R E P O R T

DISTRICT OF LAKE COUNTRY

Woodsdale Area Drainage Plan

ASSOCIATED ENGINEERING

March
2002

TABLE OF CONTENTS

BACKGROUND

SECTION 2

2.1 SITE DESCRIPTION

The lowland Woodsdale area is located in a valley bottom south of Wood Lake. The ground is gently sloped toward Wood Lake at an approximate average grade of 1%. Mild undulations in the ground surface appear to divide the area into minor drainages.

The lowland soils in the Woodsdale area are mostly lacustrine (fine-grained lake) deposits and anecdotal reports indicate they are relatively poorly drained. Soils mapping indicates that the water table is generally within two metres of the surface.

Two significant water courses are located in the lowland area. The largest, Vernon Creek, originates in the highlands to the southeast of Woodsdale. Vernon Creek flows northward into Wood Lake, with its channel favouring the west side of the valley in the study area. The second water course, Winfield Creek, originates within the study area and also drains northward into Wood Lake. Winfield Creek runs along the western edge of the valley in close proximity to the hillside. Most of the summer base flows in Winfield Creek reportedly originate as irrigation on the adjacent highlands to the west.

Both water courses are considered environmentally significant and sensitive. The community has enhanced fish habitat in Winfield Creek, and Vernon Creek is an important salmonid supporting stream. Both creeks are important community environmental amenities.

Internal drainage in the Woodsdale area occurs through a network of roadside ditches, with most drainage routed to Wood Lake along Bottom Wood Lake and Reiswig Roads. Some poorly defined cross-country drainage channels were observed in the eastern portion of the lowland area in air photographs and during a field investigation. Generally most drainage in the community area appears to go directly toward Wood Lake. In the southern most portion of the agricultural areas and in immediate proximity to the two creeks, some drainage is routed to the creeks.

2.2 WOODSDALE NEIGHBOURHOOD PLAN

The Woodsdale Neighbourhood Plan of April 1999 outlines the anticipated development in the Woodsdale area and the environmental and social concerns arising from that development. Figure 1 is adapted from the Woodsdale Neighbourhood Plan by TRUE

Consulting Group, and indicates the general form of future land uses in the Woodsdale area.

Significant commercial and multi-family developments are expected along both the north and south sides of Woodsdale Road east of Highway 97. The most intensive development areas are centred on the intersection of Woodsdale Road and Bottom Wood Lake Road and immediately east of Highway 97. An additional pocket of commercial development is located east of Reiswig Park. Much of the multi-family and commercial development will take place on land that is currently occupied by single-family homes, some land will also be removed from the ALR to accommodate new development.

The existing single-family residential areas south of the development areas will remain in their current form, as will the single family residential development north of Clement Street on the shore of Wood Lake. The single family residential area north of Seymour Street may be re-zoned for commercial use in the future. The ALR lands south of the main community area will remain as such.

SECTION 3

HYDROLOGIC AND HYDRAULIC MODELLING

The model analysis of the Woodsdale area drainage system was carried out using Visual Hydro 2000 from CAICE software, a variant of the U.S.E.P.A.'s SWMM software program. The EXTRAN component of the Visual Hydro software has full dynamic capabilities for hydraulic modelling, including backwater effects and flood wave routing.

The model analysis was centred on the effects of a short duration, intense spring/summer convective rainfall event. Rainfall IDF curves for the Kelowna Airport, in conjunction with AES rainfall distribution curves, were used to develop the rainfall events used in the model analysis. Initial experience with the model indicated that storm durations on the order of one to two hours produced the most severe runoff conditions for the study area.

Suitable design lake levels were required for Wood Lake to account for any backwater effects into the drainage system. Recorded water level data is available for Wood Lake for the period from 1955 to 1972 and for Kalamalka Lake from 1967 to 1990.

An assessment of recorded Wood and Kalamalka Lake water levels during the period for which they overlapped, indicated that water levels in the two lakes were closely related and were seldom out of agreement by more than one or two centimetres. Therefore, Kalamalka Lake water levels were used to extend the Wood Lake data set to provide a more accurate estimate of design lake levels. Four different statistical analyses were used on the water level data. For a range of return periods from 1-year to 20-years, the predicted water levels are very consistent among the four statistical methods. Wood Lake design water levels for various return periods are provided in Table 1. The values given are the highest of those provided by the four methods.

Table 1:
Wood Lake Design Water Levels for Return Periods from 1 to 20 Years

	1-year	2-year	5-year	10-year	20-year
Water Level (m – geodetic)	391.54	391.79	391.93	392.02	392.11

The model analysis combined the 5-year return period storm with the 5-year return period Wood Lake water levels. Generally the highest lake levels were recorded in the late spring-early summer, and coincide with the period in which the most severe storms could be expected to occur.

A limited field survey of the existing Woodsdale drainage system was carried out. This survey located and recorded existing culverts and ditches on Woodsdale Road between Vernon Creek and the railway right of way, and on Wood Lake Bottom Road as far south as the Vernon Creek crossing. The short existing section of storm sewer on Wood Lake Bottom Road north of Woodsdale Road was included. At the request of the District of Lake Country the various crossings of Vernon Creek were surveyed. Road crown elevations on both Wood Lake Bottom Road and Woodsdale Road in the study area were also surveyed.

Available topographic mapping for the Woodsdale area is limited to a resolution of 5 m. For this reason, drainage paths and catchment delineation was based both on the survey information and interpretation of patterns from air photos. Sub-catchment slopes were based on the overall slope of the Woodsdale area toward Wood Lake.

Potential flood storage in the agricultural fields within the Woodsdale area was not modelled. Surveyed elevations and sufficient topographic information were not available to allow this flow attenuating feature to be included.

Vernon and Winfield Creeks were not modelled since it became apparent early in the study that it was preferable to route the majority of drainage away from these watercourses as much as practical for environmental reasons.

STUDY APPROACH

SECTION 4

4.1 MODEL SCENARIOS

The following describes the model scenarios used to investigate drainage conditions in Woodsdale:

Base Model - this task included the construction of the existing condition model that would provide the base for all subsequent model scenarios. The existing drainage system and estimated existing drainage parameters were utilized in this model.

Future Condition Models with Existing Drainage System - Two distinct future hydrological conditions were modelled, the first assumed that onsite BMPs were implemented in developments to limit the peak flows entering the drainage system. The second scenario considered the required drainage improvements if developments were not required to implement on-site mitigation measures to control peak runoff. The existing drainage system was evaluated with these future conditions to determine whether it could handle the increased runoff.

Future Condition Model with Improvements - This task included multiple simulations to assess drainage improvements to handle increased flow or changed drainage patterns. These models utilized the same future development condition investigated in the scenarios above. The conceptual drainage designs were developed from the most promising of the alternatives investigated.

Pre-development Model - This task estimated the peak runoff from each sub-catchment based on assumed infiltration and impervious percentage parameters that would have been present prior to the existence of the Woodsdale community. These pre-development flow estimates are intended for comparison with predicted flows from the base and future condition models to indicate the impact of development on runoff.

4.2 MODEL INPUT PARAMETERS

The hydrologic model requires that several input parameters be estimated in order to calculate the runoff from a modelled storm event. Ideally the value of these parameters would be established by comparing measured runoff from known rainfall events with modelled results. The parameters are then adjusted until there is good agreement between measured and modelled runoff. A calibration procedure such as this requires good quality measured flow data, with corresponding rainfall data. Such data was not available for Woodsdale, at the time of this study.

Instead, hydrologic parameters were estimated based on experience and similar values used in Kelowna. These parameters include: the percentage of impervious area, infiltration parameters for pervious areas, depression storage depth and overland flow Manning's "n". The percentage of effective impervious area such as paved parking, roads, rooftops and other surfaces that contribute water to the drainage system, depends on the land use and whether impervious areas are directly connected to each other and the drainage system.

Two different hydrologic scenarios were investigated. The first considered the required drainage system upgrades if applicable storm water best management practices (BMPs) were used in new development to reduce peak runoff. These BMPs are discussed more fully in section 6, but include such measures as disconnecting impervious areas with pervious strips, grass medians between sidewalks and parking areas or streets, open shoulders, and pervious parking surfaces. Providing detention storage also reduces peak flows to the drainage system.

The second scenario assessed the required drainage system if BMPs were not applied to new development, and they were constructed according to conventional development practices. This would include paved driveways connecting directly to the road system, large parking areas draining directly to the storm drain system, roof leaders connected to storm drains or discharging to impervious surfaces, and similar practices. Table 2 compares the parameters used in the BMP and conventional scenarios. The land-use abbreviations are: SFR - single family residential, MFV - multi family village, MFL - multi family low density, CT - commercial tourist, ALR - agricultural land reserve.

Table 2:
Hydrologic Parameters Used in Drainage System Assessment

Land Use	Percentage Effective Impervious Area	
	BMP Development Scenario	Conventional Development Scenario
Existing rural SFR	25	25
Existing commercial	65	65

Land Use	Percentage Effective Impervious Area	
	BMP Development Scenario	Conventional Development Scenario
Future MFV	45	70
Future MFL	40	60
Future CT	45	75
ALR	10	10
Depression Storage – Impervious Areas	1.0 mm	
Depression Storage – Pervious Areas	3.0 mm	

In recognition that the soils in the Woodsdale area may be moderately poorly drained, and/or have a high water table, the Horton's infiltration parameters used were:

- An initial infiltration rate of 12.7 mm/hr
- Final infiltration rate of 6.35 mm/hr
- Decay coefficient of 0.00115 /s

The infiltration parameters are used to estimate the infiltration of water into pervious areas, for example lawns or agricultural land.

In addition to the estimated hydrological parameters, some of the drainage system had to be approximated due to the limited survey data available. Assumed ditch cross sections were employed to model the road-side ditches, with a Manning's "n" of 0.030 appropriate for moderately grassed conditions.

MODEL ANALYSIS

SECTION 5

5.1 EXISTING DRAINAGE SYSTEM AND LAND USES

Most of the existing drainage system in the Woodsdale community is open ditches with numerous short sections of culverts at driveways and road intersections. The only existing closed (storm sewer) drainage system is located on Bottom Wood Lake Road north of Woodsdale Road, adjacent to the existing multi-family residential development.

For the 5-year storm, most of the system performs adequately, with no flooding above existing ground. However, two locations on Bottom Wood Lake Road problems occur for the 5-year storm.

Figure 2 indicates the breakdown of subcatchments from major land parcels and the estimated peak runoff for the pre-development, existing, and future development conditions are indicated. Figure 3 indicates the location of conveyance problems for existing conditions and the 5-year storm.

The first problem location is at the outlet from the recently installed closed system north of Woodsdale Road on Bottom Wood Lake Road. The outlet slopes upwards from the last manhole invert to discharge to the existing ditch system. The change in elevation is approximately 0.7 m. The closed system is choked by the high outlet elevation and is not able to carry the flows resulting from the 5-year storm. The model indicates surcharging to ground at the manholes on Bottom Wood Lake Road.

The drainage improvements detailed in the following sections will correct this drainage deficiency. Essentially the entire ditch system north of Woodsdale Road is proposed to be replaced by a piped system that diverts flow to a wet pond facility in Reisweg Park adjacent to Wood Lake. Flows from upstream (south) of Woodsdale Road will be diverted along Woodsdale Road and then through Reiswig Park to the BMP facility. In the interim, the outlet and adjoining ditches should be re-graded to eliminate the high outlet.

South of Woodsdale Road, several culverts in the ditch along Bottom Wood Lake Road that convey flows toward Wood Lake, appear undersized. Future culvert replacements should consider using 450 mm diameter culverts to reduce head losses and subsequent backwater effects. Similar to the problem described above for the closed system north of Woodsdale Road, one culvert slopes upward and imposes a constriction and backwater effect, resulting in local surcharging to ground. This culvert and the downstream ditch should be re-graded to provide a uniform grade and better flow conditions.

The immediately required drainage improvements are indicated in Figure 3. These upgrades are intended as interim measures to address local drainage deficiencies, until development driven global system upgrades detailed in the following sections are implemented.

The model analysis did not indicate any other existing system deficiencies. Localized problems may exist in tributary portions of the system that were not modelled, and are therefore not identified in the present study.

5.2 DRAINAGE SYSTEM IMPROVEMENTS - FUTURE LAND USE CONDITIONS

The model analysis of future development conditions combined with the existing drainage system indicated that the existing system in the re-development areas would not convey the resulting increased runoff. Therefore, improvement plans were developed for the drainage system within the development areas.

Two development scenarios were considered, in the first it was assumed that storm water Best Management Practices (BMPs) would be applied to limit the runoff contributed by each development area. In the second, conventional development practices, with correspondingly higher peak runoff, were assumed. Conceptually, the drainage plans for both scenarios are similar.

For the purposes of analyzing future development in the present study, the drainage system is divided into three zones, reflecting the drainage boundaries created by Vernon and Winfield Creeks. The main zone (Village Centre) encompasses the area east of Vernon Creek to the railway right of way. The second zone (Vernon Creek) is between Vernon and Winfield Creeks, and the third zone (Winfield Creek) is between Winfield Creek and Highway 97.

Within the Village Centre zone both drainage scenarios assume that flows are routed to a centralized location in Reiswig Park adjacent to Wood Lake, prior to discharge. This location was selected to allow the implementation of a wet pond BMP facility to address storm water quality issues if required. Current regulations do not address quality issues in storm water. However, given the sensitive nature of Wood Lake, and increasing concerns with receiving water quality it is likely that some measure of treatment of storm water prior to discharge will be required in the future.

The proposed wet pond is intended to protect water quality in Wood Lake by sediment settling and removal of other storm water pollutants including nutrients. The role of a wet pond is discussed more fully in Section 7. A section of constructed channel may be included to provide a water feature in the park as a community amenity. This could be a winding channel with planted vegetation. The proposed wet pond with sediment settling, if required for quality reasons, would be similarly vegetated, though provision for periodic cleaning of accumulated sediments would need to be provided. It is anticipated that both the channel and pond would be enhanced to provide an amenity to the community and an aesthetic feature for Reiswig Park.

A piped storm water system is anticipated in areas that will be developed as multi-family or commercial due to the stated desire in the Woodsdale Neighbourhood plan to provide a village atmosphere with buildings located close to the roads with roadside parking. Ditches would require a large footprint and would displace sidewalks and structures away from the roadside. Existing ditch and swale networks would be retained in the agricultural and single family residential areas south of the main village area.

It was assumed that concrete pipe or PVC would be utilized for all drainage system pipe. Corrugated steel pipe is not recommended for low gradient applications due to its higher friction factor and tendency to retain sediments. If corrugated steel pipe (CSP) is employed for components of the drainage system, these components would have to be considerably larger. We have not designed for CSP.

The future main drainage route does not follow Bottom Wood Lake Road north of Woodsdale Road. This is due to the undersized existing storm sewer located north of Woodsdale Road. Also, there appears to be insufficient land available at the north end of Bottom Wood Lake Road adjacent to Wood Lake for locating a BMP facility there. This locale is occupied by the main sanitary lift station. However, this location could be used for an interim discharge to Wood Lake of locally originating drainage prior to the implementation of the centralized wet pond BMP facility.

It is not practical to route drainage flows from the two smaller zones (Vernon and Winfield Creek zones) across the creeks to the centralized wet pond and discharge facility. Therefore, it is anticipated that drainage from individual developments be routed through swales and soaker strips to a main swale that runs parallel to each creek outside the buffer zone. Each section of swale would have an overflow to the creek, but it is intended that most runoff be disposed of by infiltration to control the quantity and quality of water entering the creeks.

The vegetated swales would be located along the west side of the respective creeks that they would be draining to. Most likely the swales would not form a continuous system but would be implemented in sections concurrent with the (re) development of each major property. These vegetated swales could be incorporated with the proposed trail system that would run adjacent to the creeks. Figure 6 provides a conceptual sketch of the swale configuration.

The Department of Fisheries and Oceans (DFO) and the provincial Ministry of Water Land and Air Protection (MWLAP) will require stream setbacks along Vernon and Winfield Creeks that will make some of the land unavailable for development. Discussions with both agencies should be pursued to determine if the grassed swale strips would satisfy a portion of this requirement.

The alternative to the vegetated swales would be an interceptor storm sewer running parallel to each creek, ultimately discharging to a sediment settling facility and then Wood Lake. This alternative is not considered feasible due to its impact and the required land for BMP facilities in the Turtle Bay area.

5.2.1 BMP Development Scenario

This scenario assessed the required drainage system improvements that would be required to accommodate future development assuming that on-site BMPs are applied to new development in a comprehensive manner. Also implicit in this scenario is that any on-site BMPs are properly maintained, and are not removed (for example pervious areas are not paved over) over the life of the development. The BMPs are assumed to reduce the peak runoff. This reduces the required hydraulic capacity of the drainage system, reducing construction costs and consequently DCCs. Estimated construction costs for this scenario are provided in section 6.1

The conceptual arrangement of the closed system in the Village Centre zone, and the general pattern of the swale systems in the Vernon and Winfield Creek zones are shown on Figure 4.

The closed system was designed on the basis of conveying the 5-year storm runoff without surcharging pipes above crown at any location. Subsequently, the closed system was checked against the 10-year storm to ensure that the system does not surcharge to ground at any location.

Peak runoff flow rates for the five year storms are indicated on Figure 2 for each major land parcel. These flow rates reflect the instantaneous peak flow leaving the property after implementing on-site BMPs, and are not design values for on-site drainage management.

5.2.2 Conventional Development Scenario

This scenario assessed the required drainage system improvements if the proposed commercial and multi-family developments did not employ BMPs to limit peak runoff. It was assumed that conventional on-site construction and drainage practices would be employed.

Higher peak runoffs would be generated than if the proposed developments employed BMPs. This impacts the drainage systems since more upgrade work, either larger pipes or wider, deeper ditches are required to handle larger flows.

The conceptual drainage plan is similar to that for the previous BMP scenario. However, the area on Bottom Wood Lake Road north of Woodsdale Road requires an additional storm sewer draining eastward to Reiswig Park due to low east-west gradients hindering the ability to handle higher flows. Overall, storm sewer pipe sizes are larger than in the BMP scenario. The proposed drainage system improvements for this scenario are indicated on Figure 5. Cost estimates for the drainage system required for this scenario are provided in section 6.2.

CAPITAL COST ESTIMATES

SECTION 6

The following provides estimated capital costs for the two drainage plan scenarios. In both cases land acquisition costs are excluded. Note that land adjacent to Winfield and Vernon Creeks required for stream buffers zones and the swale system will be unavailable for development. Estimated costs for the enclosed drainage system includes an allowance for restoration of roads and property. If drainage system components are installed at the same time as road work, then some overall cost savings may be realized.

It is anticipated that the majority of the capital cost for the drainage system would be recovered by DCCs applied to re-development as it occurs. This is justified by the fact that the drainage system upgrades are required only to handle the additional runoff resulting from increased development. Existing land-uses require only minor system upgrading.

The capital cost of the BMP development scenario (less any land acquisition costs) is approximately $910,000 as compared to $2,344,000 for the drainage improvements required for a more conventional development practices. Both costs include a wet pond for storm water management that may be required to address water quality issues prior to discharge to Wood Lake.

6.1 CAPITAL COSTS BMP DEVELOPMENT SCENARIO

Closed Conduit Drainage System - Village Centre	
Estimated Construction Cost - Closed Piping System	$1,054,000
Engineering and Contingency @ 35%	$ 369,000
Estimated Total Cost - Closed Drainage System	*$1,423,000*
Wet Pond/Storm Water Quality Facility - Reiswig Park	
4750 m^3 Wet Pond and Settling Facility	$ 170,500
25% Environmental (Rehabilitate Reiswig Park)	$ 42,600
35% Engineering and Contingency	$ 59,00
Total	*$ 272,200*
Swale System - Vernon Creek Zone	
650 m of 0.5 m Deep, 11 m Wide Swales	$ 57,200
7 Overflows and Drains	$ 10,500
Subtotal	$ 67,700
25% for Environmental - Plantings, Trails etc.	$ 16,900
35% Engineering and Contingency	$ 23,700
Total	*$ 108,300*

Swale System - Winfield Creek Zone	
650 m of 0.5 m Deep, 11 m Wide Swales	$ 57,200
6 Overflows and Drains at Approx. 50 m Intervals	$ 9,000
Subtotal	$ 66,200
25% for Environmental - Plantings, Trails etc.	$ 16,600
35% Engineering and Contingency	$ 23,200
Total	*$ 106,000*

Grand Total - Woodsdale Drainage Plan **$1,910,000**

6.2 CAPITAL COSTS CONVENTIONAL DEVELOPMENT SCENARIO

Closed Conduit Drainage System - Village Centre	
Estimated Construction Cost - Closed Piping System	$1,278,200
Engineering and Contingency @ 35%	$ 447,400
Estimated Total Cost - Closed Drainage System	*$1,725,600*
Wet Pond/Storm Water Quality Facility - Reiswig Park	
6000 m^3 Wet Pond and Settling Facility	$ 200,600
25% Environmental (Rehabilitate Reiswig Park)	$ 50,200
35% Engineering and Contingency	$ 70,200
Total	*$ 321,000*
Swale System - Vernon Creek Zone	
650 m of 0.75 m Deep, 16 m Wide Swales	$ 83,200
7 Overflows and Drains	$ 10,500
Subtotal	$ 93,700
25% for Environmental - Plantings, Trails etc.	$ 23,400
35% Engineering and Contingency	$ 32,800
Total	*$ 149,900*
Swale System - Winfield Creek Zone	
650 m of 0.5 m Deep, 11 m Wide Swales	$ 83,200
6 Overflows and Drains	$ 9,000
Subtotal	$ 92,200
25% for Environmental - Plantings, Trails etc.	$ 23,000
35% Engineering and Contingency	$ 32,300
Total	*$ 147,600*

Grand Total - Woodsdale Drainage Plan **$2,344,000**

BEST MANAGEMENT PRACTICES

SECTION 7

Land development causes major impacts on natural drainage systems. Removing existing vegetation and increasing areas of roads, parking lots, and buildings, or any other impervious surface, will increase storm water runoff. Without measures to compensate for these changes, flooding and environmental damage will occur for even relatively minor storms. In general, urbanization increases the volume and velocity of runoff by:

- Decreasing the degree of infiltration;
- Decreasing the amount of depression storage; and
- Decreasing the amount of evapotranspiration due to vegetation removal.

Best Management Practices (BMPs) are recommended to reduce the peak flow and velocity of runoff from developed areas. BMPs for urban storm water include source control and treatment approaches. Source control BMPs involve reducing the peak runoff rate and production of pollutants or minimizing the contact between pollutants and storm water runoff. Treatment BMPs involve the physical removal of contaminants from storm water prior to its release to a water body such as a creek or lake. It is important to note that many treatment options require careful site assessment prior to ensure long-term effectiveness.

This section provides an overview of source control and treatment BMP approaches which may be suitable for the proposed development of the Woodsdale area. Interestingly, the existing form of development in the Woodsdale area already incorporates many BMPs. These include grassed swales or ditches, disconnected impervious areas, open shoulders and large pervious grassed areas. The proposed multi-family and commercial developments may eliminate the beneficial impact of many of these features if care is not taken to incorporate appropriate compensating measures in new development.

7.1 STRUCTURAL BMPS

7.1.1 Grassed Channel/Wet Swale

Swales are natural depressions or wide shallow channels used to convey and treat storm water. There are two basic design variations: grassed channels and wet swales. Both are commonly referred to as biofiltration swales.

Grassed channels are gently sloped open ditches lined with turf grass or native vegetation. Grassed channels are designed to convey storm water during runoff events and are normally dry between storms. The vegetation helps to decrease storm water flow velocities and the resulting increase in the time of concentration helps to reduce peak flow rates. Some of the water may also infiltrate into the ground, reducing the overall runoff volume.

Grassed channels are normally designed to convey the runoff from relatively large, infrequent storms (e.g., the 5 or 10-year event), while providing filtration and water quality treatment for smaller, more frequent events (e.g., the 6-month event). For the water quality storm, the flow depth does not normally exceed the height of the bottom vegetation.

Wet swales are similar to grassed channels except that the channel contains standing water between storms. Standing water may be due to a high groundwater table or high baseflow, in which case the swale will be wet for extended periods. Alternatively, check dams with or without low flow openings may be added to store the water quality storm in shallow ponding areas within the swale. Sections of the swale that will contain standing water for extended periods are planted with water-tolerant or wetland vegetation, while the side slopes are normally planted with turf.

Grassed and wet swales are suitable as on-line BMPs for storm water conveyance and treatment, particularly alongside roadways and parking lots. They provide some attenuation of peak flows for flood control with a potential for groundwater recharge. Swales are suitable for new and re-developments and can be retro-fitted to existing developments or to existing ditches if space is available.

Removal of contaminants may be accomplished through filtration by plant stems, adsorption to soil particles, and biological processes. These BMP swales are relatively effective for capturing suspended solids, oils, and particulate metals; however, they are less effective for soluble metals and nutrients. In general, contaminant removal is a function of length.

Typical construction cost for a grassed channel ranges from $50 to $125 per lineal metre. Regular maintenance of the swale is necessary and should be budgeted at 5% to 7% of total construction cost per year.

Routine inspection, preferably on a monthly basis, is recommended especially after large storms. Erosion is a potential problem in swales and should be watched for during inspections. Routine mowing is necessary to keep the grass in the active growth phase and maintain dense cover and may be required as frequently as bi-weekly during the peak growing season. Vegetative clippings should be removed to prevent clogging of outlets and prevent nutrient release. In general, debris should be regularly removed from all parts of the swale.

Because of the shallow slopes anticipated for the stream margin swales along Vernon and Winfield Creeks, it may be desired to reduce the total land area required by both the stream protection set back strips and the swales. By negotiation with the regulatory agencies, it may be possible for a portion of the swale strip to count as part of the required setback. This assumes that a viable margin of vegetation is maintained adjacent to the streams, and that the concept is acceptable to the community. It is also anticipated that the community trail system proposed for the Vernon and Winfield Creek corridors could be accommodated within the swale strips.

7.1.2 Vegetated Filter Strip

Vegetated filter strips, commonly referred to as biofilters, are similar in some respects to vegetated swales in that the runoff from the water quality storm is directed to flow over a vegetated surface. However, filter strips are broad areas that promote even sheet flow over a sloped vegetated ground surface, whereas swales are flow conveyance channels. The vegetated surface of filter strips can range from turf to forest.

In filter strip design, storm water flows are intercepted and directed over the vegetated surface before the flows become substantially concentrated. Contaminant removal mechanisms are similar to those described for grassed channels by means of filtering of suspended solids, adsorption to soil particles and plants, infiltration, and some biological action. Contaminant removal is a function of filter strip length, slope, soil permeability, size of contributing area, and runoff velocity.

Filter strips are suitable for small storms only with a bypass for larger flows to prevent erosion. Ideal use of this BMP is alongside roadways and parking lots where paved sites exist without underground collection and conveyance systems. They are suitable for new developments but may be retro-fitted to existing and redeveloping areas if space is available.

This BMP is most effective in low-density development situations with low to moderate impervious cover where there are small fluctuations in peak flows. Filter strips are susceptible to short circuiting and erosion via flow channelization and must be protected from activities that will tend to channelize flows.

Construction costs for grassed filter strips are approximately $5/m² for seeding and $12/m² for sodding the vegetated area. Maintenance of grassed strips are typically $1,300/ha/yr and should include periodic aeration of soils, re-seeding, mowing, routine inspections, and removal of trash and debris.

Vegetated filter strips are effective in the removal of particulates, but less effective for dissolved contaminants than wet ponds and constructed wetlands. They help to promote groundwater recharge and are relatively inexpensive. As with grassed and wet swales, filter strips can combine conveyance and treatment in one system to reduce development costs. However, filter strips require more land area than biofiltration swales due to their shallower flow depth.

7.1.3 Bio Retention and Dry Swales and Underdrains

Bioretention is a type of storm water filtering system where runoff is temporarily stored in a shallow depression and then allowed to gradually infiltrate through a constructed filter bed of soil and plants to an underlying drain system. This BMP is relatively new, having been developed in the early 1990's.

The bioretention system consists of a flow regulation structure/level spreader with a vegetated filter strip or grass channel leading to a shallow ponding area. The ponding area contains a surface layer of organic mulch, underlain by a planting soil bed that supports turf, shrubs, and trees underlain in turn by a sand bed and then an underdrain system.

Bioretention systems are normally designed to handle the lower volume storm flows only; larger flows are bypassed via an overflow gravel curtain and a high flow overflow structure. Contaminant removal mechanisms include infiltration, adsorption, volatization, ion exchange, microbial action, and plant uptake.

The dry swale with underdrains is essentially a design variant of bioretention. The dry swale is similar in many respects to grassed channels and wet swales. The dry swale is designed to temporarily store lower volume flows behind a weir, and then allow it to infiltrate through a soil bed to an underdrain system. Flows greater than the design volume pass over the weir and out of the swale. Contaminant removal mechanisms are similar to bioretention.

Bioretention and dry swales with underdrains are suitable for most development situations including residential areas, municipal office complexes, rooftop runoff, parking lot and roadway runoff, parks and greenspace. The dry swales with underdrains are mainly applied to moderate to large lot residential land uses and can also accommodate runoff from small impervious areas such as roofs and small parking lots.

Both bioretention and dry swales provide some attenuation of peak flows, water quality improvements, and aesthetic benefits. Dry swales can reduce development costs by combining conveyance and treatment in one system. Bioretention has greater diversity in structure than most other BMPs and is designed to mimic the natural hydrologic cycle. Bioretention also has more potential for filtering through roots and soils and adsorption of contaminants to soil particles than wet ponds. There is a relatively high construction cost associated with bioretention as they are more complex to construct than most other BMPs. The efficiency of the system is not maximized until plants are well established.

7.1.4 Wet Pond

Wet ponds are designed to temporarily detain collected runoff and can provide flood control, streambank erosion protection, and water quality improvements. Wet ponds are designed to maintain a permanent pool of water between storms.

During runoff events, the permanent pool minimizes turbulence for enhanced settling of particulates, and helps to prevent scour and resuspension of sediments. Between runoff events, flocculation and settling of fine sediments occurs under quiescent conditions in the permanent pool. In addition, non-settleable and soluble contaminants can be removed from solution or converted to less harmful forms through chemical transformations and biological action by bacteria and vegetation that develop in the permanent pool.

An integral feature of the wet pond is the sedimentation forebay. The forebay is separated from the main body of the pond and allows inflow energy to dissipate before it enters the remaining pond area. Larger sediments settle out of the flow and are concentrated in this area where they can be easily removed during routine maintenance.

Wet ponds lend themselves to multi-purpose facilities that include fish and wildlife habitat, recreational use, and aesthetic enhancements, as well as storm water management. They are one of the most aesthetically pleasing structural BMPs and can increase property values by including other uses such as recreation and fish/ wildlife habitat.

They can be implemented as small on-site facilities or larger regional facilities which leads to a wide range of observed contaminant removal efficiencies. To some extent, removal efficiency depends on the size of the permanent pool and there is often a distinction between wet ponds designed for removal of particulates only and those designed for removal of nutrients as well as particulates.

Adequate baseflow into the pond is required to maintain the permanent pool and a liner may be needed to sustain the pool in permeable soils. In the case of the proposed wet pond in Reiswig Park a small pump system to re-circulate Wood Lake water and maintain water levels during the summer may be required.

Construction costs are dependant on the volume of the wet pond. For typical numbers, the construction cost can be in the range of $\$27/m^3$ to $\$55/m^3$.

Maintenance costs are in the range of 3% to 6% of the construction cost per year. Inspection of the pond should be conducted periodically during wet weather to observe function. The sediment forebay should be cleaned every 2-3 years or when 50% of capacity has been lost. Sediment accumulated within the rest of the pond should be removed when 10% to 15% of pool volume is lost. Typically, volume loss to sedimentation is approximately 1% per year.

At the outset of the rainy season and after each significant storms, floating debris should be removed, erosion problems should be corrected, and outlet structures should be clear of debris. Mowing of side-slopes, embankments and spillways annually is recommended to prevent woody growth and weeds. The remaining buffer can be managed as a meadow with mowing every other year or managed as a forest.

Maintenance is important in retaining an effective wet pond. Inadequate maintenance can lead to problems with floating debris and scum, algae, odours, and insects. Some safety concerns are associated with the pond side slopes and permanent water pool.

Wet ponds are more expensive than extended dry detention basins as the required permanent pool volume is two to seven times larger than extended detention dry basin. However, wet ponds are capable of removing soluble contaminants such as nutrients which dry ponds are unable to do.

7.2 NON-STRUCTURAL BMPS

Structural storm water BMPs are designed to compensate for the adverse impacts of development. The previously discussed BMPs including wet ponds, filter strips, and swales are examples of structural BMPs. In contrast, non-structural storm water BMPs are designed to prevent adverse impacts from happening in the first place. Over the long term, it is reasonable to expect that preventing storm water management problems will be more effective and less expensive than correcting problems after they become an issue.

Non-structural BMPs can be divided into two broad categories. One is planning, design, and construction of developments and redevelopments to minimize or eliminate adverse impacts. The other involves education and training to promote awareness of the potential problems associated with storm runoff, and of source control approaches that can help to solve these problems. The following are non-structural BMPs which can be incorporated into the re-development of the Woodsdale area.

7.2.1 Buffers, Setbacks, and Easements

Natural site features such as riparian corridors, streams, lakes, wetlands, surface depressions, soils, and vegetation are integral to the hydrologic cycle. These features help to store, encourage infiltration and evaporation, and cleanse storm water runoff. Removal or modification of these features in conjunction with the increased impervious area associated with development causes adverse downstream impacts. These include increased runoff flow rates and volumes, contamination of receiving waters, destruction of habitat, and reduced groundwater recharge. Preservation of key natural drainage and habitat features through careful planning can minimize the adverse impacts of development.

Buffer zones, setbacks, and easements are approaches that can be used to protect the natural features discussed above. Buffer zones are strips of vegetation, either natural or planted, around water bodies. Such vegetated zones help reduce the impact of runoff by trapping sediment and sediment-bound pollutants, and encouraging infiltration. Setbacks are restrictions on development activities within a specified distance of a stream bank or other water resource. They can prevent or minimize erosion and gully formation, thus minimizing sedimentation and associated nutrient enrichment downstream. Easements are "green belts" around watercourses that can be used to protect water and also provide parks and recreational areas for residents.

As shown of Figures 5 & 6, we recommend establishing buffer zones along Vernon and Winfield Creeks in accordance with guidelines established by the DFO and MWLAP. The setback requirements are generally based on the publication "Land Development Guidelines For The Protection of Aquatic Habitiat" (DFO, 1990). As well, the provincial Streamside Protection Regulation is currently being developed and should be consulted for setback requirements.

7.2.2 Reduction of Impervious Areas

Reductions in impervious area can be undertaken by reducing the overall size of the developed area, and/or reducing the amount of impervious surfaces created within the developed area. Disconnection of impervious surfaces can be undertaken by directing runoff from roofs and paved surfaces over vegetated surfaces before it reaches the drainage conveyance system.

Reductions in impervious area can also be achieved through cluster developments that maximize undeveloped space and minimize the required length of roadway and other infrastructure. Clustering concentrates development on smaller lots into compact areas, and leaves relatively large areas undeveloped. This contrasts the conventional grid developments which cover the entire site with larger lots and result in more overall impervious area through more paved surfaces such as roads sidewalks. This approach will help address peak flow control, stream bank erosion protection, obstruction of drainage paths, water quality enhancement, groundwater recharge, and community enhancement. Clustering is suitable for new developments and redeveloping areas but has limited opportunities for use in areas of existing development.

7.2.3 Curb Elimination

The elimination of curbs has been shown to reduce pollution entering the aquatic environment. Since curbs function as channels for storm water, runoff flows at high velocities within the curbs and convey sediments and other contaminants. Without curbs, runoff can spread over large vegetated areas where runoff velocities can be reduced and pollutants can settle out and be taken up by plants or soils. To avoid erosion, flooding, and debris accumulation, the locations of curb outlets should be carefully chosen and street cleaning programs should be modified to maintain these areas.

Sections of existing curb can be removed and curb outlets can be installed at regular intervals or in appropriate areas to allow the storm water to flow onto well-vegetated areas.

7.3 AGRICULTURAL LAND USE AND STORM WATER QUALITY

In order to ensure the quality of water in Vernon and Winfield Creeks, and ultimately in Wood Lake, the District of Lake Country should encourage the agricultural community to carry out drainage management practices that protect runoff water quality. These practices are discussed briefly in this section.

Pesticides and fertilizers can provide benefits to producers but can also have negative effects if they enter groundwater or surface waterways. There are ways to reduce the risks of using pesticides and fertilizers while maintaining crop productivity.

Manure is a common form of crop fertilizer and is a valuable source of nutrients when properly managed. When improperly managed, manure can be very damaging to the environment. Manure should be kept out of waterways by implementing a storage plan. This plan includes:

.1 Appropriate manure storage: storage facility prevents escape of manure or manure leachate from surface and groundwater. Storage should be a minimum of 30 m from any source of domestic water and at least 15 m from any watercourse or lake.

.2 Manure application: manure should not be applied within the 15 m riparian leave area of any permanently wetted water body. The amount and timing of nutrient applications should match soil conditions and optimize crop uptake. Runoff or excessive leaching to any body of water should be prevented.

To prevent pesticides from entering the aquatic environment, a minimum 10 m wide pesticide-free zone should be established around all water bodies, wells, and water sources including ditches which flow into fish-bearing waters. Additional setbacks beyond the pesticide-free zone should be provided to account for spray drift. If irrigation systems are used for chemical or nutrient application, the usage of irrigation spray should ensure drift does not enter the pesticide-free zone.

The appropriate soil conservation practices, which reduce the risk of soil erosion, can vary from site to site and is dependant on soil type, climate, topography, and cropping systems. Soil erosion decreases crop yields and property values, and increases land management costs. The following measures can help to reduce sediment from entering receiving waters:

- Maintain or restore a zone of permanent riparian vegetation, preferably trees, shrubs, and grasses along watercourses. The roots of this riparian vegetation will help to stabilize the stream bank and the vegetation can provide an effective wind break.

- Consider using conservation tillage. This involves leaving at least 30% of the soil surface covered by crop residue after seeding, which protects soils from the erosive forces of rainfall, runoff, and wind.

- Further minimize winter bare soils by leaving crop residues, planting winter cover crops, and planting cover crops between crop rows where appropriate.

- Use crop rotation and the addition of organic matter to maintain soil structure to encourage infiltration.

- Protect drainage structures and subsurface drain outlets from erosion.

- Permanently grass waterways that carry surface flow across fields.

Soil compaction is a very common degradation process on agricultural lands and is usually a result of inappropriately timed tillage and heavy machinery traffic. Compacted soils increase the risk of overland flow, which causes erosion and can carry sediment and other contaminants from fields directly to watercourses. To minimize compaction, keep machinery away from wet fields and use cropping and tillage practices which enhance the soil structure and stability.

RECOMMENDATIONS

SECTION 8

The following recommendations are made for the Woodsdale area drainage plan.

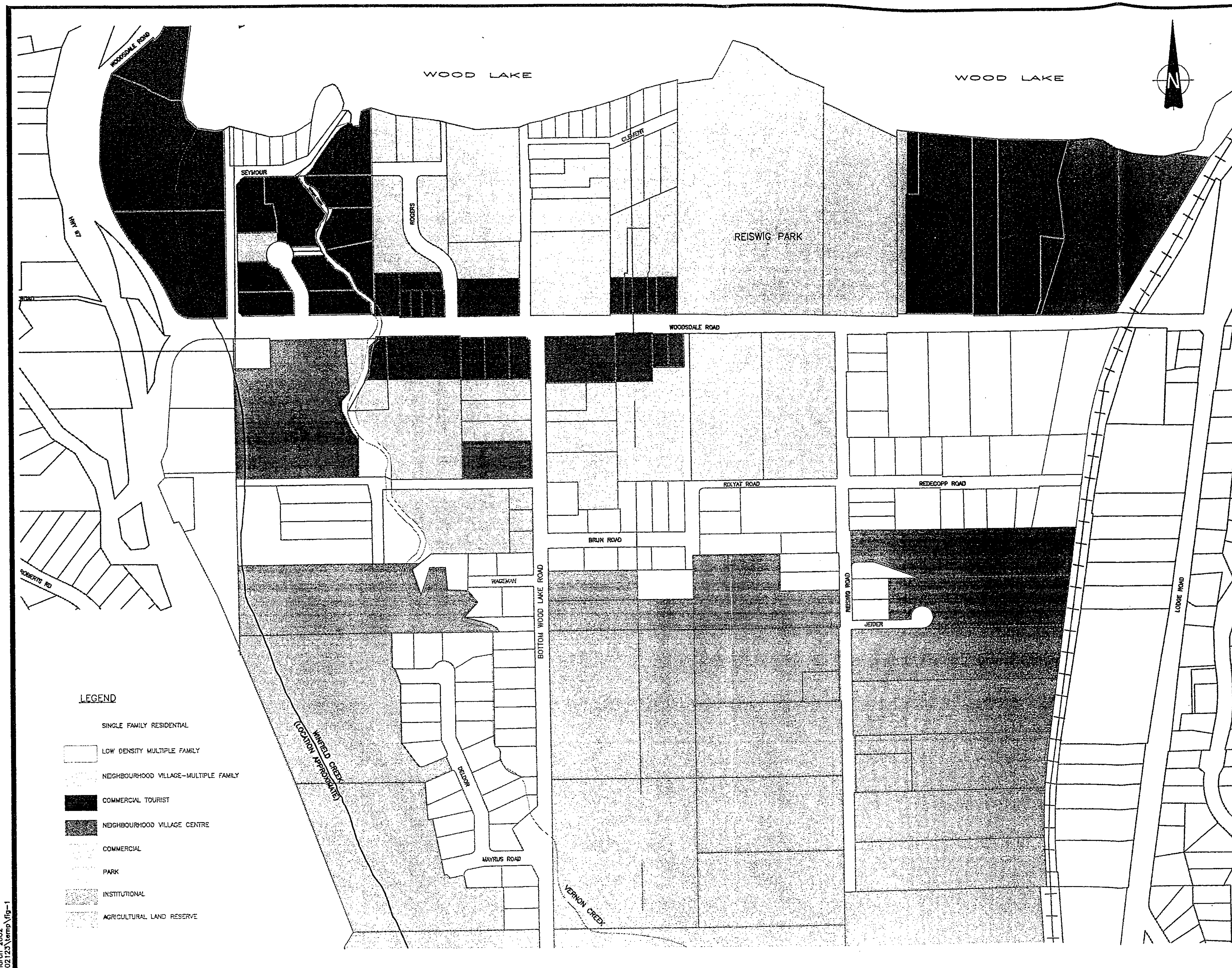
.1 Within areas of higher density multi-family and commercial development of the Village Centre zone, a piped drainage system will be required. Conceptual plans for both a "low" runoff BMP development scenario, and a "high" runoff conventional development scenario are provided in Figures 4 and 5 respectively. Open ditches and swales should be retained within existing single family residential and agricultural areas.

.2 Storm water within the Village Centre zone should be routed to a central location within Reiswig Park. A storm water management wet pond can be constructed in this location to improve water quality prior to discharge to Wood Lake, as required by future regulations or circumstances. The wet pond can become a community amenity if environmental enhancements and features such as walking paths are included in its design.

.3 Buffer zones should be established along the lengths of Vernon and Winfield Creeks. Within the two zones that will drain to Vernon and Winfield Creeks an open swale system should be used to route stormwater and protect the creeks from direct runoff. The open swale system could incorporate the community trail system anticipated for the creek corridors, and may partially satisfy stream setback requirements.

.4 Onsite BMPs should be required in re-development areas to reduce runoff volumes and protect water quality. Control of runoff volumes will reduce the size of required drainage system components and reduce their associated capital cost.

.5 Water quality in runoff from agricultural areas could be improved by the implementation of appropriate practices. These practices should be encouraged by the District in cooperation with agricultural operations.



march 2002
002123\temp\fig-1

VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 ——— 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

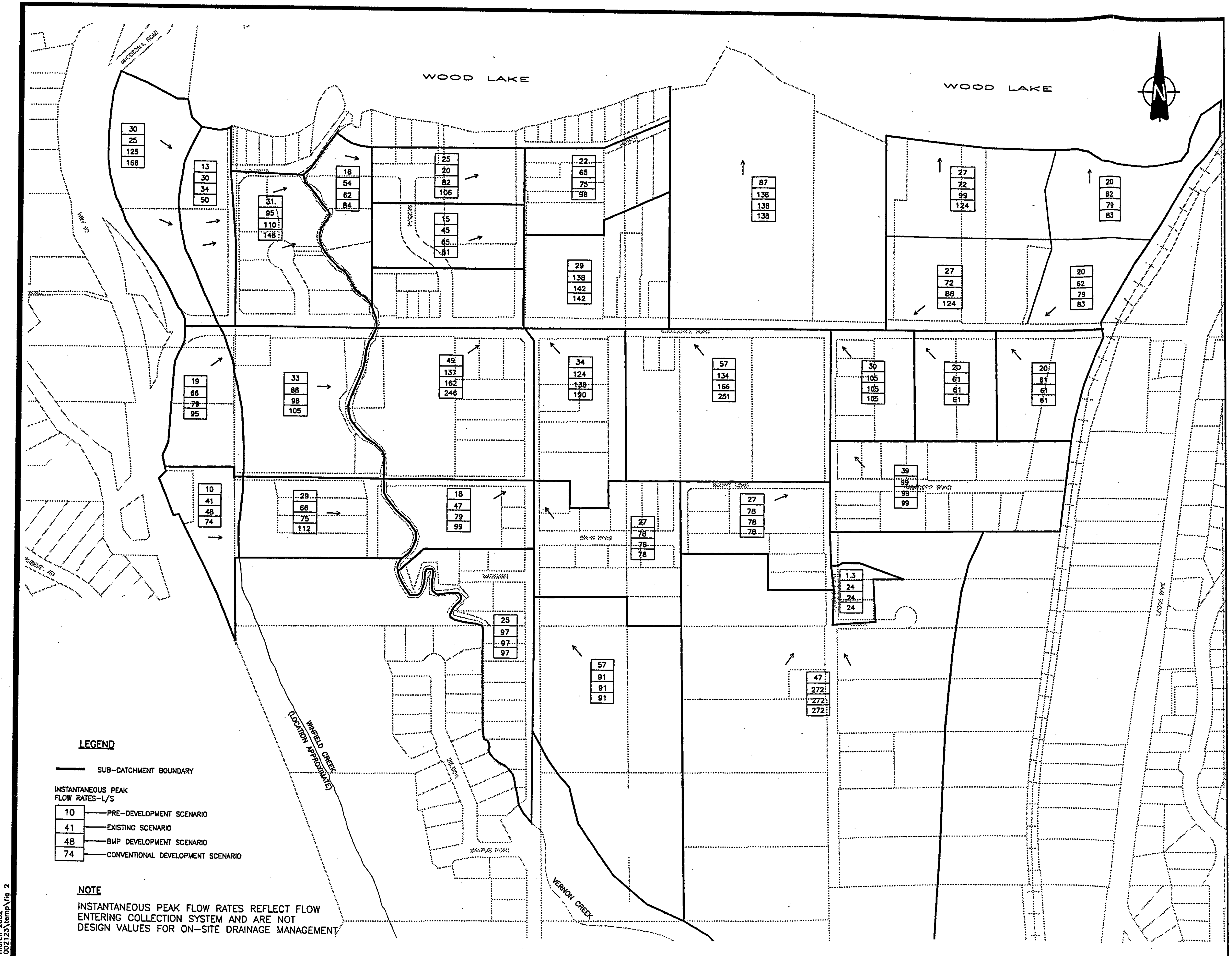
PROJECT NO.	012203
SCALE	1:5000
DRAWN	G.Q.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

PROPOSED FUTURE LAND USE

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 1		



march 2002
002123\temp\fig 2

VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 —— 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

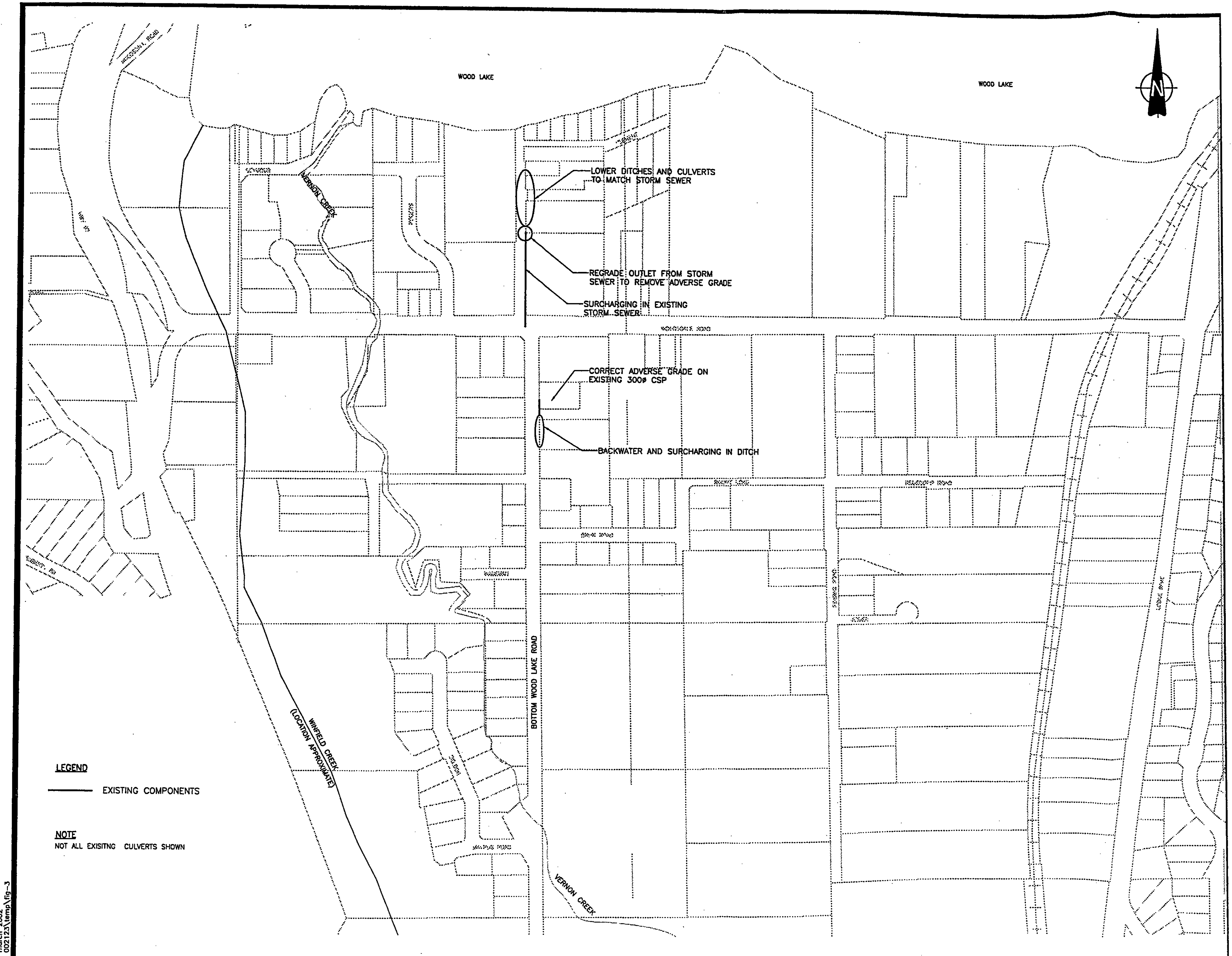
PROJECT NO.	012203
SCALE	1:5000
DRAWN	C.O.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

MODELLED CATCHMENTS AND ESTIMATED INSTANTANEOUS PEAK RUNOFF RATES

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 2		



march 2002
002123\temp\fig-3

VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 — 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

PROJECT NO.	012203
SCALE	1:5000
DRAWN	G.O.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

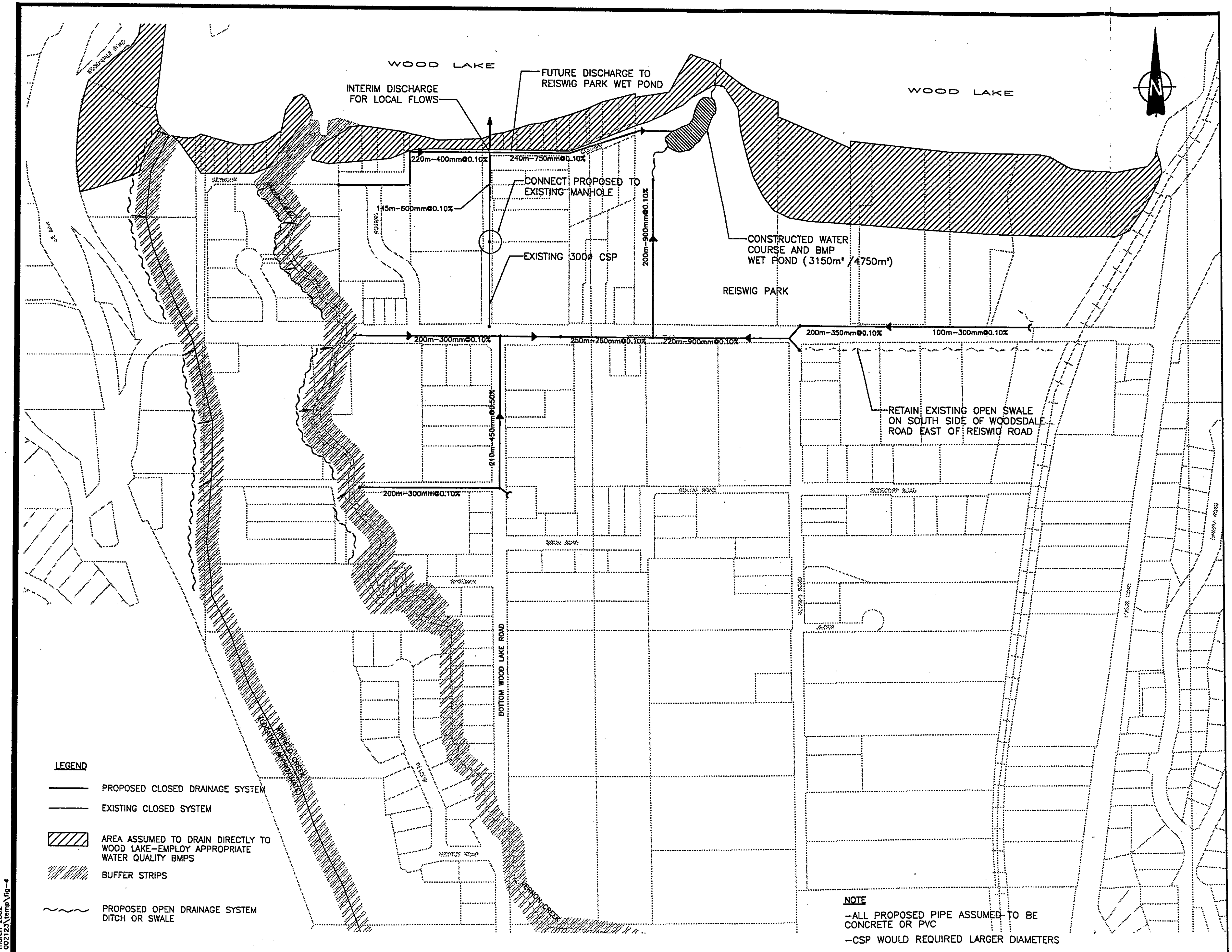
ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

INTERIM DRAINAGE IMPROVEMENTS

EXISTING LAND USES

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3		



march 2002
002123\temp\fig–4

VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 —— 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

PROJECT NO.	012203
SCALE	1:5000
DRAWN	G.O.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

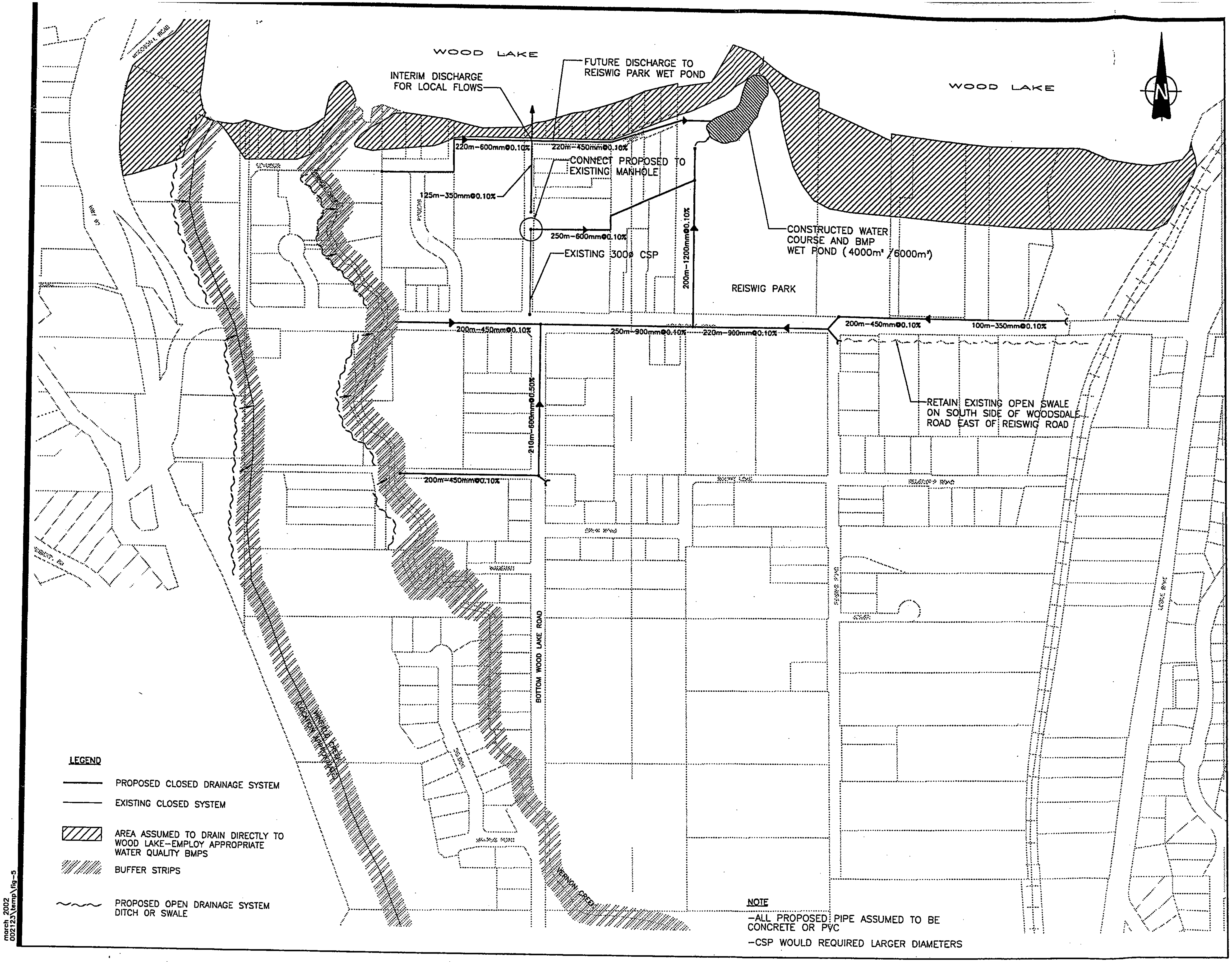
ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

DRAINAGE SYSTEM IMPROVEMENTS

FOR ON SITE BMP DEVELOPMENT SCENARIO

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4		



VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

PROJECT NO.	012203
SCALE	1:5000
DRAWN	G.Q.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

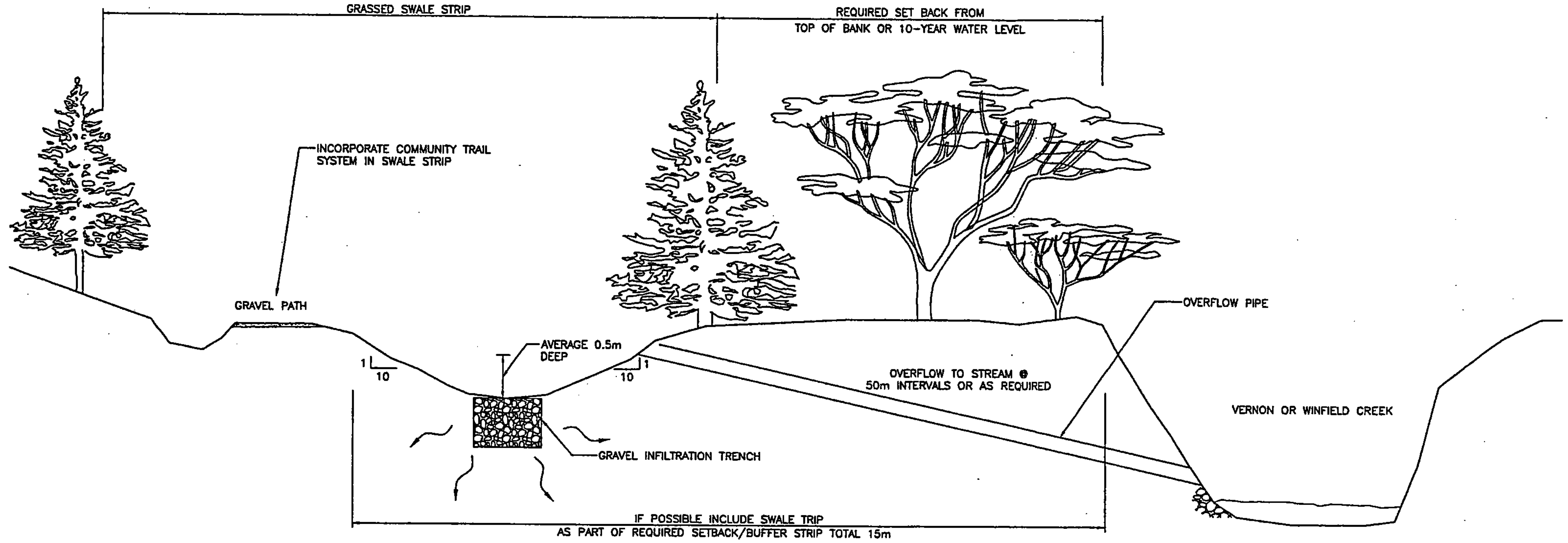
ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

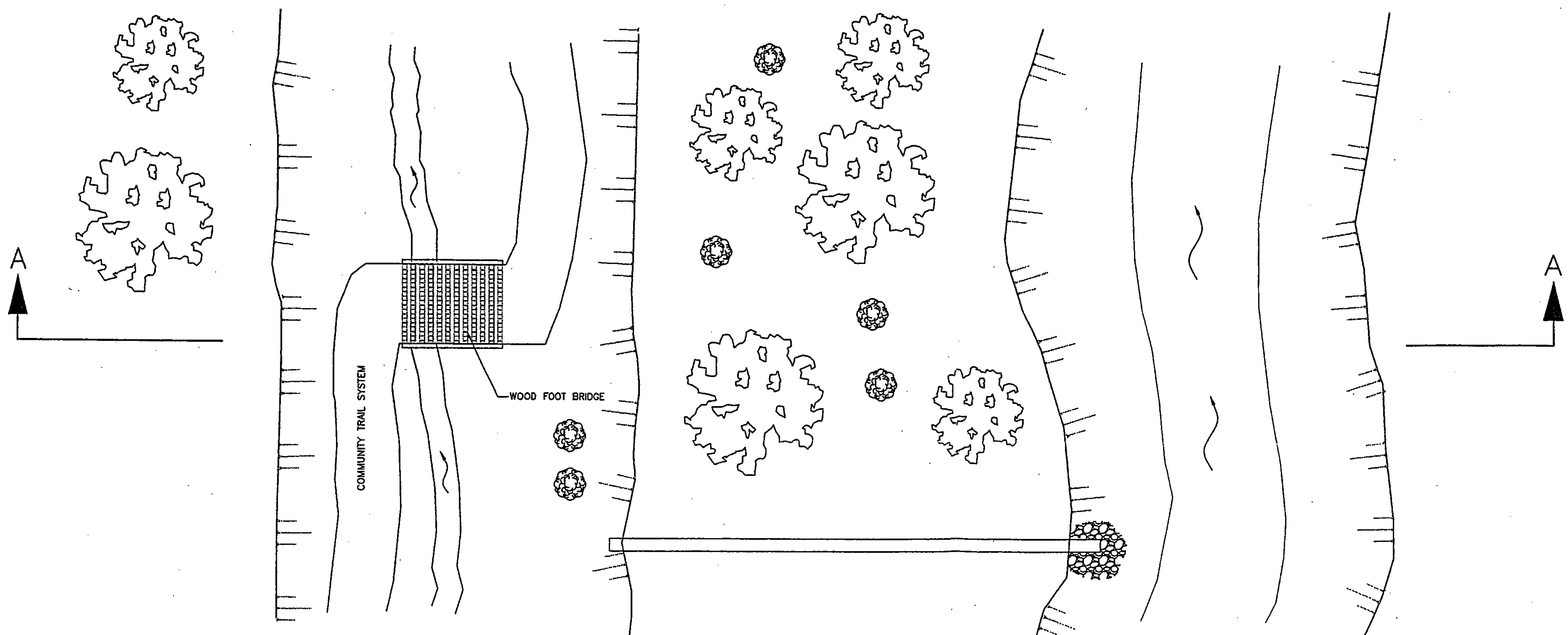
DRAINAGE SYSTEM IMPROVEMENTS

FOR CONVENTIONAL DEVELOPMENT SCENARIO

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 5		



SECTION A
N.T.S.



PLAN VIEW
N.T.S.

march 2002
002123\temp\fig-6

VERIFY SCALES

BAR IS BASED ON ORIGINAL DRAWING

0 ——— 10mm

IF NOT 10mm ON THE SHEET, ADJUST SCALES ACCORDINGLY

NO.	DATE	ENG.	BY	SUBJECT

REVISIONS

PROJECT NO.	012203
SCALE	N.T.S.
DRAWN	G.Q.
DESIGNED	M.M.
CHECKED	
APPROVED	
APPROVED	
DATE	MARCH 2002

ASSOCIATED ENGINEERING

DISTRICT OF LAKE COUNTRY
WOODSDALE DRAINAGE PLAN

CONCEPTUAL SKETCH OF
PERIMETER SWALE FOR
VERNON AND WINFIELD CREEKS

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 6		