REGIONAL DISTRICT OF CENTRAL OKANAGAN

TYNDALL ROAD AND AREA MASTER DRAINAGE PLAN

URBAN SYSTEMS

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Date: February, 1995
USL File: 1117913.1

URBAN SYSTEMS

ENGINEERS
PLANNERS
LANDSCAPE ARCHITECTS

February 16, 1995

Our File: 1117913.1

Central Okanagan Regional District
1450 KLO Road
Kelowna, BC
V1W 3Z4

Attention: Don Darling

Dear Mr. Darling:

***Re:* Tyndall Road and Area Master Drainage Plan**

We are pleased to present the completed Master Drainage Plan for the Tyndall Road Area. This report, in conjunction with the hydrogeological study completed by Terratech Western Profile Ltd. may now be used to:

- implement a practical upgrading and maintenance program to correct existing drainage deficiencies;
- evaluate development proposals with respect to stormwater managements;
- ensure adequate standards are employed during development to minimize potential drainage problems from surface sources;
- develop an equitable method of recovering the costs of providing adequate drainage for the study area;
- protect sensitive areas from the potential impacts of future development.

Thank you for this opportunity to serve the Regional District of Central Okanagan.

Sincerely,

URBAN SYSTEMS LTD.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. G. ZACHARY

A. Glen Zachary, P.Eng., M.A.Sc.
/md

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Please Note ...

This study was commissioned prior to the vote held by Winfield, Okanagan Centre, Carrs Landing, and Oyama to determine if these areas should incorporate. The vote, held in the autumn of 1994, indicated that a majority of the residents of these areas (excluding Oyama) wanted to be part of a municipality.

This report, therefore, is written as though the Regional District of Central Okanagan and the Ministry of Transportation and Highways were continuing to administer rezoning and subdivision application approvals. Over the next several years, however, the responsibilities of the Regional District and the Ministry of Transportation and Highways will be transferred to the new municipality. This will include drainage management issues.

Because of this, some of the administrative issues presented in this study will eventually be addressed differently. This should be kept in mind while reading this report.

Urban Systems Ltd.

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REFERENCES

CANADIAN CLIMATE NORMALS: 1951-1980, Atmospheric Environment Service, Environment Canada.

CITY OF KELOWNA - STAGE 1 MASTER DRAINAGE PLAN, Dayton & Knight Ltd. (1989).

DRAINAGE MANUAL, Roads and Transportation Association of Canada, (1982).

HANDBOOK OF APPLIED HYDROLOGY, V.T. Chow, McGraw-Hill Book Company, (1964).

HANDBOOK OF STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS, American Iron and Steel Institute (1984).

PRINCIPAL STATION DATA: KELOWNA A, Atmospheric Environment Service, Environment Canada (1984).

NEIGHBOURHOOD PLAN FOR SOUTHWEST WINFIELD, Reid Crowther & Partners Ltd., February, 1994.

MIDUSS USERS MANUAL, version 4.70, Alan A. Smith Inc., Dundas, Ontario, (1990).

THE U.S.E.P.A. SWMM4 STORMWATER MANAGEMENT MODEL, Environmental Research Laboratory, (1989).

TYNDALL NEIGHBOURHOOD PRE-PLAN, I.D. Systems Ltd., 2nd Draft: July 16, 1993.

URBAN DRAINAGE DESIGN GUIDELINES, Ontario Ministries of Natural Resources, Environment, Municipal Affairs, and Transportation and Communications (1987).

WATER RIGHTS MAPS WR 82-L-003-3.2.3, -3.2.4, and -3.4.2, Water Rights Branch, Ministry of Environment.

SECTION 1.0

INTRODUCTION SECTION 1.0

1.1 Master Drainage Plan Concept

Usually, development within the Okanagan Valley occurs incrementally; a small number of lots are developed in one area, then others are developed somewhere else. Growth often starts along the lake shore or within the flatter areas along the base of hill sides. As more land is required, growth moves up-hill from the developed areas. This pattern continues until developable land is no longer available.

Under this growth scenario, development often ignores natural drainage courses. Homes are built within gulleys, roads are constructed without proper use of culverts, and sometimes, drainage courses are completely obliterated. When new development occurs, adequate downstream drainage courses often no longer exist.

A master drainage plan (MDP), especially if prepared before any significant development occurs, addresses these issues on a basin-wide basis. It provides a framework within which individual stormwater management plans can be prepared for each development, confident that downstream impacts have been considered. Specifically, a master drainage plan outlines:

- primary drainage divisions;
- major drainage routes;
- ultimate receiving waters;
- sensitive areas (slope, erosion, groundwater, etc...);
- significant drainage structures (existing and required);
- projected design flows.

When prepared for the Regional District of Central Okanagan, the MDP also includes:

- capital cost estimates for required off-site works;
- estimated development unit yields;
- calculated unit costs;
- a priority schedule for recommended works.

Where applicable, stormwater quality and aesthetic issues are also addressed.

A master drainage plan is a working document. It presents general concepts and design guidelines, and provides the basis for more detailed design as development occurs. Where existing or potential deficiencies exist, it outlines corrective measures which can be implemented as required. It must not, however, be blindly applied. It is based on a given set of assumptions and conditions, and must be reviewed accordingly should these assumptions or conditions change.

1.2 Objectives

In December of 1993, the Regional District of Central Okanagan commissioned Urban Systems Ltd. to prepare a master drainage plan for the Tyndall Road area. This was to include a geotechnical investigation by Terratech Western Profile Consultants Ltd. The master drainage plan was to specifically:

.1 Define major drainage courses and contributing drainage basins;

.2 Develop design criteria applicable to the study area;

.3 Identify works required to correct existing drainage deficiencies;

.4 Evaluate impacts of further residential development upon the existing drainage systems, and identify works required to mitigate these impacts;

.5 Allocate estimated costs to existing and future development as a basis for developing appropriate cost recovery mechanisms;

.6 Develop a phased capital works plan to implement recommended improvements;

.7 Recommend standards to which future development must conform when addressing drainage issues.

The geotechnical report was to:

.8 Classify surficial soils into hydrological soil groups;

.9 Estimate infiltration parameters for each soil group;

.10 Identify general groundwater conditions;

.11 Identify areas in which soils may be unstable or may be susceptible to severe erosion.

1.3 Convenience and Emergency Drainage Systems

Drainage systems may be classified as being either a *convenience* or an *emergency* system. These have also been called *minor* and *major* drainage systems respectively.

The convenience drainage system is designed to accommodate runoff from more frequent (and usually less intense) rainfall events. Such systems are constructed to minimize inconveniences to both pedestrian and vehicular traffic due to surface ponding and flooding. Convenience system components usually include roof gutters, rainwater leaders, service connections, swales, street gutters, catchbasins, and storm sewers. In rural settings, it usually consists of ditches, swales, and culverts.

The emergency drainage system, on the other hand, is designed to eliminate the risk of property damage and/or loss of life due to flooding caused by less frequent rainfall events. It usually consists of natural streams, gulleys, man-made streets, swales, channels, culverts, and ponds.

Historically, attention has usually been focused on the convenience system, with little concern about how effective the emergency system would be. This is unfortunate since the capacity of the convenience system will always, at some time, be exceeded. Residents are often not aware of the implications of a poorly designed emergency system until damage occurs. Only then does it usually become a "priority".

> *"It must be remembered that the major system will exist in a community whether or not it has been planned or designed and whether or not development has been wisely situated with respect to it."*
>
> *URBAN DESIGN GUIDELINES, PROVINCE OF ONTARIO*

For the purposes of this study, only the emergency drainage system is considered during analyses. General comments regarding which types of convenience systems are appropriate for use in potential developments within the study area are, however, given. Specific capacities and other design details for these convenience systems must be determined as part of the individual stormwater management plans required prior to subdivision.

1.4 Improvement Priorities

To facilitate the Regional District in developing a drainage improvement program that can be phased over several years, each improvement identified in Section 5 has been assigned to one of three priority levels. These priority levels reflect different degrees of risk that must be assumed by the Regional District. The intent is to direct limited available funds towards those works that pose the greatest risk to both public and private property as well as to the general public.

The three priority levels are defined as follows:

Priority 1: Improvement is necessary to prevent significant damage to both public and private property and/or danger to the public from runoff generated under existing development conditions.

Priority 2: Improvement is necessary to prevent:

- inconvenience or annoyance from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Priority 3: Improvement is required to meet identified standards, but failure to meet these standards is unlikely to cause:

- significant inconvenience from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Works classified as a Priority 3 may be postponed until future development occurs.

Note that proposed improvements, especially structure sizes, are based on certain assumptions and preliminary information. When a specific improvement is implemented, a detailed design must be prepared based on appropriate field data. Actual field conditions may dictate an alternate design.

1.5 Analysis Methods

.1 Computer Model

Several computer models are available for estimating peak design flows and for evaluating capacities of various drainage structures. For this study, a model called MIDUSS, an acronym for Microcomputer Interactive Design of Urban Stormwater Systems, was used. It was chosen because of its versatility, ease of use, and minimal data requirements.

This last reason infers less accuracy because the model uses built-in default values. In reality, many of the parameters necessary as input to other models are useful *only when there is sufficient field data with which model calibration can be performed*. When field data is not available, these parameters are often estimated. The defaults used by MIDUSS are reasonable estimates of these parameters, and can be modified if adequate field data is available.

.2 Types of Analyses

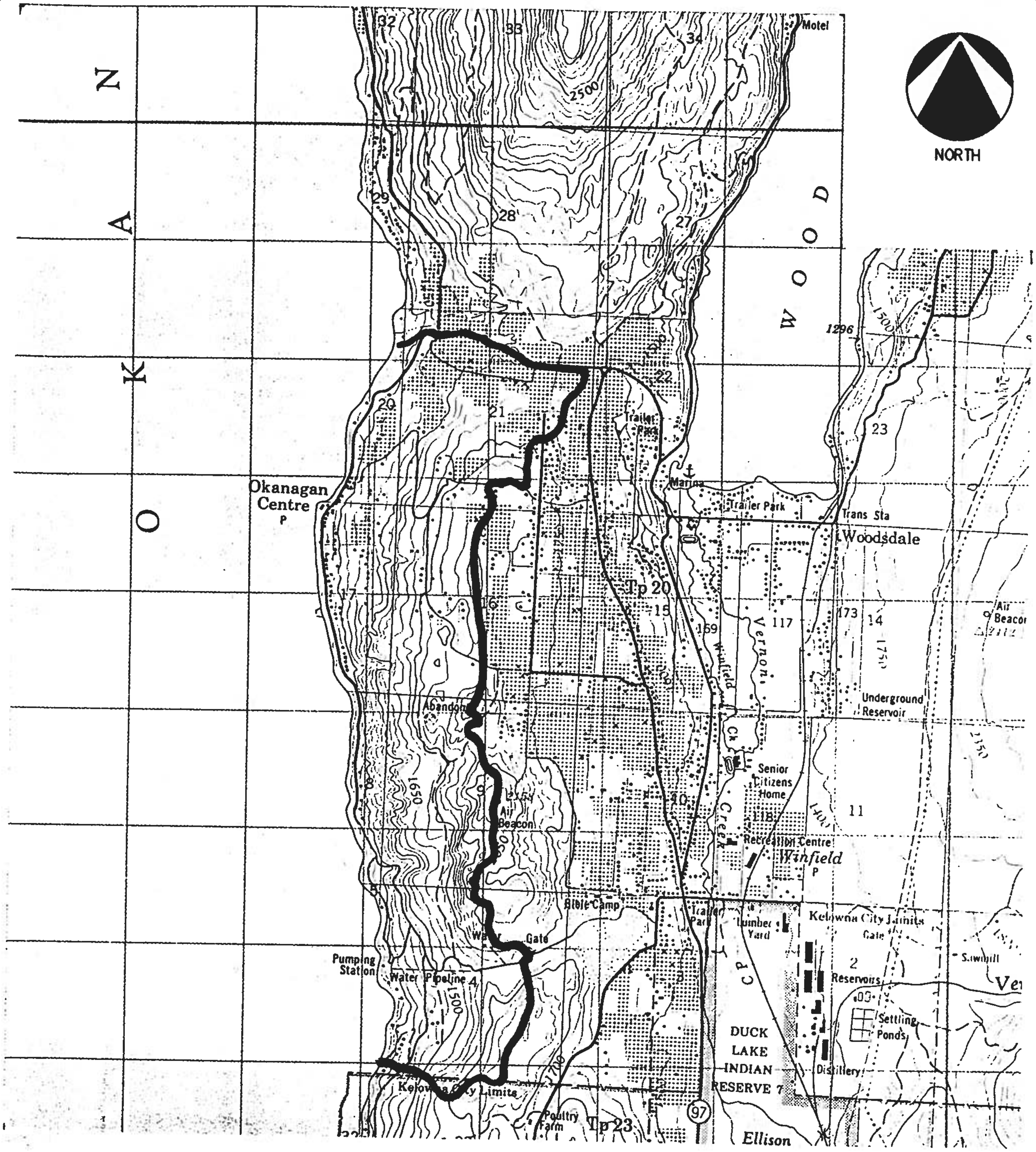
The computer model was used to determine peak flows under two sets of conditions:

- existing drainage systems with runoff from existing development conditions, and
- proposed drainage systems with runoff from future development conditions.

The first set of analyses was completed to determine existing deficiencies. This was necessary for cost allocation purposes. These analyses also provided a means of "calibrating" the computer models. The second set of analyses provided the design data for drainage structures recommended to service projected development and to correct existing deficiencies.

Typically, the conditions which generate the critical peak flow for one element of a drainage system may not generate the critical peak flow for another element of the same system. For example, a channel reach which services a small sub-basin will experience its critical peak flow from shorter, more intense rainstorms than the channel reach which carries the runoff from several large basins. The duration of the critical design storm for a detention pond is often much longer than for the storm which generates the critical peak flow in the channel upstream of the pond.

Therefore, under each land use condition, several runs were made with 100 year storms of various durations. Summaries of the resultant peak flows (and other data where required) were compiled from each run to determine the critical design conditions for each drainage system element.



URBANSYSTEMS

REGIONAL DISTRICT OF CENTRAL OKANAGAN

JOB No. 1.1179.13.1

TYNDALL ROAD & AREA MASTER DRAINAGE PLAN STUDY AREA - LOCATION

BASE SCALE 1:50,000

FIGURE 1.1

SECTION 2.0

STUDY AREA PHYSIOGRAPHY — SECTION 2.0

The analyses, conclusions, and recommendations presented in this report are based on the collection and integration of a wide variety of data. Much of the data presented within this study are basin specific. Three types of data which are better understood in the context of the study area as a whole, are:

- climate,
- surface geology, and
- land use.

Presented in this section, this information forms the foundation upon which basin-specific data are prepared.

2.1 Climate

The study area is predominantly influenced by maritime air, with occasional influxes of continental air masses. These conditions result in moderate winters, low annual rainfall, low humidity, high summer temperatures, and high evapotranspiration rates.

.1 Precipitation

Annual precipitation at lower elevations (most of the study area) is approximately 332 mm. Snowfall which accumulates at higher elevations during winter months produces an annual freshet in each watershed. At lower elevations, however, rainfall becomes the greater influencing factor with respect to drainage works. Because of the moderate winters, rainfall is experienced during all months at lower elevations. This increases the probability of rain falling on a melting snowpack, which under certain conditions, can result in rapid surface runoff.

In general, storms within the study area are more likely to exhibit low intensities and short durations. During the period from October to March, storms seldom last longer than 12 hours. During the period from April to September, however, a greater variety of storm characteristics are observed. Both short, intense storms (high peaks and low volumes of runoff) as well as longer storms (low peak and larger volumes of runoff) are experienced. Statistics indicate, however, that storms seldom exceed durations of 24 hours.

.2 Temperature

The study area experiences a great range of temperatures during the course of a year. Average winter temperatures range between -4° C and 0° C. Extreme temperatures, however, may rise enough during the winter months to generate rainfall concurrent with a melting snow pack. As noted earlier, this can result in rapid runoff conditions.

Average summer temperatures typically range between 15° C and 20° C, with frequent highs above 30° C. The evapotranspiration rate, combined with ground infiltration during the summer, is therefore usually high enough to absorb all low-intensity rainfall occurring on undeveloped land.

2.2 Geology and Hydrogeology

.1 Soil Types

The geotechnical report prepared by Terratech Western Profile Consultants Ltd. classifies the study area surficial soils into four hydrological soil groups. The characteristics of these groups are outlined in Table 2.1, and were defined by the United States Soil Conservation Service. Figures 2 and 3 of the Terratech Hydrogeological Report in Appendix B shows the location of these soil groups within the study area.

Table 2.1
United States Soil Conservation Services
Hydrological Soil Groups

Group A	Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission. The soils normally consist of deep fluvial and glacio-fluvial deposits of sands and gravels. These deposits are often interbedded and range from moderately coarse gravels to fine sands, but contain little silt.
Group B	Soils having moderate infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. The soils consist of fine sands containing a moderate amount of silt or deposits of Group A materials capped with a relatively shallow layer of silt or silty sand.
Group C	Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water, or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission. The soils usually consist of silt and sandy silt deposits.
Group D	Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious materials such as bedrock. These soils have a very slow rate of water transmission.

.2 Groundwater Conditions

In general, the study area is not subject to significant groundwater problems. Figures 2 and 3 in Appendix B highlight the few areas in which groundwater is discharged to the soil surface. These areas appear to be well defined and of limited extent.

The primary area where groundwater is a concern with respect to potential development is in the Hallam Road area (Sink S-1). This sink area exhibits ponded water in its low points. The ponding appears to be more a function of highly impermeable soils or bedrock rather than groundwater discharge. Further discussion about this area is found in Section 5.15.

.3 Unstable/Erosion Susceptible Soils

Terratech also identified areas were the soils are especially unstable or are susceptible to erosion. All of these sites are located on relatively steep slopes, often within natural gullies. Some of the areas, shown in Figures 2 and 3 in Appendix B, are classified as "active", indicating that the soil is currently sloughing or being eroded down the slope.

The Tyndall Neighbourhood Pre-Plan recognizes that upstream development could potentially disturb these sensitive areas. Any activity within these areas, but especially uncontrolled stormwater runoff, could trigger severe soil erosion and further jeopardize slope stability. Protection of these sites is strongly recommended in the pre-plan, and was seriously considered during the preparation of the master drainage plan.

2.3 Land Use

This section describes the various land uses found within the study area under existing conditions, and summarizes future land use projections. For purposes of this study, land use descriptions have been simplified to represent surface runoff potential. From a land use perspective, for example, there is a significant difference between school playgrounds and natural meadows or school parking lots and commercial centres. With respect to surface runoff potential, however, there is little difference between the identified land uses in each example set.

The land use descriptions used in this study, therefore, do not correspond directly with those outlined in a traditional Official Community Plan; they instead reflect surface runoff potential.

.1 Existing Land Use

As illustrated in Figure 2.1, only 8.5% of the study area has been extensively developed. This development contains a mix of:

- single family residential homes,
- a winery,
- a packing house,
- and 1 school.

The residential development ranges from rural acreages to fairly dense single family subdivisions. Lot sizes range from 0.13 to 2.5 ha. For purposes of this study, the following classes of residential densities are used:

- Residential Acreage - 0.8 to 2.0 ha (2 to 5 acre) lots;
- Rural Residential - approximately 0.4 ha (1 acre) lots;
- Low-Density Residential - approximately 0.2 ha (0.5 acre) lots;
- Single Family Residential - approximately 0.13 ha (0.33 acre) lots.

Approximately 16% of the study area is under active cultivation as orchards or vineyards. The rest of the area is undeveloped, with 14% of the total area as open grassland and 61.5% as naturally treed.

Table 2.2 summarizes the various land use categories assumed for this study. Also summarized are the assumed values for several of the parameters used for the computer modelling analyses. These values are addressed further in Section 3. Table 2.3 summarizes the existing land use and unit estimates for each sub-basin in the study area.

.2 Future Land Use

Two pre-plans were prepared for the Regional District of Central Okanagan which cover most of the study area. These are:

- Tyndall Neighbourhood Pre-Plan - July, 1993 by I.D. Systems Ltd.;

- Southwest Winfield Neighbourhood Plan - February, 1994 by Reid Crowther & Partners Ltd.

Each pre-plan identified areas of potential growth, including unit estimates. To date, the units projected in the pre-plans do not entirely reflect the maximum densities recommended on the soil capability map for on-site sewage disposal prepared by the Ministry of Environment. The number and type of units projected in this study, therefore, are based on the Ministry of Environment soil capability map (see Appendix A).

Essentially, several factors dictate that residential development within the study area will be relatively low-density. These include:

- limited soils capability to support on-site sewage disposal;

- relatively steep slopes;

- a strong indication by area residents that the rural ambience of the area must be maintained.

Most of the northern portion of the study area is within the Agricultural Land Reserve. This study assumes that ALR lands will remain protected from development. No new units, therefore, were projected for these properties.

Unit growth projections are given for each basin in Section 5. Figure 2.2 illustrates how the projected development is distributed throughout the study area.

.3 Equivalent Unit Analysis

In order to allocate estimated improvement costs to existing and future development, development is expressed in terms of "development units". For simplicity, each residential lot up to 0.8 ha (2 acres) in size is considered to be equivalent to a single unit. Since the number of non-residential uses is relatively small compared to projected residential growth, equivalent units for these types of development were excluded from any calculations. Such developments will need to be addressed on a project-specific basis when establishing applicable charges for drainage works.

A summary of the calculated equivalent units for each sub-basin is given in Table 2.4.

2.4 Drainage Divisions

The drainage basins illustrated in Figure 2.3 were defined by natural topography and existing roads. Major drainage routes were defined by existing ditches, natural gullies, and culvert locations. The west side of the study area is bordered by Okanagan Lake. Okanagan Centre Road forms the western boundary of each primary drainage basin.

Basin boundaries usually coincide with the high points on a road and the major drainage route would be located through the corresponding low point. This is not the case with Okanagan Centre Road since it is relatively flat throughout the portion along the lake shore. Only three existing culverts crossing this road were identified. Given the current condition of Okanagan Centre Road along the lake shore, it was difficult to accurately locate the major drainage routes and basin boundaries without conducting a significant amount of surveying. Budget constraints prevented this survey from being conducted, so only approximate boundaries and major routes were identified.

For simplicity, only 25 primary basins were identified. In reality, many more small basins exist along the eastern side of Okanagan Centre Road and west of Finch Road. These have been omitted from specific discussion and analyses since:

- each basin is relatively small;
- most consist of very steep slopes with no, or very limited development potential;
- the overall impact of runoff from these basins would be negligible on the identified major drainage routes and structures.

This master drainage plan, therefore, focuses on the primary drainage basins that:

- may be subject to significant development;
- may potentially contribute a significant amount of runoff to major routes which pass through existing or potential development.

Note that three sink areas were also identified. These areas have no positive overland drainage routes. Issues within these sinks have been addressed individually.

Table 2.2
Land Use Categories

Land Use	Density (Units/Ha)	Minimum Lot Size (Ha)	MIDUSS Modelling Paramters: Percent Impervious (Direct)	Initial Abstraction (mm): Intrcptn	Initial Abstraction (mm): Depression Storage	Initial Abstraction (mm): Total
Rural Acreage	1.2	0.83	2.0%	1.2	6.0	7.2
Rural Residential	2.5	0.40	3.0%	1.0	5.0	6.0
Low–Density Residential	5.0	0.20	4.0%	0.8	4.0	4.8
Single Family Residential	7.5	0.13	10.0%	0.5	4.0	4.5
Naturally Treed	N/A	N/A	0.0%	1.5	6.0	7.5
Natural Grassland	N/A	N/A	0.0%	1.0	5.0	6.0
Orchards	N/A	N/A	0.0%	1.0	6.0	7.0
Vineyards	N/A	N/A	0.0%	0.7	10.0	10.7
Paved Areas	N/A	N/A	95.0%	0.0	2.0	2.0

Table 2.3

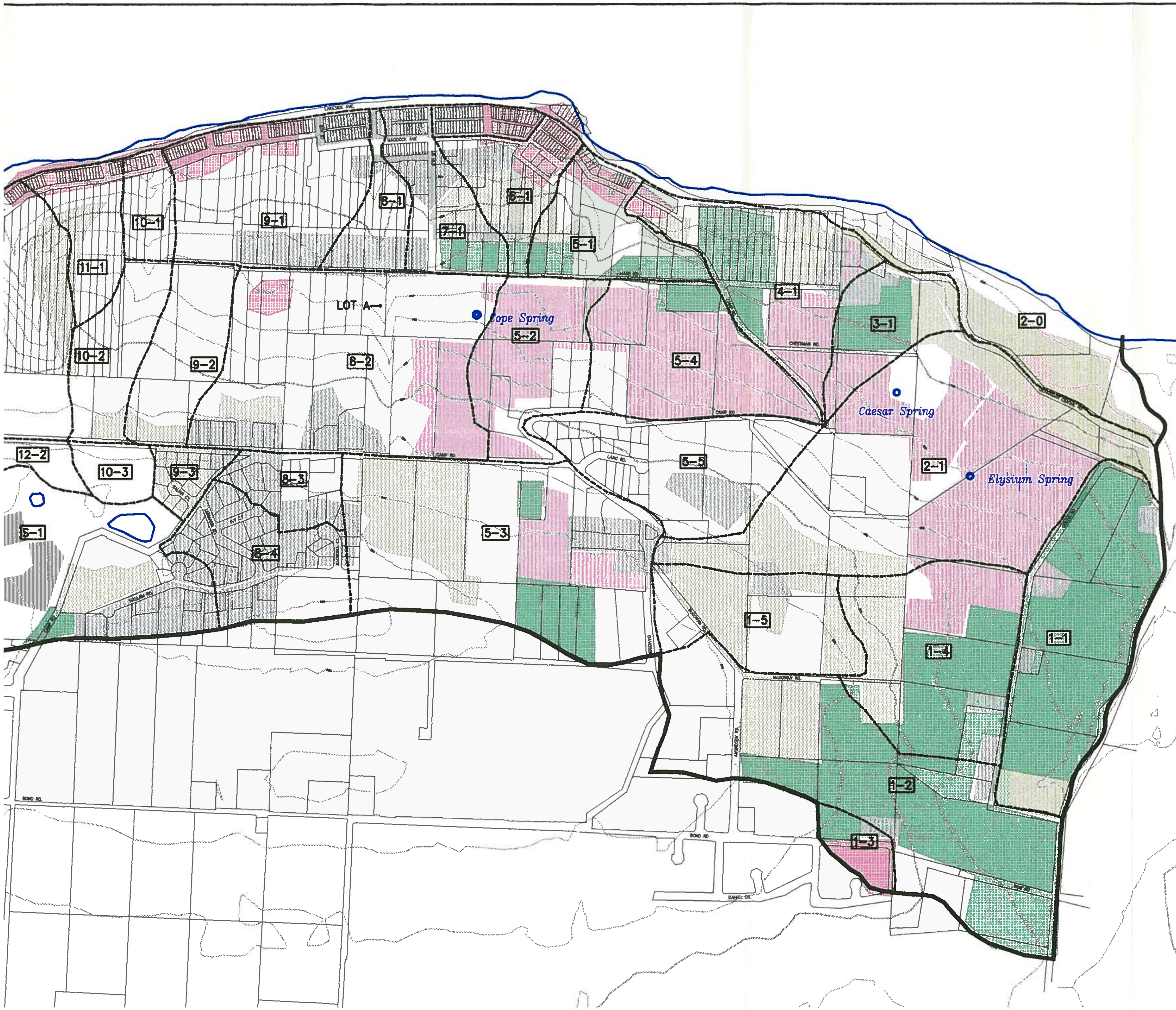
Land Use Summary – Existing Conditions

Basin	Area (hectres)											Residential Units				
	RUAC	RURES	LDRES	SFRES	NTRD	NGRS	ORCH	VNYRD	PLYGD	PAVED	Totals	RUAC 1.2	RURES 2.5	LDRES 5	SFRES 7.5	Total
1-1		1.5			0.6	1.7	19.0				22.8		4			4
1-2		0.8			10.1	4.0	19.3				34.2		2			2
1-3		0.2		1.6			0.8				2.6		1		12	13
1-4		0.9			0.8	4.7	8.6	3.9			18.9		2			2
1-5		0.6			5.0	6.0					11.6		2			2
2-0					2.0	6.8					8.8					
2-1		0.5			12.3	10.0		18.3			41.1		1			1
3-1		1.2				1.9	2.7	1.5			7.3		3			3
4-1		1.4		0.8	2.4	2.4	4.8	3.8			15.6		4		6	10
5-1				1.0	3.9	1.0	2.6				8.5				8	8
5-2					3.3			8.1			11.4					
5-3		2.4	0.5		15.2	7.6	3.9	3.8			33.4		6	3		9
5-4					1.8		1.5	12.1			15.4					
5-5		1.9			12.6	0.1					14.6		5			5
6-1		1.4		2.0	0.5	2.3	0.5				6.7		4		15	19
7-1		3.7			1.5	1.0	1.3				7.5		9			9
8-1		2.2			2.2						4.4		6			6
8-2		4.4		0.8	20.0	0.9		4.8			30.9		11		6	17
8-3			2.9		1.8						4.7			15		15
8-4		1.5	6.8		2.4						10.7		4	34		38
9-1		3.5		3.0	10.4						16.9		9		23	32
9-2					8.0	0.9					8.9					
9-3		0.4	2.3								2.7		1	12		13
10-1				0.6	2.9						3.5				5	5
10-2					6.7	0.7					7.4					
10-3					2.4						2.4					
11-1				1.4	3.5	1.0					5.9				11	11
12-1				0.3	15.5	3.0					18.8				2	2
12-2					1.9						1.9					
12-3					3.8						3.8					
S-1		3.9	0.6		17.3	2.1	0.8		2.7		27.4		10	3		13
13-1					9.9	3.0					12.9					
14-1					5.6	0.6					6.2					
14-2					1.8	1.1					2.9					
15-1					7.6	1.7					9.3					
16-1					8.8	3.2					12.0					
16-2					35.8	1.8					37.6					
17-1					1.8	2.1	0.5				4.4					
18-1					3.2	2.4	0.5				6.1					
19-1					1.7	0.3					2.0					
20-1					4.2	4.1					8.3					
21-1					14.3	5.4					19.7					
21-2					2.9						2.9					
21-3					19.5	9.9					29.4					
21-4					34.2						34.2					
21-5					13.5						13.5					
21-6					14.2						14.2					
S-2					3.2						3.2					
22-0					15.3	8.7					24.0					
23-0					9.9	1.4					11.3					
23-1					6.8	0.5					7.3					
23-2			0.9		2.9	1.4					5.2			5		5
23-3					14.1	0.7					14.8					
23-4					11.4	0.5					11.9					
23-5					12.0						12.0					
23-6					12.2						12.2					
S-3			0.5		12.0						12.5			3		3
24-0					5.1						5.1					
24-1					8.9	0.8					9.7					
25-0			2.5		4.1						6.6			13		13
Totals		32.4	17.0	11.5	467.7	107.7	66.8	56.3	2.7		762.1		84	88	88	260

Table 2.4

Land Use Summary – Future Conditions

Basin	Area (hectres)											Residential Units				
	RUAC	RURES	LDRES	SFRES	NTRD	NGRS	ORCH	VNYRD	PLYGD	PAVED	Totals	RUAC 1.2	RURES 2.5	LDRES 5	SFRES 7.5	Total
1-1		1.5			0.6	1.7	19.0				22.8		4			4
1-2		0.8	6.4		3.7	4.0	19.3				34.2		2	32		34
1-3		0.2		1.6			0.8				2.6		1		12	13
1-4		0.9			0.8	4.7	8.6	3.9			18.9		2			2
1-5		0.6			5.0	6.0					11.6		2			2
2-0					2.0	6.8					8.8					
2-1		0.5			12.3	10.0		18.3			41.1		1			1
3-1		1.2				1.9	2.7	1.5			7.3		3			3
4-1		8.9		0.8	1.8	0.3		3.8			15.6		22		6	28
5-1		1.8		1.0	3.5	0.8	1.4				8.5		5		8	13
5-2					3.3			8.1			11.4					
5-3		4.3	0.6		13.3	7.5	3.9	3.8			33.4		11	3		14
5-4		1.3			1.8		0.2	12.1			15.4		3			3
5-5		1.9			12.6	0.1					14.6		5			5
6-1		1.4	1.4	2.0	0.5	1.2	0.2				6.7		4	7	15	26
7-1		2.4	4.4		0.6		0.1				7.5		6	22		28
8-1		0.6	1.6		2.2						4.4		1	8		9
8-2	2.6	0.2	0.5	7.7	15.1			4.8			30.9	3	1	3	58	65
8-3		2.7	0.9		1.1						4.7		7	5		12
8-4		9.5			1.2						10.7		24			24
9-1		1.6	3.1	3.0	9.2						16.9		4	16	23	43
9-2	0.5	0.5	2.7	0.1	4.0	1.1					8.9	1	1	14	1	17
9-3																
10-1				0.6	2.9						3.5				5	5
10-2			0.3	3.3	3.2	0.6					7.4			2	25	27
10-3		0.4	2.3		2.4						5.1		1	12		13
11-1				1.7	3.2	1.0					5.9				13	13
12-1	3.7			4.5	7.7	2.9					18.8	4			34	38
12-2					1.9						1.9					
12-3					3.8						3.8					
S-1	1.6	6.1	1.9		14.3	0.5	0.3		2.7		27.4	2	15	10		27
13-1				1.7	8.2	3.0					12.9				13	13
14-1				1.3	4.3	0.6					6.2				10	10
14-2					1.8	1.1					2.9					
15-1	1.7	0.3		2.0	4.7	0.6					9.3	2	1		15	18
16-1				5.4	6.4	0.2					12.0				41	41
16-2		8.4		0.5	26.9	1.8					37.6		21		4	25
17-1					1.8	2.1	0.5				4.4					
18-1		0.6		1.1	2.2	1.7	0.5				6.1		2		8	10
19-1					1.7	0.3					2.0					
20-1		0.8		1.1	3.6	2.8					8.3		2		8	10
21-1		2.2		3.8	8.8	4.9					19.7		6		29	35
21-2		0.5			2.4						2.9		1			1
21-3	2.6	3.8		6.8	7.3	8.9					29.4	3	10		51	64
21-4		6.7		2.5	25.0						34.2		17		19	36
21-5	0.9	0.5			12.1						13.5	1	1			2
21-6	3.1	0.9			10.2						14.2	4	2			6
S-2		1.8		1.4							3.2		5		11	16
22-0		6.6	6.2		9.7	1.5					24.0		17	31		48
23-0		2.0			8.1	1.2					11.3		5			5
23-1		2.3	4.6		0.4						7.3		6	23		29
23-2			4.4		0.8						5.2			22		22
23-3			3.5	3.3	8.0						14.8			18	25	43
23-4	0.6		2.4	4.4	4.5						11.9	1		12	33	46
23-5	1.0	3.0	1.7	3.2	3.1						12.0	1	8	9	24	42
23-6			8.4		3.8						12.2			42		42
S-3	0.9		2.1	6.0	3.5						12.5	1		11	45	57
24-0					5.1						5.1					
24-1		1.3	3.0		5.4						9.7		3	15		18
25-0			2.5		4.1						6.6			13		13
Totals	19.2	91.0	64.9	70.8	317.9	81.8	57.5	56.3	2.7		762.1	23	232	330	536	1,121



LEGEND

- STUDY AREA BOUNDARY
- SUB-BASIN BOUNDARY
- 14-2 MIDUSS SUB-BASIN DESIGNATION

EXISTING

- RURAL ACREAGE
- RURAL RESIDENTIAL
- LOW-DENSITY RESIDENTIAL
- SINGLE FAMILY RESIDENTIAL
- NATURAL GRASS
- ORCHARD
- VINEYARD
- PAVED AREAS

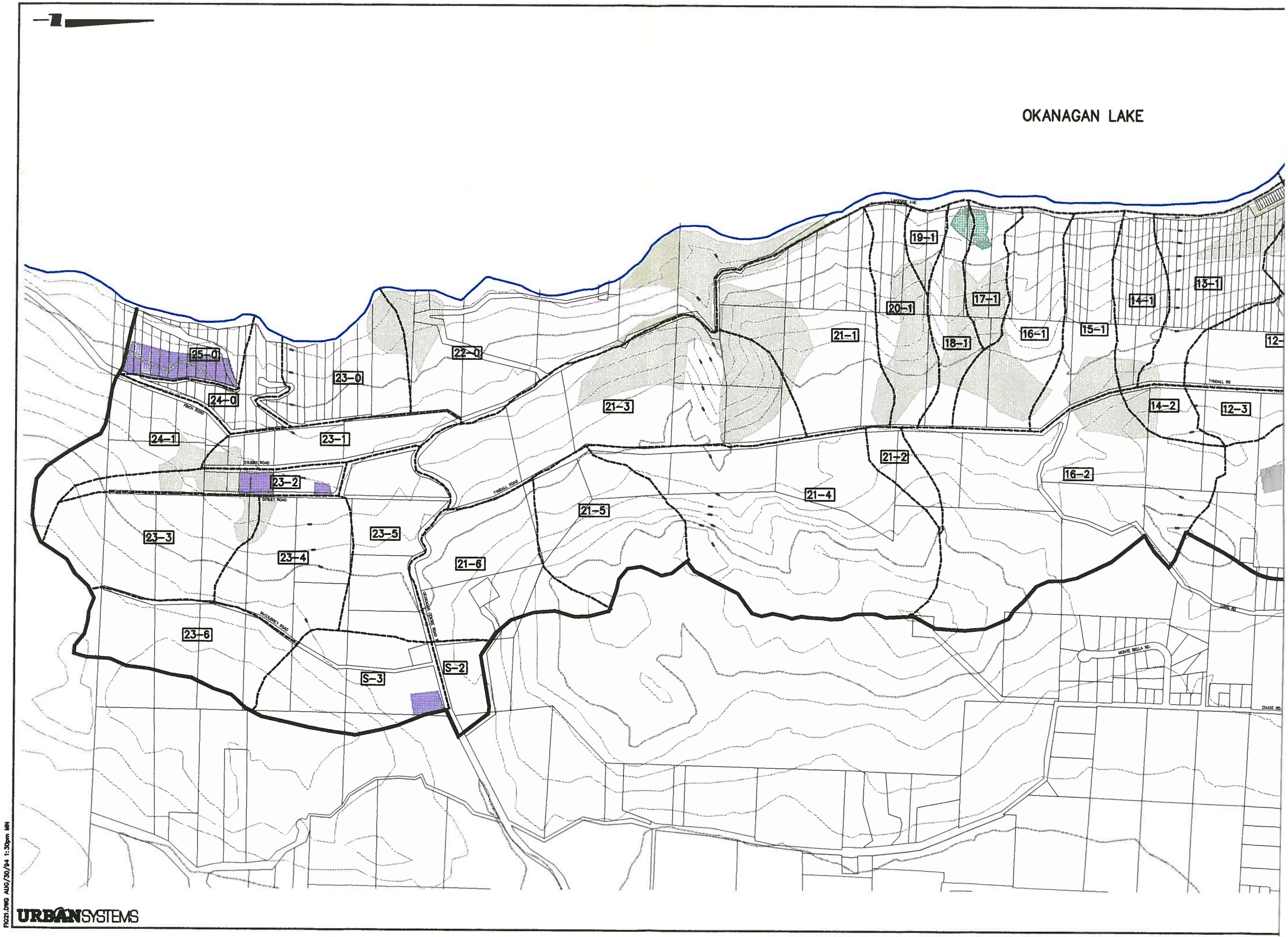
NOTE:
ALL OTHER AREAS NOT IDENTIFIED AS ONE OF THE ABOVE ARE ASSUMED TO BE NATURALLY TREED.

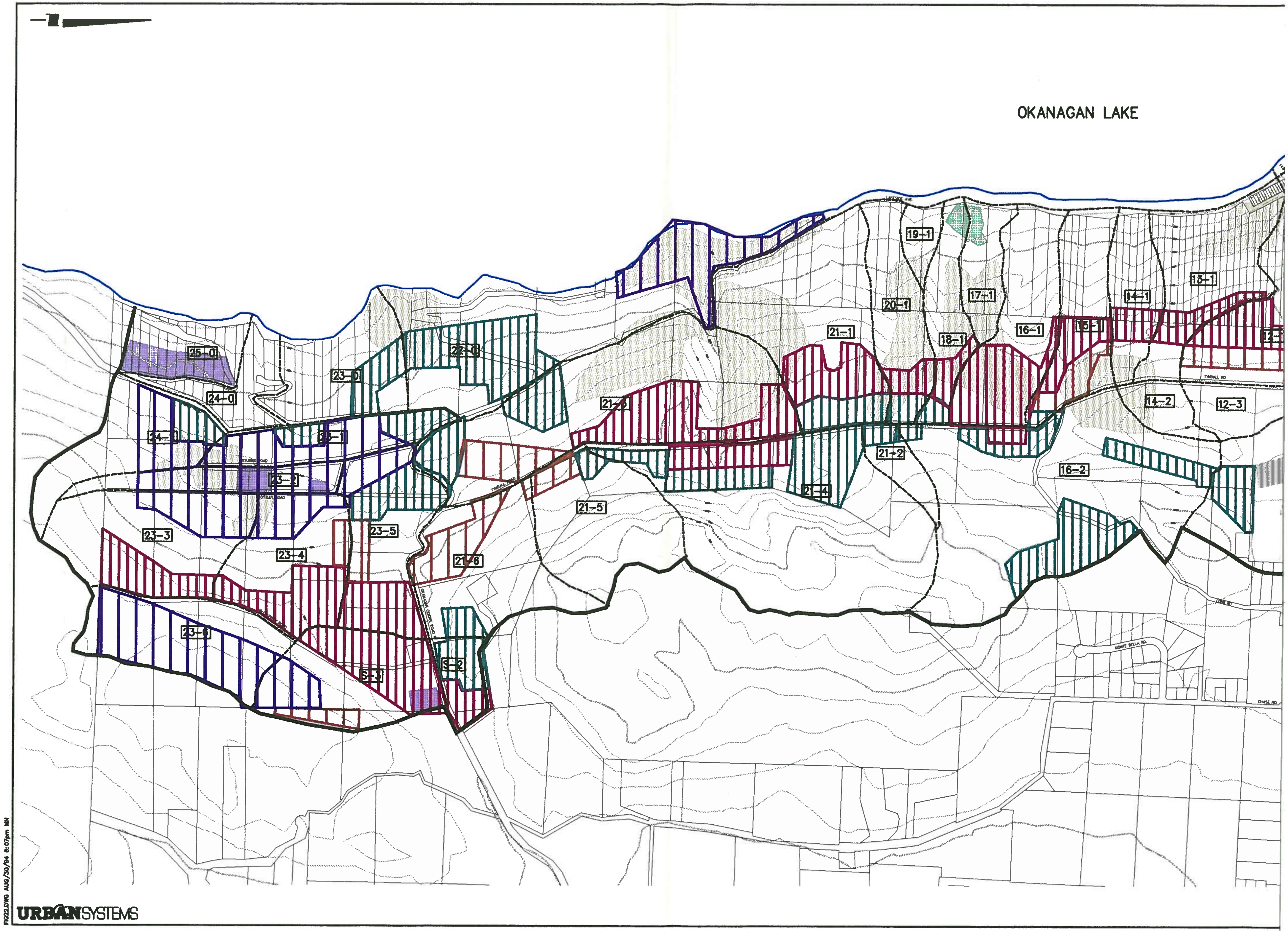
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN

EXISTING LAND USE

SCALE 1:10000
0 100 200 400m

FIGURE 2.1


OKANAGAN LAKE
25-0
24-0
23-0
22-0
24-1
23-1
23-2
23-3
23-4
23-5
23-6
S-2
S-3
21-1
21-2
21-3
21-4
21-5
21-6
20-1
19-1
18-1
17-1
16-1
16-2
15-1
14-1
14-2
13-1
12-3
FINCH ROAD
STUBBS ROAD
OTTLEY ROAD
TYNDALL ROAD
TYNDALL RD
MONTE BELLA RD.
CHASE RD.
FIG21.DWG AUG/30/94 1:30pm MN
URBANSYSTEMS


OKANAGAN LAKE
25-0
24-0
23-0
22-0
24-1
23-1
23-2
23-3
23-4
23-5
23-6
5-3
5-2
21-1
21-2
21-3
21-4
21-5
21-6
20-1
19-1
18-1
17-1
16-1
16-2
15-1
14-1
14-2
13-1
12-3
TYNDALL RD
CHASE RD.
FIG22.DWG AUG/30/94 6:07pm MN
URBANSYSTEMS

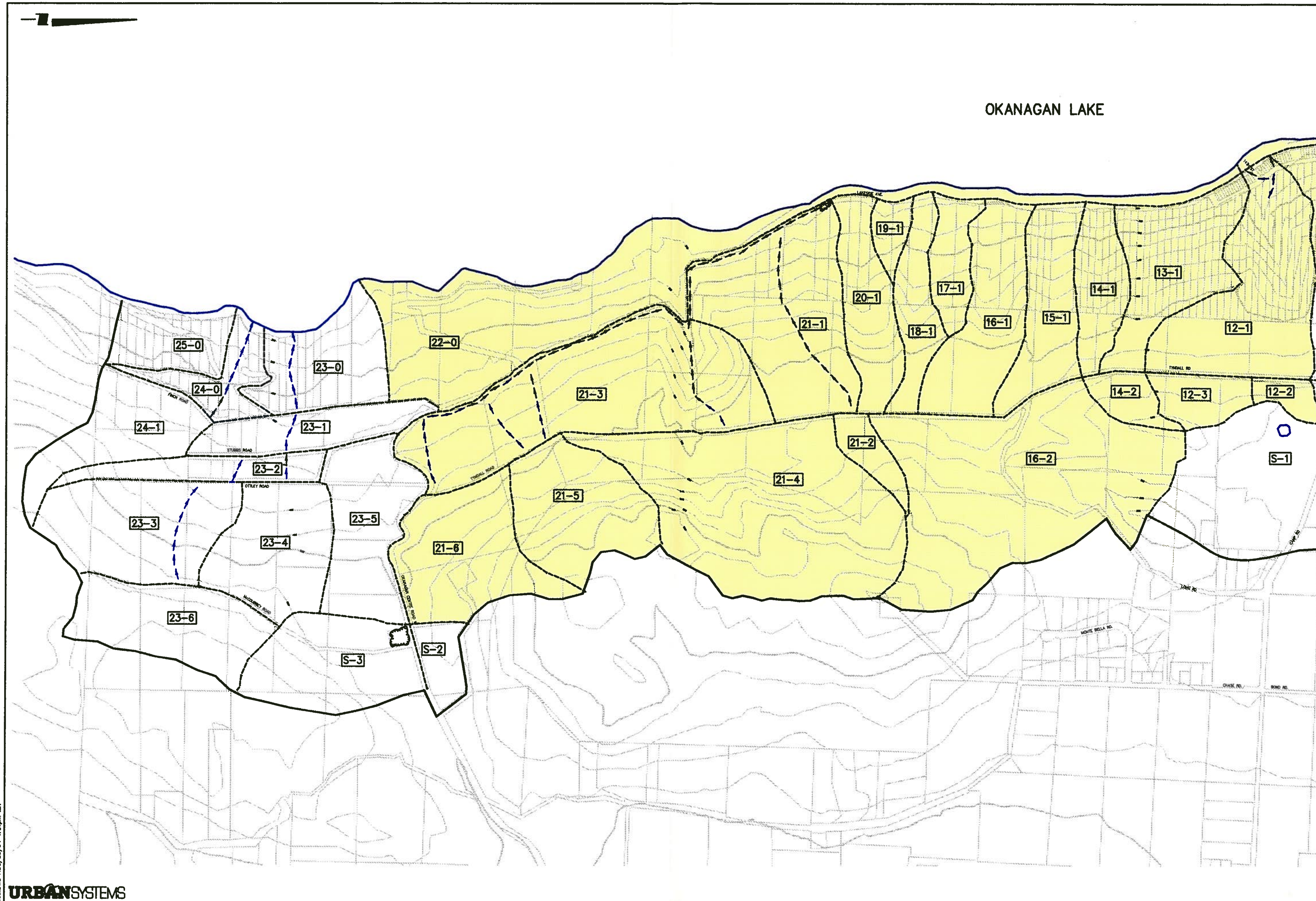
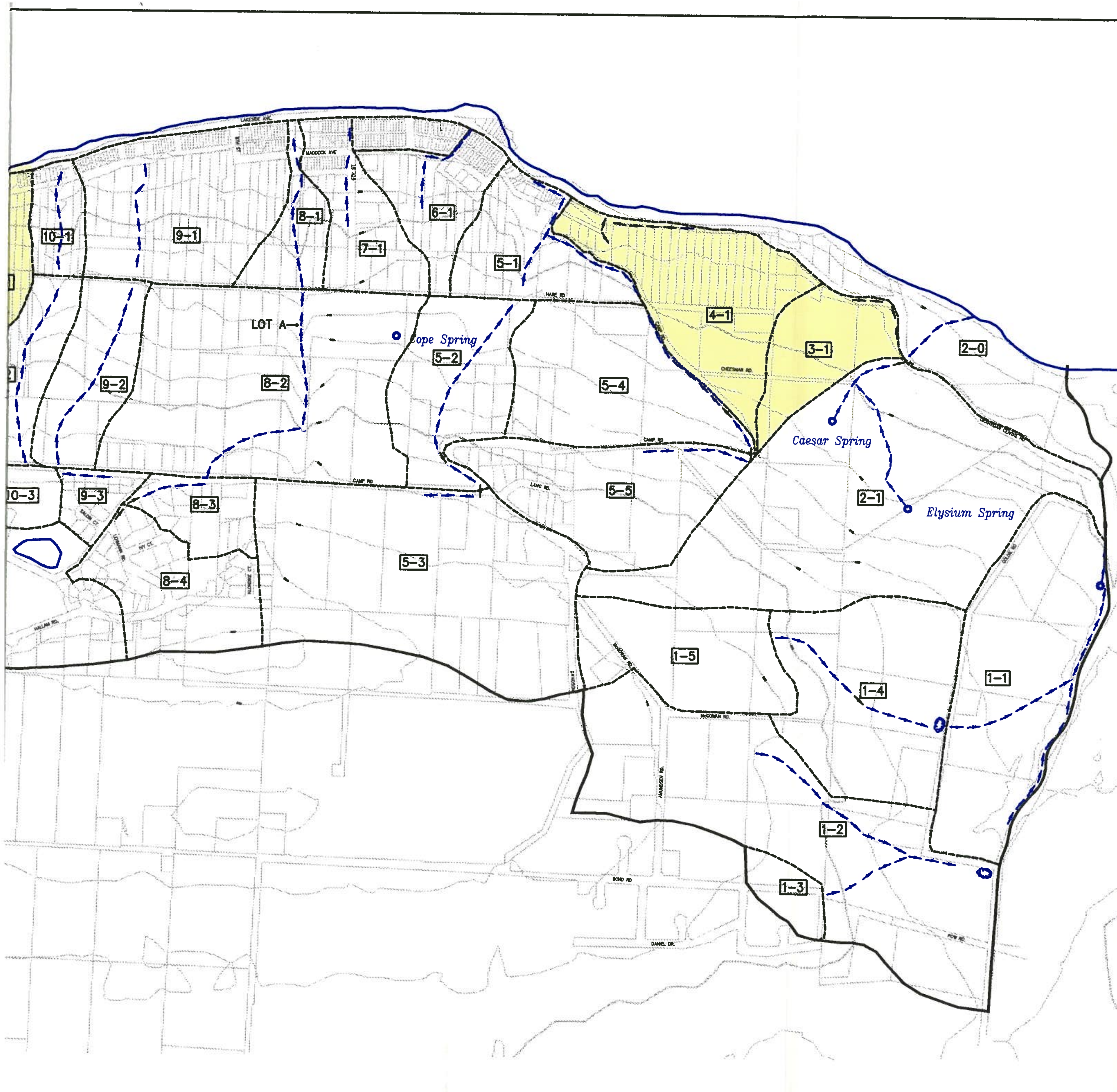


FIG8.DWG AUG/30/94 4:01pm MN



LEGEND

STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION

EXISTING DRAINAGE

PERENNIAL FLOW
INTERMITTENT FLOW
SINK
GROUND SPRING

STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS – SEE DETAILS IN SECTION 5 OF REPORT

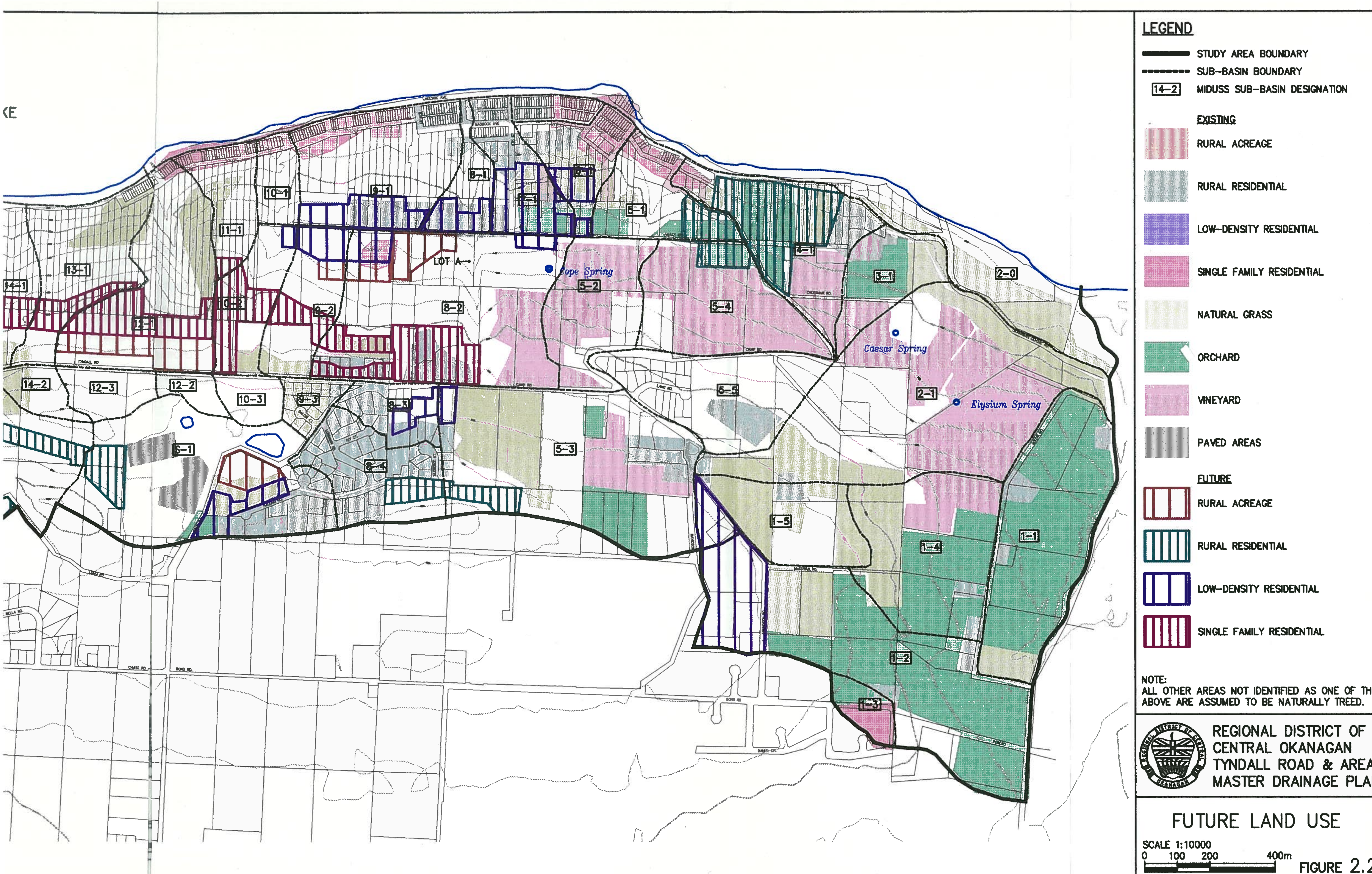
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4

REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN

DRAINAGE DIVISIONS

SCALE 1:10000
0 100 200 400m

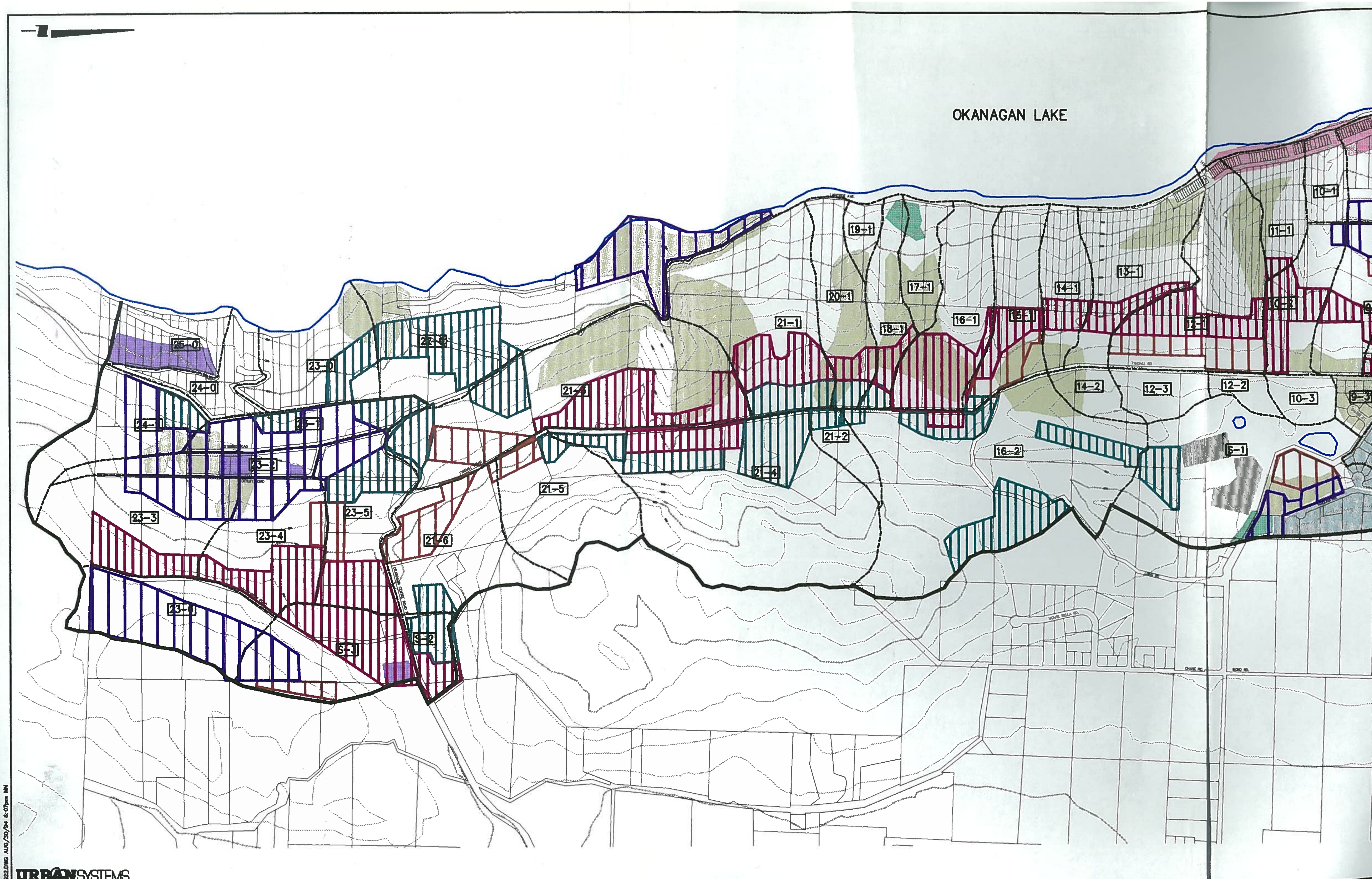
FIGURE 2.3



REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN

FUTURE LAND USE

FIGURE 2.2



OKANAGAN LAKE
25-0
24-0
23-0
22-0
24-1
23-1
23-2
23-3
23-4
23-5
23-6
S-1
S-2
21-6
21-5
21-4
21-3
21-2
21-1
20-1
19-1
18-1
17-1
16-1
15-1
14-1
13-1
12-1
11-1
10-1
10-2
9-2
14-2
12-3
12-2
10-3
9-3
16-2
6-1
TYNDALL RD
MONTE BELLA RD.
CHASE RD.
BOND RD.
URBANSYSTEMS

SECTION 3.0

ANALYSIS/DESIGN CRITERIA — *SECTION 3.0*

This section presents the criteria used for analysing existing and sizing proposed drainage system components. The Ministry of Transportation and Highways (MoTH) is the approving authority for works constructed during the development process. It also maintains and improves drainage associated with the road network. The MoTH is currently developing its own set of design standards for drainage works. For this study, however, the design criteria developed by the City of Kelowna have been adopted since the MoTH standards are not yet available.

The criteria presented in the following sections were extracted from the City of Kelowna *Stormwater Management Policies and Design Manual*. Where additional criteria were necessary, values were developed from the sources listed in the Reference section.

3.1 Design Event Return Periods

Drainage systems are typically designed to operate under the effects of two conditions:

a) the relatively frequent, usually low-intensity storm event, and

b) the relatively infrequent, but often high-intensity storm event.

The resulting drainage systems are called the *minor* and *major* systems respectively. In rural areas, these two systems are usually functionally and physically coincident. In urban areas, however, they are often totally separate systems.

The purpose of the minor system is to convey all of the runoff resulting from events that have return periods of up to 25 years. The 5 year return period is often applied to rural areas while the 25 year return period is usually reserved for high-value commercial or industrial areas. The minor system usually consists of roadside ditches, culverts, catchbasins, and underground storm sewers. It is designed to prevent inconvenience to the public during most storm events and, as a result, is often referred to as the *convenience* system.

The major system is designed to convey the runoff which results from less frequent events, normally with a return period of up to 200 years. This system may consist of natural or constructed channels, large culverts and other control structures, and natural or constructed detention ponds. It also often includes routes where flooding is permitted to occur in a controlled manner while protecting the public and their property. These routes usually consist of roadways with raised boulevards. The major system is often referred to as the *emergency* system since it comes into operation during extreme rainfall conditions.

For the purpose of this study, storms with the following return periods have been used to analyze the corresponding drainage systems:

- 10 years for the minor system;
- 100 years for the major system.

3.2 Rainfall

The closest Atmospheric Environment Service of Canada (AES) meteorological station to the study area for which intensity/duration/frequency (IDF) curves have been prepared is the Kelowna Airport. The total depth of rainfall for a storm event of any given duration can be determined from these curves.

For this study, the 10 year return period storm event will be used for sizing the convenience system while the 100 year return period storm will be used for sizing the emergency system. The total depths of rainfall for a variety of storm durations are presented in Table 3.1. The curves are illustrated in Figure 3.1.

Table 3.1
Rainfall Depths

STORM DURATION (HOURS)	RAINFALL DEPTHS (mm)	
	1:10 Yr	1:100 Yr
15 min	8.0	11.9
30 min	10.0	14.4
1	12.3	17.5
2	15.1	21.3
6	21.0	29.0
12	25.8	35.2
24	31.7	42.7

Since many of the calculations for this study are completed on computer spreadsheets, the AES plotting equation has been used to calculate the required intensities (rather than manually interpreting them from the actual curve). The equation is:

$$I = at^b$$

where: I = rainfall rate in mm/hour;
t = time in hours; and

Return Period (yrs)	2	5	10	25	50	100
Coefficient a	8.4	10.8	12.3	14.3	16.0	17.5
Exponent b	-0.676	-0.694	-0.702	-0.710	-0.715	-0.719

3.3 Rainfall Patterns

Precipitation does not normally fall at a uniform rate during a storm; the rainfall rate (intensity) varies throughout the event. For this study, two curves based on statistically analyzed data are used to simulate rainfall patterns for different storm durations.

Reproduced from the City of Kelowna design manual, and located in Appendix A, these curves show the portion of total rainfall within a given portion of a storm's duration. One curve is for relatively short storms (durations of 6 hours or less). The other curve is for longer storms with durations from 6 to 24 hours. A uniform (flat) storm pattern is assumed for durations exceeding 24 hours.

Selected values from each curve are summarized in Table 3.2.

Table 3.2
Rainfall Distribution Patterns

PERCENT OF STORM DURATION	PERCENT OF TOTAL STORM RAINFALL	
	6 HOUR OR LESS DURATION	GREATER THAN 6 HOUR DURATION
0	0	0
17	18	16
33	56	37
50	74	58
67	87	80
83	95	94
100	100	100

3.4 Effective Rainfall

Not all of the rain that falls onto a catchment area contributes to the surface runoff. Some of it is intercepted by foliage, some is stored in surface depressions, and some is infiltrated into the ground. The effective rainfall is the rainfall that is net of these mechanisms. This section outlines the selected values used in this study for each rain-loss mechanism.

.1 Initial Abstraction (Interception and Depression Storage)

The amount of rainfall kept from contributing to surface runoff through interception and depression storage is call the *initial abstraction*. Although many factors influence the values of these parameters, this study assumes that each value is a function of land use. For example, a natural meadow will have less depression storage than a furrowed vineyard. A treed area will intercept more rainfall than a grassed area. Table 2.2 summarizes the values assumed for the land uses outlined in Section 2.

.2 Infiltration

This study uses the Horton's equation for calculating the amount of rainfall which infiltrates into the soil during a rainfall event. The equation incorporates initial and saturated infiltration rates, as well as a parameter to reflect the response time. It is given as:

$$f_{capac} = f_c + (f_0 - f_c)e^{-t/K}$$

where:

f_{capac}	=	maximum infiltration capacity of the soil
f_c	=	final (constant) infiltration capacity
f_0	=	initial infiltration capacity
t	=	elapsed time from start of rainfall
K	=	decay time constant

The values for each parameter are dependent upon the type of soils present within the study area. Based on the geotechnical report specifically prepared by Terratech Western Profile Consultants Ltd. for the study area, Table 3.3 summarizes the infiltration parameter values used in this study. Each of the four identified soil types are described more fully in Section 2.

Table 3.3
Infiltration Parameter Values

Soil Group	Infiltration Rate (mm/hr)		Decay Coefficient k (hours)
	fo (initial)	fc (ultimate)	
A	2,500	200	2.5
B	150	100	0.7
C	3.5	1.0	0.3
D	0.2	0.04	0.07

3.5 Time of Concentration

The time of concentration (t_c) represents the time it takes for overland flow to reach a basin's outlet from the furthest point in the basin. This value of this parameter significantly affects the peak flow rate generated during the computer analyes. Of the many methods available to determine the time of concentration for drainage basins, MIDUSS uses the following:

$$t_c = \frac{6.989(nL)^{0.6}}{I_{eff}^{0.4}\,S^{0.3}}$$

where:

t_c	=	time of concentration in minutes
n	=	Manning's roughness coefficient
L	=	travel length, meters
I_{eff}	=	effective rainfall intensity, mm/hr
S	=	average surface slope, m/m

Unless there is substantial reason reduce it, the minimum value of t_c used for impervious areas in this study is 10 minutes, regardless of the calculated value. Since MIDUSS does not have the option of specifying a minimum t_c value, minimum values of L were calculated based on t_c = 10 minutes.

3.6 Culverts

Culverts on major drainage routes should normally be sized to accommodate the design peak flow (1:100 year event for this study) at a headwater to culvert diameter ratio of 1.0. In this study, for practicality, the headwater diameter ratio has been increased to whatever depth can safely be accommodated at each particular location.

Generally, proposed culvert sizes are calculated using two separate assumptions (the larger size calculated governs):

a) inlet control conditions, and

b) outlet control conditions.

For this study, since ditch slopes are generally steep enough to prevent tailwater ponding, and culverts are relatively short in length, preliminary culvert sizes were based on inlet control conditions. A nomograph for circular CSP culverts based on inlet control conditions is included in Appendix A. Wherever there is not enough depth to install a culvert of the specified diameter, two or more culverts must be installed which have the combined capacity of the larger, single unit.

Regardless of calculated culvert sizes, The Ministry of Transportation and Highways recommends the following minimum diameters:

a) 400 mm for driveways;
b) 450 mm for roads within residential subdivisions and two-lane highways.

3.7 Open Channels

.1 Hydraulics

Hydraulic design of open channels is based on cross-sectional geometry, slope, design flow, and proposed construction materials. The Manning equation is used for hydraulic calculations under uniform flow conditions. A table of representative *n* values for open channels is contained in Appendix A.

Wherever possible, open channels are designed to flow under sub-critical conditions. This is often achieved by introducing check dams which create "hydraulic steps" which effect sub-critical slopes. Where this is not feasible, it is assumed that the channel will be armoured to protect against erosion.

.2 Erosion

The geotechnical report prepared by Terratech Western Profile Consultants Ltd. recommends a maximum velocity of 0.3 m/s for unprotected natural channels. Table A-2 in Appendix A presents the maximum allowable velocities for channels constructed with other types of soils and which employ various erosion prevention techniques. For situations not represented by the values presented in this table, erosion protection measures must be designed based on site-specific data.

.3 Freeboard

In general, all open channels should function with a minimum freeboard of 0.3 meters. If the channel is lined, then the lining freeboard should be a minimum of 0.2 meters.

3.8 Base Flows

Several of the drainage channels located within the study area contain perennial flows due to ground springs. These flows fluctuate seasonally, and perhaps even in response to individual rainfall events. The flows were estimated from field observations and used as the base flows for the computer analyses where applicable.

3.9 Floodplain

Floodplains are the areas adjacent to watercourses which are inundated by water during extreme flow conditions. Floodplain criteria are established by the Water Management Branch of the Ministry of Environment, Lands and Parks. The limits of floodplains are normally established on the basis of a flow with a return period of 200 years. There are two levels of criteria as follows:

1. For basins with a peak 200 year return period flow rate less than 80 m^3/s the floodplain is the area within 15m horizontal or 1.5m vertical from the top of the normal flow channel.

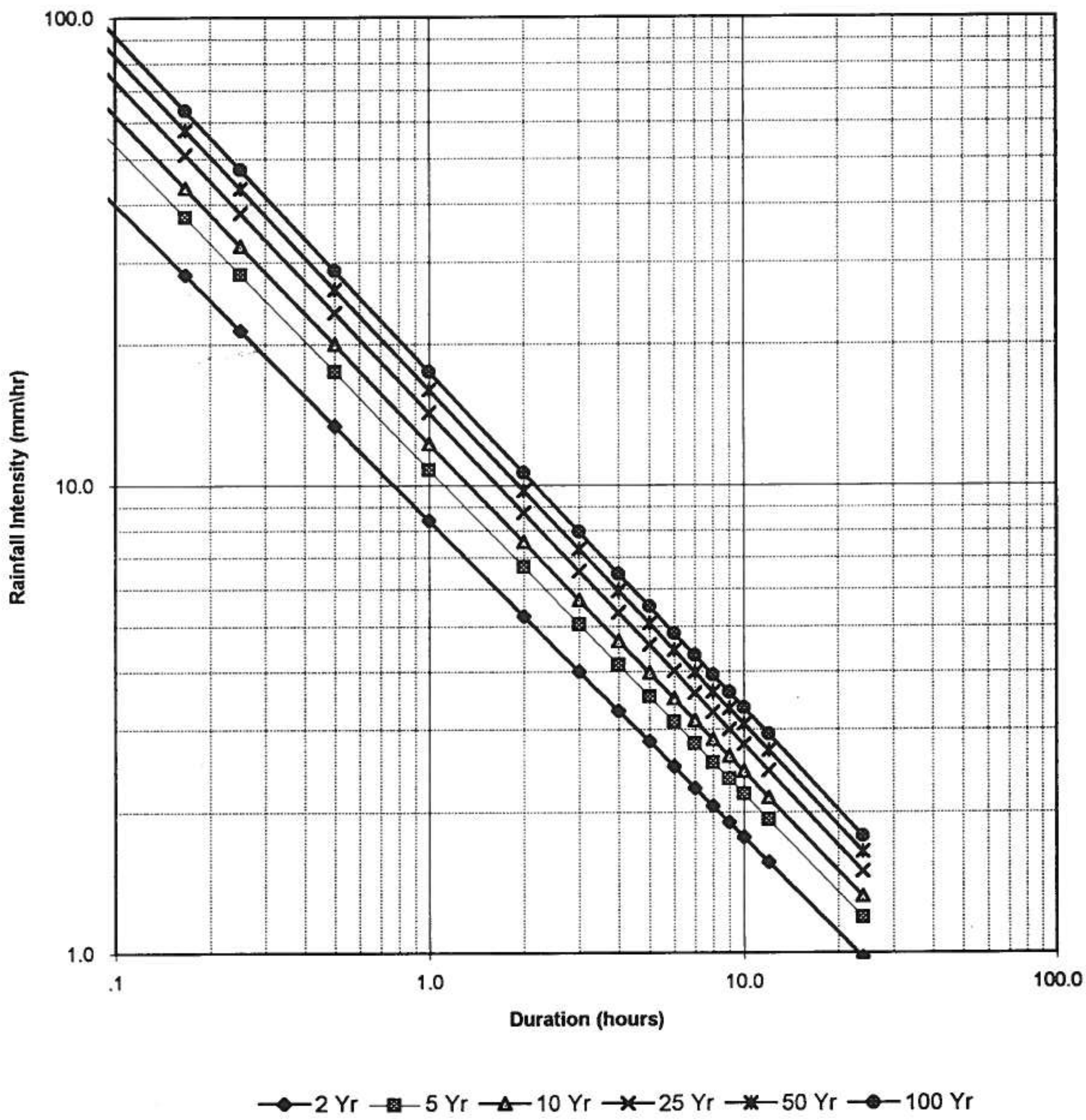
2. For basins with a peak 200 year return period flow rate greater than 80 m^3/s the floodplain is the area determined to be inundated using hydraulic backwater computational methods.

The study area does not contain significant stream-related floodplain areas. It does, however, contain numerous sites where natural gullies fan out near the lake shore. These sites are not subject to the floodplain criteria outlined above.

3.10 Road Standards

The Regional District of Central Okanagan requires that where the gross lot area is 0.1677 ha or less, new roads must have curbs and gutters. Developments with gross lot areas 0.1700 ha or greater may choose to use rural road sections (gravel shoulders and ditches). In developing the values for the various modelling parameters, this study assumes that urban road sections are used only for developments with lot areas of 0.1677 ha. or less.

Figure 3.1
Design Rainfall Curves



SECTION 4.0

ENVIRONMENTAL ISSUES *SECTION 4.0*

4.1 General

The Tyndall Road Pre-Plan indicated strong local concern for maintaining the natural character of the study area. This is reflected in recommendations to:

- maintain relatively low development densities;
- preserve tracts of undeveloped lands;
- protect steep slopes;
- maintain access to the lake.

Even with relatively low densities, however, development will have an impact on the local environment, especially with regard to drainage in areas bordered by steep slopes. New roads will intercept and concentrate rainfall into surface flows that must be managed to prevent erosion and sediment deposition. These and other issues are discussed in this section.

4.2 Okanagan Lake Shoreline

The B.C. Ministry of Environment, Lands, and Parks was contacted to confirm whether or not the lake shore within the study area was used as a spawning ground by any of the Okanagan Lake fish . Apparently, the shoreline under consideration is, in fact, used by spawning Kokanee salmon. The lake shore apparently supports a moderate density of spawning fish; approximately 1 or 2 fish per lineal metre of shoreline.

This area, therefore is sensitive to any activities that would increase silt deposition within the immediate shore area. Potentially damaging activities would include:

- routing surface runoff through open channels inadequately protected against erosion;

- stripping hill sides (or constructing roads) for development without implementing proper sediment transport control measures during construction;

- stockpiling topsoil in areas subject to surface runoff during rainfall events.

Considering the value of Kokanee salmon to Okanagan Lake, measures must be taken to prevent erosion and subsequent silt deposition from occurring.

4.3 Wildlife Habitat

The Ministry of Environment, Lands, and Parks also indicated that many of the gullies within the study area provide important wildlife habitat. Apparently, these gullies contain unique plant species necessary to support small wildlife populations. One of the primary reasons these plants grow in these gullies is the availability of sub-surface water.

There is little or no evidence of surface flows through the natural gullies within the study area. Apparently, however, the rainfall which infiltrates into the ground upstream of these gullies flows through the gullies just below the ground surface. This provides sufficient moisture to support the existing plant species.

Photo 7-12 (Appendix D) illustrates the impact of the sub-surface flows on domestic cedar trees. Note the increased height of the trees closest to the centre of the channel. This indicates greater water availability within the bottom of the gulley.

In general, the Ministry of Environment is concerned that development and associated drainage works within the study area will intercept and direct rainfall away from the gullies which contain the unique vegetation required to support local wildlife populations. Since the Ministry of Environment has not yet created a detailed inventory of these habitats, it is considering a policy that would require either the Regional District of Central Okanagan or prospective developers to conduct a thorough environmental impact study to:

- determine existing flora and fauna in all gullies downstream of proposed development;
- identify potential impacts due to the proposed development;
- recommend measures to protect all gullies which contain unique species;
- ensure the continued supply of sufficient sub-surface water is protected.

4.4 Slope Protection

Tyndall and Hare Roads are, for the most part, located on a narrow plateau. This plateau is separated from Okanagan Lake by a very steep bank, furrowed by a series of deep gullies running from east to west. As discussed in Section 2.2.3, these gullies consist of soils that are either under active erosion, or that have high erosion potential.

It is imperative, therefore, that surface runoff be controlled to prevent damage to the gullies between Tyndall and Okanagan Centre Roads. This may be accomplished by using:

- enclosed pipe systems;
- armoured open channels;
- upstream retention ponds;
- groundwater recharge systems.

Recommendation of a specific system for each drainage basin will, for the most part, need to be based on detailed site information. In some areas, the slopes are simply too steep or unstable to allow construction with machinery. In other cases, the soils may not permit use of infiltration systems.

The feasibility of implementing these systems within the study area are discussed further in Section 5.

4.5 Stormwater Runoff Quality

The study area is primarily rural, and even under developed conditions, the highest residential density will be approximately 7.5 units per hectare. Under these conditions, the primary pollutant will most likely be total suspended solids (TSS). Other potential pollutants may include:

- biological oxygen demand (BOD);
- nutrients (phosphorous, nitrogen, nitrates, and nitrites);
- metals (copper, lead, and zinc);
- pathogens.

Methods for removing pollutants from, or at least reducing the amount of pollutants in stormwater are called Best Management Practices (BMPs). Usually, BMPs which effectively remove total suspended solids from stormwater also remove a substantial amount of other pollutants as well.

Storm runoff may be contaminated during both the construction and post-construction phases. The most significant pollutant encountered during the construction phase is total suspended solids. The other pollutants generally become more prominent after construction is completed.

Appropriate measures must be taken to minimize the amount of stormwater-borne pollutants from entering the lake.

4.6 Construction Related BMPs

Without controls, the erosion of soil during construction activities typically results in a significant impact on drainage systems and receiving waters. Catch basins and storm sewers can often become filled with sediment. The media in infiltration-based systems can become totally clogged. Fish habitats may become severely, or even permanently damaged.

The keys to minimizing these impacts are to:

a) prevent the occurrence of erosion in the first place, and

b) intercept and control sediment-laden runoff.

Prevention measures include the following:

- Plan development to match existing terrain so disturbance of soil is minimized.
- Schedule construction during periods of dry weather and suspend activities during periods of heavy rainfall.
- Retain as much existing vegetation as possible and re-vegetate as soon as possible after construction.
- Direct runoff away from disturbed areas.
- Minimize the length of exposed slopes.

Since it is virtually impossible to completely prevent erosion from occurring during construction, sediment control measures are recommended to minimize this impact. These measures include the following:

- Construct silt fences along the base of bare slopes and around stockpiles. These physical barriers filter sediment laden runoff through fine openings.

- Construct sediment control ponds at points of discharge from the development site. Suspended solids settle out of the runoff as it flows through the pond.

Because these BMPs trap sediment, they must be maintained throughout the duration of the construction project. This maintenance includes regular inspections, cleaning, and repairs when necessary.

4.7 Post Construction BMPs

When the construction period is complete and the site restored, various pollutants continue to enter the runoff stream. Many BMPs are available to remove the pollutants (with varying degrees of success) from storm runoff. These include:

- oil-water separators;
- swirl concentrators and helical band regulators;
- wet or dry detention ponds;
- constructed wetlands;
- vegetated swales and filter strips;
- infiltration systems.

All of the noted BMPs require routine maintenance to ensure their ongoing effectiveness at removing pollutants. The maintenance may include regular cleaning, collection and removal of sediment deposits, mowing and vegetation removal, or renovation of filter media.

4.8 Application to Study Area

Most of the BMPs listed in Section 4.7 require reasonably large sites. There are few such sites available within the study area. In addition, because the study area borders Okanagan Lake, each of the numerous small basins would require individual systems.

Under existing conditions, natural infiltration appears to fulfil at least two functions:

a) It prevents rainfall from concentrating on the surface and forming destructive, high-velocity flows that would erode existing gullies and deposit large amounts of silt into the lake.

b) The rainfall is stored in the ground to nourish unique vegetation as it slowly flows through the gullies.

Considering the desirability of maintaining these qualities, the first option for managing storm runoff quality *and* quantity is to discharge it to ground wherever feasible. Where this is not feasible, adequate measures must be taken to reduce flow velocities and to protect against channel erosion.

The feasibility of using ground infiltration systems will depend upon soil permeability and slope stability. These issues have been generally addressed by the Terratech geotechnical report, and it appears that infiltration systems may be feasible within most of the study area. Specific site conditions, however, must be confirmed to ensure proposed systems will function adequately.

It is recommended that all future development within the study area be carried out with consideration for the Best Management practices outlined in the following documents, in the context of site-specific conditions:

1. B.C. Environment, *Urban Runoff Quality Control Guidelines for the Province of British Columbia.*

2. Department of Fisheries and Oceans, *Land Development Guidelines for the Protection of Aquatic Habitat.*

SECTION 5.0

BASIN ANALYSES — *SECTION 5.0*

This section presents information which is specific to each drainage basin within the study area. For most basins, the information includes:

- a description of existing land use;
- a description of projected land use;
- a description of existing drainage conditions;
- an outline of future drainage requirements;
- a discussion of significant issues;
- a summary of computer modelling results;
- a list of existing deficiencies and proposed improvements;
- a budgetary cost estimate for proposed works.

For some of the basins, however, the presented information is limited since appropriate drainage can be recommended only after preliminary lot and road lay-outs have been prepared. Under these circumstances, developers of land within these basins must prepare site-specific Stormwater Management Plans as discussed in Section 7.2.

Figures 2.1 and 2.2 indicate the existing and future land uses respectively for the study area. The basin and sub-basin boundaries have been super-imposed on each drawing for reference purposes. Tables 2.3 and 2.4 summarize the land use for each sub-basin under existing and future development conditions respectively. Table 5.1 summarizes the field and analysis data collected for the existing culverts. Tables 5.2 and 5.3 summarize the values of various analysis parameters for each sub-basin under existing and future development conditions respectively. Proposed improvements are summarized in Table 5.4.

Reference is often made to Tyndall Road Pre-Plan Planning Units. The location of these units are shown on Figure A-5 in Appendix A. Basin and proposed improvement details are illustrated on Figures 5.1 to 5.8 located at the end of this section.

5.1 Basin 1

Existing Land Use

Although some of the basin has been left in a natural state, most of it has been cultivated into orchards and vineyards. Sub-Basin 1-3 is the only area in which residential development has occurred.

Future Land Use

Most of Basin 1 is within the Agricultural Land Reserve. Of the 12.6 hectares of undeveloped land that are outside of the Agricultural Land Reserve, only 6.4 ha are developable. This is due to slopes which are greater than 30%. The lot density which could be supported within these areas is dependant upon the soil capacity for on-site sewage disposal. The MoEP soil capacity map prepared for the Regional District does not extend this far north, but based on the soil drainage characteristics outlined in the Terratech geotechnical study, an average residential density of 5 lots/ha has been assumed.

Existing Drainage

This basin is located within the northern part of the study area. It has been divided into five sub-basins based on:

- natural topography;
- road alignments;
- existing culvert locations.

The basin is part of the Jessie Creek watershed, but the creek has been slightly re-aligned in two places. The first re-alignment is along the eastern part of Goldie Road near the Okanagan Centre Road junction. The creek channel has been intersected by Goldie Road, with no installed culvert.

The second re-alignment occurs at the western intersection of Goldie and Okanagan Centre Roads. The portion of Jessie Creek within Sub-Basin 1-1 flows along the south ditch of Okanagan Centre Road, then crosses the road through a 600 mm dia. culvert at the Goldie Road (west) intersection. Drainage within the area is accomplished solely by natural gullies, road ditches, and infiltration to ground.

Analysis Results

All five sub-basins were modelled under existing and developed conditions. Since the amount of potential development is relatively small compared to the size of the basin, peak flows at the basin outlet increased to only 0.518 cms from a pre-development peak of 0.512 cms.

Deficiencies and Improvements

The only existing deficiency that was noted was at culvert 10 (Goldie (west) and OK Centre Road). Remaining improvements are recommended to minimize inconveniences during more extreme rainfall and snowmelt events.

No. 1 Install an inlet structure on the culvert @ the intersection of Goldie (west) and OK Centre Roads. This is to improve overall capacity.

No. 2 Since this is a low point on Goldie Road, a culvert should be installed to prevent ponding and possible road damage.

No. 3 Goldie Road (east) intersects Jessie Creek and isolates the upper reach from the lower reach. A culvert should be installed to prevent ponding on the east side of Goldie Road and possible damage to nearby buildings.

No. 4 The ditch along the east side of Goldie Road (east) needs to have a better defined section. This must be completed before Improvement No. 3 is completed.

No. 5 Before the required channel is constructed, an easement should be obtained to protect it from future encroachment.

NOTE: Improvements 3, 4, and 5 might be re-aligned to stay within the road right-of-ways. This will have to be confirmed by a detailed topographical survey as part of the detailed design.

5.2 Basin 2

Existing Land Use

Basin 2 is also developed primarily into orchards and vineyards. A small portion has been left naturally treed, especially on steeper slopes.

Future Land Use

Virtually all of the land within Basin 2 is also within the Agricultural Land Reserve. Of the land that is not, only a very small portion is situated on a slope less than 30%. Essentially, further development within this basin is considered unlikely. For purposes of this study, the design parameter values selected for both existing and future land use conditions are identical.

Existing Drainage

The basin and sub-basins are defined primarily by topography and location of a culvert across Okanagan Centre Road. (The size of this culvert could not be determined since both the inlet and outlet are severely clogged with vegetation.) This culvert provides passage for Peach Brook, which apparently flows year-round. The upper portion of this channel has, at one time, been straightened. It appears to be fed by two groundwater springs; Caesar Spring and Elysium Spring.

Except for the Peach Brook channel, drainage within "Sub-Basin" 2-0 is essentially overland to the lake. A culvert of unidentified diameter is installed across the driveway to the property on the west side of OK Centre Road for Peach Brook. It appears to have limited capacity, however, due to excessive weed growth around its entrance. Since this culvert is on private property, it is not shown on Figure 5.2.

Analysis Results

The computer analysis indicated that no surface runoff is anticipated under design storm conditions. This is due to the rural characteristics of the basin as well as the well-drained soils. The only anticipated flows are those generated by Caesar Spring and Elysium Spring. The estimated design flow is 0.050 cms.

Deficiencies and Improvements

No. 1 The inlet and outlet to culvert 10 should be cleared of vegetation to ensure adequate capacity for Peach Brook.

5.3 Basin 3

Existing Land Use

Except for a few rural houses, this small sub-basin is mostly orchard and vineyard. A portion has also been left as meadow.

Future Land Use

Almost all of this sub-basin is within the Agricultural Land Reserve, and therefore no additional development is anticipated.

Existing Drainage

Topography defines the north and south boundaries of this sub-basin. Okanagan Centre Road forms the western boundary. A low point on Okanagan Centre Road constitutes the basin outlet. There is, however, no culvert across the road at this location.

Analysis Results

A computer analysis under existing development conditions was conducted to establish the design flow for the proposed culvert. This was estimated to be 0.144 cms. This flow appears high for a relatively small basin, but this is due to a short time of concentration and the low permeability of the basin soils.

Deficiencies and Improvements

If land within this basin is extracted from the Agricultural Land Reserve for development purposes, then the Developer must be required to prepare a Stormwater Management Plan as outlined in Section 7.2. Specific deficiencies which should be addressed include:

No. 1 Confirming the natural outlet location for the basin and installing a culvert across Okanagan Centre Road at this location.

No. 3 Ensuring that the downstream route from the proposed culvert is, and remains, clear of obstructions and development. The upper portion of this channel will need to be armoured to protect it from erosion.

5.4 Basin 4

Existing Land Use

Much of this sub-basin has been developed into orchards, vineyards, and pasture. A small number of homes have been constructed within the extreme southern part of the subject area.

Future Land Use

Two of the large land parcels are still within the Agricultural Land Reserve. Most of the remaining land could be developed where the slope is less than 30%. The MoEP soil capability map for on-site sewage disposal does not extend this far north. Therefore, based on the soils information presented in the Terratech geotechnical report, a residential lot density of 2.5 units/ha has been assumed.

Existing Drainage

The natural basin was intersected by Camp Road. The road now forms the southeast boundary of the sub-basin. The northern boundary is dictated by topography, and the western boundary is established by Okanagan Centre Road. There are probably several low spots on Okanagan Centre Road that constitute basin outlets, and in reality, Sub-Basin 4-1 should be further divided into small sub-basins. No culverts across Okanagan Centre Road were noted during field reconnaissance and therefore it is assumed that all of the effective rainfall eventually infiltrates into the ground, even if it does reach the ditch on the east side of Okanagan Centre Road.

Analysis Results

This basin was modelled to provide a design flow estimate for at least one culvert across OK Centre Road. The peak flow was estimated to be 0.034 cms.

Deficiencies and Improvements

More fieldwork must be done to establish the outlets and boundaries of the individual sub-basins within Basin 4. When development is proposed within this sub-basin, a Stormwater Management Plan must also be prepared as outlined in Section 7.2. For now, the following general improvements are recommended.

No. 1 Install a culvert across OK Centre Road. A more detailed site survey will be required to determine the best location for this culvert.

No. 2 Improve the ditch section on the east side of OK Centre Road. If a site survey indicates some low-spots, it may be feasible to re-grade the ditch to drain to the single culvert recommended in Improvement No. 1 above.

5.5 Basin 5

Existing Land Use

This basin contains a variety of land uses. Most of the residential development is located along Okanagan Centre Road on a fairly steep slope. A few farm yards are scattered throughout the sub-basins, but most of the area is developed as orchards or vineyards. The remaining areas are either naturally treed or open meadow.

Future Land Use

Most of Sub-Basins 5-3 and 5-4, and a significant portion of Sub-Basin 5-2, are within the Agricultural Land Reserve. The Tyndall Road Pre-Plan indicates that no further development is anticipated within Sub-Basin 5-1. Approximately 50% of Sub-Basin 5-5 has a slope greater than 30%, and therefore only a portion of it may be developable. The MoEP soil capability map for on-site sewage disposal does not extend far enough north to determine the minimum lot size allowable within Sub-Basin 5-5. Based on the Terratech geotechnical report, however, it is assumed that the minimum lot size will be 2.5 ha. This must be confirmed prior to development.

Existing Drainage

Starting upstream with Sub-Basin 5-3, Camp and Davidson Roads not only form the sub-basin boundary, but also the major drainage route to Sub-Basin 5-2. A natural gulley forms the rest of the downstream route through Sub-Basin 5-2 to Sub-Basin 5-1. This route eventually discharges onto Camp Road near Okanagan Centre Road.

Sub-Basin 5-5 drains into the west ditch along Camp Road. Currently, excess runoff flows across Camp Road at its most northern hair-pin turn, and is directed along a virtually non-existent ditch to Okanagan Centre Road.

The south-west part of Sub-Basin 5-1 actually consists of several small drainage basins fronting Okanagan Centre Road. Further field reconnaissance will be required, however, to accurately delineate each drainage route and sub-basin boundary.

Analysis Results

The basin was modelled under both existing and developed conditions. Since the projected amount of development within the basin is relatively small, the analysis indicated that peak flows are unlikely to increase significantly once the projected residential growth has occurred. This will change if the minimum lot size is decreased. The modelled peak flows increased from 0.013 to 0.021 cms.

Deficiencies and Improvements

Under existing conditions, several deficiencies must be addressed. These are detailed below.

No. 1 Install a culvert across Okanagan Centre Road in an appropriate location to direct flows from Camp Road to the lake. A drainage channel on the downstream side of the culvert, protected from encroachment, will also be required.

No. 2 Improve the ditch section along Camp Road from point 20 to OK Centre Road. This is necessary to keep flows off private property as well as off the road surface.

No. 3 Protect the natural gulley from Hare Road to Camp Road from future encroachment.

No. 4 Install a culvert across Hare Road where the road crosses the natural gulley.

No. 5 Protect the natural drainage course from Camp Road to Hare Road from future encroachment.

No. 6 Install a culvert across a private driveway off Camp Road (see Photograph 5-40).

No. 7 Install a culvert across a second private driveway off Camp Road (see Photograph 5-40).

No. 8 Construct a well-defined ditch on the south side of Camp Road to ensure runoff enters the major drainage course and stays off the road surface.

No. 9 Install a culvert across Camp Road to convey flow from the east ditch to the south ditch where the road turns west. This is to prevent runoff from crossing the road on the surface as well as from depositing materials on the road.

No.10 Improve the ditch section along Camp Road from Hare Road to point 20.

No.11 Install a culvert across Hare Road at Camp Road.

No.12 Improve the ditch section along Camp Road from the north hair-pin to Hare Road.

No.13 Install a culvert across Camp Road to facilitate flows that must cross the road at this point because of the curve. The other option is to construct a ditch to direct the flow north onto private property. This must be investigated further.

5.6 Basin 6

Existing Land Use

The lower, or western part of this sub-basin has been developed to a Medium-Density Single Family level. This area also contains a packing-house complex. The remainder of the sub-basin is primarily rural residences with grassed meadows. A small amount of orchard is located within the eastern, or upper part of sub-basin.

Future Land Use

Sub-Basin 6-1 is within the Tyndall Road Pre-Plan Area 8. Based on the Pre-Plan, the minimum lot size for this area would be 0.25 ha. This is supported by the MoEP soil capability map. All of the potential development will likely occur off Hare Road.

Existing Drainage

This sub-basin is riddled with natural gullies along its western boundary. The gullies, however, are intercepted by Maddock Road and directed to the lake via Fourth Street. Ditches are either non-existent, or very poorly defined. There is a catch basin at the corner of Fourth and Okanagan Centre Road which directs flow into a 300 mm dia. culvert across Okanagan Centre Road.

Analysis Results

The analyses indicated that peak runoff from this basin is minimal. The small amount of development expected is anticipated to increase peak flows from 0.024 to 0.029 cms.

Deficiencies and Improvements

No. 1 Improve ditching along the east side of Maddock Road and along Fourth Street.

When development does occur, it will be necessary for the applicant to ensure that runoff from the proposed development does not impact downstream properties. This includes:

- ensuring that buildings, especially homes, do not exist in the selected drainage route;
- that measures are implemented to prevent channel erosion under flow conditions.

5.7 Basin 7

Existing Land Use

Almost all of the existing residential development within this basin is located in the lower, or western portion. The upper, or eastern part of the basin is primarily naturally treed or cultivated land.

Future Land Use

Sub-Basin 7-1 is located within Planning Unit 8 as outlined in the Tyndall Road Pre-Plan. Development of 0.25 ha lots may occur off Hare Road. The lower, or western part of Sub-Basin 7-2 is within Planning Unit 6, while the remainder of the sub-basin is within the Agricultural Land Reserve. For the area within Planning Unit 6, the minimum lot size recommended by the Pre-Plan is 0.5 ha. The MoEP soil capability map indicates that part of the area can support minimum lot sizes of 0.2 ha, while the other part can only support lots no smaller than 0.8 ha.

For purposes of this study, the 0.5 ha minimum lot size is assumed where the slope is less than 30%.

Existing Drainage

Drainage within Sub-Basin 7-1 occurs along several natural gullies and constructed driveways. The primary route is along the Sixth Street corridor between Hare and Maddock Roads. A small ditch along the south side of south side of Sixth Street directs flows to a 400 mm culvert across Okanagan Centre Road.

Currently, flow intercepted by Maddock Road *may* or *may not* enter the ditch along Sixth Street. Much depends upon the actual slopes of the road surface since flows would have to cross Maddock Road south of the Sixth Street intersection. This should be verified with a detailed topographic survey.

Photograph 7-12 also shows a house and garage that is constructed within the base of a natural gulley. More field reconnaissance is required to determine if, under existing conditions, significant surface runoff would flow down the gulley and through the yard or if it would stay on the trail on the Sixth Street R.O.W. The varying height of the cedar trees indicates that more moisture is available at the centre of the gulley than on its flanks.

Analysis Results

The MIDUSS analyses indicate that the existing peak flows are relatively small and can easily be accommodated by the existing structures. Since future development will be low-density residential, and rural road sections will be used, the potential future peak flows are anticipated to be 0.022 cms.

Deficiencies and Improvements

Although the existing culvert across OK Centre Road has adequate capacity to accommodate the design peak flows, there is great potential for runoff to erode the hill side as well as to damage existing homes because of inadequate drainage courses. The following improvements are recommended to address this issue.

No. 1 Install a culvert across Maddock Avenue on the south side of 6th Street.

No. 2 Construct a well-defined channel along the 6th Street R.O.W. and armour it to prevent erosion.

No. 3 Install a culvert to divert flow from the north side of the 6th Street R.O.W. to the south side.

No. 4 Improve ditch along upper portion 6th Street. This basically requires excavation to better define a channel. It should be seeded with grass to prevent erosion.

5.8 Basin 8

Existing Land Use

Most of Basin 8 is naturally treed. There is, however, some rural residential development along Tyndall Road and some medium-density single family development within Sub-Basins 8-3 and 8-4.

Future Land Use

The drainage basin spans several Planning Units as defined in the Tyndall Road Pre-Plan, with different levels of development potential. Sub-Basin 8-1 is within Planning Unit 8, which allows a minimum lot size of 0.25 ha. This is slightly larger than what is allowed by the MoEP soil capability map, so for this study, the 0.25 ha lot size will be assumed.

On the east side of Hare Road, Sub-Basin 8-2 spans Planning Unit 6, while west of Tyndall Road, the sub-basin is within Planning Unit 10. A significant portion of this sub-basin also has slopes greater than 30%. Within the Planning Unit 6 portion of the sub-basin, the Pre-Plan recommends a minimum lot size of 0.5 ha. The MoEP soil capability map, however, a minimum lot size of 0.8 ha. This 0.8 ha minimum lot size restriction extends throughout most of Sub-Basin 8-2, except for a strip along the west side of Tyndall Road. This area may have a minimum lot size of 0.13 ha as outlined in the Pre-Plan and as supported by the MoEP soil capability map.

Therefore, where the slope is less than 30%, minimum lots sizes of 0.8 ha and 0.13 ha have been assumed as per the MoEP soil capability map. Little land is left within Sub-Basins 8-3 and 8-4 for further development, therefore, only a few units have been assumed in these areas.

Existing Drainage

Runoff from Sub-Basin 8-3 flows along the various roads to a 500 mm dia. culvert across Camp Road. The flow follows a natural gulley to a 300 mm dia. culvert across Hare Road. Photograph 8-24 illustrates how another 300 mm dia. culvert was installed on private property so that the gulley could be filled by the owner of Lot A. The gulley continues until it discharges into the parking lot of the Okanagan Centre community hall on 7th Street. A well-defined drainage course does not exist from the parking lot to the lake.

Analysis Results

There is no evidence that significant flows have occurred within the natural gulley. The gulley, as shown in Photograph 8-12 is filled to prevent flow into the community hall parking lot. It is likely that most of the rainfall within Basin 8 infiltrates into the ground prior to reaching the end of the natural gulley. The computer analysis indicated that under the 100 year design conditions, peak flows are anticipated to increase from 0.049 to 0.079 cms.

Deficiencies and Improvements

No. 1 Install a culvert across Okanagan Centre Road and ensure there is an adequate drainage course to the lake.

No. 2 Construct an adequate drainage channel around the community hall parking lot and along the 7th Street R.O.W. to Okanagan Centre Road. The section between Maddock Avenue and OK Centre road should be seeded with grass for erosion control.

No. 3 Install a culvert across Maddock Avenue.

No. 4 Part of the channel from Camp Road to Hare Road (30 -20) is fairly well defined as a natural channel. The upper portion, however, is less well defined. It must be better identified and protected from encroachment when and if the properties it passes through are developed.

5.9 Basin 9

Existing Land Use

Most of this basin has been left naturally treed. There is, however, some low-density single family development near its western boundary along Okanagan Centre Road. There is also some rural residential development along Hare and Tyndall Roads.

Future Land Use

The southern basin boundary encompasses part of one property which is within the Agricultural Land Reserve. The Tyndall Road Pre-Plan indicates that lots with a minimum area of 0.25 ha may be developed along Hare Road. Some of the remaining part of the basin is within Area 6 of the Pre-Plan, and the rest is in Area 10. Within Area 6, lots may be no smaller than 0.5 ha. The MoEP soil capability map, however, recommends a minimum lot size of 0.8 ha for most of this area, except along Hare Road. Much of this area, within Sub-Basin 9-2, has slopes greater than 30%. Therefore, only a few units have been assumed. For the part of the basin which is along Tyndall Road, lots as small as 0.13 ha have been assumed.

Existing Drainage

Drainage within this basin is mostly through natural gullies. Field reconnaissance suggests that surface runoff seldom, if ever, occurs within these gullies. It is assumed that most of the rainfall infiltrates to ground.

There is a 600 mm dia. culvert across Hare Road which directs flow intercepted by the road into a natural gulley. This drainage route eventually discharges onto Maddock(?) road. Throughout Sub-Basin 9-1, numerous natural gullies exist which could potentially direct runoff from the rural residential sites along Hare Road toward the lake.

A 600 mm dia. culvert (No. 30) was installed across Camp Road on the north side of an access lane. This culvert directs the runoff from sub-basin 9-3 onto Lot A, Plan 42884. The owner has complained that the runoff flows across his septic field and impacts its functionality. Culvert 9-30 is not located at the low-point, which is approximately 80 m to the south. This is further discussed in the section on Basin 10.

Analysis Results

A computer analysis was completed for both existing and future development conditions primarily to evaluate the effectiveness of the existing culvert on Hare Road. Peak flows are anticipated to increase from 0.042 to 0.052 cms.

Deficiencies and Improvements

At the lower end of almost every gulley within Sub-Basin 9-1, a residence or some other building has been constructed. Since most of the rainfall infiltrates into the ground under existing conditions, these homes seem to be in little danger of damage from high flows. Any development upstream of these gullies, however, may concentrate surface runoff and discharge it into a gulley. *Extreme care must be taken to ensure that this does not occur unless sufficient steps are implemented to maintain the safety of the existing downstream homes.* (See photographs 9-15 and 9-17 for examples.)

Specific improvements have been identified for the main route which services the upper sub-basins. These are outlined as follows:

No. 1 Install a culvert across OK Centre Road. Ensure an adequate drainage channel is maintained to the lake.

No. 2 Install a culvert across Maddock(?) on the south side of 8th Street.

No. 3 Improve the ditch section along Maddock(?) and 8th Street from the natural gulley to OK Centre Road (17 - 10).

No. 4 The channel from Hare Road to Maddock(?) is a natural gulley. The soil is sandy silts which can not support high velocities. Since a culvert across Hare Road discharges into this gulley, it is imperative that an armoured channel be constructed.
As shown in photograph 9-17, a garage is also located within the gulley. There are several options for addressing this particular deficiency, however, an inlet/drop structure and culvert to Maddock(?) Road has been assumed for cost estimate purposes. A preliminary design should be conducted during which the Regional District, in consultation with the property owner, may elect to implement one of the following actions:

- proceed with detailed design of the proposed system;

- re-locate the garage, armour the cut slope, and construct a ditch to Maddock(?);

- maintain the status-quo and address damages as and when they occur.

Although the gulley is well-defined, it should be protected from future encroachment.

No. 5 The existing culvert across Camp Road must be removed and re-installed *along* Camp Road across an east-side access lane. This will ensure flows are not discharged onto the Lot A septic field, but instead are directed to the low-spot on Camp Road.

5.10 Basin 10

Existing Land Use

Except for one property off Tyndall Road, several low-density residential properties along Okanagan Centre Road, and one small med-density residential subdivision near Tyndall and Camp Roads, this basin has been left naturally treed.

Future Land Use

Most of the property just south of Tyndall Road, within Sub-Basin 10-2, is within the Agricultural Land Reserve. All of Sub-Basin 10-1 and the lower part of Sub-Basin 10-2 have slopes over 30%. The remaining undeveloped portion of Sub-Basin 10-3 is not only within Jack Seaton Park, but also has slopes which are mostly over 30%. No development has been assumed in these areas.

Existing Drainage

Basin 10 is characterized by a well-defined gulley extending through the lower portion of Sub-Basin 10-2 and all of Sub-Basin 10-1. Sub-Basin 10-3 drains to a low point on Tyndall Road. There is, however, no culvert at this location to transport flows across the road. The low point is directly above an existing rural residential property through which potential runoff would flow.

Analysis Results

A computer model of the entire basin was developed for both existing and future conditions to size required culverts. Peak flows at culvert 10-10 are anticipated to increase from 0.006 to 0.038 cms.

Deficiencies and Improvements

No. 1 Install a culvert across OK Centre Road. Ensure an adequate channel exists from the road to the lake.

No. 2 Photograph 10-12 shows a garage at the bottom of the natural gulley through sub-basin 10-1. A ditch must be constructed to direct potential flows away from the house and into the ditch along OK Centre Road. The ditch should be re-seeded to protect against potential erosion.

No. 3 Install a culvert across Hare Road. Ensure outlet has adequate splash-pad protection.

No. 4 A ditch will be required to route potential runoff around the developed part of Lot B, Plan 42884 when the culvert across Tyndall Road is installed. A route will need to be established with the property owner for the ditch. In order to protect the proposed channel from future encroachment, an easement should also be obtained. Grass should be sown in the ditch to prevent erosion.

No. 5 A culvert is required across Tyndall Road to drain the low point in the east ditch. Runoff currently ponds, then flows across the road onto Lot B.

5.11 Basins 11 to 22

Existing Land Use

This group of drainage basins span an area which is primarily undeveloped. There are few low-density residential properties along Okanagan Centre Road within the lower portions of Sub-Basins 11-1, 12-1, 16-1, 17-1, 18-1, 19-1, 20-1, and 21-1. There are also a few individual rural residential properties spread through out the area, mainly off Tyndall Road.

Two new residential areas have recently been developed through the construction of access roads. The first road accesses the lower portion of lots B through H via the 14th Street R.O.W. The second road accesses the upper portion of lots 225 to 228 and 1-16 via lot 64 off Tyndall Road.

Future Land Use

The Tyndall Road Pre-Plan has divided this area into several Planning Units. These are detailed as follows (refer to map in Appendix A):

Planning Unit 10

Most of the development with the basins under consideration in this section will occur within this area. The Pre-Plan recommends a minimum lot size of 0.13 ha on slopes less than 30%. The MoEP soil capacity map, however, shows that not all of the developable land can support this density. A significant portion of the area can only support minimum lot sizes of 0.4 to 0.8 ha.

Planning Unit 16

Only a small portion of this area, located through the central part of Sub-Basin 16-2, has development potential. The Pre-Plan suggests minimum lot sizes of 0.13 ha, but the MoEP soil capability map limits the lot sizes to 0.4 ha.

Planning Unit 17

This area covers the extremely steep slope and waterfront along Okanagan Centre Road. Most of this area has slopes over 30%. The Pre-Plan indicates that little development potential exists in this area, however, individual homes may still be constructed on the existing lots.

Planning Unit 18

This area consists of a small delta. It has not been included in a specific drainage basin because any drainage concerns must be addressed on a site-specific basis. The Pre-Plan recommends that this area be purchased for a regional park. If this is not done, then lots no smaller than 0.25 ha could be developed.

Planning Unit 19

For the areas with slopes less than 30%, the Pre-Plan recommends a minimum lot size is 0.13 ha. The MoEP soil capability map, however, suggests minimum lot sizes of 0.4 has west of Okanagan Centre Road, and 0.8 ha west just off Tyndall Road. These latter densities have been applied in this study.

Existing Drainage

Both Tyndall Road and Okanagan Centre Road form the major drainage routes along the lower portions of each sub-basin. The sub-basins directly east of Okanagan Centre Road are scored with numerous natural gullies. The Terratech geotechnical report indicates that the soils within this area have high erosion and instability potential, yet field reconnaissance indicates little or no historical surface flows through the gullies. This suggests that most, if not all of the rainfall in this area is infiltrated to ground.

Several culverts are located across Tyndall Road. In most cases, there is no well defined drainage route from these culverts to the natural gullies. This is actually beneficial since it allows greater opportunity for flows to spread over a larger surface and infiltrate into the ground.

No culverts were observed across Okanagan Centre Road within the subject area. The ditching along the east side of Okanagan Centre Road is virtually non-existent once the road levels-out along the lake shore. A reasonable ditch exists from the Tyndall Road intersection to the northern boundary of Sub-Basin 21-1.

Analysis Results

A computer analysis for Basin 21 was prepared to size the culvert required across Okanagan Centre Road. No computer analyses were conducted for the other basins within the subject area. Selection of preferred drainage routes and stormwater management methods require more site-specific information than is available within the scope of this study. It is therefore recommended that when development applications are received, individual Stormwater Management Plans be prepared as outlined in Section 7.2.

Deficiencies and Improvements

Although the recommended Stormwater Management Plans will address required site-specific improvements to manage stormwater runoff, there are some general deficiencies that should be addressed. These are discussed below.

Basin 21

No. 1 Install a culvert across OK Centre Road.

No. 2 Improve east ditch along OK Centre Road. The primary objective is to define an adequate channel section.

No. 3 Improve and armour east ditch to provide adequate section and erosion protection.

No. 4 Improve and armour east ditch to provide adequate section and erosion protection.

No. 5 Improve east ditch section.

No. 6 Clear entrance to culvert across Tyndall Road.

5.12 Basin 23

Existing Land Use

Most of this basin has been left undeveloped and naturally treed. Almost all of the narrow, lake front lots have had homes constructed on them. A few rural residential properties have also been constructed along Finch, Stubbs, and Ottley Roads.

Future Land Use

The Tyndall Road Pre-Plan indicates no further development within most of Sub-Basin 23-0. Areas with slopes less than 30% within the three larger lots in the northern part of the sub-basin may, however, be developed into 0.4 ha lots.

A pre-plan for the rest of the subject area, called Southwest Winfield, was prepared for the Regional District of Central Okanagan by Reid Crowther & Partners Ltd. Within Sub-Basins 23-1, 23-2, and part of 23-5 it recommends a minimum lot size of 0.5 ha. The MoEP soil capability map supports this by indicating that lots could be as small as 0.2 ha. (The 0.5 ha limit was assumed for this study.)

Part of Sub-Basins 23-3 and 23-4 have slopes over 30%. The area immediately east of Ottley Road may be developed into 0.2 ha lots, however, further east, the lot areas must be increased to 0.8 ha. Immediately west of McCoubrey Road, the lots could be as small as 0.13 ha.

Existing Drainage

The basin drainage is characterized by a wide, gentle swale upstream of Finch Road. A 300 mm dia culvert on Ottley Road, and a low-point on Stubbs road define the drainage route within this subtle, indistinct channel. A low point on Finch road defines the beginning of the drainage channel down the slope to the lake. No culvert exists across Finch Road at this location, nor does a well-defined downstream channel.

There is no evidence of historical surface flows within the drainage route. This suggests that most of the rainfall infiltrates into the ground.

Analysis Results

Computer models were prepared for both existing and future development conditions. The analyses results indicate that the peak flows will increase from 0.216 to 0.336 cms.

Deficiencies and Improvements

No. 1 As development occurs within the basin, a well-defined drainage channel will be required from Finch Road to the lake. The Regional District should purchase Lot 6 and construct the required channel. The channel will need to be armoured for erosion control.

Lot 6 could be used as a Regional District waterfront park. The channel could be designed architecturally to blend-in with the natural features of the surrounding area. The estimated capital costs do not, however, reflect the proposed park and amenities.

No. 2 Install a culvert across Finch Road.

No. 3 Construct a swale from Stubbs Road to Finch Road. The swale should be grassed for erosion protection. It must also be protected from future encroachment.

No. 4 Install a culvert across Stubbs Road.

No. 5 Install a culvert across Ottley Road in the east Stubbs Road ditch.

No. 6 Improve the east Stubbs Road ditch from Ottley Road to proposed culvert 30.

No. 7 Construct a swale from Ottley Road to Stubbs Road. The swale should be grassed for erosion protection. It must also be protected from future encroachment.

No. 8 Improve ditch section on east side of Stubbs Road.

No. 9 Potential flows from Ottley Road to Stubbs Road must cross private property at culvert 50. During field reconnaissance, the outlet of culvert 50 was not located. It is possible that the culvert extends completely across Lot 1 and has a buried outlet in the Stubbs Road ditch. It is also possible that the culvert outlet is buried in the west Ottley Road ditch. Regardless, an overland channel across Lot 1 is the preferred option. This channel may be grassed and must be protected from future encroachment.

No.10 The existing 300 mm dia. culvert must eventually be replaced by two 450 mm dia. culverts. Two culverts are required since there is insufficient depth available to install a single, larger diameter culvert which has adequate inlet capacity to accommodate the design flow.

No.11 A portion of the channel from culvert 60 on McCoubrey Road to culvert 50 on Ottley Road (the ditch portion along Ottley Road) must be improved. It only requires better section definition.

No.12 The rest of the channel from culvert 60 on McCoubrey Road to culvert 50 on Ottley Road requires protection from future encroachment.

5.13 Basin 24

Existing Land Use

Except for a few homes on the waterfront lots, most of this basin is naturally treed.

Future Land Use

No further development is anticipated within Sub-Basin 24-0. Lots with a minimum area of 0.5 ha, however, may be developed within Sub-Basin 24-1 where the slope is less than 30%.

Existing Drainage

Finch Road intercepts and concentrates surface runoff from Sub-Basin 24-1 into a low point not serviced by a culvert. A natural gulley through Sub-Basin 24-0 directs flows to the lake. An access road forms most of the northern boundary of Sub-Basin 24-0 as well as a secondary drainage route.

Analysis Results

Computer models, for both existing and future land use conditions, were prepared for the entire basin. The analyses indicate that peak flows are anticipated to increase from 0.000 to 0.015 cms.

Deficiencies and Improvements

No. 1 Obtain a 10 m wide easement along the natural gulley from Finch Road to the lake to prevent future encroachment.

No. 2 Install a culvert across Finch Road. It will also require a splash-pad on the outlet to prevent gulley-bottom erosion.

5.14 Basin 25

Existing Land Use

This small drainage basin really consists of several small, independent basins which drain directly to Okanagan Lake. Development consists of single family homes on larger (0.5 ha) lots.

Future Land Use

No further development is anticipated within this basin.

Existing Drainage

The only formal drainage system currently used is the eastern ditch of the access road from Finch Road. This ditch, however, drains into sub-basin 24-0. It is assumed runoff from the individual lots is managed (or un-managed) privately.

Analysis Results

No analyses were completed for this basin because of the individual, private lots extending to the lake.

Deficiencies and Improvements

None were identified.

5.15 Sink S-1

Existing Land Use

Except for a few medium-density residential properties on Hallam Court, this area is basically undeveloped. It is mostly treed, but does contain a large, wet-lands type area and two cleared areas. One of these areas is used for two baseball diamonds, and the other is a set of tennis courts.

Future Land Use

Much of the Sink S-1 is within the boundaries of Jack Seaton Park. No development, therefore, is anticipated within this area. The Tyndall Road Pre-Plan recommends minimum lots areas of 0.13 ha within the portion of the sink which is south of the park boundary, but the MoEP soil capability map identifies limited areas where only 0.4 ha or larger lots may be developed.

The only other area which may have development potential, is Planning Unit 11. The Pre-Plan suggests minimum lot areas of 0.25 ha, however, the MoEP soil capability map indicates a minimum lot area of only 0.8 ha. The 0.8 ha lot area has been assumed.

Existing Drainage

Since the subject area is a sink, there is no positive outlet for surface runoff. A 500 mm dia. culvert exists across Camp Road, but is used more for pond level equalization than for drainage control. Standing water was noted in the culvert and in several locations within the sink during field reconnaissance.

Analysis Results

No analyses were completed for this sink.

Deficiencies and Improvements

Drainage issues within Sink S-1 should be addressed during the development application process for the two areas with development potential. This will need to be completed in consultation with the Regional District of Central Okanagan Parks Department to ensure drainage works do not conflict with existing or proposed recreational facilities.

5.16 Sinks S-2 and S-3

Existing Land Use

The subject areas are primarily undeveloped and naturally treed. There are only three rural residences located off Okanagan Centre Road.

Future Land Use

The Tyndall Road Pre-Plan recommends a minimum lot size for the Sink S-2 area of 0.13 ha. The MoEP soil capability map indicates, however, that the minimum lot area should be 0.4 ha. The latter has been assumed for this study.

McCoubrey Road is currently being upgraded as part of a new subdivision. For Sink S-3, the Southwest Winfield Pre-Plan indicates potential for R1 (835 m^2) lots and RU-5 (0.25 ha) lots within areas that have slopes less than 30%. The MoEP soil capability map indicates that lots with a minimum area of 0.13 ha could be developed within the northern part of the sink area. Within the southern part of Sink S-3, the minimum lot size would be only 0.2 ha.

Existing Drainage

Within Sink S-2, runoff flows into the ditch on the northern side of Okanagan Centre Road, and ponds at a low spot approximately 50 m east of the McCoubrey Road intersection. There is no positive outlet for this low spot.

Sink S-3 drains into the low area immediately southwest of the McCoubrey and Okanagan Centre Roads intersection. This particular low area is now owned by the Winfield and Okanagan Centre Irrigation District. It functions as a waste site for overflow from the former Hiram Walker water reservoir. It would make an ideal retention pond for both Sink S-1 and S-2, especially since a 600 mm dia. culvert across McCoubrey Road was recently installed.

Analysis Results

A computer analysis was conducted to determine if the existing retention pond site has adequate volume to store potential runoff until it disposed of through evaporation and infiltration. The analyses indicated that the runoff volume of approximately 115 cu.m. is much less than the estimated storage volume of 1,500 cu.m.

Deficiencies and Improvements

No. 1 Part of the ditch along the west side of McCoubrey Road must be better defined to ensure potential runoff flows into the sink area.

No. 2 A culvert should be installed across OK Centre Road to drain Sink S-2 into Sink S-3. Alternatively, the north ditch along OK Centre Road might be able to be re-defined to drain toward culvert 50 on Tyndall Road.

No. 3 A ditch along the south side of Okanagan Centre Road will also be required to direct potential flows into the culvert crossing McCoubrey Road.

Table 5.1

Existing Culvert Data

ID No.	Size [mm]	Lnth [m]	Location	Inlet Capcty [cms]	Design Flow Exstng [cms]	Design Flow Dvlpd [cms]	Req'd Headwtr Exstng [m]	Req'd Headwtr Dvlpd [m]	Avlble Head* [m]	Req'd Dia. [mm]	Comments
BASIN 1											
10	600	*14*	OK Centre Rd E	0.320	0.512	0.518	0.36	0.39	0.50		2x200mm outlets; 90 deg bend **> Improve Inlet**
22	450	*14*	OK Centre Rd E	0.160	N/A	N/A					
23	400	*14*	OK Centre Rd E	0.125	N/A	N/A					90 deg bend; C.B.
70	300	*12*	La Cresta Rd	0.057	0.021	0.016					
BASIN 2											
10	N/A	14	OK Centre Rd W	N/A	0.050	0.050					dense vegetation **> Clear Inlet**
BASIN 5											
70	300	12	Camp Rd	0.057	0.006	0.006					
BASIN 6											
10	300	31	OK Centre Rd W	0.057	0.024	0.029					has CB; local minor drainage
BASIN 7											
10	400	11	OK Centre Rd W	0.125	0.010	0.022					
BASIN 8											
20	300	*12*	Hare Rd	0.057	0.046	0.071		0.06	0.30		
22	400	18	Hare Rd	0.125	0.016	0.062					
24	300	*12*	east of Hare Rd	0.057	0.046	0.071		0.06	0.20		under fill on private property
30	500	15	Camp Rd	0.200	0.041	0.038					
BASIN 9											
20	600	22	Hare Rd	0.320	0.010	0.026					
30	600	8	Tyndall; Near Camp	0.320	0.010	N/A					
BASIN 12											
10	600	12	OK Centre Rd W	0.320	N/A	N/A					
12	450	*14*	access road	0.160	N/A	N/A					
20	500	*14*	Tyndall Rd	0.200	N/A	N/A					
30	500	15	Tyndall Rd	0.200	N/A	N/A					
BASIN 14											
20	500	12	Tyndall Rd	0.200	N/A	N/A					
BASIN 21											
70	500	*14*	Tyndall Rd	0.200	0.004	0.045					
50	600	17	Tyndall Rd	0.320	0.000	0.008					75% buried **> Clear Inlet**
60	450	*14*	Tyndall Rd	0.160	0.050	0.052					
74	500	*14*	Tyndall Rd	0.200	0.091	0.095					
80	500	*14*	Tyndall Rd	0.200	0.091	0.095					
BASIN 23											
40	300	*12*	Ottley Rd	0.057	0.000	0.054					inlet 75% buried **> Clear Inlet**
50	300	*12*	Ottley Rd	0.057	0.218	0.311	Off Chrt	Off Chrt		2x450	outlet not found **> Replace**
60	500	*14*	McCoubrey Rd	0.200	0.217	0.296	0.07	0.21	0.50		new in '94
62	500	*14*	McCoubrey Rd	0.200	0.072	0.098					new in '94
SINK 1											
10	500	*14*	Hallam Crt	0.200	N/A	N/A					no capacity deficiency anticipated
20	500	15	Camp Rd	0.200	N/A	N/A					mainly for water level equaliztion
SINK 3											
10	600	*14*	McCoubrey Rd	0.320	0.002	0.069					new in '94
20	500	*14*	McCoubrey Rd	0.200	0.002	0.069					

NOTES: *Existing capacity is calculated on the assumption that damaged, partially buried entrances have been fully restored.*

** Available head is the height above the crown of the culvert inlet as measured in the field.*

Table 5.2

Basin Modelling Parameters – Existing Conditions

Basin	Area (ha)	Pervious Lngth (m)	Pervious Avg Slope	Impervious Directly Cnctd	Impervious Lngth (m)	Runoff Parameters Manning "n"	fo (mm/hr)	fc (mm/hr)	k (hrs)	Ia (mm)
1-1	22.8	520	15%	0.2%	799	0.180	3	1	0.3	6.9
1-2	34.2	630	12%	0.1%	707	0.260	717	88	1.0	7.0
1-3	2.6	150	7%	6.4%	539	0.300	2,500	200	2.5	5.4
1-4	18.9	400	15%	0.1%	791	0.170	175	78	0.6	7.5
1-5	11.6	300	11%	0.2%	672	0.320	1,447	155	1.7	6.6
2-0	6.8		22%	0.0%	974	0.290	69	6	0.4	8.3
2-1	41.1	730	19%	0.0%	892	0.240	462	54	0.8	8.5
3-1	7.3	420	15%	0.5%	809	0.190	4	1	0.3	7.3
4-1	15.6	400	21%	0.8%	945	0.230	20	12	0.3	7.6
5-1	8.5	320	29%	1.2%	1,111	0.330	31	20	0.4	6.8
5-2	11.4	300	25%	0.0%	1,028	0.220	2,025	166	2.1	9.8
5-3	33.4	400	11%	0.3%	691	0.330	472	104	0.9	7.3
5-4	15.4	400	23%	0.0%	979	0.150	1,132	97	1.3	10.0
5-5	14.6	320	21%	0.4%	952	0.490	2,307	192	2.4	7.3
6-1	6.7	330	25%	3.6%	1,033	0.300	525	43	0.8	5.7
7-1	6.7	290	19%	1.5%	906	0.370	1,535	123	1.6	6.5
8-1	5.2	220	21%	1.5%	954	0.480	2,330	186	2.4	6.8
8-2	23.4	455	27%	0.7%	1,081	0.420	2,376	194	2.4	7.7
8-3	4.7	190	16%	2.5%	830	0.440	941	128	1.3	5.8
8-4	10.7	250	16%	3.0%	819	0.430	157	63	0.6	5.6
9-1	16.9	330	23%	2.4%	985	0.460	2,278	182	2.3	6.7
9-2	16.4	480	19%	0.0%	893	0.460	2,500	200	2.5	7.3
9-3	2.7	125	19%	3.9%	891	0.410	1,085	126	1.3	5.0
10-1	3.5	170	42%	1.7%	1,336	0.470	2,500	200	2.5	7.0
10-2	7.4	300	25%	0.0%	1,039	0.470	2,500	200	2.5	7.4
10-3	2.4	130	19%	0.0%	891	0.500	1,110	129	1.4	7.5
11-1	5.9			2.4%		0.410	2,500	200	2.5	6.5
12-1	18.6			0.2%		0.440	2,275	190	2.3	7.2
12-2	1.9			0.0%		0.500	71	47	0.4	7.5
12-3	3.6			0.0%		0.500	8	5	0.1	7.5
S-1	27.4	350	15%	0.5%	810	0.420	183	20	0.4	7.0
13-1	12.9			0.0%		0.420	2,427	197	2.4	7.2
14-1	6.2			0.0%		0.470	2,368	195	2.4	7.4
14-2	2.9			0.0%		0.370	31	21	0.2	6.9
15-1	9.3			0.0%		0.440	2,070	182	2.2	7.2
16-1	12.0			0.0%		0.410	2,050	181	2.2	7.1
16-2	37.6			0.0%		0.460	4	2	0.1	7.4
17-1	4.4			0.0%		0.290	2,500	200	2.5	6.7
18-1	6.1			0.0%		0.330	2,230	189	2.3	6.9
19-1	2.0			0.0%		0.450	2,500	200	2.5	7.3
20-1	8.3			0.0%		0.330	2,273	190	2.3	6.8
21-1	19.7	510	33%	0.0%	1,183	0.400	2,214	188	2.3	7.1
21-2	2.9	320	24%	0.0%	1,017	0.500	2	1	0.2	7.5
21-3	29.4	320	33%	0.0%	1,190	0.380	2,139	184	2.2	7.0
21-4	34.2	720	30%	0.0%	1,132	0.500	20	13	0.2	7.5
21-5	13.5	400	36%	0.0%	1,232	0.500	10	6	0.2	7.5
21-6	14.2	550	30%	0.0%	1,122	0.500	797	66	0.9	7.5
S-2	3.2	130	15%	0.0%	799	0.500	2,422	194	2.4	7.5
22-0	24.0			0.0%		0.370	1,069	115	1.3	7.0
23-0	11.3	180	28%	0.0%	1,093	0.460	365	34	0.6	7.3
23-1	7.3	90	20%	0.0%	931	0.480	913	85	1.1	7.4
23-2	5.2	400	16%	0.7%	816	0.390	610	96	1.0	6.6
23-3	14.8	450	22%	0.0%	975	0.480	655	69	0.9	7.4
23-4	11.9	340	24%	0.0%	1,009	0.490	2,119	180	2.2	7.4
23-5	12.0	330	18%	0.0%	863	0.500	2,422	197	2.4	7.5
23-6	12.2	220	20%	0.0%	920	0.500	4	1	0.3	7.5
S-3	12.5	290	20%	0.2%	925	0.500	1,242	100	1.4	7.4
24-0	5.1	110	32%	0.0%	1,163	0.500	306	30	0.6	7.5
24-1	9.7	500	25%	0.0%	1,024	0.470	1,116	139	1.4	7.4
25-0	6.6		34%	1.5%	1,210	0.460	14	8	0.3	6.5

These sub-basins were not modelled. (shaded rows)

Table 5.3

Basin Modelling Parameters – Future Conditions

Basin	Area (ha)	Pervious Lngth (m)	Pervious Avg Slope	Impervious Directly Cnctd	Impervious Lngth (m)	Runoff Parameters Manning "n"	fo (mm/hr)	fc (mm/hr)	k (hrs)	Ia (mm)
1-1	22.8	520	15%	0.2%	799	0.180	3	1	0.3	6.9
1-2	34.2	630	12%	0.8%	707	0.240	717	88	1.0	6.5
1-3	2.6	150	7%	6.4%	539	0.300	2,500	200	2.5	5.4
1-4	18.9	400	15%	0.1%	791	0.170	175	78	0.6	7.5
1-5	11.6	300	11%	0.2%	672	0.320	1,447	155	1.7	6.6
2-0	6.8		22%	0.0%	974	0.230	68	6	0.4	6.3
2-1	41.1	730	19%	0.0%	892	0.240	462	54	0.8	8.5
3-1	7.3	420	15%	0.5%	809	0.190	4	1	0.3	7.3
4-1	15.6	400	21%	2.2%	945	0.360	20	12	0.3	7.2
5-1	8.5	320	29%	1.8%	1,111	0.380	31	20	0.4	6.6
5-2	11.4	300	25%	0.0%	1,028	0.220	2,025	166	2.1	9.8
5-3	33.4	400	11%	0.5%	691	0.330	472	104	0.9	7.2
5-4	15.4	400	23%	0.3%	979	0.180	1,132	97	1.3	9.9
5-5	14.6	320	21%	0.4%	952	0.490	2,307	192	2.4	7.3
6-1	6.7	330	25%	4.4%	1,033	0.350	525	43	0.8	5.4
7-1	6.7	290	19%	3.3%	906	0.420	156	64	0.6	5.4
8-1	5.2	220	21%	1.9%	954	0.460	1,475	150	1.7	6.3
8-2	23.4	455	27%	2.7%	1,081	0.390	1,753	167	1.9	7.2
8-3	4.7	190	16%	2.5%	830	0.450	941	128	1.3	6.1
8-4	10.7	250	16%	2.7%	819	0.460	157	63	0.6	6.2
9-1	16.9	330	23%	2.8%	985	0.450	1,847	164	2.0	6.3
9-2	16.4	480	19%	1.6%	893	0.420	1,787	170	2.0	6.4
9-3	*Data for this sub-basin has been incorporated into sub-basin 10-3.*									
10-1	3.5	170	42%	1.7%	1,336	0.470	2,500	200	2.5	7.0
10-2	7.4	300	25%	4.6%	1,039	0.400	1,357	151	1.6	5.9
10-3	5.1	130	19%	2.0%	891	0.450	1,097	127	1.4	6.2
11-1	5.9			2.9%		0.400	2,500	200	2.5	6.4
12-1	18.8			2.8%		0.400	1,713	168	1.9	6.5
12-2	1.9			0.0%		0.500	71	47	0.4	7.5
12-3	3.8			0.0%		0.500	8	5	0.1	7.5
S-1	27.4	350	15%	1.1%	810	0.440	183	20	0.4	6.8
13-1	12.9			1.3%		0.400	2,117	184	2.2	6.8
14-1	6.2			2.1%		0.430	1,894	174	2.0	6.7
14-2	2.9			0.0%		0.370	91	21	0.2	6.9
15-1	9.3			2.8%		0.430	1,565	160	1.8	6.7
16-1	12.0			4.5%		0.450	992	158	1.3	6.1
16-2	37.6			0.8%		0.470	4	2	0.1	7.1
17-1	4.4			0.0%		0.290	2,500	200	2.5	6.7
18-1	6.1			2.1%		0.340	1,807	170	2.0	6.4
19-1	2.0			0.0%		0.450	2,500	200	2.5	7.3
20-1	8.3			1.6%		0.360	1,962	177	2.1	6.6
21-1	19.7	510	33%	2.3%	1,183	0.380	1,760	169	1.9	6.4
21-2	2.9	320	24%	0.5%	1,017	0.490	2	1	0.2	7.2
21-3	29.4	320	33%	2.9%	1,190	0.350	1,931	175	2.1	6.1
21-4	34.2	720	30%	1.3%	1,132	0.480	20	13	0.2	7.0
21-5	13.5	400	36%	0.2%	1,232	0.490	10	6	0.2	7.4
21-6	14.2	550	30%	0.6%	1,122	0.490	797	66	0.9	7.3
S-2	3.2	130	15%	6.1%	799	0.410	1,394	150	1.6	5.3
22-0	24.0			1.9%		0.440	462	89	0.8	6.3
23-0	11.3	180	28%	0.5%	1,093	0.450	365	34	0.6	7.1
23-1	7.3	90	20%	3.5%	931	0.420	913	85	1.1	5.3
23-2	5.2	400	16%	3.4%	816	0.420	610	96	1.0	5.2
23-3	14.8	450	22%	3.2%	975	0.440	131	47	0.5	6.2
23-4	11.9	340	24%	4.6%	1,009	0.420	1,250	143	1.5	5.8
23-5	12.0	330	18%	4.2%	863	0.430	1,795	170	2.0	5.9
23-6	12.2	220	20%	2.8%	920	0.430	4	1	0.3	5.6
S-3	12.5	290	20%	5.6%	925	0.410	490	68	0.8	5.6
24-0	5.1	110	32%	0.0%	1,163	0.500	306	30	0.6	7.5
24-1	9.7	500	25%	1.6%	1,024	0.460	389	108	0.9	6.5
25-0	6.8		34%	1.5%	1,210	0.460	14	8	0.3	6.5

(shaded) *These sub-basins were not modelled.*

Table 5.4
Improvements Summary

Item No.	Location	Description	Design Flow [cms]	Culvert Design Dia. [mm]	Culvert Design Qty	Structure Req'd Inlet	Structure Req'd Outlet	Channel Design X-Sec Type	Channel Design Depth [m]	Lngth [m]	Prty	Cost
BASIN 1												
1	Culvert 10	Improve Inlet	0.518		1	1					1	$1,700
2	Culvert 30	Install New	0.004	450	1					12	3	$2,700
3	Culvert 50	Install New	0.034	450	1					12	2	$2,700
4	Channel 60–22	Improve Ditch	0.034					I	0.10	290	2	$1,600
5	Channel 60–22	Protect Corridor								100	2	Note 3
BASIN 2												
1	Culvert 10	Clear Inlet									1	$300
BASIN 3												
1	Culvert 10	Install New	0.144	450	1					14	2	$3,200
2	Channel 10–Lake	Cnstrct,Amr/Protect	0.144					II	0.10	70	2	$77,400
BASIN 4												
1	Culvert 10	Install New	0.034	450	1					14	2	$3,200
2	OK Centre Road	Construct/Protect	0.034					II	0.10	250	2	$1,600
BASIN 5												
1	Culvert 10	Install New	0.021	450	1					14	2	$3,200
2	Channel 20–10	Improve Ditch	0.021					I	0.10	180	1	$1,100
3	Channel 30–20	Protect Corridor								180	3	Note 3
4	Culvert 30	Install New	0.017	450	1					14	2	$3,000
5	Channel 40–30	Protect Corridor								570	3	Note 3
6	Camp Road	Install New Culvert	0.016	450	1					12	2	$2,500
7	Camp Road	Install New Culvert	0.016	450	1					14	2	$3,000
8	Part Chnl 40–30	Construct Ditch	0.016					I	0.10	120	2	$500
9	Culvert 40	Install New	0.016	450	1					16	2	$3,600
10	Channel 50–20	Improve Ditch	0.009					I	0.10	300	2	$1,200
11	Culvert 50	Install New	0.009	450	1					14	2	$3,200
12	Channel 60–50	Improve Ditch	0.006					I	0.10	460	2	$1,900
13	Culvert 60	Install New	0.006	450	1					16	1	$3,600
BASIN 6												
1	Chnl 6th St – 10	Improve Ditch	0.029					I	0.10	320	2	$1,300

Item No.	Prty	Cost
1–1	1	$1,700
2–1	1	$300
5–13	1	$3,600
5–2	1	$1,100
7–1	1	$2,700
7–2	1	$20,200
7–3	1	$3,600
7–4	1	$800
8–3	1	$2,700
9–1	1	$3,200
9–2	1	$2,700
9–3	1	$1,200
9–4	1	$82,100
9–5	1	$2,500
10–2	1	$65,600
10–4	1	$12,800
10–5	1	$3,000
21–6	1	$300
23–1	1	$289,300
23–2	1	$2,500
1–3	2	$2,700
1–4	2	$1,600
1–5	2	Note 3
3–1	2	$3,200
3–2	2	$77,400
4–1	2	$3,200
4–2	2	$1,600
5–1	2	$3,200

Table 5.4
Improvements Summary

Item No.	Location	Description	Design Flow [cms]	Culvert Design Dia. [mm]	Culvert Design Qty	Structure Req'd Inlet	Structure Req'd Outlet	Channel Design X-Sec Type	Channel Design Depth [m]	Lngth [m]	Prty	Cost
BASIN 7												
1	Culvert 12	Install New	0.022	450	1					12	1	$2,700
2	Channel 14–12	Construct/Armour	0.022					I	0.20	200	1	$20,200
3	Culvert 14	Install New	0.022	450	1					16	1	$3,600
4	Hare Rd – 14	Improve Ditch	0.022					I	0.20	140	1	$800
BASIN 8												
1	OK Centre Rd	Install New Culvert	0.079	450	1					14	2	$3,200
2	12 – OK Centre R	Construct Ditch	0.079					I	0.20	150	2	$1,100
3	Culvert 10	Install New	0.079	450	1					12	1	$2,700
4	Part Chnl 30–20	Protect Corridor								300	3	Note 3
BASIN 9												
1	Culvert 10	Install New	0.052	450	1					14	1	$3,200
2	8th St Culvert	Install New	0.052	450	1					12	1	$2,700
3	Channel 17–10	Improve Ditch	0.052					I	0.20	290	1	$1,200
4	Channel 20–17	Armour/Protect	0.026					I	0.10	310	1	$82,100
5	Culvert 30	Re–Align								12	1	$2,500
BASIN 10												
1	Culvert 10	Install New	0.038	450	1					14	2	$3,200
2	Channel 12–10	Construct Ditch	0.038					I	0.10	80	1	$65,600
3	Culvert 20	Install New	0.034	450	1					12	2	$2,500
4	Part Chnl 30–20	Construct Ditch	0.010					I	0.10	90	1	$12,800
5	Culvert 30	Install New	0.010	450	1					14	1	$3,000
BASIN 21												
1	Culvert 10	Install New	0.150	450	1					16	2	$3,600
2	Channel 20–10	Improve Ditch	0.150					I	0.20	150	2	$1,100
3	Channel 30–20	Improve/Armour Ditch	0.117					I	0.20	110	2	$11,100
4	Channel 40–30	Improve/Armour Ditch	0.094					I	0.20	670	2	$67,600
5	Channel 50–40	Improve Ditch	0.008					I	0.10	500	2	$2,000
6	Culvert 50	Clear Inlet									1	$300

Item No.	Prty	Cost
5–4	2	$3,000
5–6	2	$2,500
5–7	2	$3,000
5–8	2	$500
5–9	2	$3,600
5–10	2	$1,200
5–11	2	$3,200
5–12	2	$1,900
6–1	2	$1,300
8–1	2	$3,200
8–2	2	$1,100
10–1	2	$3,200
10–3	2	$2,500
21–1	2	$3,600
21–2	2	$1,100
21–3	2	$11,100
21–4	2	$67,600
21–5	2	$2,000
23–10	2	$2,500
23–11	2	$1,100
23–4	2	$3,400
23–5	2	$2,500
23–6	2	$1,100
23–7	2	$1,100
23–8	2	$1,100
23–9	2	$1,100
24–1	2	Note 3
24–2	2	$2,500
S3–1	2	$1,100

Table 5.4
Improvements Summary

Item No.	Location	Description	Design Flow [cms]	Culvert Design: Dia. [mm]	Culvert Design: Qty	Culvert Design: Structure Req'd Inlet	Culvert Design: Structure Req'd Outlet	Channel Design: X-Sec Type	Channel Design: Depth [m]	Lngth [m]	Prty	Cost
BASIN 23												
1	Channel 20–10	Construct/Armour	0.336					III	0.15	250	1	$289,300
2	Culvert 20	Install New	0.336	800	1					12	1	$2,500
3	Channel 30–20	Define/Protect	0.331					III	0.25	110	3	$1,200
4	Culvert 30	Install New	0.331	800	1					12	2	$3,400
5	Culvert 45	Install New	0.049	450	1					12	2	$2,500
6	Channel 45–30	Improve Ditch	0.049					I	0.20	120	2	$1,100
7	Channel 40–30	Define/Protect	0.054					III	0.10	90	2	$1,100
8	Part Chnl 50–30	Improve Ditch	0.311					II	0.30	160	2	$1,100
9	Part Chnl 50–30	Improve/Protect Route	0.311					III	0.25	60	2	$1,100
10	Culvert 50	Replace With New	0.311	450	2					12	2	$2,500
11	Part Chnl 60–50	Improve Ditch	0.296					II	0.30	90	2	$1,100
12	Channel 60–Ottley	Protect Corridor									3	Note 3
BASIN 24												
1	Channel 20–10	Protect Corridor									2	Note 3
2	Culvert 20; Finch	Install New	0.015	450	1					12	2	$2,500
SINK 3												
1	Part Chnl 20–10	Improve Ditch	0.069					II	0.10	130	2	$1,100
2	OK Centre Rd	Install New Culvert	0.019	450	1					14	3	$3,200
3	OK Centre Rd	Improve Ditch	0.019					I	0.10	50	3	$1,100

Item No.	Prty	Cost
1–2	3	$2,700
5–3	3	Note 3
5–5	3	Note 3
8–4	3	Note 3
23–12	3	Note 3
23–3	3	$1,200
S3–2	3	$3,200
S3–3	3	$1,100

Sub–Totals	
Priority 1	$501,900
Priority 2	$226,000
Priority 3	$8,200
Total	$736,100

NOTES:

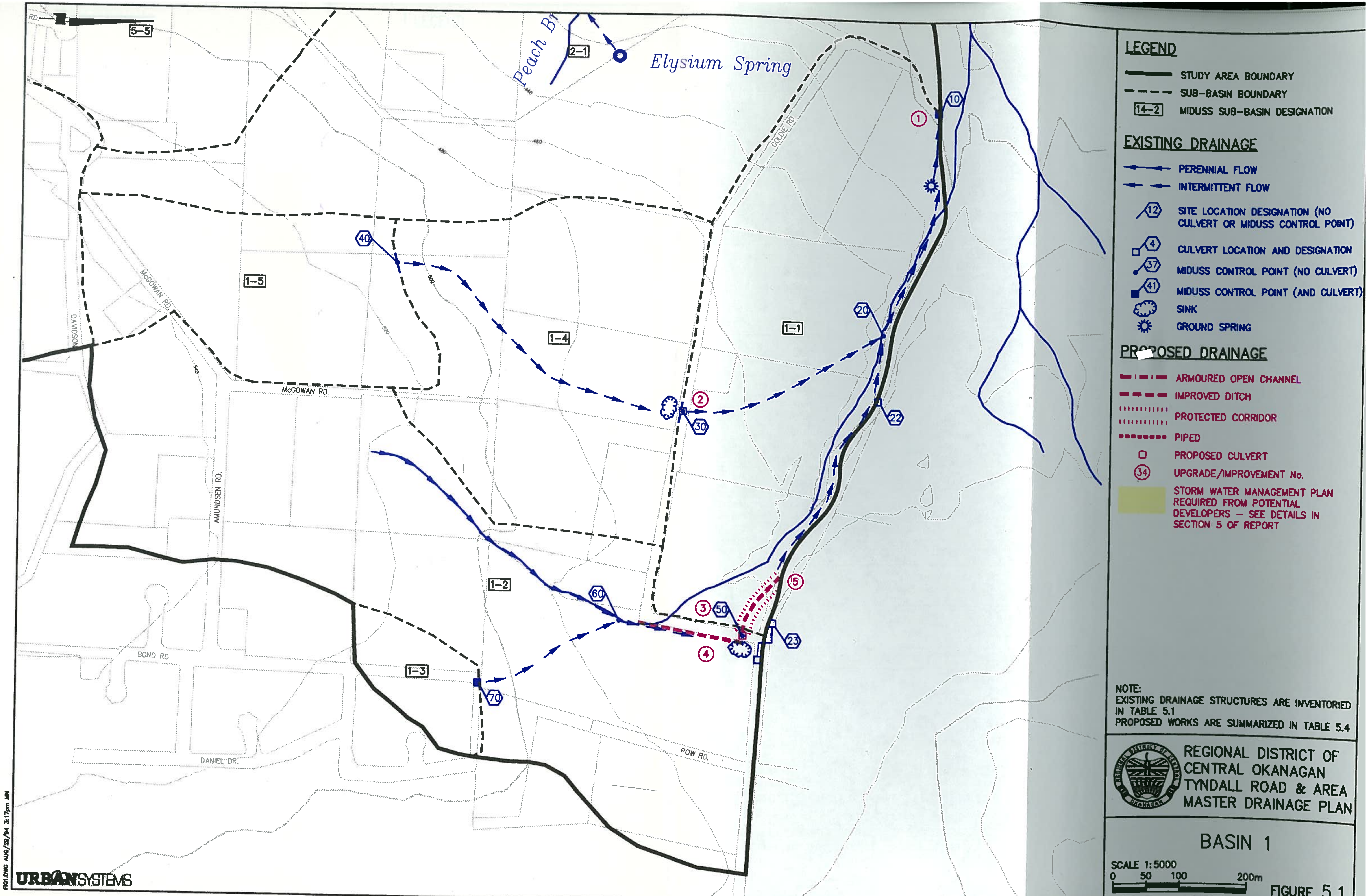
(1) *Costs (in 1994 dollars) include 40% for Engineering and Contingencies; 5% RDCO & MOTH Administration; 7% GST.*

(2) *Improvements are shown on Figures 1–8 and are identified by the Item Number.*

(3) *These corridors would be dedicated by the developer at time of subdivision.*

(4) *Land purchase and easement costs were estimated for works not in road right–of–ways that are unlikely to be dedicated by the developer*

(4) *at time of subdivision (see Note 3 above).*



5-5
2-1
Peach Br
Elysium Spring
GOUDIE RD
1-5
1-4
1-1
1-2
1-3
McGOWAN RD.
DAVIDSON
AMUNDSEN RD.
BOND RD
DANIEL DR.
POW RD.
LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS - SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASIN 1
SCALE 1:5000
0 50 100 200m
URBAN SYSTEMS

FIGURE 5.1

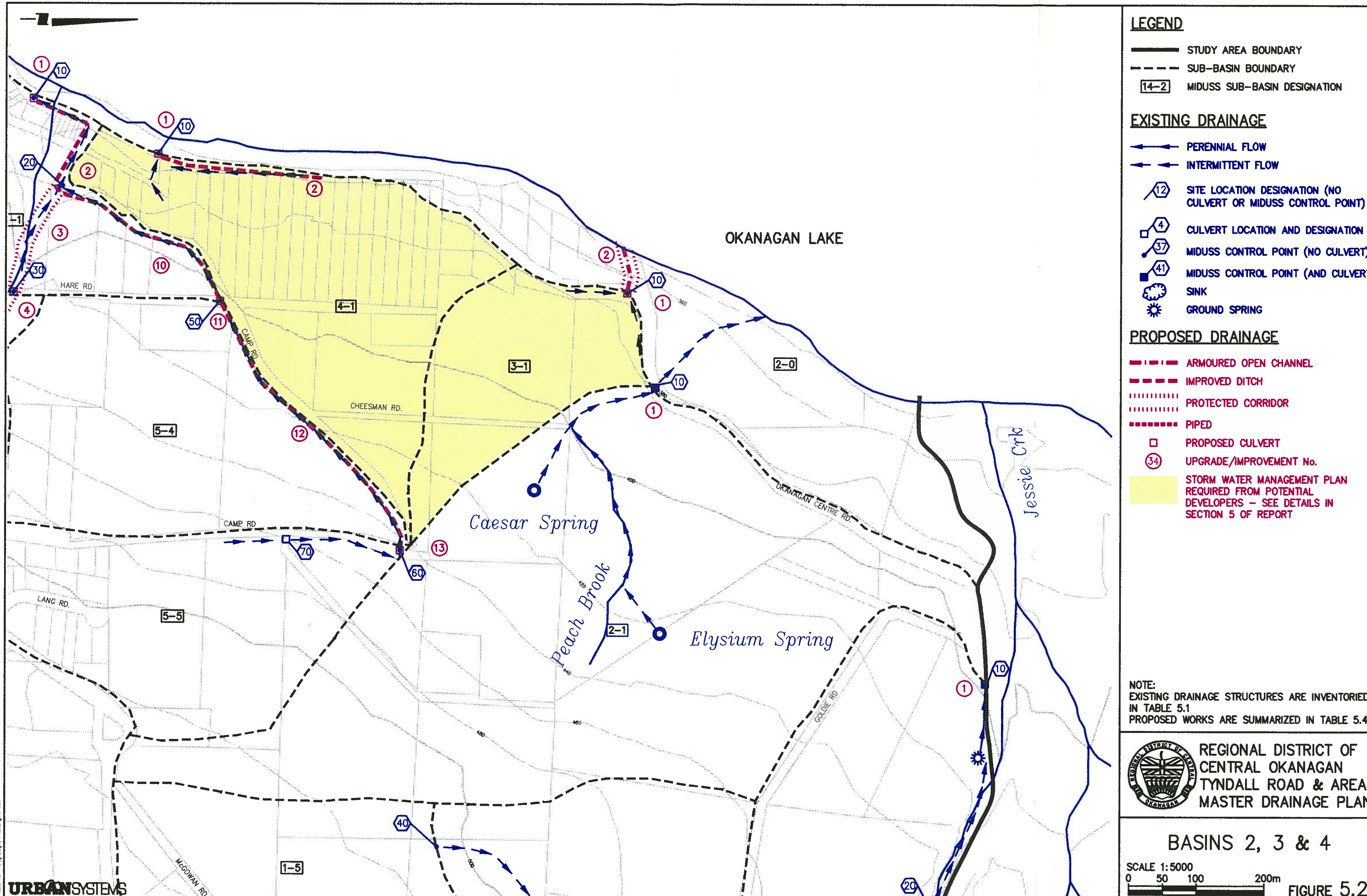
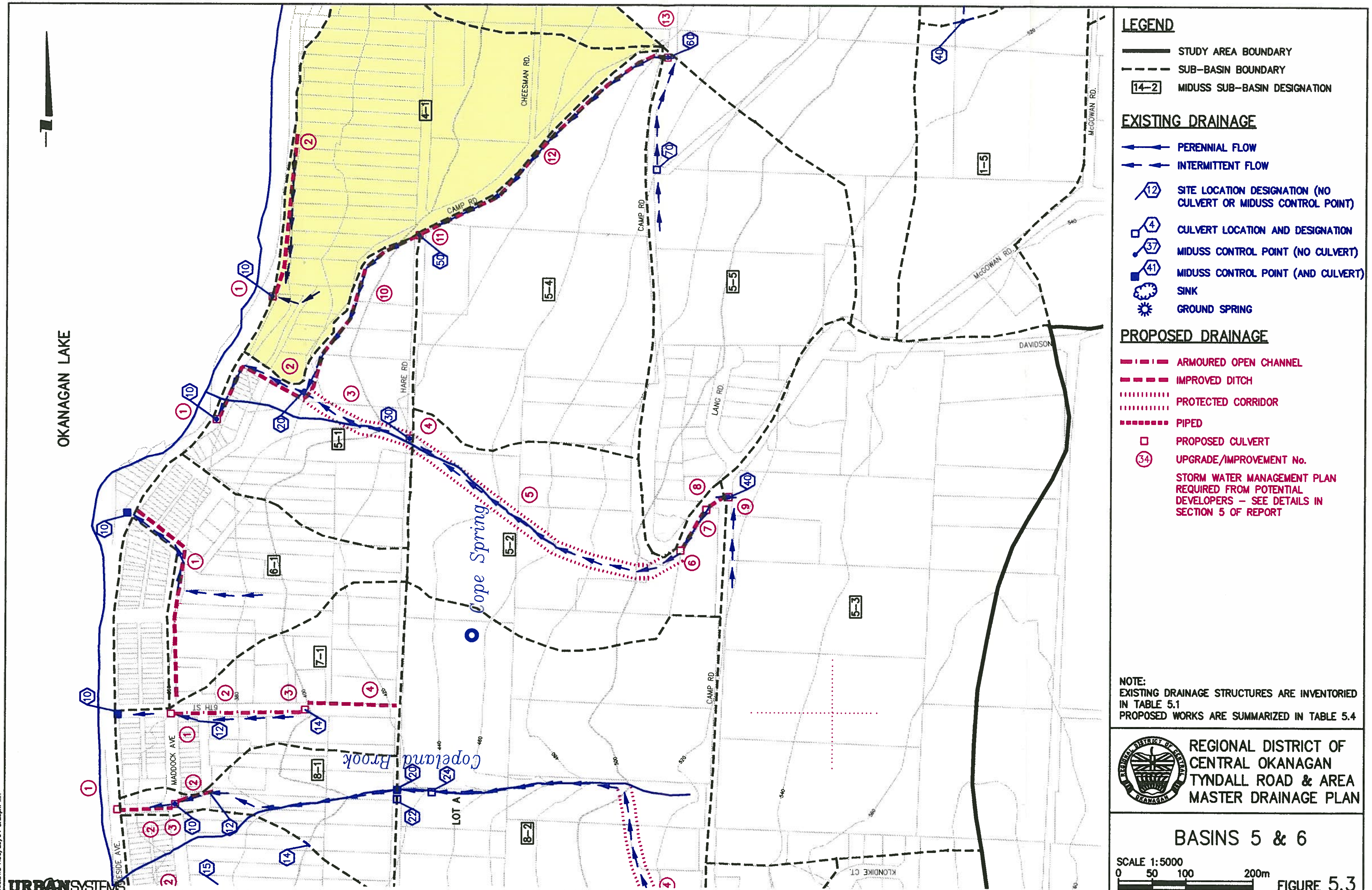
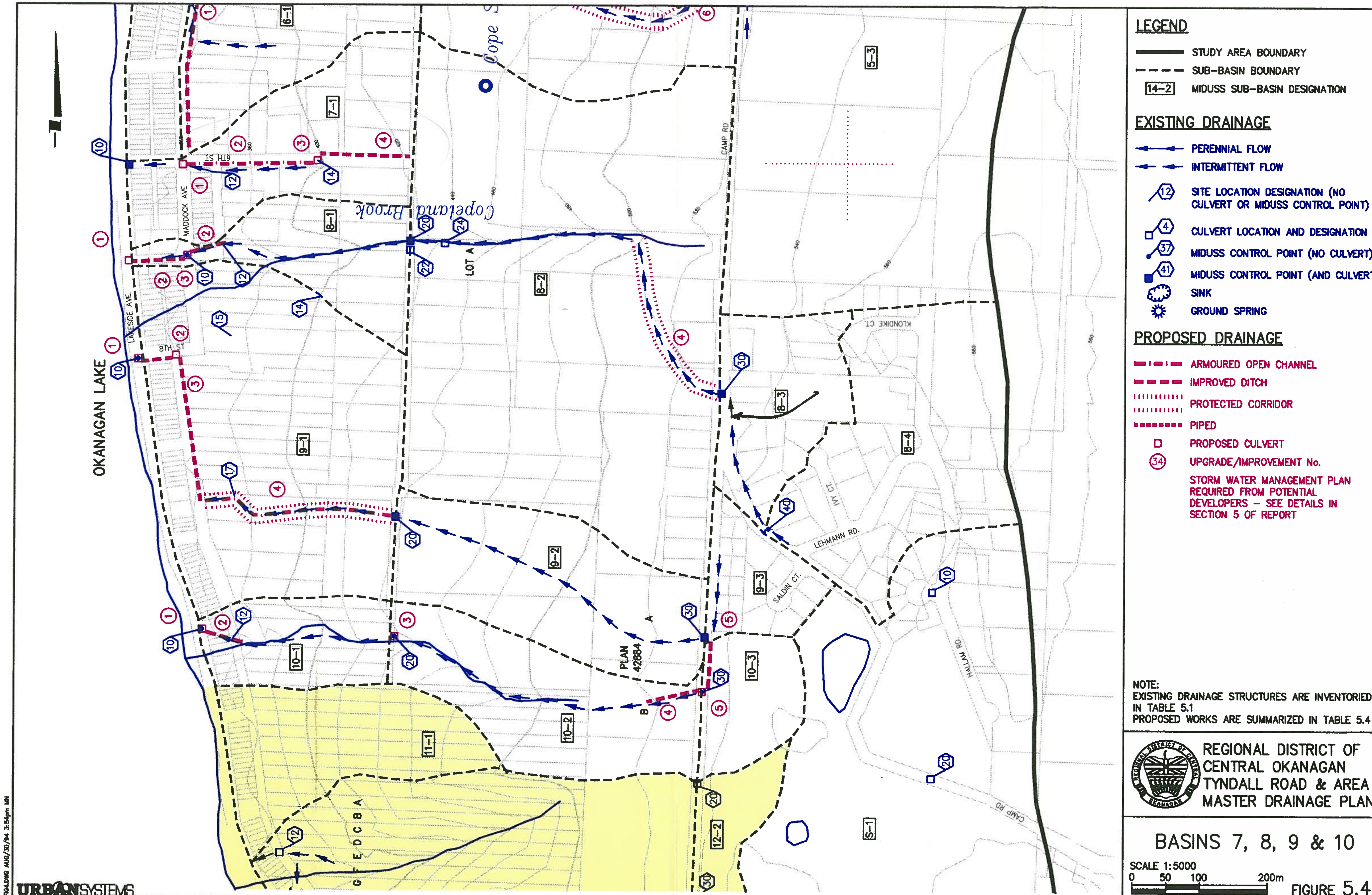
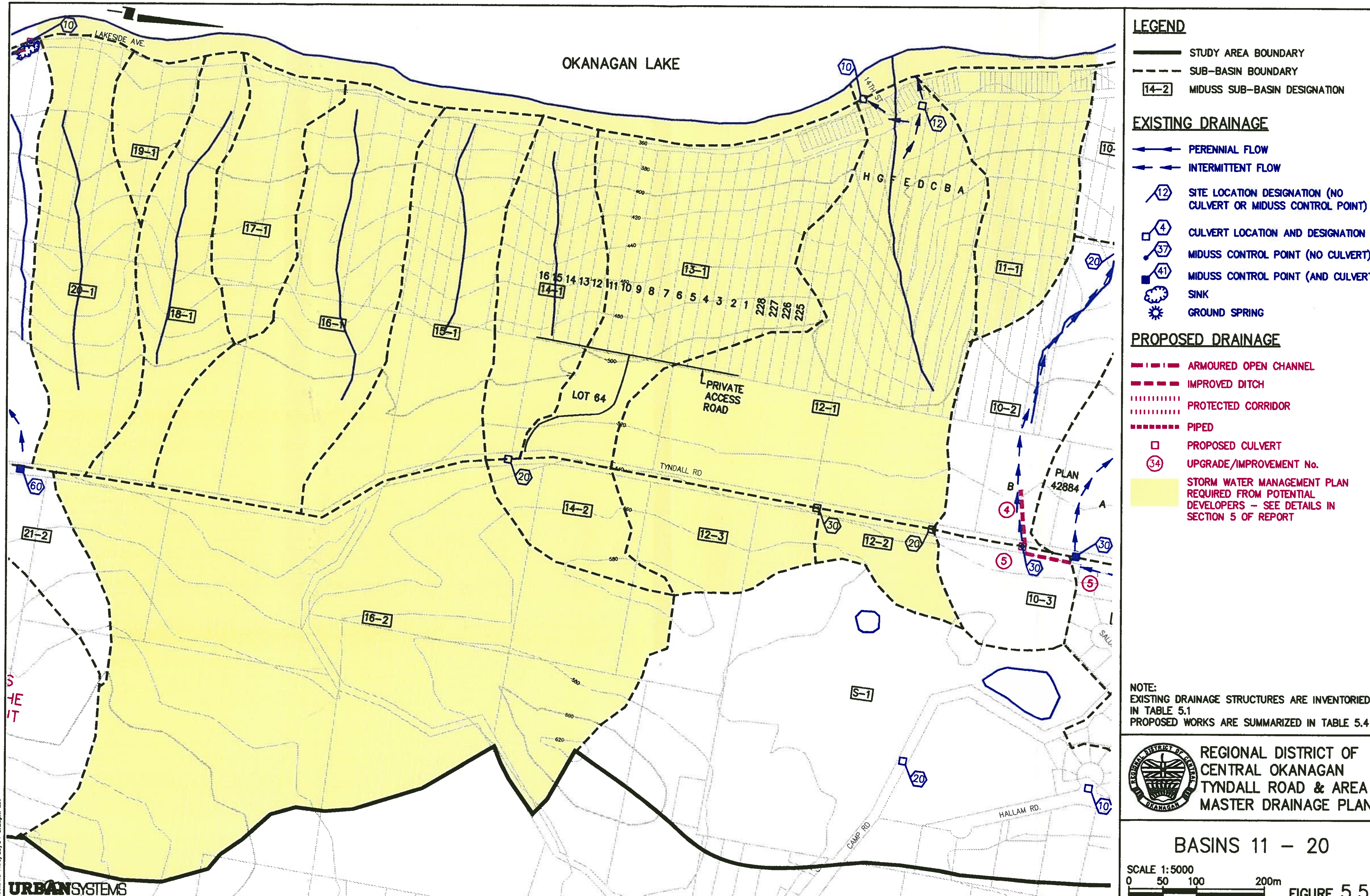

OKANAGAN LAKE
HARE RD
CAMP RD
CHEESMAN RD.
LANG RD.
OKANAGAN CENTRE RD.
GOLDIE RD
McGOWAN RD
Caesar Spring
Elysium Spring
Peach Brook
Jessie Crk
4-1
3-1
2-0
2-1
5-4
5-5
1-5
LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS – SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 2, 3 & 4
SCALE 1:5000
0 50 100 200m
URBANSYSTEMS
FIG2.DWG AUG/29/94 3:21pm MN

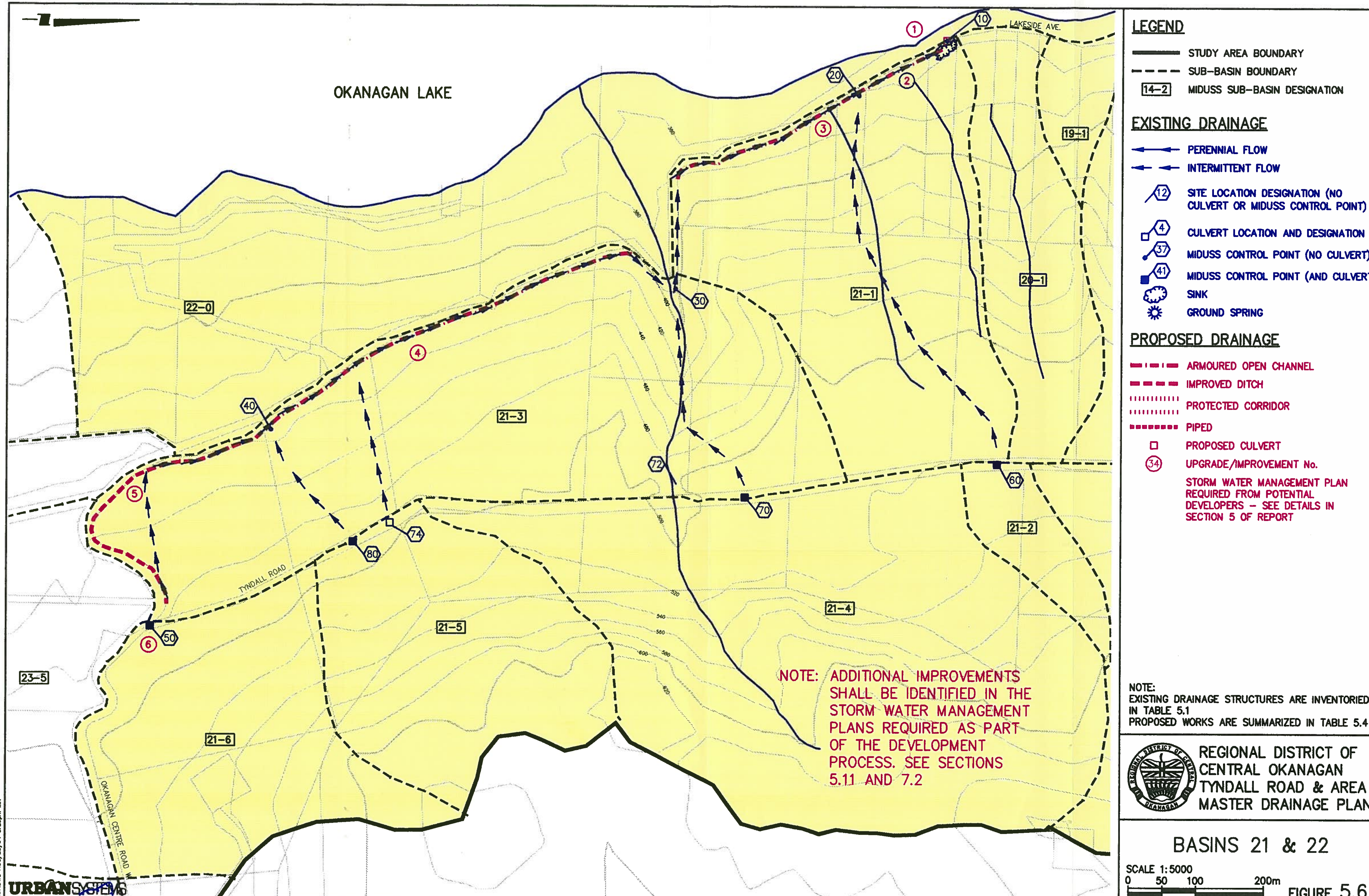
FIGURE 5.2


LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS – SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
OKANAGAN LAKE
CHEESMAN RD.
CAMP RD
HARE RD
LANG RD.
McGOWAN RD.
DAVIDSON
MADDOCK AVE
61ST ST
KLONDIKE CT.
LOT A
Cope Spring
Copeland Brook
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 5 & 6
SCALE 1:5000
0 50 100 200m
FIGURE 5.3
URBAN SYSTEMS
FIG3.DWG AUG/29/94 5:26pm MM


LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS - SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
OKANAGAN LAKE
Copeland Brook
6TH ST
8TH ST
MADDOCK AVE
LAKESIDE AVE
CAMP RD
KLONDIKE CT.
IVY CT.
LEHMANN RD.
SALDIN CT.
HALLAM RD.
LOT A
PLAN 42884
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 7, 8, 9 & 10
SCALE 1:5000
0 50 100 200m
FIGURE 5.4
URBAN SYSTEMS

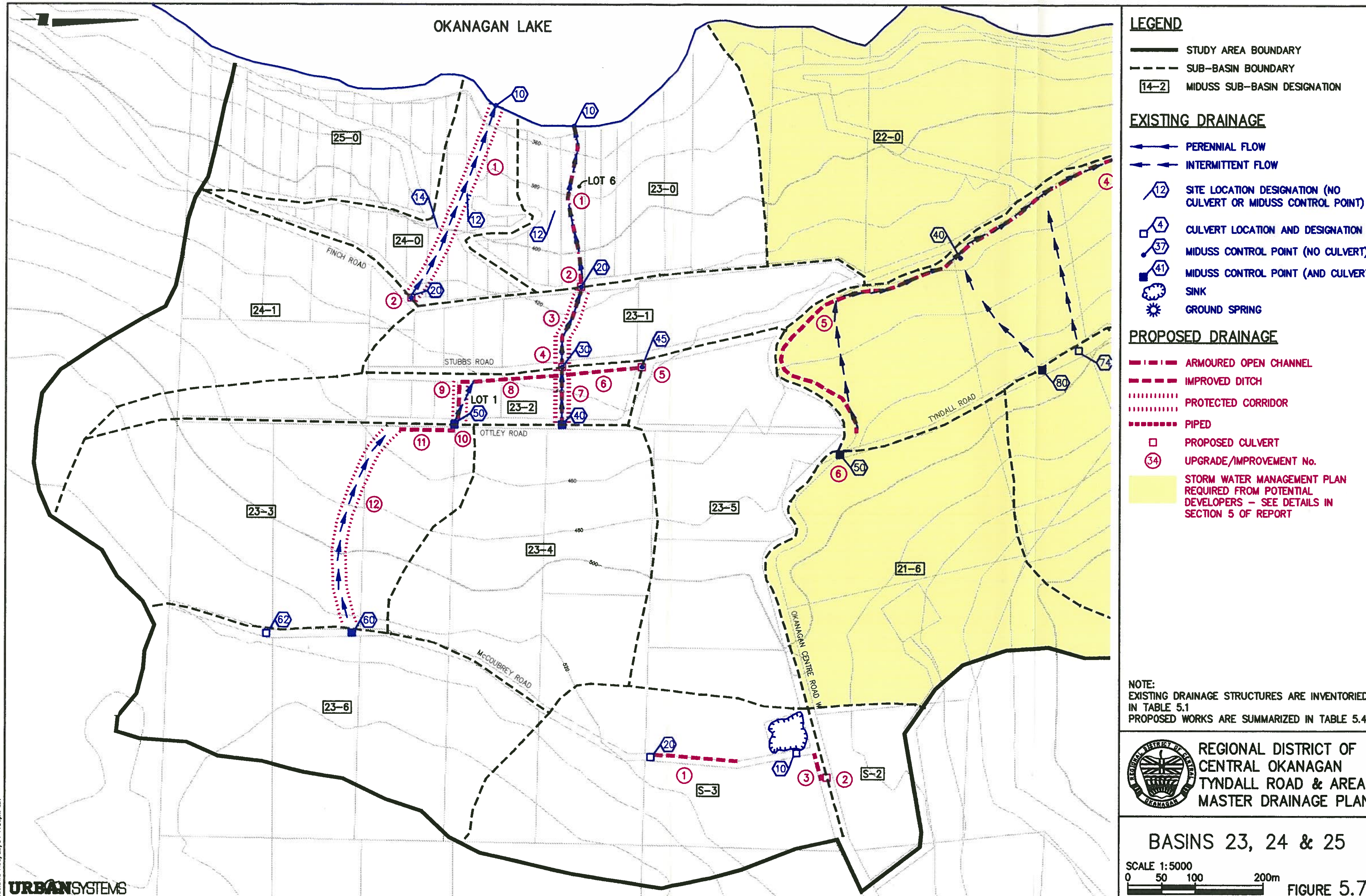


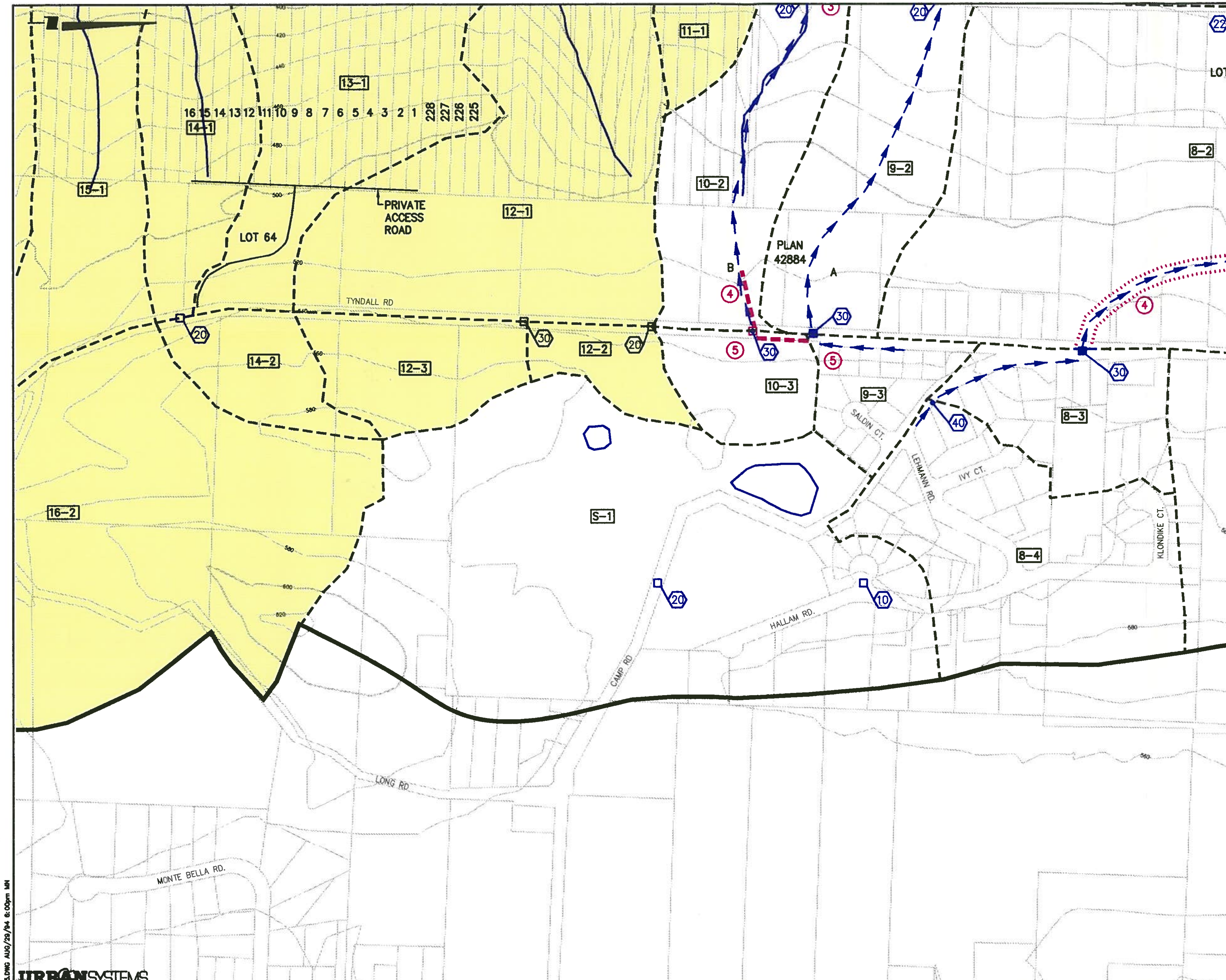
OKANAGAN LAKE
LAKESIDE AVE.
14TH ST.
TYNDALL RD
PRIVATE ACCESS ROAD
LOT 64
PLAN 42884
HALLAM RD.
CAMP RD
19-1
17-1
20-1
18-1
16-1
15-1
14-1
13-1
11-1
12-1
10-2
14-2
12-3
12-2
10-3
16-2
21-2
S-1
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 228 227 226 225
H G F E D C B A
LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
12 SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
4 CULVERT LOCATION AND DESIGNATION
37 MIDUSS CONTROL POINT (NO CULVERT)
41 MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
34 UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS - SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 11 - 20
SCALE 1:5000
0 50 100 200m
FIGURE 5.5
URBAN SYSTEMS



OKANAGAN LAKE
LAKESIDE AVE.
TYNDALL ROAD
OKANAGAN CENTRE ROAD
22-0
21-1
21-2
21-3
21-4
21-5
21-6
20-1
19-1
23-5
NOTE: ADDITIONAL IMPROVEMENTS SHALL BE IDENTIFIED IN THE STORM WATER MANAGEMENT PLANS REQUIRED AS PART OF THE DEVELOPMENT PROCESS. SEE SECTIONS 5.11 AND 7.2
LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS - SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 21 & 22
SCALE 1:5000
0 50 100 200m
URBAN SYSTEMS

FIGURE 5.6


OKANAGAN LAKE
25-0
24-0
24-1
23-0
23-1
23-2
23-3
23-4
23-5
23-6
22-0
21-6
S-2
S-3
LOT 6
LOT 1
FINCH ROAD
STUBBS ROAD
OTTLEY ROAD
McCOUBREY ROAD
TYNDALL ROAD
OKANAGAN CENTRE ROAD W
LEGEND
STUDY AREA BOUNDARY
SUB-BASIN BOUNDARY
14-2 MIDUSS SUB-BASIN DESIGNATION
EXISTING DRAINAGE
PERENNIAL FLOW
INTERMITTENT FLOW
SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
CULVERT LOCATION AND DESIGNATION
MIDUSS CONTROL POINT (NO CULVERT)
MIDUSS CONTROL POINT (AND CULVERT)
SINK
GROUND SPRING
PROPOSED DRAINAGE
ARMOURED OPEN CHANNEL
IMPROVED DITCH
PROTECTED CORRIDOR
PIPED
PROPOSED CULVERT
UPGRADE/IMPROVEMENT No.
STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS - SEE DETAILS IN SECTION 5 OF REPORT
NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4
REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN
BASINS 23, 24 & 25
SCALE 1:5000
0 50 100 200m
URBANSYSTEMS
FIGURE 5.7



LEGEND

- STUDY AREA BOUNDARY
- SUB-BASIN BOUNDARY
- 14-2 MIDUSS SUB-BASIN DESIGNATION

EXISTING DRAINAGE

- PERENNIAL FLOW
- INTERMITTENT FLOW
- 12 SITE LOCATION DESIGNATION (NO CULVERT OR MIDUSS CONTROL POINT)
- 4 CULVERT LOCATION AND DESIGNATION
- 37 MIDUSS CONTROL POINT (NO CULVERT)
- 41 MIDUSS CONTROL POINT (AND CULVERT)
- SINK
- GROUND SPRING

PROPOSED DRAINAGE

- ARMOURED OPEN CHANNEL
- IMPROVED DITCH
- PROTECTED CORRIDOR
- PIPED
- PROPOSED CULVERT
- 34 UPGRADE/IMPROVEMENT No.
- STORM WATER MANAGEMENT PLAN REQUIRED FROM POTENTIAL DEVELOPERS – SEE DETAILS IN SECTION 5 OF REPORT

NOTE:
EXISTING DRAINAGE STRUCTURES ARE INVENTORIED IN TABLE 5.1
PROPOSED WORKS ARE SUMMARIZED IN TABLE 5.4

REGIONAL DISTRICT OF CENTRAL OKANAGAN
TYNDALL ROAD & AREA MASTER DRAINAGE PLAN

SINK 1

SCALE 1:5000
0 50 100 200m

FIGURE 5.8

SECTION 6.0

FINANCIAL CONSIDERATIONS SECTION 6.0

In order to assist the Regional District in planning and budgeting for drainage improvements within the study area, budgetary capital cost estimates were prepared and summarized for each of the proposed improvements. Estimates of projected lot yields, based on current information, were also prepared for each basin in terms of equivalent units. This section presents data required for evaluating the feasibility of implementing a development cost charge (or similar) cost recovery method.

6.1 Allocation Philosophy

Essentially, the improvements proposed in Section 5 are required because of one or both of the following reasons:

a) to correct an existing deficiency;

b) to service new development.

An existing deficiency is one that requires improvement of the existing drainage system to meet the standards outlined in Section 3.0, even if no further development occurs. In most cases an existing deficiency becomes more significant when additional development occurs. In these situations, the improvement is sized to accommodate future design requirements, but the costs must be allocated to both existing and future development for cost recovery.

There are several methods of allocating estimated costs of an improvement to the two categories outlined above. The two primary methods are discussed briefly as follows:

.1 Allocation Based on Flow Rates

Under this method, the peak flow rate under existing conditions is determined, appropriate works are sized, and associated costs are estimated. The same is done for each successive growth stage (i.e. existing + future development). Only the *incremental cost* of works required to service each successive growth stage are allocated to the additional units of that growth stage.

Under this method, the majority of costs are usually allocated to existing residential units, and the least cost is allocated to future units. This places a heavy burden on existing residents through increased taxes.

.2 Allocation Based on Development Units

Another option is to base the allocation on the total number of units serviced by the improvement. If an improvement is deemed to correct an existing deficiency as well as service future development, its cost is pro-rated based on the number of existing and future units within the service basin. A portion of the estimated cost is therefore allocated to existing deficiencies and the remainder is allocated to future development (and potential recovery from developers).

If an improvement is deemed necessary only to service future development, then its entire cost is allocated to the future units.

.3 Adopted Method

For the purposes of this study, the second method has been adopted. All Priority 1 improvements were considered as existing deficiency corrections with benefits to future development. Priority 2 and 3 improvements were assumed to be required primarily because of or for future development. This is an initial assumption to provide an analysis for further discussion, consideration, and evaluation by the Regional District. Costs have been allocated on a per-basin basis. It may be feasible to combine several of the basins into one service area to simplify administration.

6.2 Unit Cost Analysis

A summary of proposed improvements, total estimated capital costs, and assigned priority is outlined in Table 5.4. Table 6.1 summarizes the unit cost for each basin.

These costs:

- are expressed in 1994 dollars for current construction;
- exclude land, easement, and right-of-way purchases;
- include an additional 35% for engineering and construction contingencies;
- include 7% GST;
- exclude administration by the Regional District and the Ministry of Transportation and Highways;
- are for preliminary budget purposes only.

6.3 Cost Recovery Methods

The Regional District and the Ministry of Transportation and Highways must be involved in implementing the proposed drainage improvements. The Regional District is in the better position to raise and manage funds for the proposed works. The Ministry Of Transportation and Highways is in the better position to assume responsibility as technical advisors and to implement improvements.

The Regional District advises that they have the ability to create legislation for the collection of funds from existing and proposed developments for required drainage works. Methods normally considered include:

- local service areas for drainage
- development cost charges
- latecomer agreements

Currently, the Regional District may use only voluntary gifting agreements as a means of generating revenue for future drainage system improvements. The other methods listed above would require legislative changes. Considering that the study area will soon be incorporated as part of the "Lake Country" municipality, all of these options will be available for cost recovery purposes.

Although the Ministry of Transportation and Highways could collect funds from developers, it would have difficulty applying these funds to specific drainage works. It can, however, through the role of approving authority, act as technical advisors to implement the drainage plan. Its primary functions are seen as follows:

- to determine what works are required for each development proposal both on and off site;
- to order, review, and approve a Stormwater Management Plan as part of the approval process;
- to protect and acquire the required drainage corridors;
- to make minor drainage improvements which are complementary to the plan;
- to arrange for design and construction of works where required.

.1 Initial Approach

Recognizing that the Regional District supports continuation of controlled development within the study area, it is suggested that:

- the drainage concept in this study be adopted as the basis on which drainage issues are addressed and assessed;
- an appropriate gifting agreement be prepared to allow accumulation of funds for capital works identified in the drainage plan. (This agreement could include both construction of works and payment of funds into a capital account for future drainage works.);
- the Regional District prepare specified area bylaws to raise the funds identified for the existing deficiency portion of the drainage works;

- the Ministry of Transportation and Highways and the Regional District (depending on the circumstances) both take steps to protect identified drainage corridors and detention pond sites required for future construction.

.2 Long Term

For the long term, the new municipality should assess the best method of obtaining required capital funds from new development. Until subdivision approving authority is transferred to the new municipality, the Ministry of Transportation and Highways should continue, as part of the development application processing procedure, to:

- identify development specific drainage works (both on and off site);

- ensure major drainage works required to implement the plan are constructed to specified standards.

Local service areas or development cost charge sectors should be as large as possible to minimize administrative costs. Preferably, there would be only one or two within the study area. In identifying these areas for cost recovery purposes, the following criteria must also be considered:

.1 Area boundaries must follow legal lot lines rather than drainage basin boundaries.

.2 Costs must be allocated to each defined area in a justifiable manner. For example, it might be difficult to justify including the costs (and also units) from Southwest Winfield in the Okanagan Centre cost recovery area. In this case, two areas would be more justifiable.

6.4 Proposed Interim Gifting Agreement

Further to Section 6.3.1, an analysis was conducted to determine what the average unit cost would be for the entire study area if it was calculated using only costs and EU estimates for basins that contain both. For example, the units for basins 11 to 20 were excluded because no costs were estimated for works in the basins.

As shown in Table 6.1, this average unit cost is $1,031. As an interim measure, the Regional District may wish to apply this unit cost as follows:

- as part of the rezoning process, the developer would be asked to "gift" an amount equivalent to (the number of proposed units) x (the average unit cost) calculated above for future drainage works;

- if the development is located in an area where a comprehensive stormwater management plan is required, and it is larger than two or three lots, then the developer would be required to conduct the SMP and construct offsite works at his expense;

- the Regional District would credit the funds spent on the SMP and approved offsite works against the required "gifting agreement" up to, but not exceeding, the value of that agreement.

In this way, small developments of two or three lots located within areas requiring SMPs are not penalized by having to conduct a costly SMP; the developer simply pays his gifting agreement. Developers of larger subdivisions, however, aren't penalized by having to do both. They would, however, pay the greater of either the gifting agreement or the combined cost of a SMP plus offsite works.

Table 6.1

Unit Cost Summary

Basin	Estimated Costs				Equivalent Units (EU)			Unit
	Total	Priority 1	Deficiency(1)	Net (2)	Existing	Future	Total	Cost (3)
1	$8,700	$1,700	$710	**$7,990**	23	**32**	55	**$250**
2	$300	$300	$300		1		1	
3	$80,600			**$80,600**	3		3	
4	$4,800			**$4,800**	10	**18**	28	**$267**
5	$26,800	$4,700	$2,950	**$23,850**	22	**13**	35	**$1,835**
6	$1,300			**$1,300**	19	**7**	26	**$186**
7	$27,300	$27,300	$8,780	**$18,520**	9	**19**	28	**$975**
8	$7,000	$2,700	$1,870	**$5,130**	76	**34**	110	**$151**
9	$91,700	$91,700	$68,780	**$22,920**	45	**15**	60	**$1,528**
10	$87,100	$81,400	$9,040	**$78,060**	5	**40**	45	**$1,952**
11					11	**2**	13	
12					2	**36**	38	
13						**13**	13	
14						**10**	10	
15						**18**	18	
16						**66**	66	
17								
18						**10**	10	
19								
20						**10**	10	
21	$85,700	$300		**$85,700**		**144**	144	**$595**
22						**48**	48	
23	$306,900	$291,800	$6,370	**$300,530**	5	**224**	229	**$1,342**
24	$2,500			**$2,500**		**18**	18	**$139**
25					13		13	
SINK 1					13	**14**	27	
SINK 2						**16**	16	
SINK 3	$5,400			**$5,400**	3	**54**	57	**$100**
Totals	$736,100	$501,900	$98,800	**$637,300**	260	**861**	1,121	
Selected Totals for Average Unit Cost (4)				**$637,300**		**618**		**$1,031**

NOTES:

(1) *The DEFICIENCY costs represents the portion of the Priority 1 cost that is attributable to exsiting units. For example, $710 = 23 EU / 55 EU * $1700.*

(2) *The NET cost is the difference between TOTAL cost and the DEFICIENCY cost.*

(3) *The unit cost is calculated as NET ESTIMATED COST / FUTURE EU.*

(4) *An average unit cost (based on FUTURE units only) is calculated using only the data indicated by* [boxed cell] .

SECTION 7.0

POLICIES — SECTION 7.0

Some drainage issues are best addressed through formal policies adopted by the Regional District Board and enforced through bylaw. Two which are pertinent to the study area are discussed in this section for consideration by the Regional District.

7.1 Soil Loss Control

During typical subdivision construction, lots are laid-out and surveyed, services (including drywells or storm sewers) are installed, roads with curb and gutter are constructed, and *then* house construction starts. During the period when building construction is under way, soil from the building site is often washed onto the paved roadway and carried into the storm sewer or dry well system. This is especially true where roof leaders discharge onto un-stabilized soil.

Drywells are the most sensitive to this abuse, and may have their useful lifespan reduced by 10-20 years! Sediment transported through a conventional storm sewer system is deposited into catch basins, manhole sumps, and eventually into the receiving water or channel. Ditches and culverts often are filled with sediment. This is not only a form of pollution, but a situation that requires additional maintenance to restore design capacities.

To make matters worse, contractors will sometimes store topsoil *right on the paved road, without the protection of a soil loss control system.* Any water flowing along the gutter quickly transports significant amounts of this material into the drainage system.

The Regional District should consider implementing a policy which requires the building permit holder to take defined measures to prevent soil loss from the subject property into the storm sewer system. In this case, the storm sewer system would include a paved road equipped with curb and gutter. This policy would increase administration costs because of the required enforcement. It could, however, also prevent costly maintenance to newly installed drainage systems.

7.2 Stormwater Management Plans

When a development consisting of more than 2 or 3 units is proposed, the Regional District (or approving authority) should request a stormwater management plan which clearly identifies:

- site topography based on geodetic elevations;
- how stormwater generated on site will be collected and disposed of;
- how stormwater entering the site from upstream sources will be managed;
- how runoff from the major design storm will be safely transported to the nearest major drainage route or receiving water, taking into consideration erosion control, bank stability, and protection of adjacent properties;
- the potential impact of proposed storm runoff discharges on downstream properties;
- how site soil loss will be prevented during construction, if applicable.

The plan should include a summary of the design peak flows for both the minor and major systems. Channel design velocities should also be provided for open channel sections. Piped sections for major design flows must include detailed capacity calculations for both the piped section and the inlet.

Under most circumstances, compliance with the above requirements would normally be adequate to ensure drainage concerns are properly addressed. Some of the drainage basins within the Tyndall Road area, however, pose additional challenges that must be considered very carefully prior to any development activity. To ensure that these issues (outlined in Section 4) are properly addressed, Stormwater Management Plans for these areas (highlighted in yellow on Figure 2.3 and Figures 5.1 to 5.8) must be prepared under the following additional guidelines:

.1 No Discharge Through Steep Gullies

Each of the identified sub-basins drains to the lake via one of the many steep, natural gullies between Tyndall Road and OK Centre Road. Considering the sensitive nature of these gullies, their susceptibility to erosion, and their wildlife habitat value, they must not be used as drainage routes for storm runoff from proposed developments.

Under existing, natural conditions, there is no evidence of surface flows through these gullies. This is due to the:

- excellent drainage characteristics of the soil, and to the
- naturally distributed rainfall pattern.

Under these conditions, little opportunity exists for the rainfall to become surface runoff and eventually be concentrated into stream flow within the gullies. Without appropriate measures, traditional development activities will result in concentrated runoff entering the gullies.

The required Stormwater Management Plan must show how runoff from impervious areas (roads, driveways, roof leaders, etc...) will be disbursed back into the ground *in a non-concentrated fashion*. Such provisions must be made to accommodate runoff from events with return periods up to 100 year inclusive.

Potential methods include:

- multiple dry-wells;
- infiltration trench systems (perforated pipes);
- filter strips (over pervious trenches);
- retention/groundwater recharge ponds;

.2 Site-Specific Geotechnical Studies

The proposed development site must be evaluated by a geotechnical engineer to ensure that the proposed storm water disposal method:

- will have adequate capacity to dispose of the estimated runoff from the design storm events;
- will not adversely affect the top-of-slope stability due to increased groundwater or saturated conditions.

.3 Alternate Drainage Systems

In situations where detailed site investigation proves that safe disposal of anticipated runoff to the ground is infeasible, and use of a gulley for storm runoff transportation to the lake is deemed essential, then a proposed design and construction methodology for an alternate system must be presented to the approving authority. The design must include:

- a plan/profile drawing of the proposed route from the development to the lake shore;
- detailed cross-sections (existing and proposed ground) along the entire route, spaced as directed by the approving authority;
- a geotechnical report which addresses slope stability issues;
- a written description of how the works will be installed, how erosion will be controlled during and after construction, and how the site will be re-habilitated afterward.

This route should be clear of buildings, animal shelters, or any other structure that could potentially be damaged by storm water flows. If such structures do exist, then adequate measures must be proposed to protect them.

If the proposed route passes through private property, evidence must be provided by the developer that an easement will be granted for the proposed drainage purposes.

7.3 Development Permit Areas

In order to protect the many sensitive areas generally identified in this study and in the neighbourhood plans prepared prior to it, the Regional District should consider establishing development permit areas. These controlled areas would be established to protect wildlife habitat, erosion-sensitive soils, and potentially unstable slopes.

Specific area delineation would have to be based upon further investigation since current available data is insufficient. The criteria to be met under the DPAs would need to be established and incorporated into the Official Community Plan.

SECTION 8.0

CONCLUSIONS AND RECOMMENDATIONS — SECTION 8.0

8.1 Conclusions

.1 Under current land use conditions, the study area has few significant drainage deficiencies. Most deficiencies are caused by poorly defined drainage channels or culvert discharges into natural gullies in which houses or other buildings have been situated.

.2 Much of the study area consists of soils which have very good drainage characteristics. Peak flows from surface runoff are therefore relatively insignificant under existing development conditions.

.3 The steep bank and natural gullies between Tyndall Road and Okanagan Lake are very susceptible to erosion and slope instability. Under existing natural conditions, there is no evidence that storm runoff has flowed over the surface of these gullies. The gullies are an important feature of the study area because they provide a unique habitat for small wildlife and unusual plants.

.4 Based on the amount and type of residential development projected for the study area, only moderate peak runoff increases are anticipated. This is primarily due to the anticipated use of rural road sections (ditches) rather than urban road sections (curb & gutter) with conventional storm sewer systems.

.5 Groundwater does not appear to be a concern except in a few localized areas which contain springs.

8.2 Recommendations

.1 Direct discharge to natural gullies from storm sewer systems should not be permitted unless:

- the developer verifies that no houses or other buildings within the gulley will be adversely affected;
- steps are taken to ensure that the gulley is not eroded by the anticipated flows;
- easements are in place to provide maintenance access along the entire length of the channel.

This includes discharge to ditches that drain through culverts which discharge to natural gullies.

.2 Wherever possible, require use of groundwater recharge systems for stormwater disposal. These systems should be designed to accommodate runoff from events with return periods of 100 years or less. This approach will:

- minimize or eliminate potential damage to the natural gullies by either direct discharges or by construction activities required to install channel armouring or storm sewers;

- minimize negative environmental impacts upon Okanagan Lake since potential pollutants in the storm runoff will be substantially removed by the soil prior to entering the groundwater table;

- maximize the amount of sub-surface moisture within the natural gullies required to sustain existing plant growth and preserve wildlife habitat.

It is imperative that all groundwater recharge systems be designed by a geotechnical engineer and that the design be reviewed by the appropriate approving authority (MoTH for now).

.3 An emergency overland route, clear of houses or other buildings, must be provided for every road low-spot where storm runoff can pond. An emergency overland route must also be provided where roads dead-end on a down-slope. These emergency routes must direct design flows to the nearest major drainage route. Discharge from these routes must not be permitted to enter any of the natural gullies located on the steep slope between Tyndall Road and Okanagan Lake. (See recommendation No.1.)

.4 Secure right-of-ways and easements on private properties through which identified major drainage routes pass.

.5 Several improvements have been identified for most of the drainage basins. These works have been prioritized to ensure attention is given to the more serious deficiencies first. To date, the Ministry of Transportation and Highways has assumed the responsibility of implementing drainage improvements within the Regional District, and should develop a budget for completing the works as outlined.

Prior to implementing any of the improvements proposed in this study, detailed plans must be prepared based on site-specific data. Field information may dictate special or alternate solutions other than those proposed.

.6 Every subdivision application must be accompanied by a stormwater management plan that clearly shows:

- how surface and subsurface drainage from each lot will reach the nearest major drainage route;
- how natural *and* future drainage from upstream lands draining into the proposed subdivision will be accommodated;
- the specified design flows and supporting criteria/assumptions for both the proposed subdivision *and contributing upstream lands*;

Since there are several areas within drainage basins 11 to 22 that are extremely sensitive to any soil or vegetative disturbance, the Regional District and the Ministry of Transportation and Highways must ensure that any development activity within these areas must be conducted under strict control. To ensure that this occurs, the development approving authority must require the developer of lands within these basins to prepare an *extensive* Stormwater Management Plan as outlined in Section 7.2.

.7 Ditches which are part of a major drainage course must not be replaced with a culvert and fill unless written approval is issued by the appropriate approving authority. The application must be accompanied by a design prepared by an engineer which includes:

- a detailed plan and profile of the proposed installation outlining sizes, grades, and geodetic invert elevations;
- calculations supporting the peak design flow estimate and culvert size selection.

.8 Appropriate regulatory agencies must be consulted for approvals whenever proposed works impact a recognized natural stream (even if the stream is often dry).

.9 The Regional District should seriously consider establishing Development Permit Areas within the study area to protect wildlife habitat, potentially unstable slopes, and erosion-sensitive gullies.

.10 Only deficiencies with major drainage routes have been specifically identified in this study; there are numerous minor works located within currently developed areas that do not function adequately. An annual budget should be developed to systematically inspect and remedy these minor deficiencies, which include:

- poorly defined ditches;
- partially buried or damaged culvert inlets and outlets;
- lack of curbs on road edges (runoff erodes shoulder and passes through private property prior to entering ditches);
- clogged dry wells and catch basin inlets;

- isolated low spots that require well-defined channels to major routes to prevent property damage from runoff generated by major storms.

.11 The Regional District and the Ministry of Transportation and Highways should develop a clearer understanding of each other's role in stormwater management. Responsibility for:

- long range planning,
- design reviews and approvals,
- periodic inspection and maintenance, and
- funding

must be clearly defined and pursued by these organizations.

.12 The Regional District should proceed to refine the capital cost recovery methodology with ongoing assistance of the Ministry of Transportation and Highways. The suggested mechanism for each group of improvements is as follows:

- Existing Deficiencies to be funded by a Regional District specified area bylaw.

- New Development to be funded initially by a developer "gifting" agreement, and ultimately by a development cost charge bylaw.

This issue must be addressed as part of the Lake Country Municipality negotiations.

.13 The Regional District should seriously consider purchasing Lot 6 in Basin 23 to allow construction of a major drainage route to the lake. If purchase of this lot is not possible, no building permits should be issued for it until an agreement with the owner has been reached to provide an adequate drainage channel.

APPENDIX A

TYPICAL MANNING ROUGHNESS COEFFICIENTS	
CLOSED CONDUITS	**Manning "n" Range**
Concrete pipe and box	0.012
Corrugated steel pipe or pipe arch • Unpaved • 100% Paved	 0.024 0.012
PVC (smooth)	0.011
LINED OPEN CHANNELS	**Manning "n" Range**
Concrete • Formed, no finish	 0.013 - 0.017
Gravel bottom sides • Formed concrete • Dry rubble (rip-rap)	 0.017 - 0.020 0.023 - 0.033
Asphalt • Rough	 0.016
UNLINED OPEN CHANNELS	**Manning "n" Range**
In clean gravelly/soil, uniform section	0.022 - 0.025
Earth • Grass, some weeds • Sides clean, gravel bottom	 0.030 - 0.035 0.025 - 0.030
Channels not maintained, vegetation uncut: • Dense weeds, high as flow depth	 0.08 - 0.12
NATURAL STREAM CHANNELS	**Manning "n" Range**
Minor streams • Dense growth of weeds	 0.035 - 0.05

TYPICAL MANNING ROUGHNESS COEFFICIENTS	
HIGHWAY CHANNELS AND SWALES WITH MAINTAINED VEGETATION	**Manning "n" Range**
Depth of flow up to 0.20m: • Bermuda grass, Kentucky Bluegrass: • Length 0.10 to 0.15m • Length about 0.30m • Length about 0.60m	 0.050 - 0.090 0.090 - 0.180 0.150 - 0.300
Depth of flow up to 0.20 to 0.45m: • Bermuda grass, Kentucky Bluegrass: • Length 0.10 to 0.1m • Length about 0.30m • Length about 0.60m	 0.040 - 0.060 0.070 - 0.120 0.100 - 0.200
STREET AND EXPRESSWAY GUTTERS	**Manning "n" Range**
Concrete gutter, trowelled finish	0.012
Asphalt pavement: • Rough texture	 0.016
OVERLAND FLOW	
Dense turf	0.300 - 0.480
Dense shrubbery and forest litter	0.400
Concrete or asphalt	0.010 - 0.013
Gravelled surface	0.030 - 0.012
Bare clay-loam (eroded)	0.120 - 0.033
Range (natural)	0.010 - 0.320

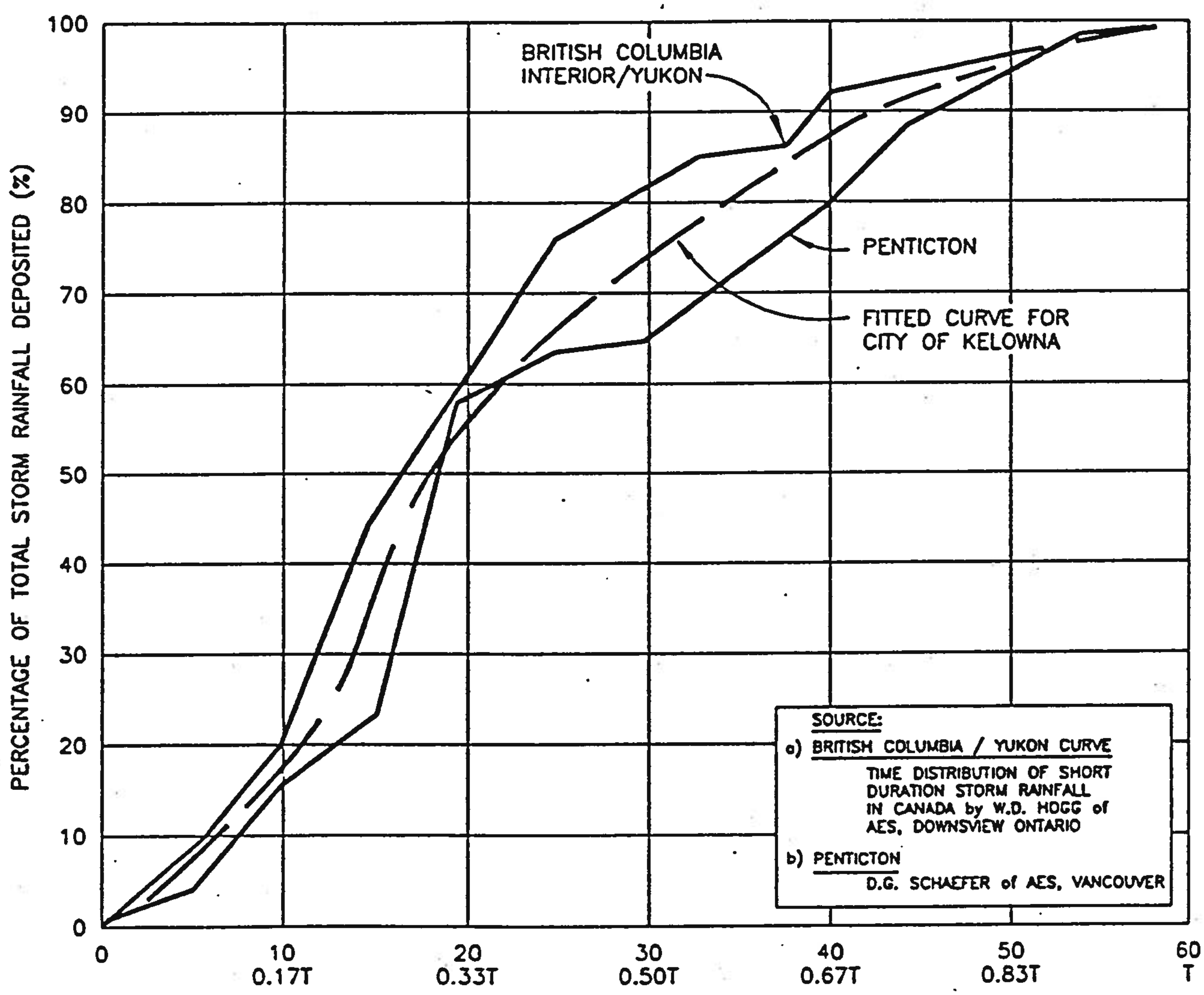
TABLE A-2

MAXIMUM RECOMMENDED VELOCITIES IN EARTH AND GRASS LINED CHANNELS			
EARTH - SOIL TYPE	**PERMISSIBLE VELOCITIES M/Sec**		
Fine Sand (noncolloidal)		0.5	
Sandy Loam (noncolloidal)		0.5	
Silt Loam (noncolloidal)		0.6	
Ordinary Firm Loam		0.9	
Fine Gravel		1.2	
Stiff Clay (very Colloidal)		1.4	
Graded Loam to Cobbles (noncolloidal)		1.4	
Graded, Silt to Cobbles (colloidal)		1.7	
Alluvial Silts (noncolloidal)		0.9	
Alluvial Silts (colloidal)		1.4	
Coarse Gravel (noncolloidal)		1.8	
Cobbles and Shingles		1.7	
Shales and Hard Pans		1.8	
GRASS LINED	**<0.5%**	**5 - 10%**	**>10%**
Erosion Resistant Soils	1.2	0.9	0.7
Highly Erodible Soils	0.9	0.7	0.5

Note: A variety of values for each soil type are recommended by various authors. The above values are more conservative for soil types considered highly erosive.

FIGURE A-1

CURVES SHOW THAT 50 % OF SELECTED ONE HOUR STORM RAINFALL EVENTS DEPOSIT A CERTAIN PERCENTAGE OF TOTAL STORM RAINFALL IN A SPECIFIED TIME PERIOD

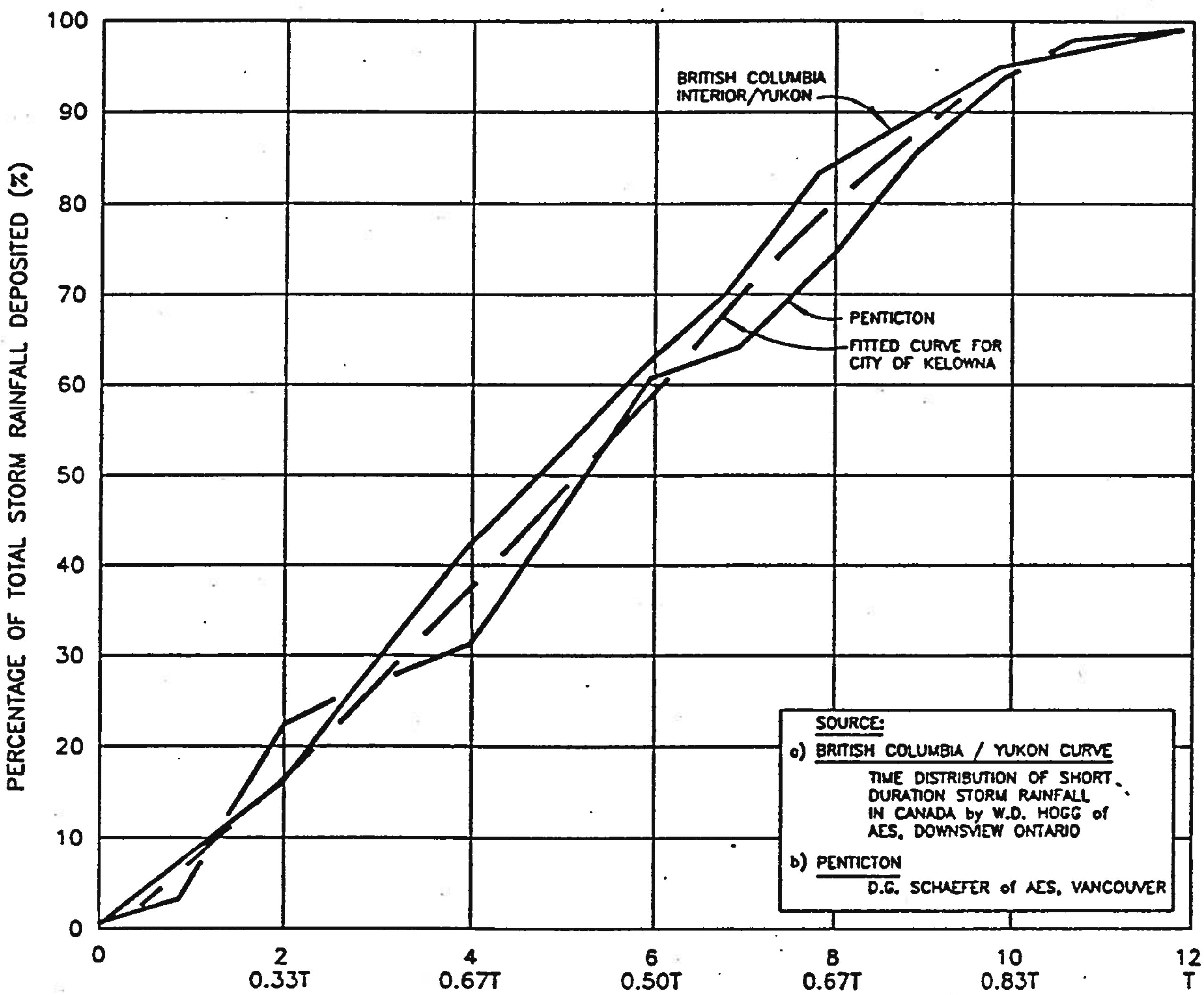


1 HOUR STORM FOR ≥ 6 HOUR (SHORT STORMS) RAIN DISTRIBUTION PATTERN

Source: City of Kelowna Stormwater Management Policies and Design Manual.

FIGURE A-2

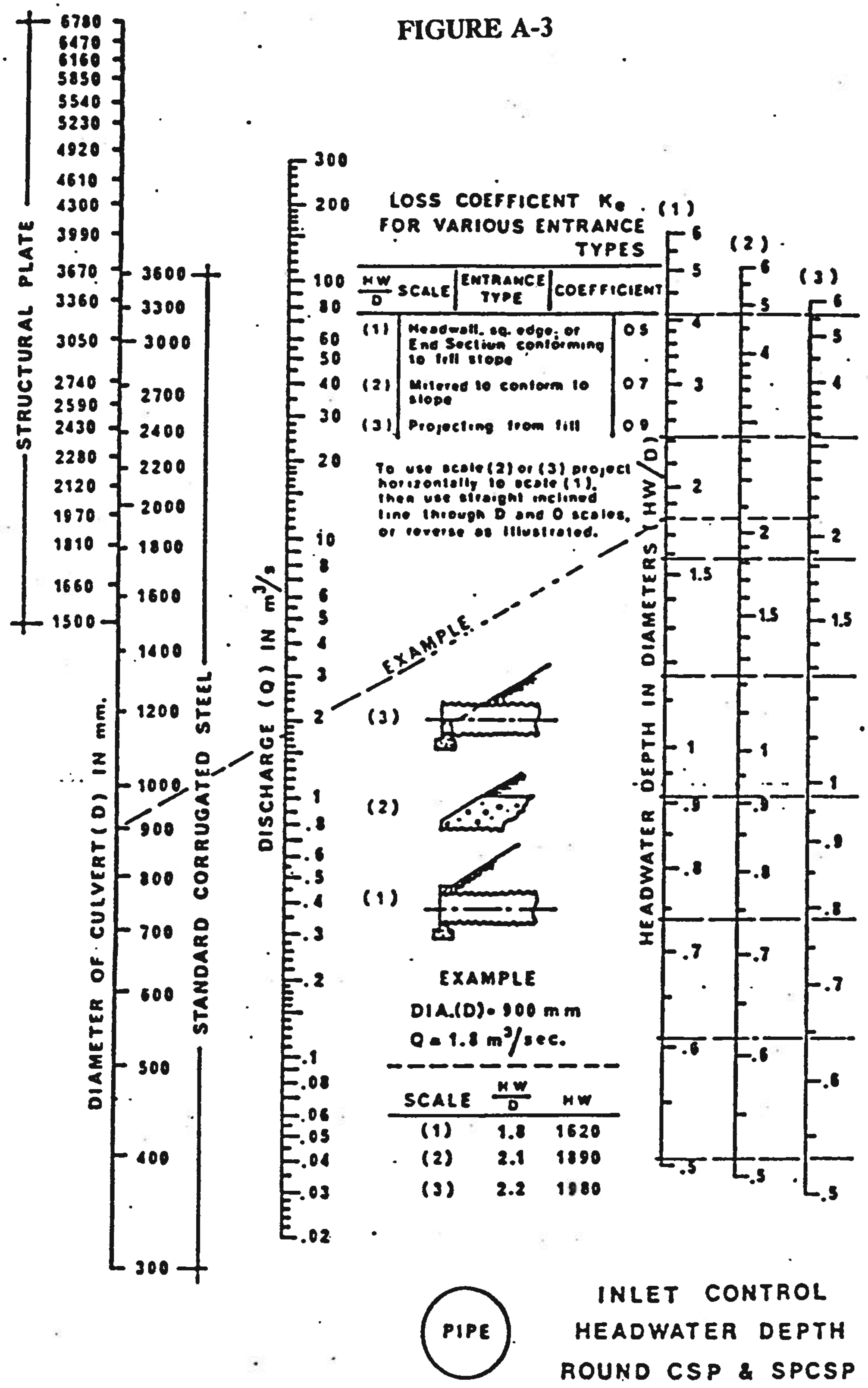
CURVES SHOW THAT 50 % OF SELECTED ONE HOUR STORM RAINFALL EVENTS DEPOSIT A CERTAIN PERCENTAGE OF TOTAL STORM RAINFALL IN A SPECIFIED TIME PERIOD



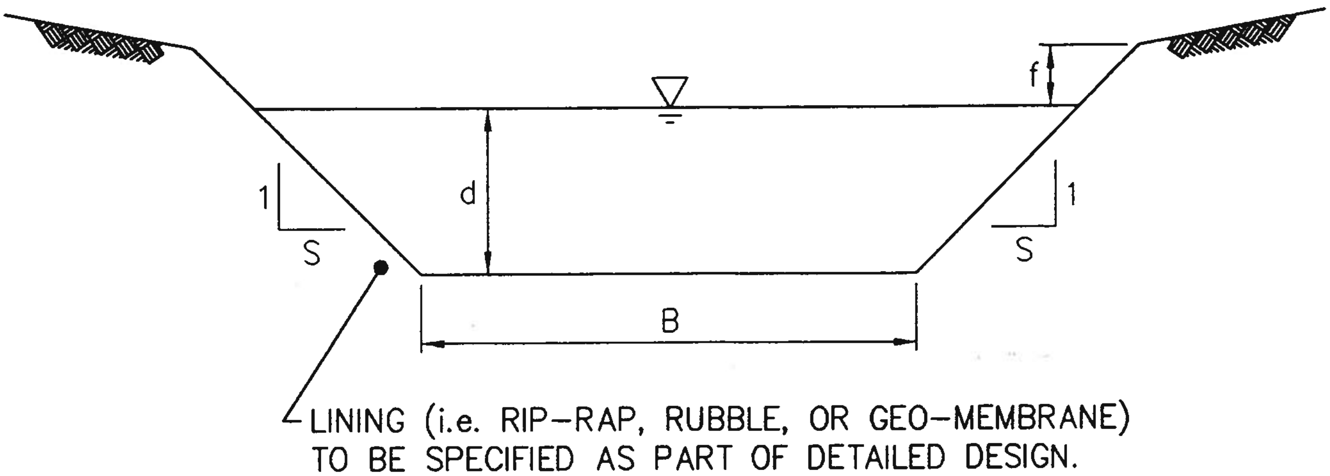
12 HOUR STORM FOR > 6 HOUR(LONG STORMS) RAIN DISTRIBUTION PATTERN

Source: *City of Kelowna Stormwater Management Policies and Design Manual.*

FIGURE A-3



Inlet control nomograph for corrugated steel pipe culverts. The manufacturers recommend keeping HW/D to a maximum of 1.5 and preferably to no more than 1.0. Data is derived from nomographs published by the Bureau of Public Roads.[9]



TYPE	B(m)	S(m)	d(m)	f
I	0.3	1.0	by design	0.3
II	0.5	1.5	by design	0.3
III	1.0	1.5	by design	0.3

URBAN SYSTEMS

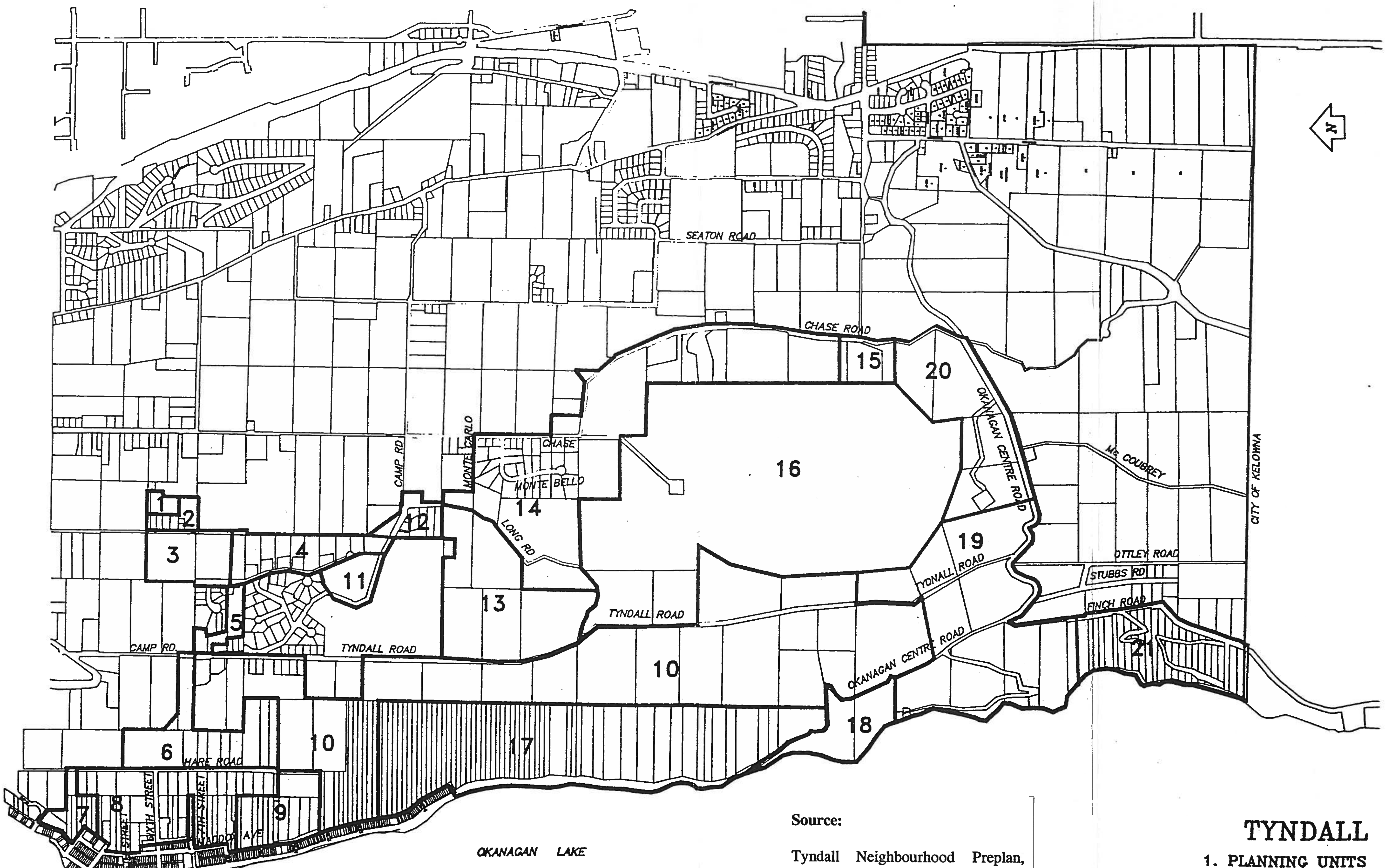
REGIONAL DISTRICT OF CENTRAL OKANAGAN

TYNDALL ROAD & AREA MASTER DRAINAGE PLAN TYPICAL CHANNEL IMPROVEMENTS

JOB No. 1.1179.13.1

SCALE: NTS

FIGURE A-4



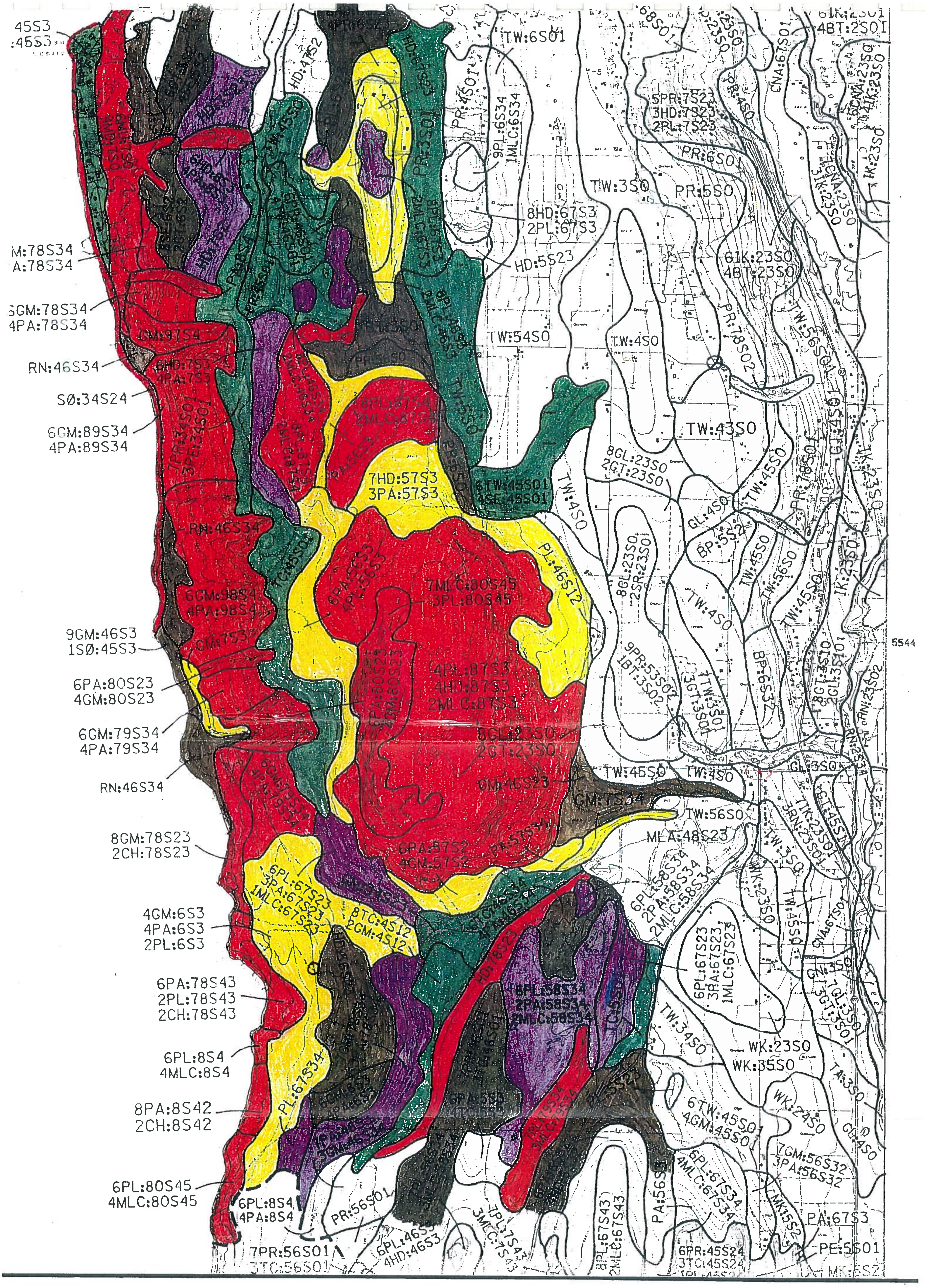
Source:

Tyndall Neighbourhood Preplan,
I.D. Systems Ltd.
2nd Draft: July 16, 1993

TYNDALL

1. PLANNING UNITS

Figure **A-5**



MINISTRY of ENVIRONMENT
SOIL CAPABILITY MAPPING

UNITS: ACRE

Figure **A-6**

3:1 | 2:1 | 1:1 | 1:2 | UNSUITABLE

APPENDIX B

DRAINAGE STUDY
TYNDALL ROAD - OKANAGAN CENTRE
HYDROGEOLOGICAL INVESTIGATION

Report
to
REGIONAL DISTRICT OF CENTRAL OKANAGAN
Kelowna, B.C.

Terratech Western Profile Consultants Ltd.
Salmon Arm, B.C.

R.T. PACK, P. Eng.
Review Engineer

23 March 1994
File: 503-10

R.J. NEDEN, P. Eng.
Project Engineer

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
R. J. NEDEN
23 March 1994

terratech
WESTERN PROFILE

TABLE OF CONTENTS

1.0 INTRODUCTION

This report presents the results of a hydrogeological investigation in the area of Tyndall Road and Okanagan Centre. The purpose of the work is to characterize the soil and groundwater conditions that may affect future development and drainage requirements. The study is limited to the area shown on Figure 1. We understand that the results of this study will form part of the overall Master Drainage Study being performed for the Regional District of Central Okanagan by Urban Systems Ltd. and that the comments and recommendations presented would be used as guidelines for future sub-division development.

The objective of this study was to investigate the distribution of soil, bedrock and groundwater conditions. This report provides recommendations for infiltration capacities for use in area-wide run-off projections and for mitigation of potential problems in these areas.

This investigation was verbally authorized on 4 January 1994 by Mr. G. Zachary, P. Eng. of Urban Systems Ltd. on behalf of the Regional District of Central Okanagan.

Use of this report is subject to the Statement of General Conditions which is attached to this report. The reader's attention is specifically drawn to these conditions as it is considered essential that they be followed for the proper use and interpretation of this report.

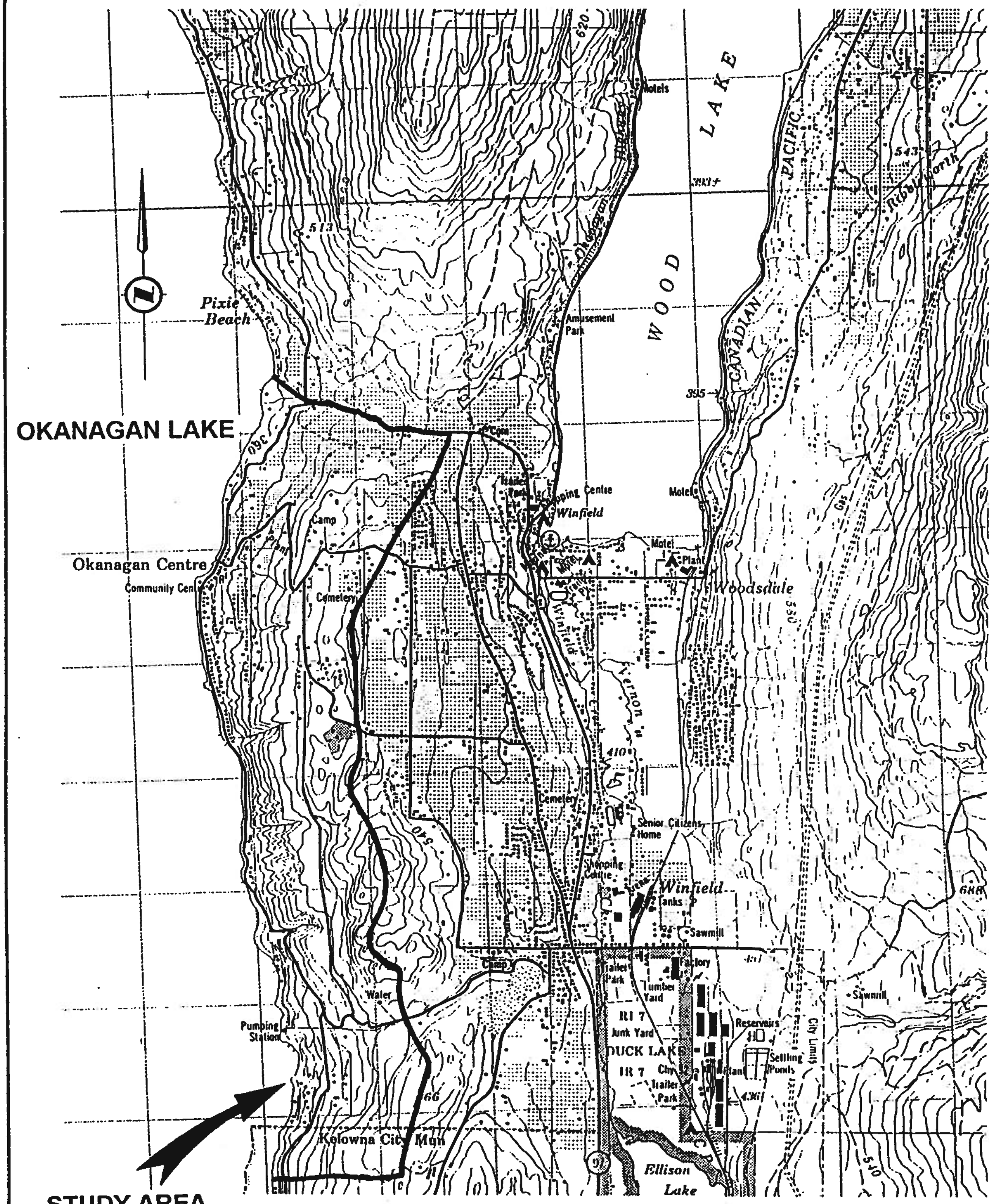
2.0 METHODOLOGY

The procedure followed consisted of:

- review of existing topographic and surficial geology mapping,
- review and interpretation of existing aerial photographs,
- field mapping of soil deposits as indicated by road cut exposures, shallow hand-excavated pits and landforms,
- documentation of seepage areas and ponding areas,
- compilation of all data on maps and interpretation of this data to provide recommendations for mitigation of potential problems.

Existing information on the surficial geology was obtained from a report by Nasmith[*] .

[*] Nasmith, H.W. 1962. "Late Glacial History and Surficial Deposits of the Okanagan Valley, British Columbia" B.C. Ministry of Energy Mines and Petroleum Resources Bulletin 46.



Client
REGIONAL DIST. OF CENTRAL OKANAGAN

Title
LOCATION PLAN
TYNDALL RD.- OKANAGAN CENTRE DRAINAGE

Job No.	Date	
503-10	Mar '94	**FIGURE 1**

terratech WESTERN PROFILE

Black and white aerial photographs of the subject area, taken in May 1990, were examined to determine the geologic and topographic features of the study area. Photos examined include flight line BCB 90004, frames 117 to 122 inclusive.

After completion of the aerial photo interpretation work, field mapping of soil deposits and seepage areas was completed during February and March 1994.

3.0 SUBSOIL CONDITIONS

3.1 Regional Setting

The history of formation of surficial deposits of the area has been interpreted by Nasmith. Mapping by Nasmith indicates the north portions of the subject area to consist of glacial lake sediments, with outwash terraces immediately south and mixed unconsolidated deposits in the southern half of the study area, on the west side of the ridge.

3.2. Soil Units

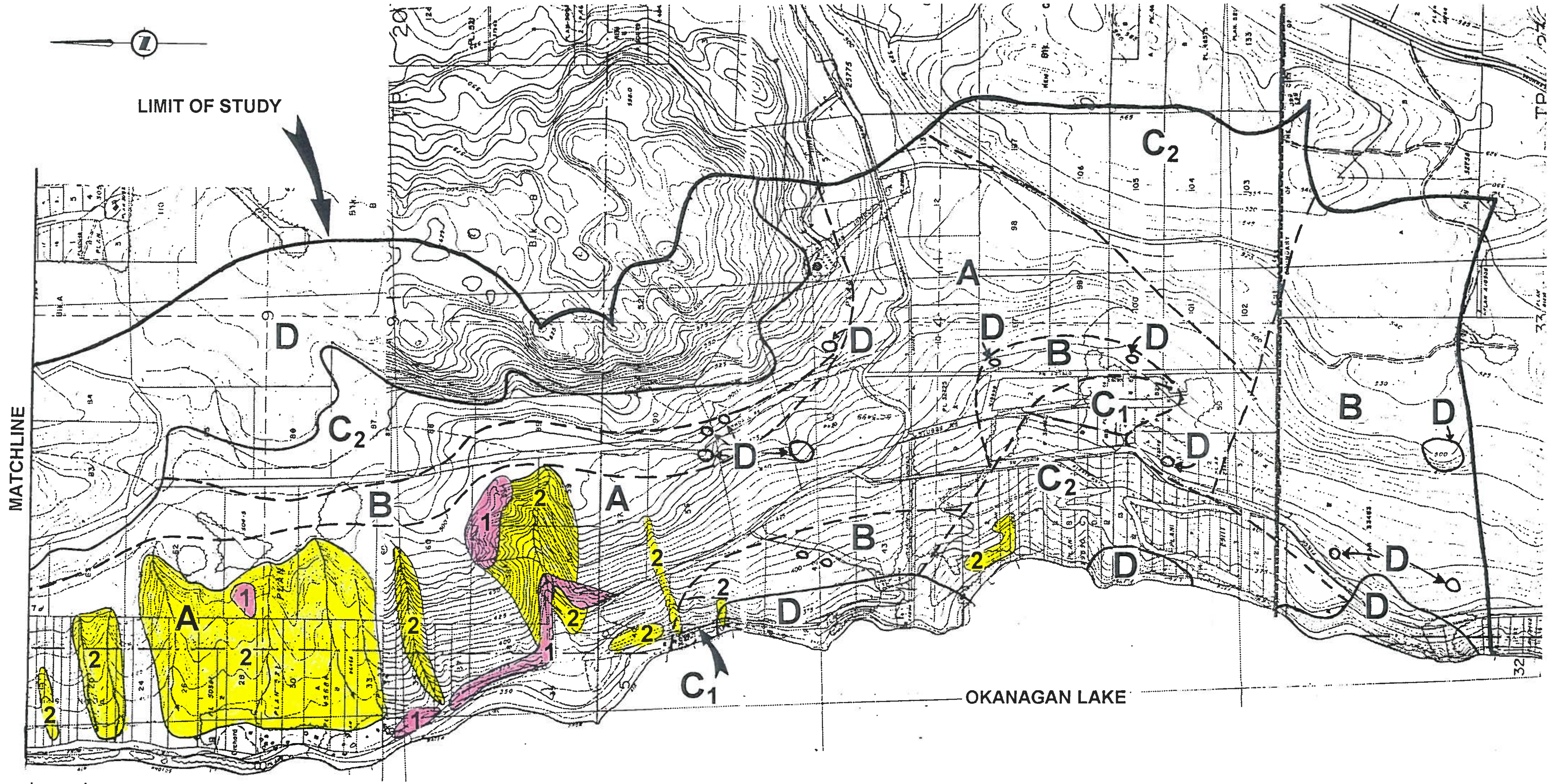
Based upon the investigation noted in Section 2.0 above, the subsoils of the study area has been separated into 4 groups, primarily on the basis of infiltration characteristics. The interpreted extent of these soil types are shown on Figures 2 and 3. General descriptions of these soil and bedrock types are given below:

Group A -- Deep fluvial and glacio-fluvial deposits of sands and gravels. These deposits are often interbedded and range from moderately coarse gravels to fine sands, but contain little silt. These deposits are expected to have high rates of infiltration.

Group B -- Fine sands containing a moderate amount of silt or deposits of Group A materials capped with a relatively shallow layer of silt or silty sand. These deposits are expected to have moderate rates of infiltration.

Group C -- Deposits of silt and sandy silt or soils with a shallow layer that would impede downward movement of water. This group has been sub-divided into C_1; glacio-lacustrine deposits of silt and C_2; basal moraine of dense silty sand, reworked silty moraine and areas of shallow bedrock or shallow basal moraine. These soils are expected to have slow rates of infiltration.

Group D -- Bedrock or very shallow bedrock. These materials are expected to have very slow rates in infiltration.



Legend

- Seepage
P - Ponding
- Area of anticipated high groundwater (not including Okanagan Lake)

Symbol	Soil Type	Infiltration Rate
A	Deep sands and gravels	High
B	Fine sand, some silt	Moderate
C	Silt, sandy silt, moraine	Slow
D	Bedrock, very shallow bedrock	Very Slow

Symbol	Erosion/Instability Potential
1	Active
2	High

NOTES:
1. Base drawing supplied by Urban Systems Ltd.
2. Boundaries shown are approximate only.

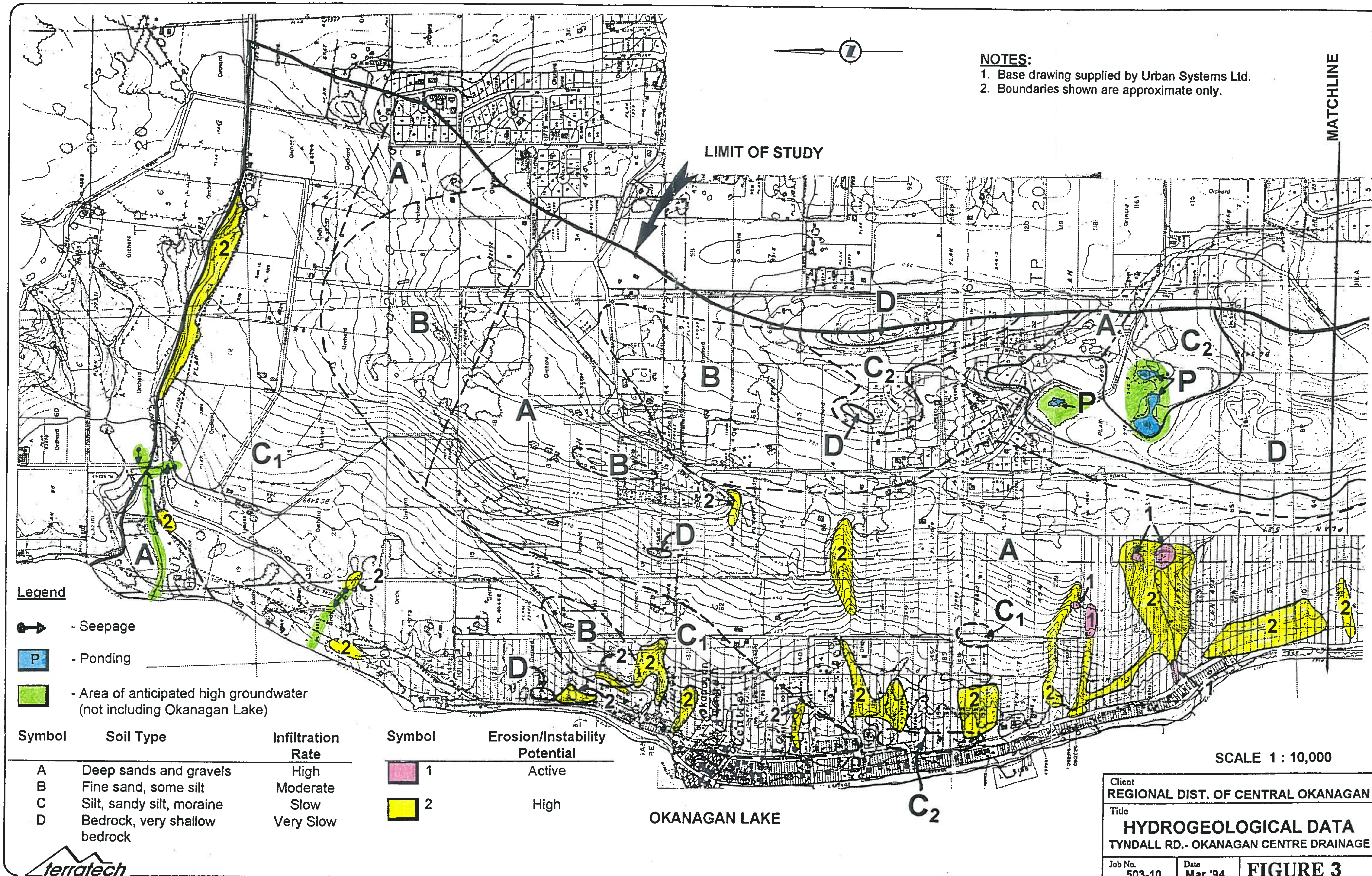
SCALE 1 : 10,000

terratech WESTERN PROFILE

Client
REGIONAL DIST. OF CENTRAL OKANAGAN

Title
HYDROGEOLOGICAL DATA
TYNDALL RD.- OKANAGAN CENTRE DRAINAGE

Job No. 503-10 | Date Mar '94 | FIGURE 2


NOTES:
1. Base drawing supplied by Urban Systems Ltd.
2. Boundaries shown are approximate only.
MATCHLINE
LIMIT OF STUDY
OKANAGAN LAKE
SCALE 1 : 10,000
Legend
- Seepage
P - Ponding
- Area of anticipated high groundwater (not including Okanagan Lake)
Symbol | Soil Type | Infiltration Rate
A | Deep sands and gravels | High
B | Fine sand, some silt | Moderate
C | Silt, sandy silt, moraine | Slow
D | Bedrock, very shallow bedrock | Very Slow
Symbol | Erosion/Instability Potential
1 | Active
2 | High
Client
REGIONAL DIST. OF CENTRAL OKANAGAN
Title
HYDROGEOLOGICAL DATA
TYNDALL RD.- OKANAGAN CENTRE DRAINAGE
Job No. 503-10
Date Mar '94
FIGURE 3
terratech WESTERN PROFILE

4.0 GROUNDWATER CONDITIONS

4.1 Seepage

Two adjacent zones of seepage were observed near the junction of Carr's Landing Road and Okanagan Centre Road West, as shown on Figure 3, attached. This seepage is likely due to water transmitted by sand layers between siltier layers. Another zone of seepage was also noted on Okanagan Centre Road West, approximately 0.5 km southwest of the above-noted intersection as shown on Figure 3, attached. This flow is at the downstream end of a ditch collecting water near an orchard. The flow crosses under the road (through a culvert) and flows in a gentle swale downslope.

4.2 Ponding

Three closely adjacent areas of ponding were observed adjacent to Camp Road near the top of the ridge, as shown on Figure 3, attached. This ponding is in local depressions in low permeability (C_2) soils or where there is little soil over bedrock (D).

5.0 GENERAL ENGINEERING INTERPRETATION

5.1 Infiltration Characteristics of Soils

Infiltration characteristics of each soil group have been estimated for the purposes of computer simulation of the infiltration and run-off of the study area. These characteristics are summarized on Table 1.

TABLE 1

INFILTRATION CHARACTERISTICS OF SITE SOILS

SOIL GROUP	A	B	C	D
Soil Classification	Deep Sands and Gravels	Fine Sands, some silt or shallow silt cap	Silt, sandy silt, basal moraine, silty reworked moraine	Bedrock, very shallow bedrock
% Fines (silt and clay)	≤ 15	20 - 30	35 +	N.A.
Infiltration Rate	High	Moderate	Slow	Very Slow
* f_o (cm/s) * f_c (cm/s) * k (sec^{-1})	10^{-1} to $5x10^{-2}$ 10^{-1} to $5x10^{-3}$ (1 to 3) x 10^{-4}	(5 to 1) x 10^{-3} $5x10^{-3}$ to $5x10^{-4}$ (3 to 6) x 10^{-4}	10^{-4} to $5x10^{-5}$ 10^{-4} to 10^{-6} (0.7 to 2) x 10^{-3}	$5x10^{-6}$ 10^{-6} (3 to 5) x 10^{-3}

* Notes:

- Parameters of the Horton Infiltration Equation $f_p = f_c + (f_o - f_c)\, e^{-kt}$ where:

  f_p = infiltration rate of soil at time, t

  f_c = ultimate (minimum) infiltration rate of soil

  f_o = initial (maximum) infiltration rate of dry soil with little or no vegetation

  k = decay coefficient

- These infiltration rates are approximate only and should not be used for design of specific construction projects.

5.2 Groundwater Assessment

As noted in Section 4.0, seepage and ponding of water was noted in a few fairly localized areas. High groundwater levels can be expected near these areas and adjacent to the creek flowing downslope of Carr's Landing Road and near the flood level of Okanagan Lake. Difficulties with foundation drainage, septic field operation and discharge of roof runoff to dry-wells can be expected in these areas. Hence buildings, septic fields and dry-wells may not be suitable in these areas and would require site-specific investigation.

Poor performance of septic systems can also be expected in and near Group D (very shallow bedrock) areas.

In Group C (silty) soils, there could also be difficulties with septic fields and residential dry wells, depending upon the thickness of silt and the presence or absence of sand at the specific site. Site specific testing should be undertaken in these areas.

If more major discharges of water to the ground are contemplated, site specific investigations should be conducted to evaluate the suitability of the site with regard to infiltration capacity and slope stability.

5.3 Erosion and Slope Instability

As shown on Figures 2 and 3, several areas of active erosion have been observed on the air photos and/or on site. These locations are all on steep gulley slopes, road cuts or in road ditches. These active erosion/instability features are in materials varying from silts to bedded sands and gravels.

A small amount of erosion was noted in the ditch adjacent to Okanagan Centre Road in the gulley at the north end of the study area. The rip-rap observed in the ditch was too coarse to prevent erosion of the underlying silt and fine sand.

In addition, Figures 2 and 3 show the location of areas that have a high potential for erosion or instability in the future. Erosion can also occur on the more level areas where water flow is more concentrated. Erosion of the site soils can be expected when the water velocity exceeds approximately 0.3 m/sec. (1fps). Hence the velocity predicted by the computer analysis can be used to predict areas of potential erosion due to over-land flow.

6.0 CONCLUSIONS

The soils of the subject area are interpreted as resulting from glacial, glacio-fluvial, glacio-lacustrine and fluvial depositional environments. As a result, the particle sizes and infiltration characteristics can vary widely, as indicated by Table 1.

These environments of deposition can also result in very mixed materials. The areas defined on Figures 2 and 3 are for the purposes of this study only and are very general. These maps should not be used for zoning and development approvals as each and every location has not been field verified. More detailed geotechnical evaluations should be undertaken for specific sites as they are proposed for development.

Difficulties with disposal of water to the ground may be encountered in areas of soil Groups C and D. A few areas of high groundwater levels were also noted that could result in difficulties with disposal of water to the ground.

Areas of active erosion or slope instability are noted on Figure 2 and 3. More extensive areas of high potential for future erosion or instability are also shown on Figures 2 and 3.

STATEMENT OF GENERAL CONDITIONS

1. STANDARD OF CARE

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area. No other warranty, expressed or implied is made.

2. BASIS OF THE REPORT

This report has been prepared for the specific site, design objective, development and purpose that was described to Terratech Western Profile Consultants Ltd. (TWPCL) by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the report are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to TWPCL, unless TWPCL is specifically requested by the Client to review and revise the report in light of such alteration or variation.

3. USE OF THE REPORT

The information and opinions expressed in this report are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THIS REPORT OR ANY PORTION THEREOF WITHOUT TWPCL'S EXPRESS WRITTEN CONSENT. TWPCL WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTY(S) AS APPROVED USERS. The contents of this report remain the copyright property of TWPCL, who authorizes only the Client and Approved Users to make copies of the report, and only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof, or any copy of the report or portion thereof, to any other party without the express written permission of TWPCL.

4. COMPLETE REPORT

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to TWPCL by the Client, communications between TWPCL and the Client, and to any other reports prepared by TWPCL for the Client relative to the specific site described in the report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS, AND OPINIONS EXPRESSED IN THE REPORT, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. TWPCL CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

5. INTERPRETATION OF THE REPORT

(a) Nature and Exactness of Soil Description: Classification and identification of soils, rocks, and geologic units have been based upon commonly accepted methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from these systems have been used, they are specifically mentioned. Classification and identification of the type and condition of soils, rock and geologic units are judgmental in nature. Accordingly, TWPCL cannot warrant or guarantee the exactness of the descriptions of insitu ground conditions set forth in the Report.

(b) Logs of Test Holes, Pits, Trenches, etc.: The test hole logs are a record of information obtained from field observations and laboratory testing of selected samples as well as an interpretation of the likely subsurface stratigraphy at the test hole sites. In some instances normal sampling procedures do not recover a complete or any sample. Soil, rock, or geologic zones have been interpreted from the available

TABLE 2

SITE SOIL DATA

SOIL GRP.	TEST NO.	DEPTH (ft.)	EST. GRAIN SIZE (%) >3"	GRAVEL	SAND	FINES	UNIF. CLASS.	GENETIC MAT'L M	F^G	L^G	?	COMMENTS
B	1	3	10	10	50	30	SM_3		✓			12' cut
C	2	2	5	10	45	40	SM_4	✓				12' cut
A	3	1	10	20	65	5	SW		✓			5' cut
A	4	0-7	-	25	70	5	SP		✓			house exc. - some bedding
C	5	1	-	-	10	90	ML-CL			✓		
B	6	0.5	-	10	70	20	SM_2		✓			fine sand
A	7	10	10	30	50	10	SM_1		✓			12' cut
B	8	7	5	25	40	30	SM_3	?	?			10' cut, compact
C	9	6	10	20	40	30	SM_3	✓				dense, grey below 5', (same above 5', but brown), 10' cut, overlain by looser mat'l
A	10	7	10	40	40	10	SP-GP		✓			8' cut loose
A	11	2	15	45	35	5	GW		✓			20' cut; invert slope (gulley) ≈ 23° - minor inv. erosion
A	12						GP		✓			Bedded gravel & sand (or little silt) ravelling slopes on gulley to NE
C	13	2	5	10	25	60	ML		?			3' cut
B	14	1	5	25	50	20	SM_2		✓			native ground surface
B?	15	1.5	-	5	45	50	ML- SM_4		✓			native ground surface
C	16	1.5	-	10	50	40	SM_4		✓			native ground surface
A?	17	2	-	25	60	15	SM_1		✓			2' cut
B	18	2-5	-	30	50	20	SM_2		✓			10' road cut
B	19	3	-	10	60	30	SM_3		✓			3' road cut, fine sand
A	20	1-5	-	30	60	10	SM_1		✓			6' road cut
A	21	1-4	-	10	80	10	SM_1		✓			4' road cut
C	22	1-3	5	25	40	30	SM_3	✓				4' road cut
A?	23	1-5	10	50	40	-	GP		✓			
B	24	1-2	-	20	60	20	SM_2		✓			
B	25	1-2	-	10	75	15	SM_1		✓			
NA	26											Slight evidence of bed erosion in past (a few cobbles in invert), 15' cut
A	27	2-5	-	30	70	-	SP		✓			
C	29	2-3	-	-	20	80	CL		?	?		
A	30	2-3	10	20	60	10	SM_1		✓			
A	31	1-2	-	45	50	5	SP-GP		✓			
C	32	3-4	-	-	10	90	ML-CL		?	?		5' road cut
A	33	1-4	-	30-60	40-70	-	SP-GP		✓			25'-30' road cut, ravelling
A	34	1-3	10	40	50	-	SP		✓			ravelling cut slopes
A	35	1-3	10	40	40	10	SM_1		✓			4' road cut
A	36	1-15	10	40	35	15	GM-SM_1		✓			15' road cut -bedded S&G
C	37	0-1.5 1.5-9	- -	- 30	20 45	80 25	ML SM_2		 ✓	? 		9' road cut

TABLE 2 cont'd

SOIL GRP.	TEST NO.	DEPTH (ft.)	EST. GRAIN SIZE (%) >3"	GRAVEL	SAND	FINES	UNIF. CLASS.	GENETIC MAT'L M	F^G	L^G	?	COMMENTS
A	38	0-6	10	25	50	15	SM_1		✓			6' cut
C	39	0-8	-	-	30	70	ML			?	C	low-non plastic, some rounded
											?	gravel lower in deposit
C	40	0-6	10	20	50	20	SM_2	?				Ablation-unsorted over fine sand
C	41	0-5	-	-	30	70	ML			?		
		5-7	-	10	80	10	SM_1		?			
C	42	0-5	-	-	20	80	ML			?		few thin layers CL road cut
		5-15	15	30	45	10	SM_1		✓			
B	43	0-10	5	25	40	30	SM_3		?			Outwash? road cut
C	44	0-5	-	-	10	90	ML			?		some CL, road cut
A	45		15	30	45	10	SM_1		✓			
A	46	0-6	10	20	60	10	SM_1		✓			road cut
B?	47	0-3	-	10	50	40	SM-ML		?			road cut
		3-8	10	40	40	10	SM_1		✓			road cut
A	48	0-8	10	30	50	10	SM_1		✓			road cut
A	49	0-3	-	10	85	5	SP		✓			road cut
A	50	0-5	5	20	60	15	SM_1		✓			road cut
B	51	0-3	5	20	55	20	SM_2		✓			road cut
A	52	0-2.5	-	10	85	5	SP		✓			shovel pit
A	53	0-2	-	10	70	20	SM_2		✓			shovel pit
		2-8	5	20	70	5	SP		✓			shovel pit
B	54	0-1.5	-	-	70	30	SM_3		✓			shovel pit
C	55	1-4	-	-	30	70	ML(NP)			?		road cut
		4-5	-	80	20	-	GP		✓			road cut
C	56	0-20	-	-	20	80	ML(NP)			?		road cut
C	57	0-10	-	-	20	80	ML			✓		shovel pits on cut - finely bedded
C	58	0-6	-	-	20	80	ML(NP)			✓		road cut
C	59	2-3.5	-	-	10	90	ML(NP)			✓		road cut
C	60	0-15	-	-	10	90	ML(NP)			✓		road cut
C	61	0-8	-	-	50	50	ML/SM_4			?		layers of ML & SM_4
C	62	0-6	-	-	20	80	ML(NP)			?		road cut
		6-20	10	40	40	10	SM_1		✓			
C	63	0-5	-	-	40	60	ML		?	?		road cut
		5-10	-	10	70	20	SM_2		✓			
C	64	0-10	-	-	55	45	SM_4 (fine)		?			road cut
		10-25	-	-			SM_2 /ML-CL		?			layered sand and silts
C?	65	0-2	5	20	30	45	ML		?	?		1.5' shovel pit
C?	66	0-1.5	-	15	30	55	ML		?	?		1.5' shovel pit
C	67	0-1.5	-	-	60	40	SM_4		✓			road cut
B	68	0-4	-	5	85	10	SM_1		✓			bldg. cut
		4-5	-	-	10	90	ML			?		
B	69	0-1.5	-	20	50	30	SM_3		✓			road cut
C	70	0-1.5	-	-	10	90	ML			✓		small cut
A?	71	0-3	5	30	45	20	SM_2		✓			road cut

TABLE 2 cont'd

SOIL GRP.	TEST NO.	DEPTH (ft.)	EST. GRAIN SIZE (%)				UNIF. CLASS.	GENETIC MAT'L				COMMENTS
			>3"	GRAVEL	SAND	FINES		M	F^G	L^G	?	
A	73	0-1.5	5	40	40	15	SM_1		?			Fluvial?
A	74	0-2	5	45	40	10	SM_1		?			Fluvial?
B	75	0-2	5	30	35	30	SM_3		✓			road cut
C	76	0-4	5	15	30	50	ML	?				reworked moraine?
		4-6	5	40	50	5	SP-GP		✓			bedded; from gravel to fine sand
C?	77	0-2	-	5	50	45	ML-SM		?	?		shovel pit
A	78	0-2	-	-	90	10	SM_1		✓			shovel pit
B	79	0-2	-	10	70	20	SM_2		?			shovel pit
B	80	0-2	-	-	90	10	SM_1		?			shovel pit; likely shallow

APPENDIX C

Table C−1

Selected MIDUSS Analysis Results

Peak Overland Flows

Basin	Existing Conditions				Developed Conditions			
	15 min	30 min	1 hr	2hr	15 min	30 min	1 hr	2hr
105	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
104	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.001
103	0.020	0.021	0.017	0.012	0.016	0.015	0.015	0.012
102	0.003	0.004	0.003	0.002	0.027	0.025	0.025	0.020
101	0.345	0.412	0.455	0.445	0.345	0.412	0.455	0.445
201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
301	0.098	0.128	0.144	0.139	0.098	0.128	0.144	0.139
401	0.012	0.012	0.011	0.009	0.034	0.032	0.031	0.025
505	0.006	0.005	0.005	0.004	0.006	0.005	0.005	0.004
504	0.000	0.000	0.000	0.000	0.005	0.004	0.004	0.003
503	0.010	0.009	0.009	0.007	0.016	0.015	0.015	0.012
502	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
501	0.010	0.009	0.009	0.007	0.015	0.014	0.014	0.011
601	0.024	0.022	0.022	0.017	0.029	0.027	0.027	0.021
701	0.010	0.009	0.009	0.007	0.022	0.020	0.020	0.016
804	0.031	0.030	0.029	0.023	0.028	0.027	0.026	0.021
803	0.011	0.011	0.011	0.008	0.011	0.011	0.011	0.008
802	0.016	0.015	0.015	0.012	0.062	0.058	0.058	0.045
801	0.008	0.007	0.007	0.006	0.010	0.009	0.009	0.007
903	0.010	0.009	0.009	0.007				
902	0.000	0.000	0.000	0.000	0.026	0.024	0.024	0.019
901	0.040	0.038	0.037	0.029	0.046	0.044	0.043	0.034
1003	0.000	0.000	0.000	0.000	0.010	0.009	0.009	0.007
1002	0.000	0.000	0.000	0.000	0.033	0.031	0.031	0.024
1001	0.006	0.006	0.005	0.004	0.006	0.006	0.005	0.004
2106	0.000	0.000	0.000	0.000	0.008	0.008	0.008	0.006
2105	0.072	0.091	0.080	0.037	0.077	0.095	0.083	0.039
2104	0.004	0.000	0.000	0.000	0.045	0.041	0.041	0.032
2103	0.000	0.000	0.000	0.000	0.083	0.079	0.078	0.061
2102	0.033	0.043	0.050	0.049	0.037	0.045	0.052	0.051
2101	0.000	0.000	0.000	0.000	0.044	0.042	0.041	0.033
2306	0.139	0.193	0.217	0.212	0.242	0.282	0.296	0.279
2303	0.000	0.000	0.000	0.000	0.046	0.044	0.043	0.034
2304	0.000	0.000	0.000	0.000	0.054	0.051	0.050	0.039
2305	0.000	0.000	0.000	0.000	0.049	0.047	0.046	0.036
2302	0.004	0.003	0.003	0.003	0.017	0.016	0.016	0.013
2301	0.000	0.000	0.000	0.000	0.025	0.024	0.023	0.018
2300	0.000	0.000	0.000	0.000	0.006	0.005	0.005	0.004
2401	0.000	0.000	0.000	0.000	0.015	0.014	0.014	0.011
2400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1000	0.013	0.013	0.012	0.010	0.029	0.028	0.027	0.022
2000	0.000	0.000	0.000	0.000	0.019	0.018	0.018	0.014
3000	0.002	0.002	0.002	0.002	0.069	0.065	0.064	0.051

Table C−2

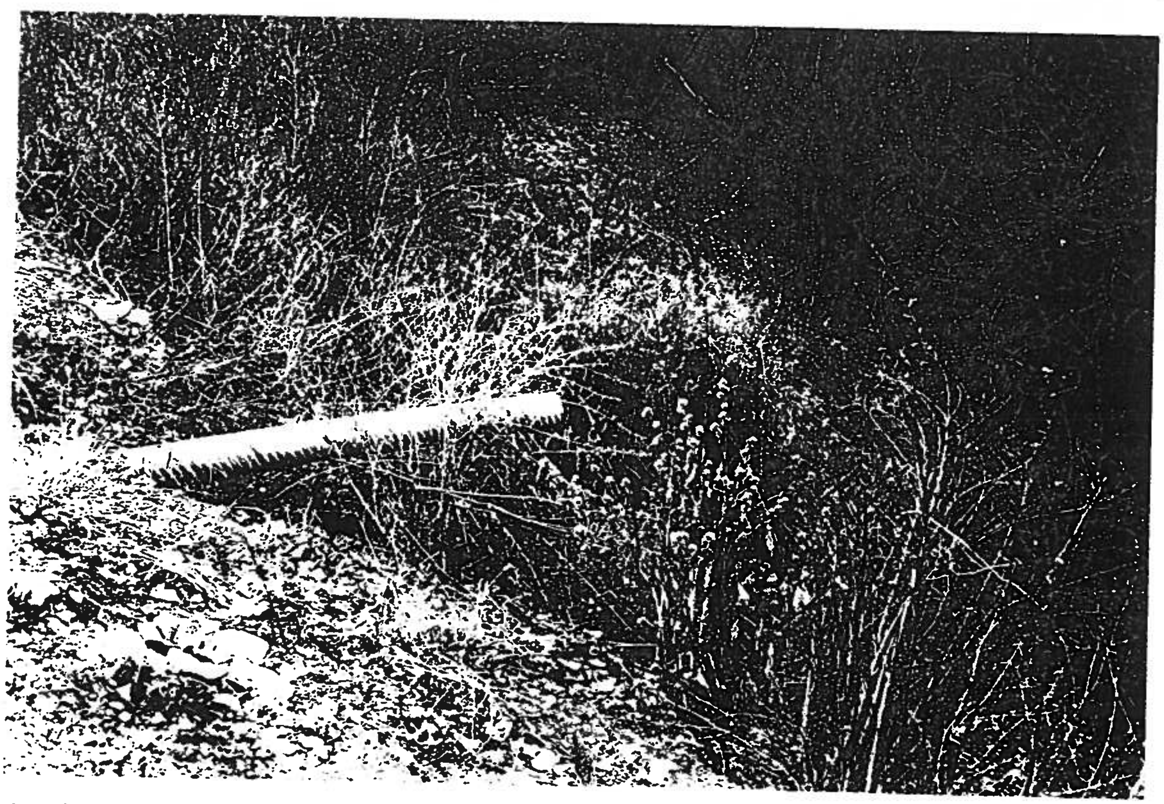
Selected MIDUSS Analysis Results

Peak Junciton Flows

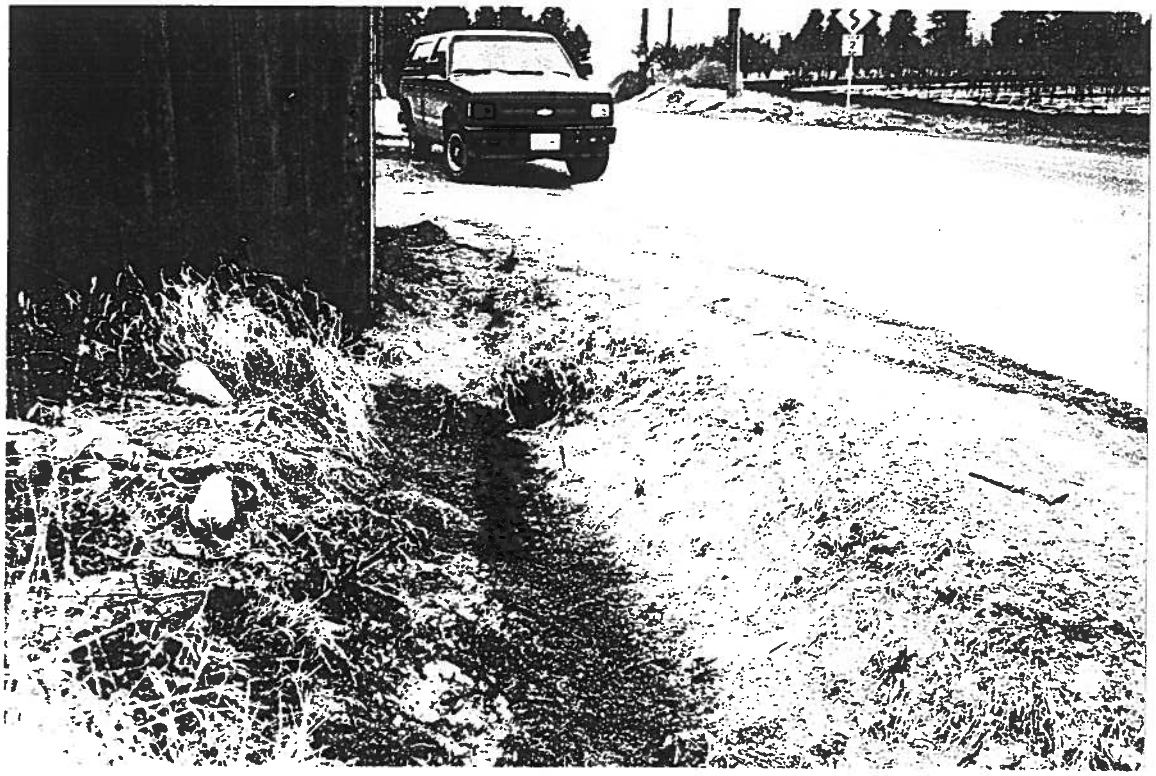
	Existing Conditions				Developed Conditions			
Basin	15 min	30 min	1 hr	2hr	15 min	30 min	1 hr	2hr
105	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
104	0.004	0.004	0.004	0.003	0.004	0.004	0.003	0.003
103	0.020	0.021	0.017	0.012	0.016	0.015	0.015	0.012
102	0.023	0.023	0.021	0.014	0.033	0.034	0.033	0.028
101	0.348	0.415	0.463	0.452	0.357	0.421	0.469	0.457
201	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
301	0.098	0.128	0.144	0.139	0.098	0.128	0.144	0.139
401	0.012	0.012	0.011	0.009	0.034	0.032	0.031	0.025
505	0.006	0.005	0.005	0.004	0.006	0.005	0.005	0.004
504	0.005	0.005	0.005	0.004	0.009	0.009	0.009	0.007
503	0.010	0.009	0.009	0.007	0.016	0.015	0.015	0.012
502	0.010	0.010	0.009	0.007	0.016	0.017	0.016	0.012
501	0.013	0.012	0.012	0.010	0.021	0.021	0.021	0.018
601	0.024	0.022	0.022	0.017	0.029	0.027	0.027	0.021
701	0.010	0.009	0.009	0.007	0.022	0.020	0.020	0.016
804	0.031	0.030	0.029	0.023	0.028	0.027	0.026	0.021
803	0.041	0.040	0.037	0.031	0.038	0.037	0.034	0.029
802	0.041	0.046	0.045	0.035	0.071	0.059	0.059	0.052
801	0.042	0.049	0.047	0.037	0.079	0.072	0.065	0.056
903	0.010	0.009	0.009	0.007				
902	0.010	0.010	0.009	0.007	0.026	0.024	0.024	0.019
901	0.042	0.038	0.037	0.029	0.052	0.047	0.045	0.042
1003	0.000	0.000	0.000	0.000	0.010	0.009	0.009	0.007
1002	0.000	0.000	0.000	0.000	0.034	0.031	0.031	0.024
1001	0.006	0.006	0.005	0.004	0.038	0.038	0.034	0.027
2106	0.000	0.000	0.000	0.000	0.008	0.008	0.008	0.006
2105	0.072	0.091	0.080	0.037	0.077	0.095	0.083	0.039
2104	0.004	0.000	0.000	0.000	0.045	0.041	0.041	0.032
2103	0.074	0.089	0.079	0.037	0.117	0.116	0.115	0.095
2102	0.033	0.043	0.050	0.049	0.037	0.045	0.052	0.051
2101	0.105	0.130	0.127	0.081	0.150	0.150	0.149	0.125
2306	0.139	0.193	0.217	0.212	0.242	0.282	0.296	0.279
2303	0.143	0.197	0.218	0.212	0.238	0.291	0.311	0.290
2304	0.139	0.192	0.217	0.211	0.238	0.290	0.320	0.302
2305	0.000	0.000	0.000	0.000	0.049	0.047	0.046	0.036
2302	0.139	0.191	0.216	0.212	0.235	0.288	0.331	0.316
2301	0.137	0.190	0.216	0.211	0.231	0.288	0.336	0.321
2300	0.137	0.190	0.215	0.211	0.229	0.287	0.336	0.322
2401	0.000	0.000	0.000	0.000	0.015	0.014	0.014	0.011
2400	0.000	0.000	0.000	0.000	0.015	0.015	0.014	0.011
1000	0.013	0.013	0.012	0.010	0.029	0.028	0.027	0.022
2000	0.000	0.000	0.000	0.000	0.019	0.018	0.018	0.014
3000	0.002	0.002	0.002	0.002	0.069	0.065	0.064	0.051

APPENDIX D

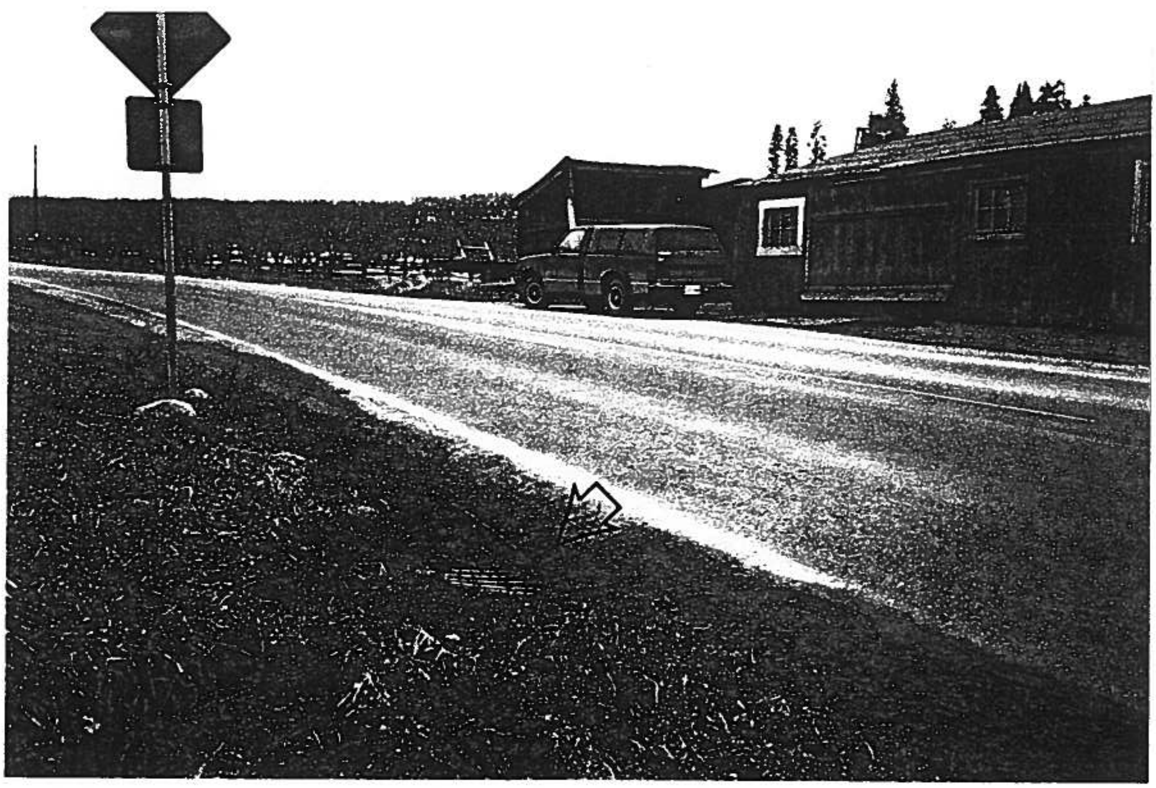
1-10 OK Centre Road East: South Ditch (Inlet)



1-10 OK Centre Road East: North Ditch (Outlet)

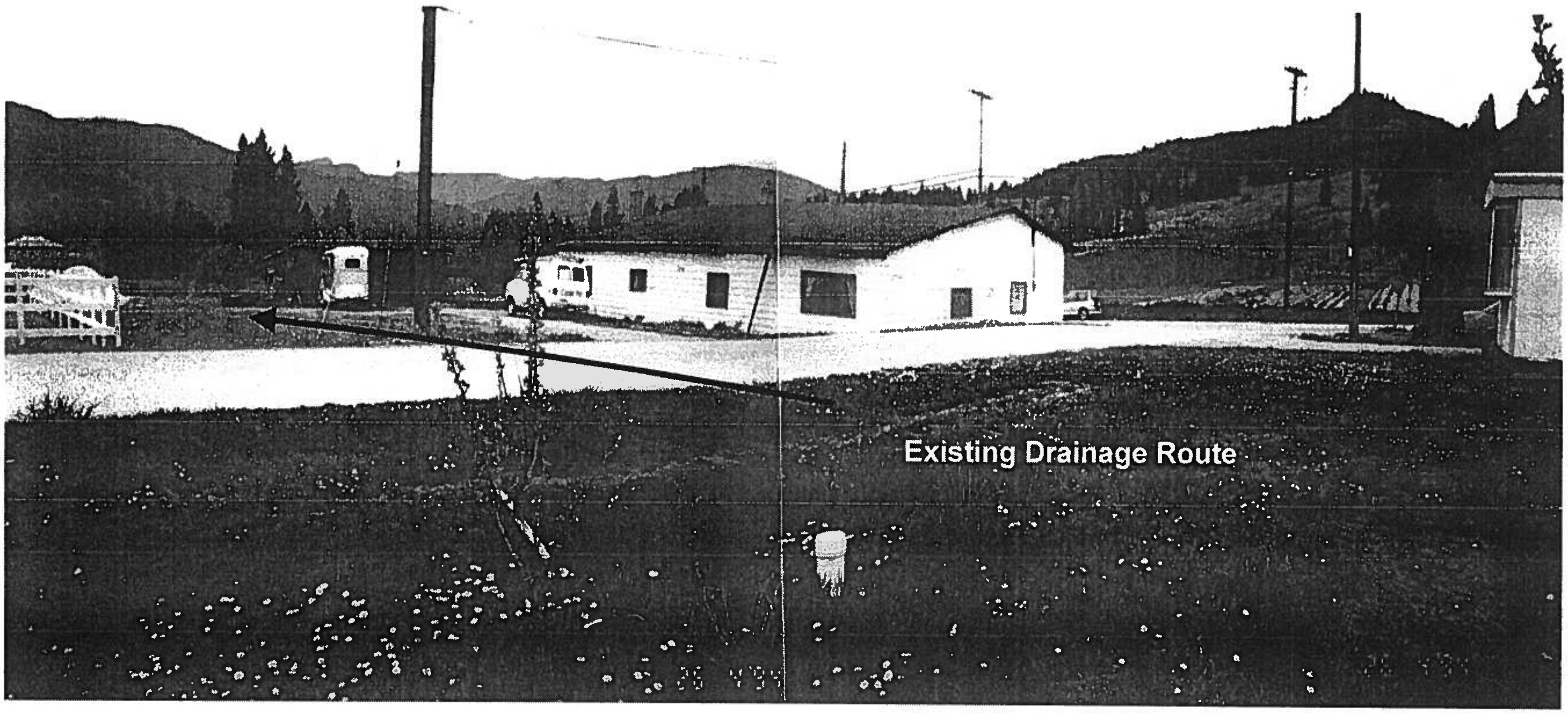


1-24 OK Centre Road East: South Ditch (Inlet)

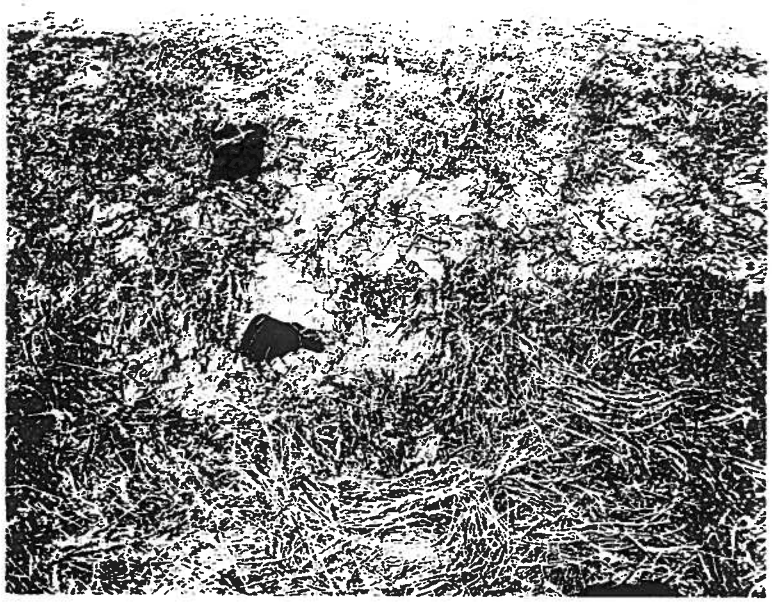


1-24 OK Centre Road East: North Ditch (Catchbasin)

DRAINAGE INVENTORY PHOTOGRAPHS



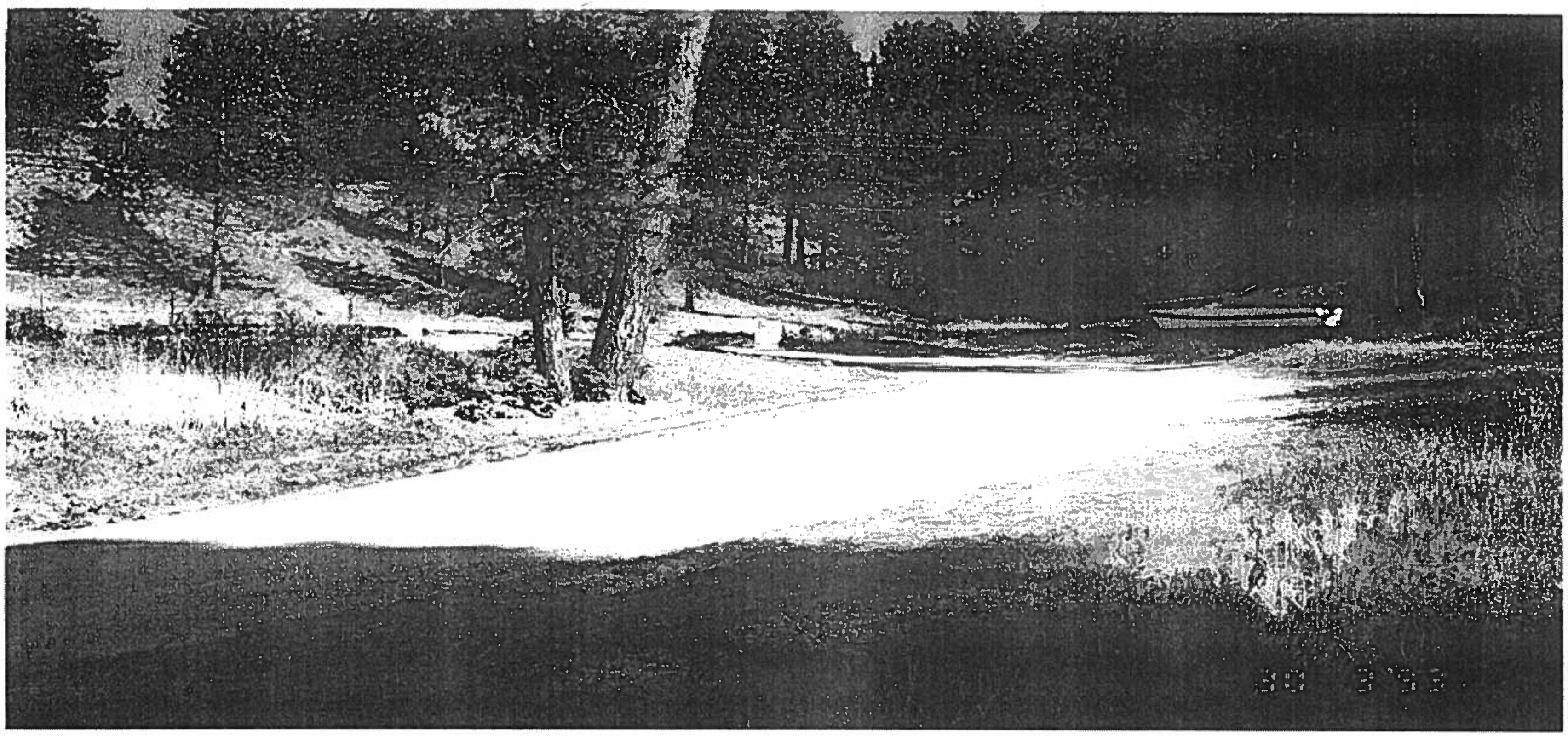
1-50 Okanagan Centre Road East & Goldie Road



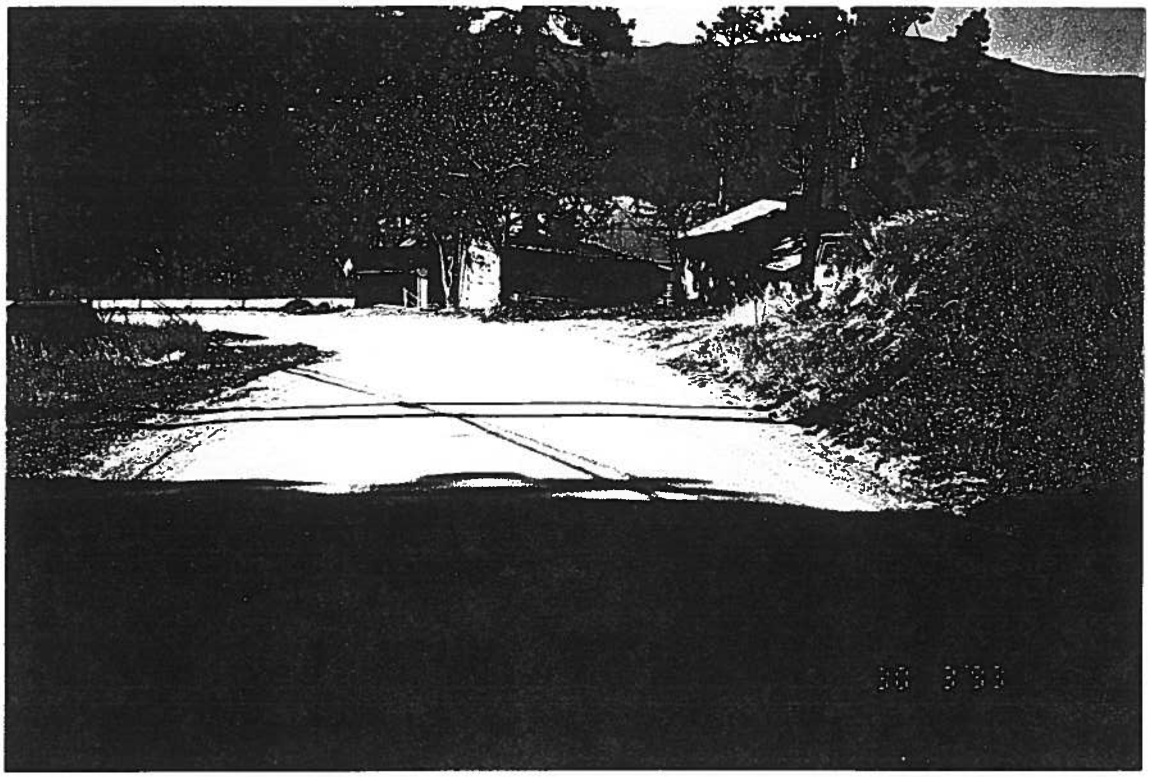
1-70 Cresta Road (Inlet)

2-10 OK Centre Road West: East Ditch (Inlet)

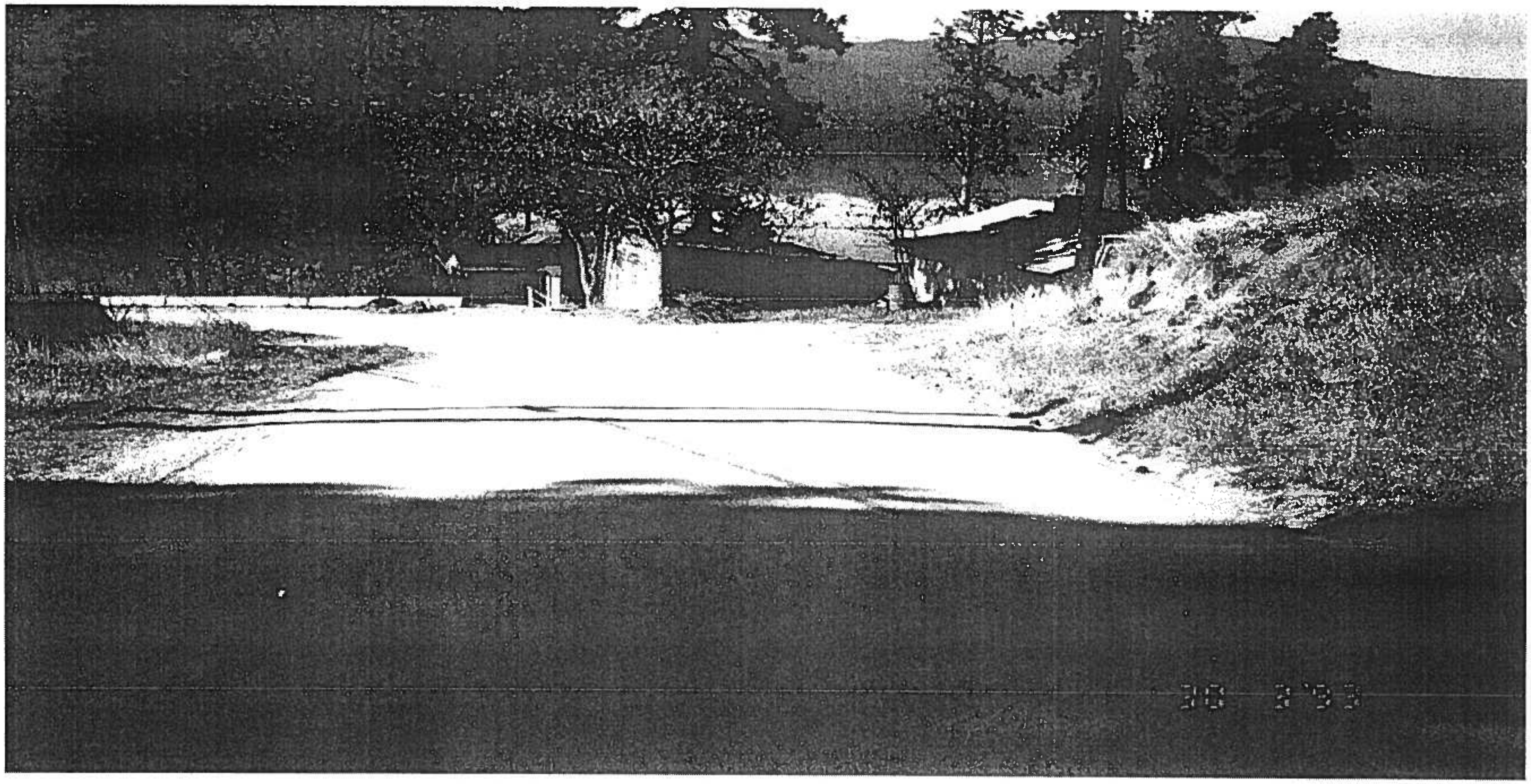
2-10 OK Centre Road West: West Ditch (Outlet)



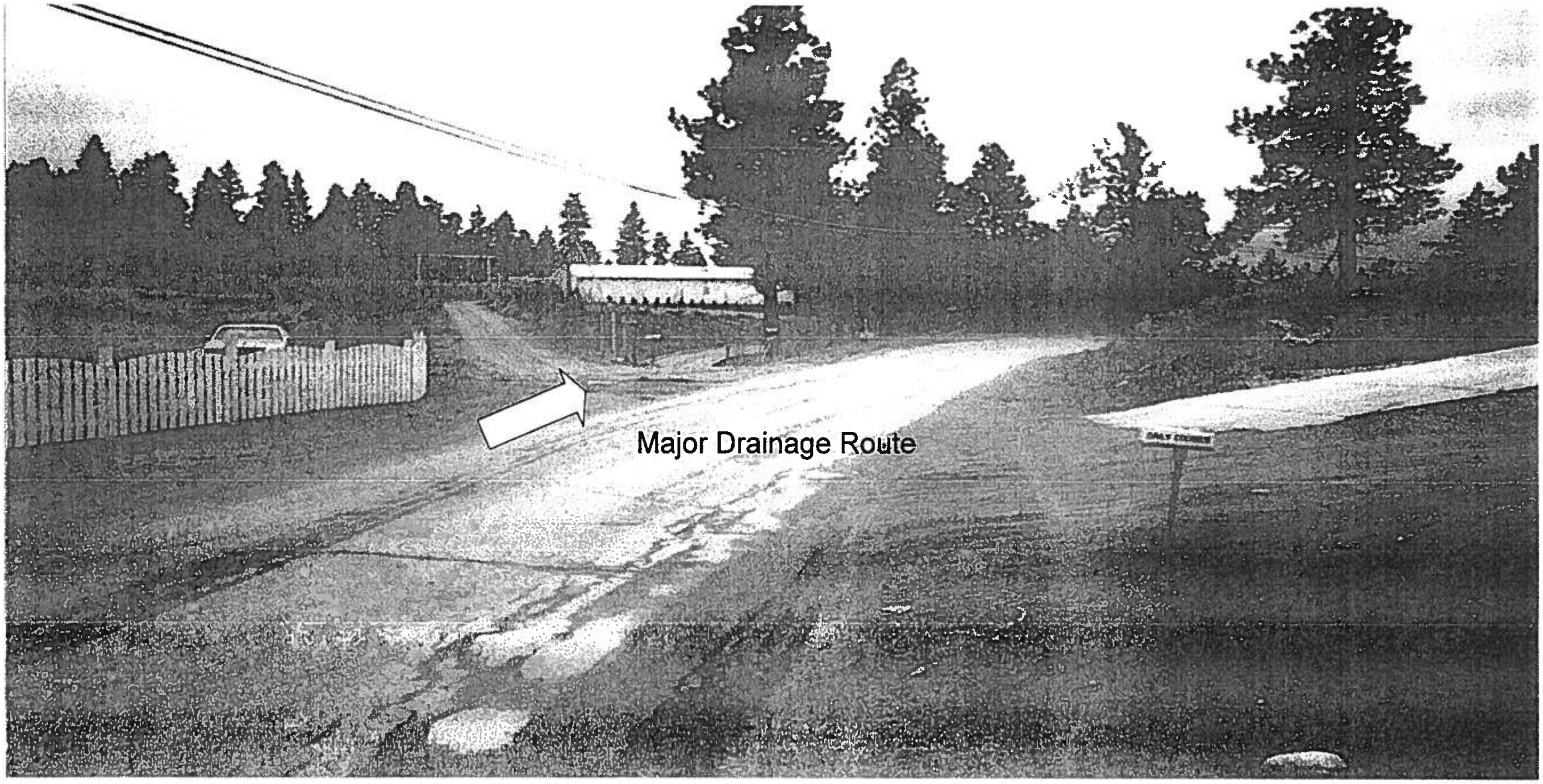
5-20 Camp Road: Looking Upstream



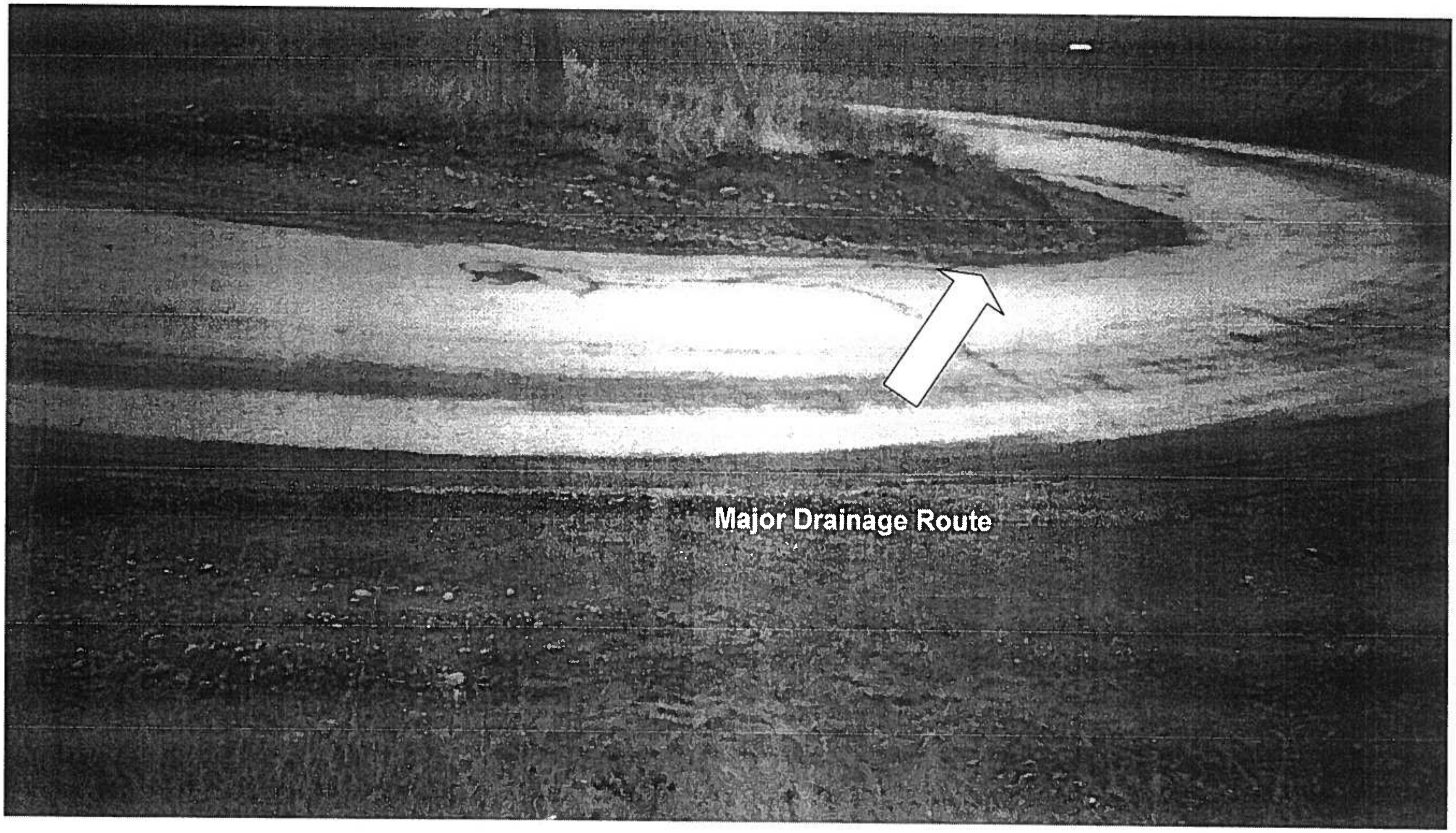
5-20 Camp Road: Looking Downstream



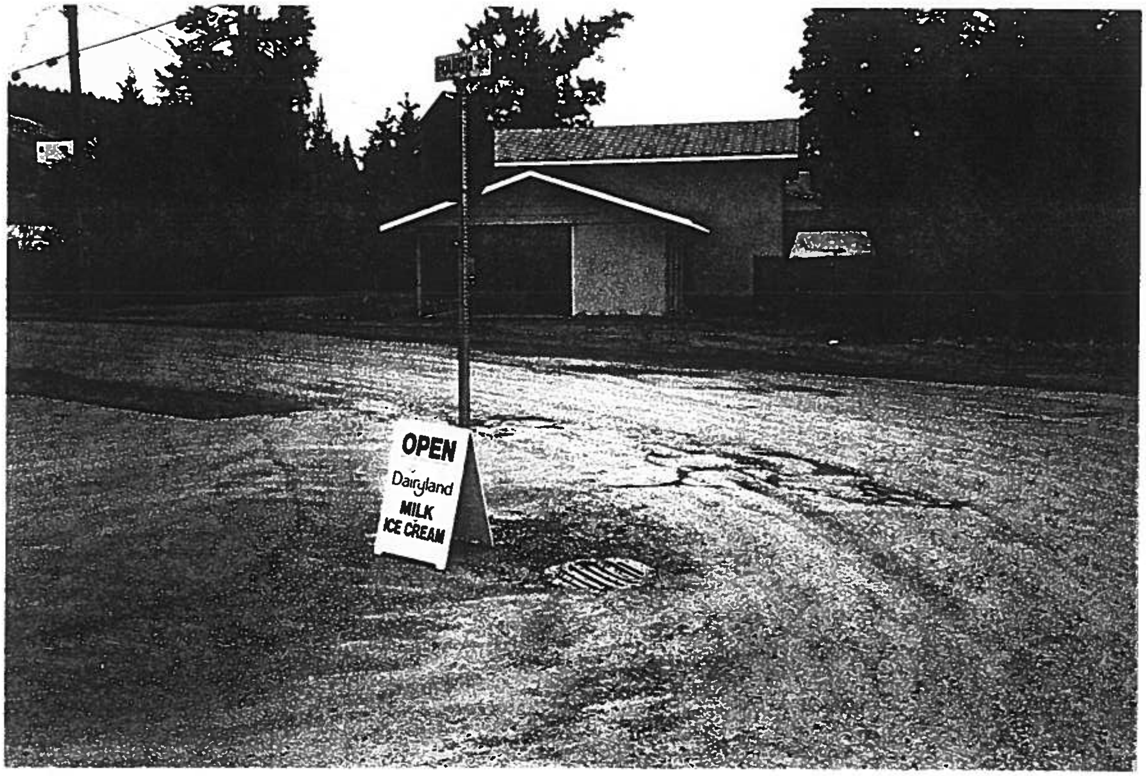
5-20 Camp Road: Looking Downstream



5-40 Camp Road West of Davidson Road



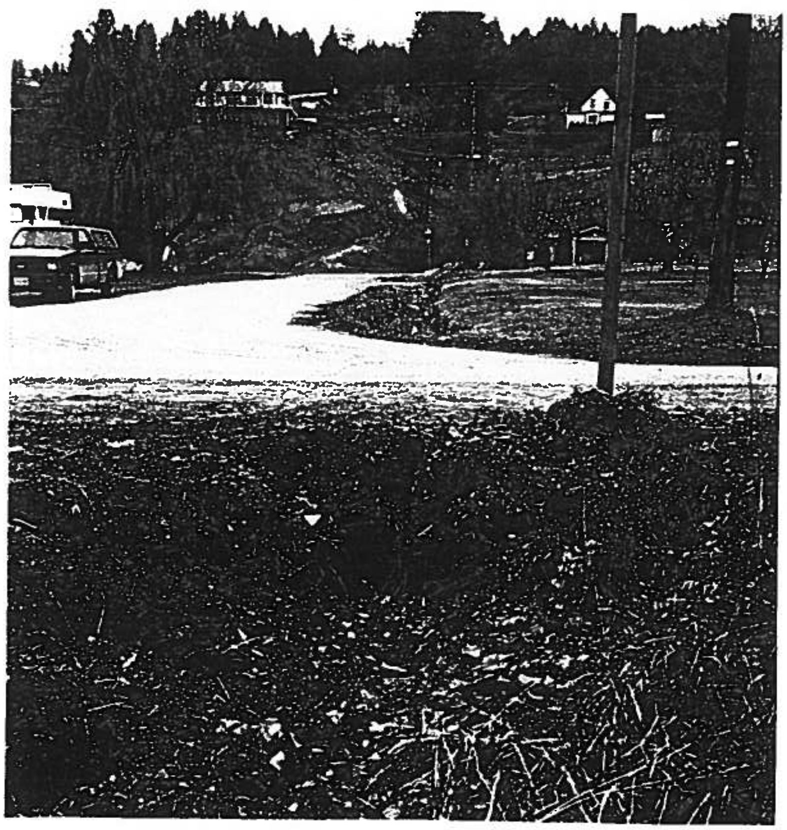
5-60 Camp Road East of Hare Road



6-10 OK Centre Road West @ Fourth Street (Catchbasin)

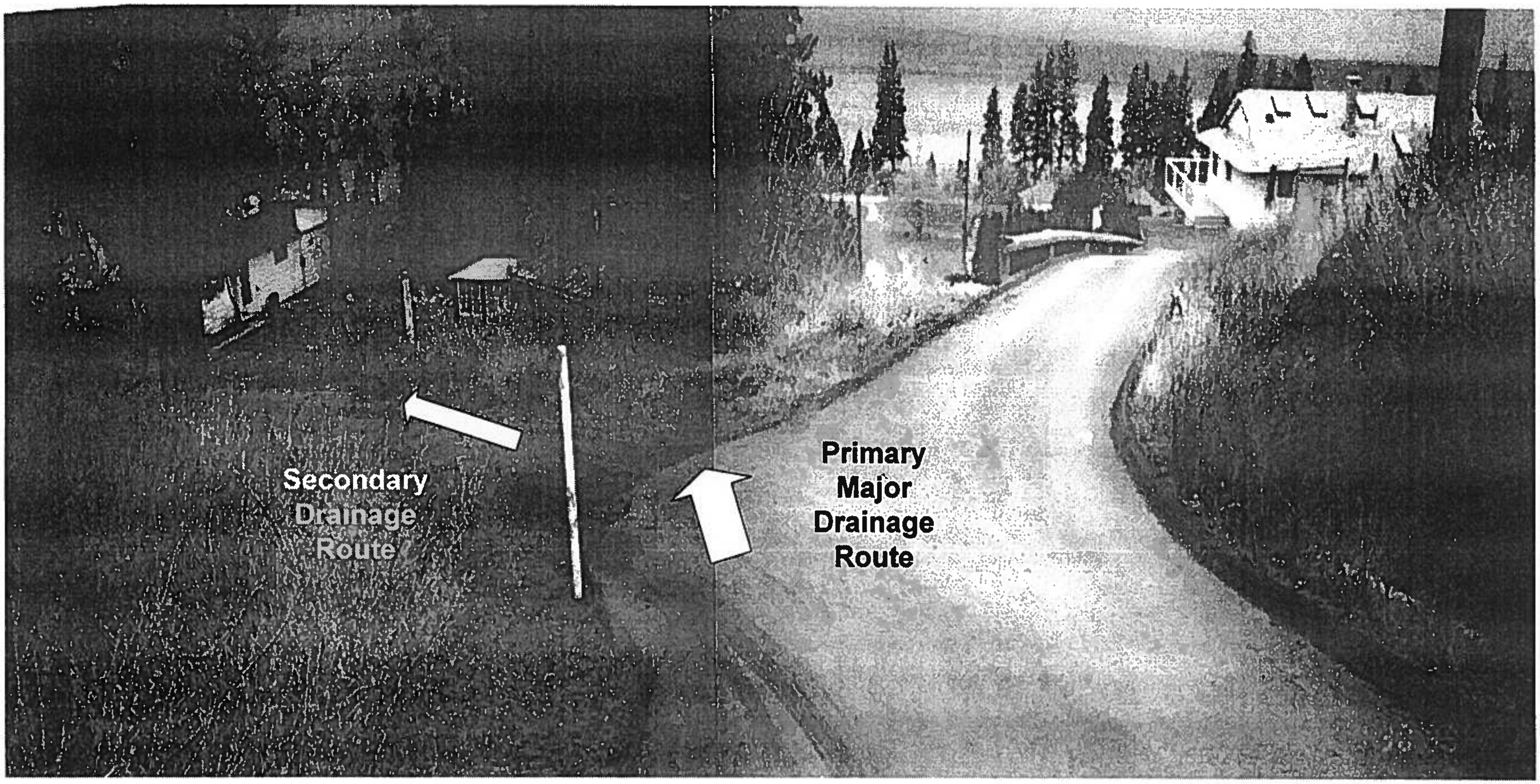
6-10 OK Centre Road West @ Fourth Street (Outlet)

7-10 OK Centre Road West @ Sixth Street (Inlet)



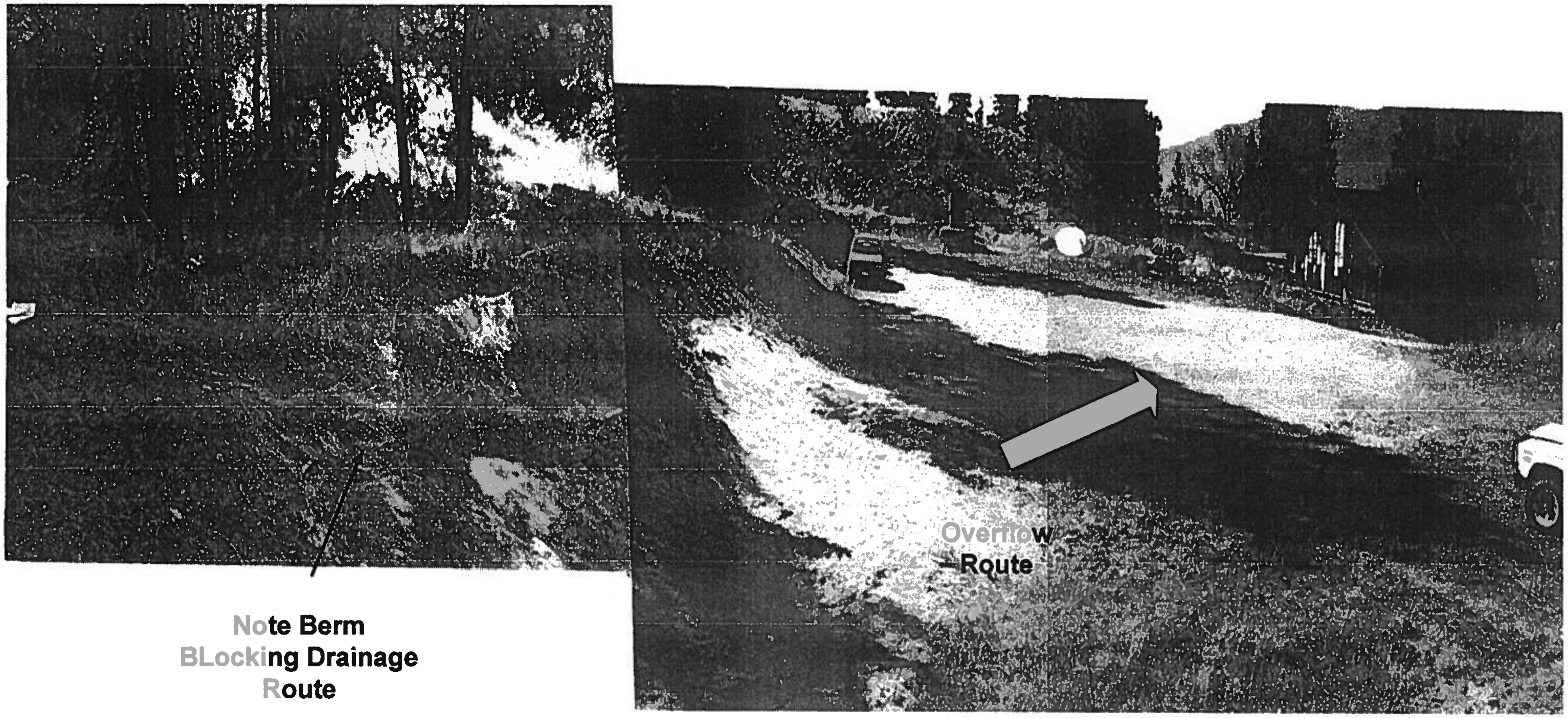
7-10 OK Centre Road West @ Sixth Street (Outlet)

7-12 Sixth Street Right-Of-Way



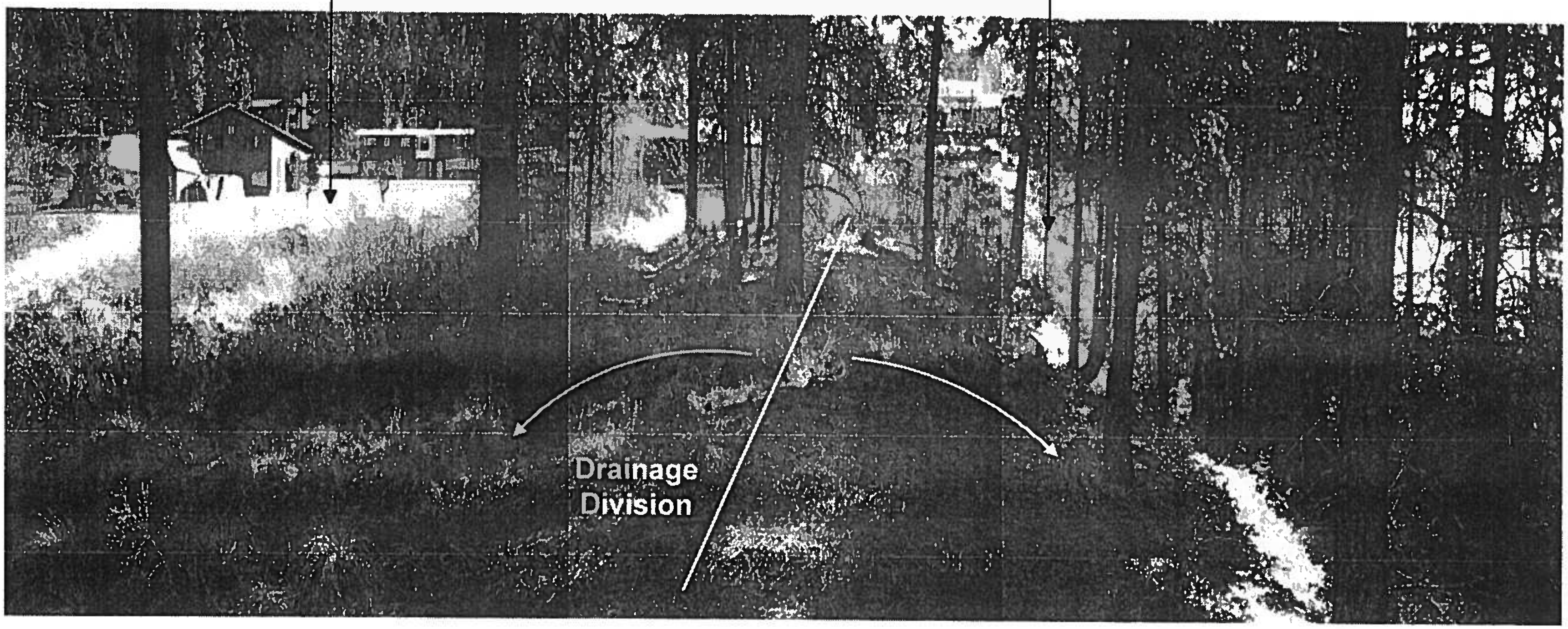
7-14 Sixth Street Right-Of-Way; Just South of Hare Road

8-10 Seventh Street Right-Of-Way; Just West of Maddock Road

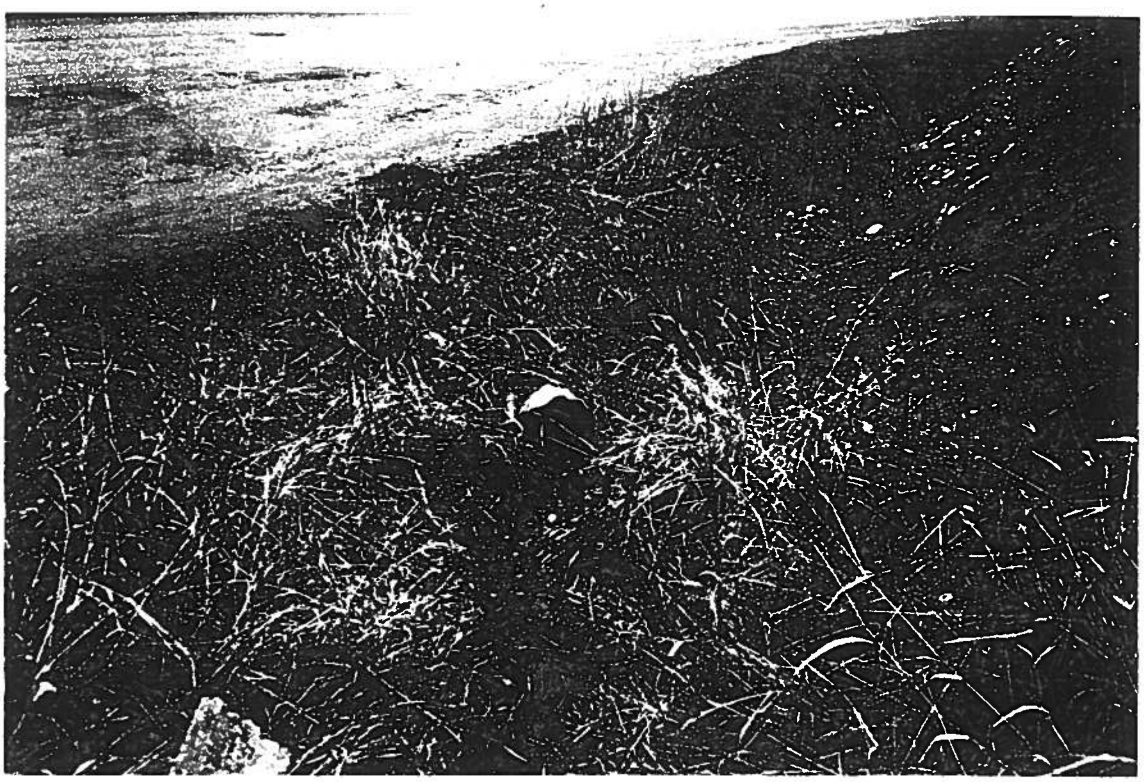


8-12 Major Route Through Community Hall Parking Lot

Note potential to easily direct surface flows into either basin.



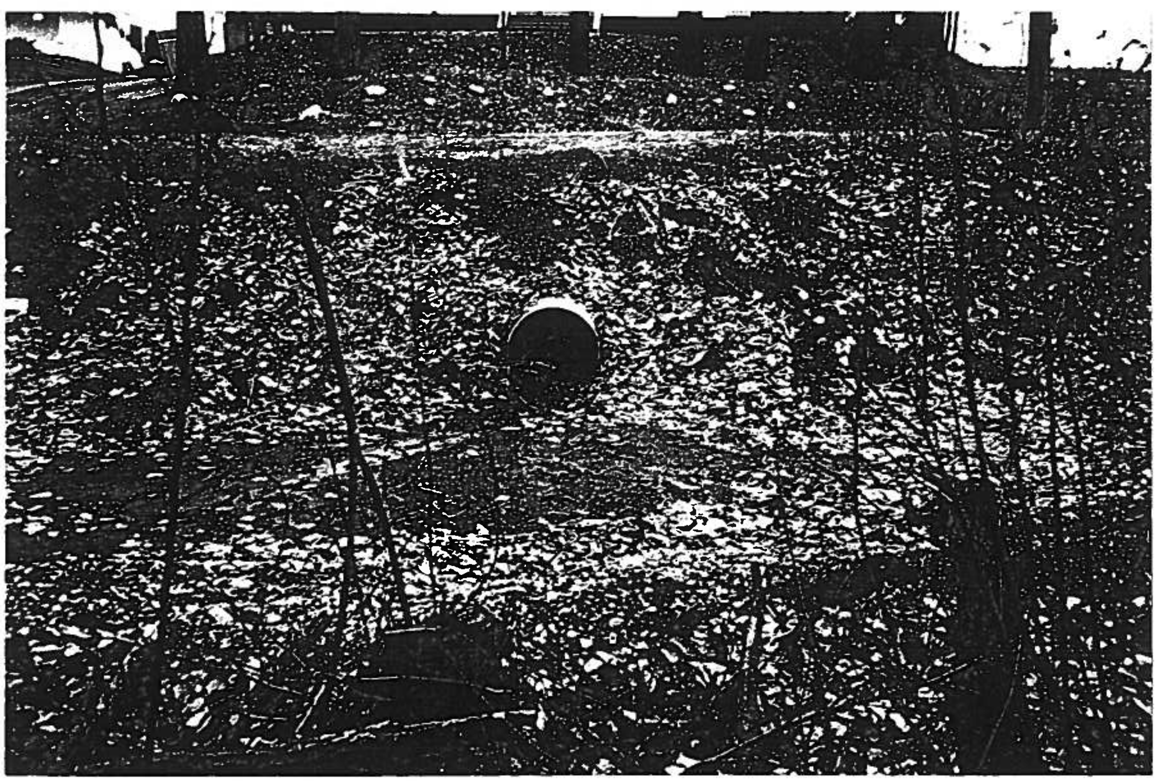
8-14 Drainage Division Between Basins 8 and 9



8-20 Hare Road: Primary Route (Inlet)

8-22 Hare Road: Secondary Route (Inlet)

8-30 Camp Road @ Tyndall Road (Inlet)



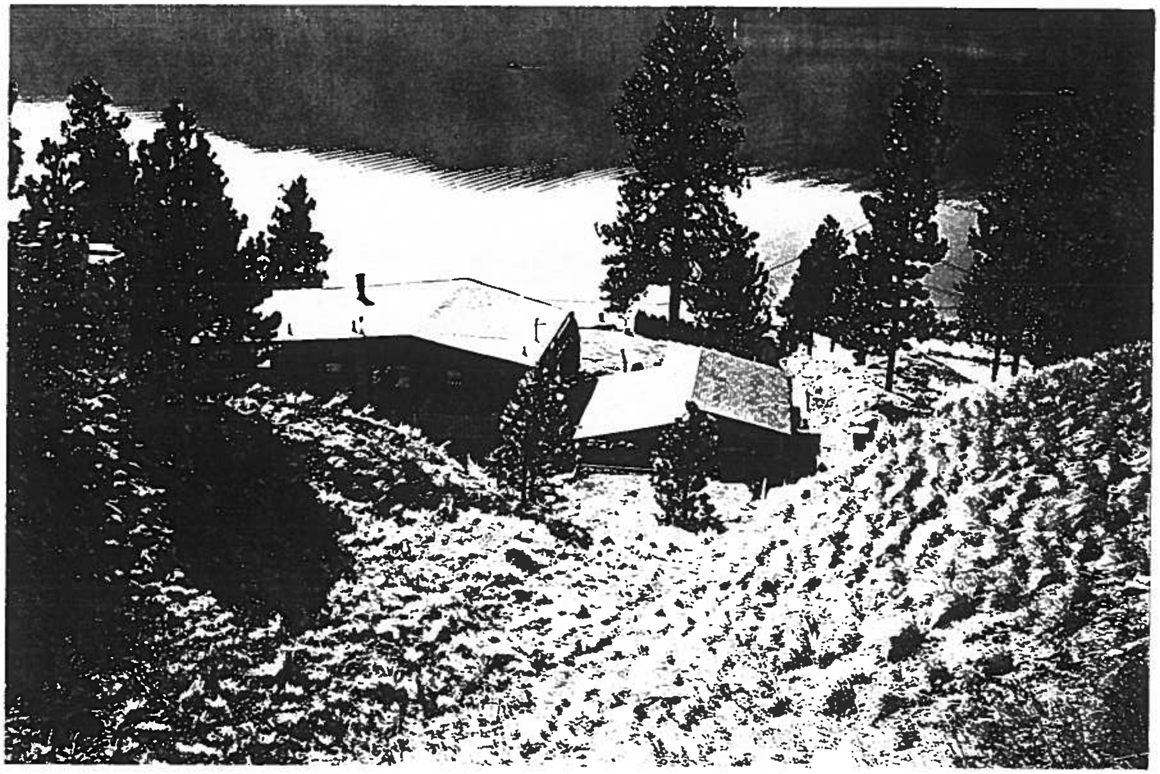
8-30 Camp Road @ Tyndall Road (Outlet)

9-15 Home in Gulley Near Eighth Street

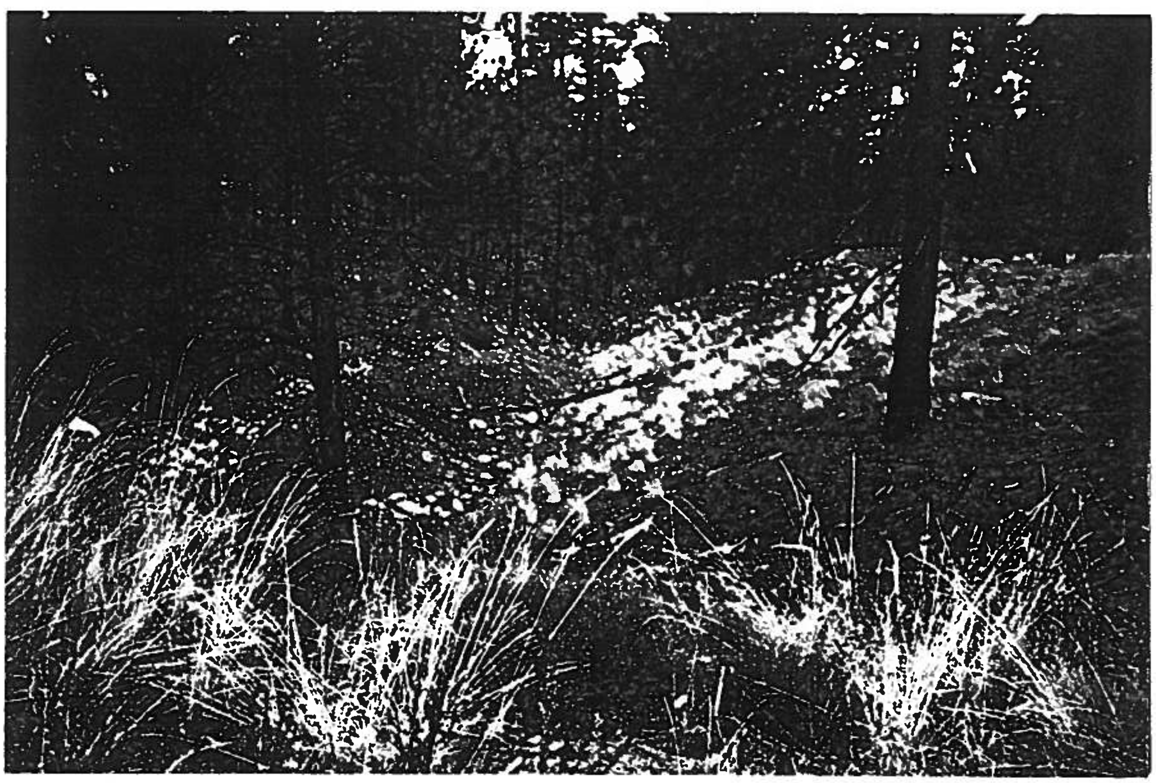
9-17 Home in Gulley Near Tenth Street

9-20 Hare Road (Inlet)

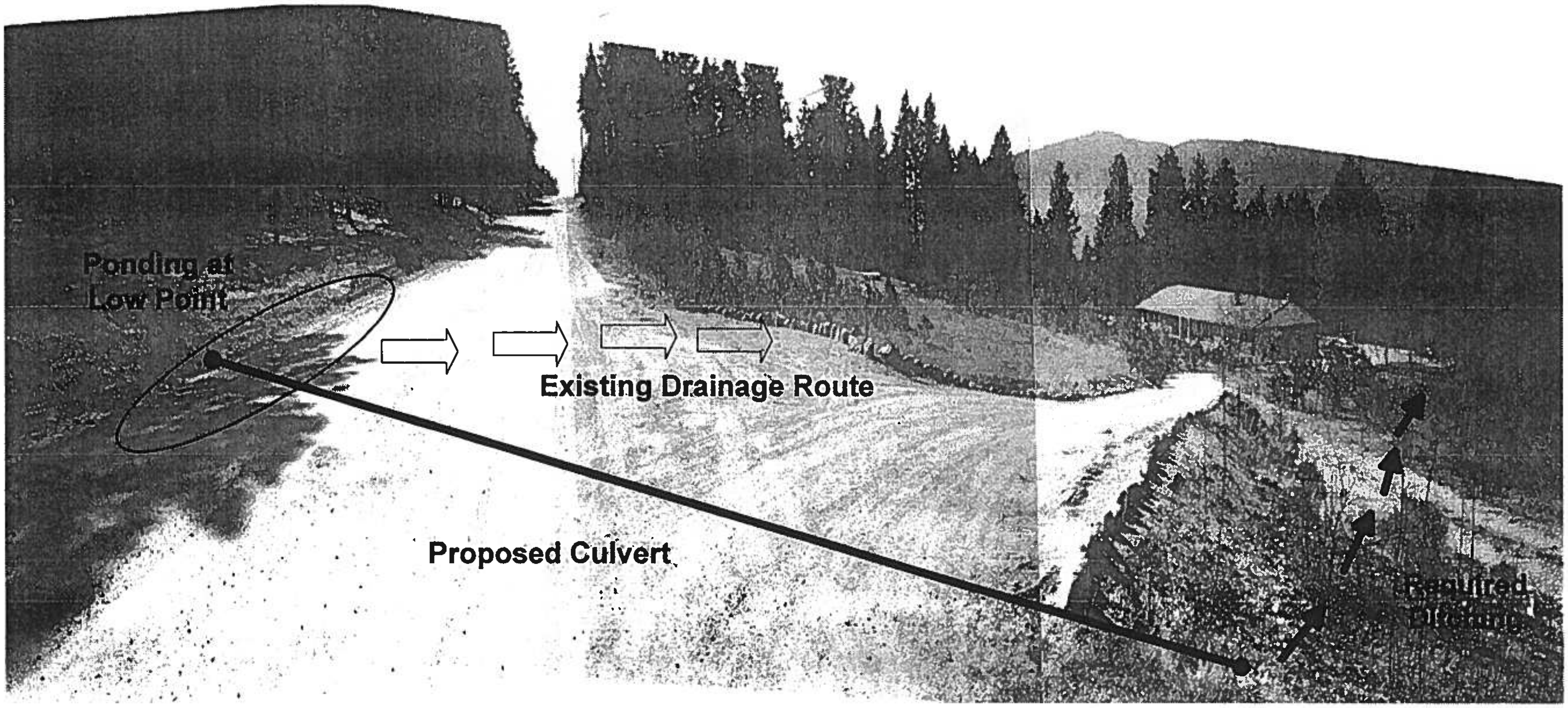
9-20 Hare Road (Outlet)



10-12 Home in Gulley Near Eleventh Street



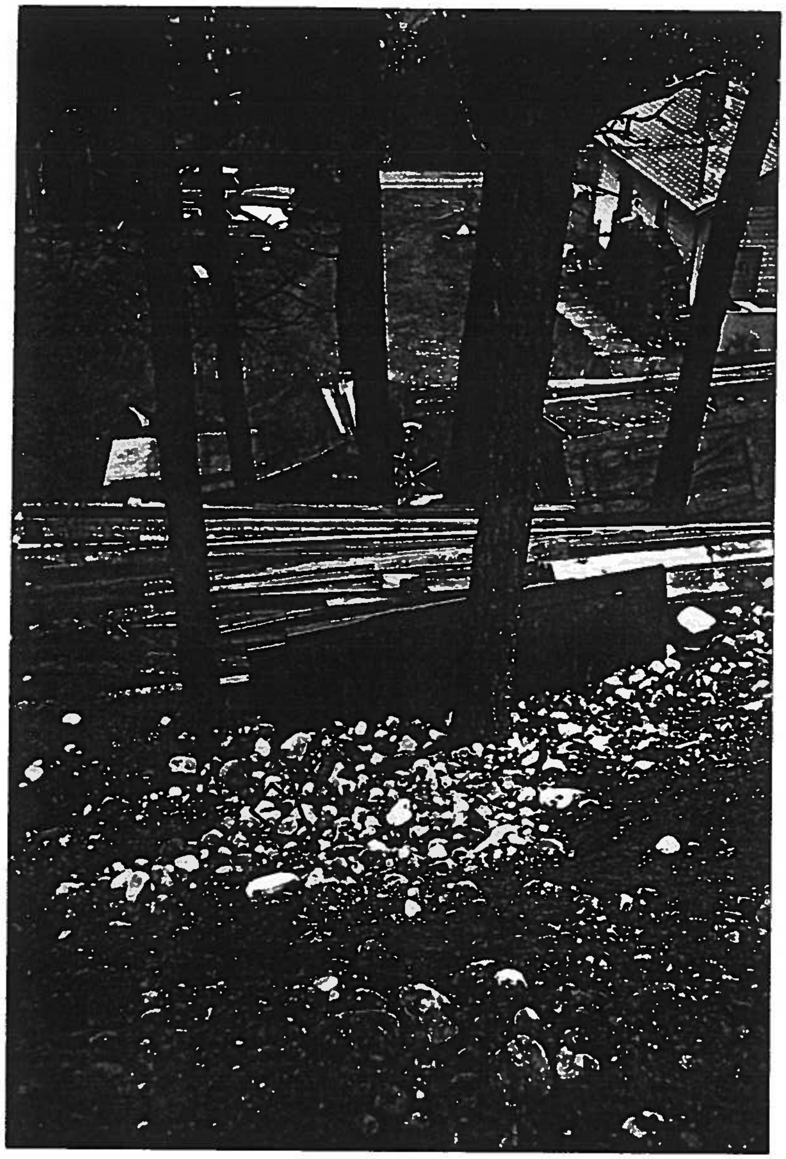
10-20 Hare Road: Downstream of Proposed Outlet



10-30 Tyndall Road: Culvert and Ditching Required

12-10 OK Centre Road West @ Fourteenth Street (Inlet)

12-10 OK Centre Road West @ Fourteenth Street (Outlet)

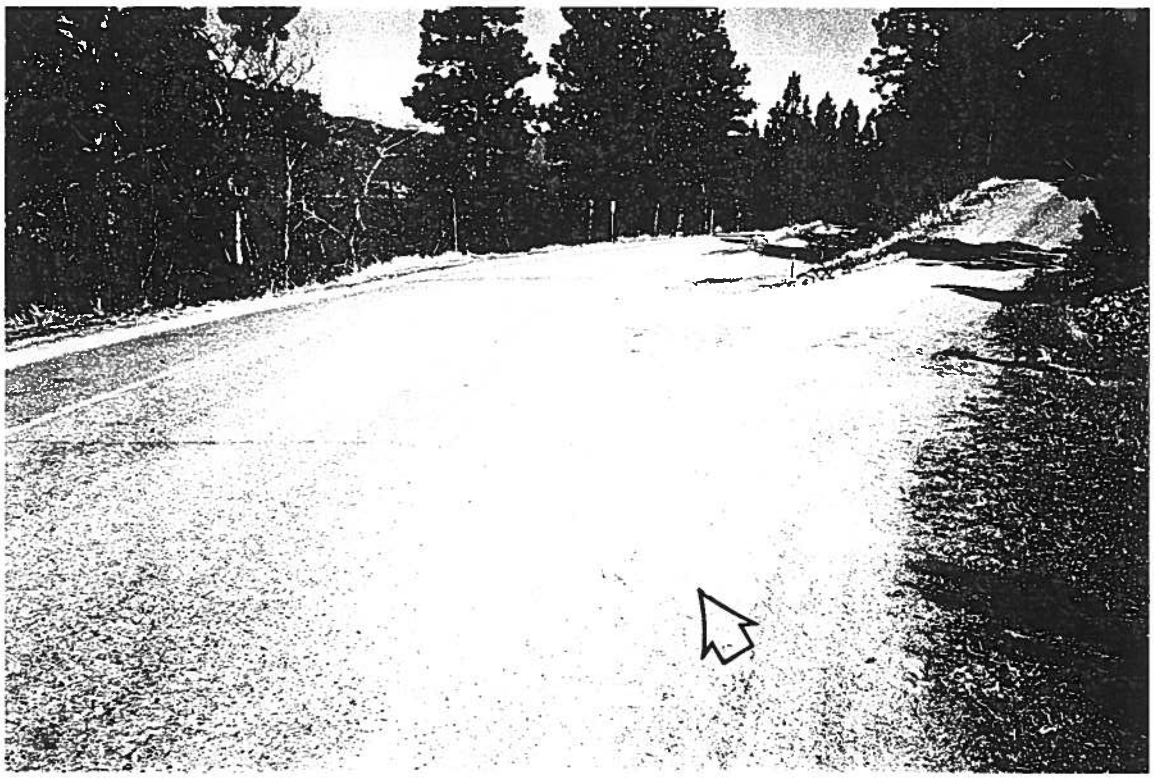


12-12 Discharge Onto Private Property (Outlet)

14-20 Tyndall Road (Inlet)

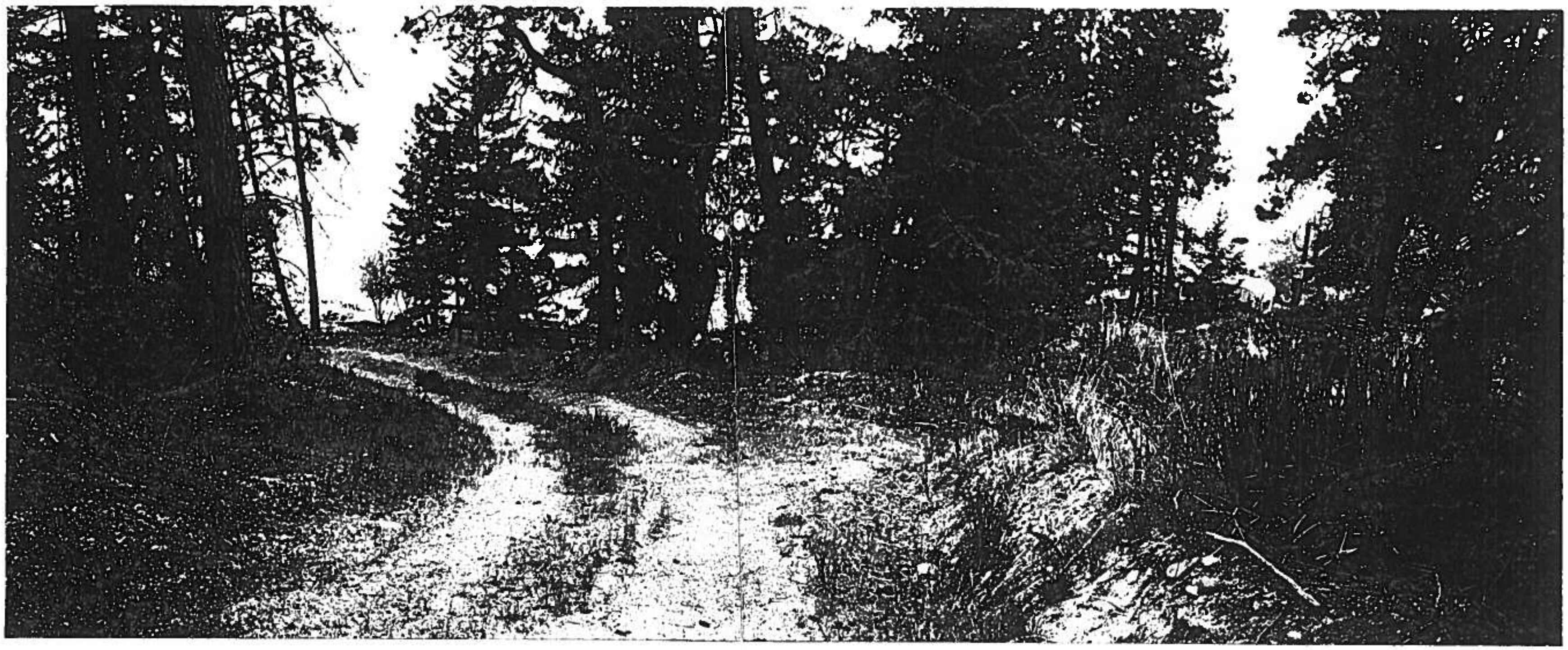
14-20 Tyndall Road (Outlet)

21-30 OK Centre Road West: Active Erosion Area



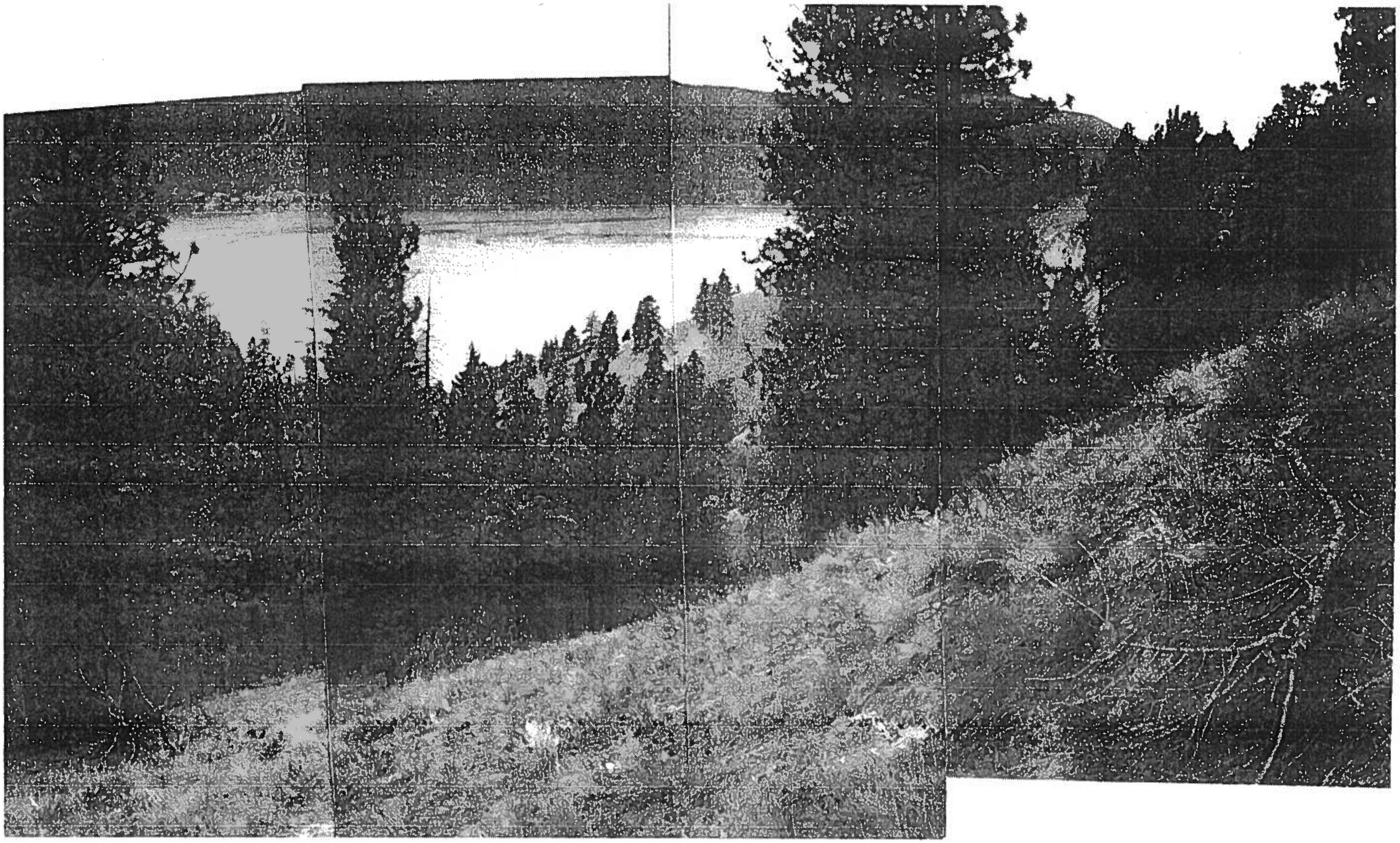
21-10 OK Centre Road West: Typical Lack Of Ditches

21-30 OK Centre Road West: Active Erosion Area



23-10 Lot 6, Plan 11333: Existing Drainage Route

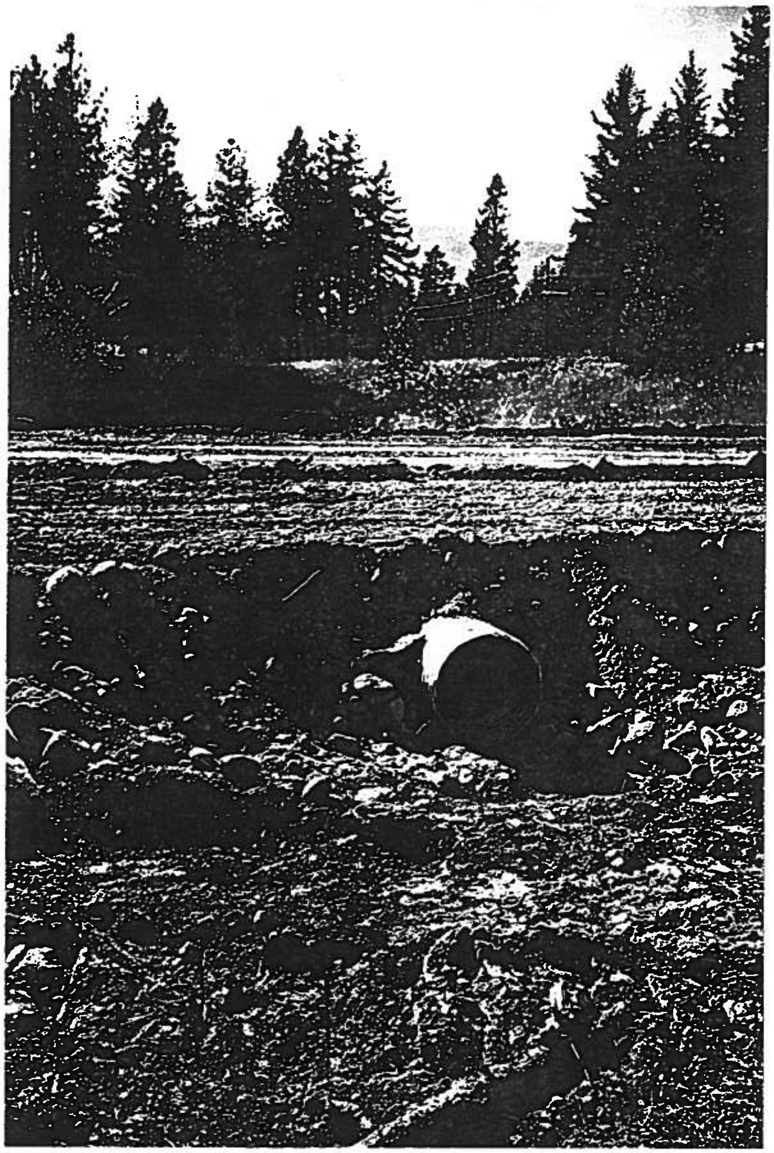
DRAINAGE INVENTORY PHOTOGRAPHS



21-72 Active/Potential Erosion Site Off Tyndall Road

24-12 Existing Drainage Route: Looking D/S

24-14 Existing Drainage Route: Looking Upstream



S3-10 McCoubrey Road (Inlet)