,003	6,512	11,878	3,103	3,770		
Volume of Dead Storage is	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		
% Land Area Utilized	62%	59%	76%	68%	69%	49%	76%	57%	67%	48%	59%		