Irrigation
FACTSHEET

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IRRIGATION ECONOMICS

The selection and design of an irrigation system is a complex problem that requires thorough analysis. Although the benefits from irrigation can be dramatic, consideration of various technical, economic and financial factors must be made before the capital investment can be justified.

Factors to consider include water quality, soil type, topography, climate, frequency of drought, anticipated yield increases, capital investment, operating expenses, and labour requirements. In addition, the system may have alternative uses such as manure disposal, crop cooling, or frost protection. This analysis, together with crop alternatives and preference may reduce the options considerably. Since every farm is different, it is necessary to adapt the analysis to site specific situations.

Approach

Use the tables and worksheets found in the following pages to develop the expenses for each system. The following approach is suggested:

1. General description of the system and design.
2. Estimate capital investment.
3. Estimate ownership expenses including depreciation, interest, property taxes, and insurance.
4. Estimate direct operating expenses including power, fuel, repairs, and labour.
5. Estimate the additional value of production.
6. Summarize the results for each system into one or more of the following statements:
    a) Total Irrigation Expenses
    b) Impact on Net Farm Income
    c) Impact on Cash Flow

To illustrate the procedure an example including a set of worksheets used to work through an economic assessment are provided. Calculations in the worksheets are explained in the following sections.

WORKSHEET 1: General Description and Design

Basic information about the property and sprinkler system should be recorded on Worksheet 1. Information includes; source of water, type of irrigation system, irrigated acreage, annual irrigation requirement, application rate, operating hours, pump information. The average annual gross inches applied each year can be estimated from Table 1.

Table 1 ESTIMATED ANNUAL IRRIGATION REQUIREMENT

Location	Irrigation Requirement	
	[inches]	[mm]
Abbotsford	12	305
Agassiz	6	152
Armstrong	17	432
Campbell River	14	356
Chilliwack	7	178
Duncan	12	305
Hope	13	330
Kamloops	32	813
Kelowna	26	660
Langley	9	229
Nanaimo	14	356
Prince George	14	356
Sumas	9	229
Terrace	12	305
Williams Lake	18	457

The following equations are used to determine the number of hours of operation and number of irrigations required during the irrigation season. A flow rate of 450 gpm will apply one acre-in/hr. Acre-inches are determined by using the value in Table 1 and multiplying by the area to be irrigated.

See the example for more information on determining pumping head.

Equation 1:

Operating hours $= \frac{450 \text{ gpm}}{\text{acre-in/hr}} \times \frac{\text{amount applied annually [acre-in]}}{\text{system flow rate [gpm]}}$

Where: Amount applied annually = area irrigated x annual irrigation requirement
System flow rate = number of sprinkler x flow rate per sprinkler

WORKSHEET 2: Capital Investment, Depreciation, and Interest

An estimate of the capital investment should be obtained from dealers and summarized on Worksheet 2. All costs, including freight and installation should be considered. The tractor and wagon investment should be prorated to the irrigation system according to hours of use for irrigation relative to the total annual use.

The capital investment is converted into an annual indirect expense by taking into consideration the useful life, salvage value, and interest rates. Salvage value is the estimated trade-in value at the end of its useful life. It can be estimated by using 10% of the original capital investment for most irrigation system components. An interest rate of 8% (midway between a savings rate of 4% and a lending rate of 12%) can be used in this analysis. The calculations for Annual Depreciation and Annual Interest are given in Equations 2 and 3.

Other indirect expenses, fixed or overhead, associated with ownership of capital assets include insurance, property taxes, and a water license or water taxes.

For more information on equipment costs the Irrigation Equipment Costs (1994) factsheet is available from the Resource Management Branch.

Equation 2:

Annual Depreciation $= \frac{\text{Initial Investment} - \text{Salvage Value}}{\text{Useful Life}}$

Equation 3:

Annual Interest $= \frac{(\text{Initial Investment} + \text{Salvage Value}) \times \_\_\%}{2}$

WORKSHEET 3: Direct Operating Expenses

This part of the analysis estimates expenses that vary directly with system use. These include electricity, fuel and oil associated with pumping or moving the system, repairs, maintenance, and labour. To determine labour requirements the number of irrigations per year need to be calculated, see Equations 4 and 5. Additional harvesting expenses could be also be incurred. If extra fertilizer and chemicals are used on the crop, the yield response should more than offset the added expense.

Electrical pumping expenses are calculated by Equation 6. If the annual operating hours do not exceed 725 hrs, a minimum bill may be charged by the power utility based on the connected load. The minimum bill can be estimated by using 725 hrs in Equation 4. The 1998 rate for an irrigation pump service is $0.0324 / kwh.

Equation 4:

Hours per interval = 24 hrs/day x irrigation interval [days]

Equation 5:

irrigations $= \frac{\text{Operating hours}}{\text{hours per interval}}$

Where: The irrigation interval is the number of days it takes to irrigate the entire property.
Hours per interval are the number of hours the sprinklers will run to irrigate the property once.

Equation 6:

$E = \frac{HP \times T \times 0.746 \times C}{0.80}$

Where: E = annual electrical cost ($/yr)
HP = horsepower required by the pump (hp)
T = annual hours of operation (hrs)
C = cost per kilowatt-hour (kw/hr)

Pumping expenses for other fuels can be calculated by Equation 7.

If a diesel pumping unit was used for the example in this chapter, the annual operating costs could be estimated by Equation 8.

For irrigation systems that use tractor fuel, oil and lubrication for uses other than pumping the costs are estimated by multiplying the annual hours of tractor use for irrigation by the tractor horsepower (hp), times a factor times the cost per litre for the fuel. The factor is 0.248 for diesel tractors and 0.387 for gasoline tractors.

Repairs and maintenance are estimated on Worksheet 2. Multiply the Initial Investment by the repair % found in Table 2. The repair % may have to be adjusted to reflect unusual amounts of annual use.

Equation 7:

$$P = \frac{WHP \times T \times C}{F}$$

Where: P = pump operating expense ($/yr)
WHP = calculated in Equation 8.
T = annual hours of operation (hrs)
C = cost per unit of fuel ($/litre)
F = water horsepower hours per unit fuel (WHP/litre)

Equation 8:

$$WHP = \frac{H \times Q}{3900}$$

Where: H = pump head
Q = application rate (gpm)

Table 2 REPAIRS, MAINTENANCE AND EXPECTED LIFE

System Components	R & M % of Capital Cost	Expected Life (years)
Well	0.5	25
Intakes		
Concrete Structures	0.5	20
Suction Line screens	10.0	5
Pumps		
Turbine - Bowls	6.0	7
- Columns	4.0	20
Centrifugal	4.0	15
Submersible	4.0	15
Motors		
Electric	1.0	25
Diesel	5.0	15
Gasoline	5.0	9
Propane	5.0	14
Electrical Wiring	1.0	25
Mainline and laterals		
Steel: coated, lined and buried	0.5	40
coated and buried	0.8	20
coated and surface	1.5	12
Aluminum: surface	2.0	15
PVC: buried	0.5	40
Sprinklers	5.0	8
Tractor (Irrigation Share)	2.0	12
Wagon (Irrigation Share)	2.0	25
Valves and Miscellaneous	0.5	20

Suggested labour requirements to operate various irrigation systems are outlined in Table 3. For example, the labour required for a wheelmove system is estimated at 0.5 hours per irrigation per acre. This time includes an allowance for moving the system.

With an increased crop yield, there could also be additional harvesting expenses such as labour, fuel and repairs.

Table 3 LABOUR REQUIREMENTS TO OPERATE VARIOUS IRRIGATION SYSTEMS

Type of System	Hrs / Irrigation / Acre
Handmove	1.2
Wheelline	0.5
Stationary Gun	1.2
Traveling Gun	0.3
Solid Set	0.15
Center Pivot	0.05

WORKSHEET 4: Irrigation Expenses / Break Even Analysis

The analysis must also consider the added value of crops produced. The value produced is obtained by multiplying the expected increase in crop yield times the total acres, times the value per unit of the crop. The value per unit is used in a breakeven analysis while the added value of production is required for the profitability and cash flow analysis.

Worksheet 4 summarizes both direct and indirect expenses, and provides a breakeven analysis. The additional forage yield required to breakeven on direct expenses and total expenses for our example is calculated in Equation 9.

WORKSHEETS 5 & 6: Impact of Net Farm Income and On Cashflow

The impact of the system on Net Farm Income (profitability) can be estimated by completing Worksheet 5. The impact the system will have on your cash flow can be estimated by using Worksheet 6

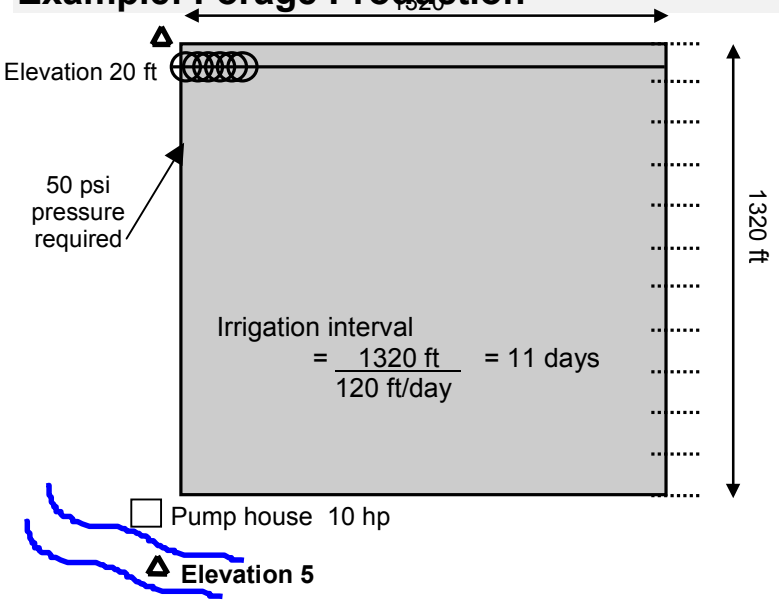
Equation 9:

$$\text{Yield required} = \frac{\text{Expenses [\$]}}{\text{Price of crop [\$/ton]}}$$

Where: Expenses can be either total direct or total indirect expenses.

The following example goes through the process of assessing the feasibility of an irrigation system using the worksheets provided in this factsheet. All values in the gray areas and in italics are values determined for this example Where more explanation for the equations in the worksheets was required there is an accompanying explaination in the example. You may do your own economic analysis of your irrigation system in the spaces provided in the worksheets.

Example: Forage Production



The water supply for this system is from a river, situated 15 feet below the highest point in the field. 50 psi is required at the hookup point for sprinkler operation. The system consists of four wheellines with a total of 33 sprinklers. The flow rate per sprinkler is 5 gpm, therefore the total system flow rate is 165 gpm. The system has a 12 hour set time. The wheelline is moved 60 feet twice a day, therefore it takes 11 days to cover the entire property.

This system is located in Abbotsford. The annual irrigation requirement is 12 inches. The area irrigated is 40 acres.

The price of forage is estimated at $150 per ton

WORKSHEET 1

Record the information about the irrigation system. Determine the annual irrigation requirement, and system flow rate as described in Worksheet 1.

Annual requirement is 40 acre x 12 in. = 480 acre-in
System flow rate is 5 gpm x 33 = 165 gpm

Operating Hours

Equation 1:

$$\text{Operating hrs} = \frac{450 \text{ gpm} \times 480 \text{ acre-in}}{\text{acre-in/hr} \quad 165 \text{ [gpm]}}$$

= 1309 hours

Pumping Head

wheelline pressure requirement 50 psi	= 115 ft
friction loss in the mainline	= 20 ft
elevation difference	= 15 ft
Total pumping head	= 150 ft

Pump Size

$$\text{Diesel WHP} = \frac{H \times Q}{3960} = \frac{165 \times 150}{3960} = 6.25 \text{ hp}$$

Estimate pump efficiency 70%
(use the value 0.70)

B.H.P = W.H.P / efficiency = 6.25 / 0.70 = 9 hp

A 10 hp pump would be chosen for this site

WORKSHEET 2

Initial Investment

Supplier estimated value.

Useful Life

Table 2 contains expected life for many irrigation components.

Salvage Value

Generally estimated at 10% of the initial investment. Mainline and lateral lines and motor are estimated at 20% of the initial investment.

Annual Depreciation

Equation 2: calculation for Mainline

$$\text{Annual Depreciation} = \frac{\$4700 - \$940}{15} = \$251$$

Annual Interest

Equation 3:

$$\text{Annual Interest} = \frac{(\$4700 + \$940) \times 8\%}{2} = \$226$$

Repairs and Maintenance %

Table 2 provides the % of the initial investment that annual repair and maintenance is expected to be.

Annual Repairs and Maintenance

This is equal to the annual R&M % multiplied by the initial investment.

WORKSHEET 3

Electricity Expenses

Use the hours per year of operation and the motor horsepower as calculated in Worksheet 1. The cost of electricity in $/kwh can be obtained from your power company or electrical bill.

Fuel, Oil and Lubrication

These item are not a factor in this example, however for irrigation systems that employ tractors to move the system or fuel powered pumps. The cost of using these items should be calculated. Estimate the number of hours that each item is in use, the power of the engine and the cost of the fuel.

Determine the Labour Requirements

Use Equations 4&5 to determine the number of irrigations per year.

Equation 4:
Hours per interval = 24 hrs/day x 11 days = 264 hrs

Equation 5:

$$\#\ \text{irrigations} = \frac{1309\ \text{hours}}{264\ \text{hrs/irrigation}} = 5\ \text{irrigations}$$

Determine the hours of labour required for the irrigation system per acre from Table 3.

Finish the calculation as in Worksheet 3.

Additional Harvesting

Estimate the additional yield gained from irrigation For this example a value of 2 ton/acre is be used.

Estimate the cost to harvest forage on a per ton basis. $13/ton is used in this example. Determine the total cost by multiplying by the number of acres being harvested.

WORKSHEET 4

For the per acre calculations divide the Total column is divided by the acres irrigated, in this example it is 40 acres.

Direct Expenses

Use values calculated in Worksheet 3.

Indirect Expenses

Actual values should be used for insurance, water licenses and taxes. The depreciation and interest are taken from Worksheet 2. Any other expenses not shown in the worksheet should also be added.

Total Expenses

Add the indirect and direct expenses together.

Breakeven Analysis

Determine the value of the forage in $/ton. For this example the value $150/ton is used

Calculate the yield required to breakeven using total and direct expenses as calculated on Worksheet 4.

Equation 9: calculated for total expenses

$$\text{Yield} = \frac{\$125.75/\text{acre}}{\$150/\text{acre/tonne}} = 0.84\ \text{ton/acre}$$

If the yield increases only 0.84 ton/acre the system will pay for itself.

WORKSHEET 5 and 6

To finance the irrigation system the farm borrowed one half the capital investment ($9450) at 12% over 10 years. We assumed the other half came from a savings account earning 4% interest

Additional Income

Estimate the additional yield gained from irrigation. This will be the same value determined in Worksheet 3 when calculating the additional harvesting cost.

Use the same forage value of $150/ton as used in Worksheet 4.

2 ton x $150/acre x 40 acres = 1200

Income is reduced by the loss of interest from the $9450 used to pay for the system. 4% x 9450 = 378

Additional Expenses

Use the additional expenses that were calculated in Worksheet 3 and 4.

The loan payment used in Worksheet 6 is estimated at $1678 per year. The interest shown on Worksheet 5 is an average annual expense over the 10 year period ($728).

Excess Income over Expenses: (Worksheet 5)

Income – Expenses = 11622 – 3587 = 8037

Additional Net Farm Income: (Worksheet 5)

This takes annual depreciation into consideration, use the value for annual depreciation calculated in Worksheet 2.

Additional Net Cash Flow: (Worksheet 6)

Income – Outflow = 11622 – 4542 = 7080.

WORKSHEET 1

GENERAL DESCRIPTION AND SYSTEM DESIGN

	Example	
1. Source of Water: Surface _____	√ river	
Well _____		
Depth of water _____		
2. Type of Distribution System	Wheelline	_____
3. Acres Irrigated by System	40 acres	_____
4. Average Annual Irrigation Requirement Per Acre (From Table 1)	12 in.	_____
5. Total Gross Acre-Inches Applied Annually *40* (Line 3) x *12* (Line 4) =	480 acre-in	_____
6. System Flow Rate (gpm) *5* Gpm/sprinkler x *33* No. of sprinklers =	165 gpm	_____
7. Operating Hours Per Season (450 x *480* (Line 5)) / *165* (Line 6) =	1309 hr	_____
8. Pumping Head (ft) (See example)	150 ft	_____
9. Pump size		
W.H.P. = (*165* (Line 6) x *150* (Line 8)) /3960 =	6.25 hp	_____
B.H.P. = W.H.P./Efficiency = *6.25* / *0.7* =	9 hp (10 hp)	_____

WORKSHEET 2

INVESTMENT, DEPRECIATION, INTEREST, AND REPAIRS & MAINTENANCE

	INITIAL INVESTMENT ($)		USEFUL LIFE (Yrs)		SALVAGE VALUE ($)		ANNUAL DEPRECIAT'N ($)		ANNUAL INTEREST *8* % ($)		R & M (%)		ANNUAL R & M ($)	
Irrigation system items:														
Well	~		~		~		~		~		~		~	
Intake	1000		5		100		180		44		10		100	
Pump_____	1000		15		100		60		44		4		40	
Motor_____	1300		25		260		42		62		1		13	
Electrical Wiring	1000		25		100		36		44		1		10	
Mainline_____	4700		15		940		251		226		2		94	
Lateral	9000		15		1800		480		432		2		180	
Sprinklers	400		8		40		45		176		5		20	
Valves & Misc.	500		20		50		22		22		.05		3	
_____														
(a) SUBTOTAL	18900				3390		1116		1050				460	
Irrigation share of:														
Tractor	~				~		~		~				~	
Wagon	~				~		~		~				~	
(b) SUBTOTAL	~				~		~		~				~	
(c) TOTALS (a + b)	18900				3390		1116		1050				460	

WORKSHEET 3
DIRECT EXPENSES

	ANNUAL EXPENSES ($) Example	
ELECTRICITY EXPENSES		
System use *1309* hrs/year (Worksheet 1) x (motor *10* hp/) (Worksheet 1) x .764 x $*0.0324*/kwh =	324	_____
FUEL, OIL, AND LUBRICATION		
Pumping		
(Engine use ~ hrs/yr x ~ (W.H.P.) x $~ (Fuel Cost) / litre) / (~ (W.H.P./ unit of fuel)) =	~	_____
Moving System		
Tractor (diesel) use ~ hrs/yr x ~ hp x 0.248 x $~ (Fuel Cost) per litre =	~	_____
Tractor (gas) use ~ hrs/yr x ~ hp x 0.387 x $~ (Fuel Cost) per litre =	~	_____
Total Fuel, Oil, and Lubrication Expenses	~	_____
REPAIRS AND MAINTENANCE (From Worksheet 2)	460	_____
LABOUR (From Table 2 and Example)		
0.5 hrs/irrigation/acre x $ *8* /hour x no. *5* irrigations x *40* acres =	800	_____
ADDITIONAL HARVESTING		
2 tons/acres x $ *13* /ton x *40* acres =	1040	_____
OTHER		
_____	~	_____
_____	~	_____
Total Other Expenses		
TOTAL DIRECT EXPENSES	2624	_____

WORKSHEET 4
IRRIGATION EXPENSES / BREAKEVEN ANALYSIS

	TOTAL Example		PER ACRE	
DIRECT EXPENSES (From Worksheet 2)				
Electricity	324	_____	8.00	_____
Fuel, Oil, Lubrication	~	_____	~	_____
Repairs and Maintenance	460	_____	11.60	_____
Labour	800	_____	20.00	_____
Additional Harvesting	1040	_____	26.00	_____
Other	~	_____	~	_____
_____	~	_____	~	_____
_____	~	_____	~	_____
Total Direct Expenses	2624	_____	65.60	_____
INDIRECT EXPENSES				
Insurance	160	_____	4.00	_____
Water License or Taxes	80	_____	2.00	_____
_____	~		~	
_____	~		~	
Depreciation (Worksheet 2)	1116	_____	27.90	_____
Interest (Worksheet 2)	1050	_____	27.00	_____
Total Indirect Expenses	2401	_____	60.00	_____
TOTAL EXPENSES	5030	_____	125.75	_____
BREAKEVEN ANALYSIS				
Value Per Unit ($ per ton)			150.00	_____
Yield Required to Breakeven:				
(1) Direct Expenses: $*60.60* (Acre) / $ *150* (ton) =			0.40	_____
(2) Total Expenses: $ *125.75* (Acre) / $ *150* (ton) =			0.84	_____

Note: If the irrigation system is used for another purpose (e.g.) manure disposal),
The indirect expenses should be prorated among the alternative uses.

WORKSHEET 5
IMPACT ON NET FARM INCOME

	TOTAL		PER ACRE	
ADDITIONAL INCOME				
2 tons x $ 150 x 40 acres (Acre / ton)	12000	_____	300.00	_____
Less reduced income (e.g. interest on savings)	-378	_____	-9.45	_____
Total Additional Income	11622	_____	390.55	_____
ADDITIONAL EXPENSES (Worksheet 3)				
Electricity	324	_____	8.00	_____
Fuel, Oil, Lubrication	~	_____	~	_____
Repairs and Maintenance	460	_____	11.60	_____
Labour	800	_____	20.00	_____
Additional Harvesting	1040	_____	26.00	_____
_____				
_____				
Insurance	160	_____	4.00	_____
Water License or Taxes	80	_____	2.00	_____
Loan Interest (see example)	728	_____	18.00	_____
Miscellaneous	~	_____	~	_____
_____	~	_____	~	_____
Less reduced expenses	~	_____	~	_____
Total Additional Expenses	3592	_____	89.80	_____
EXCESS INCOME OVER EXPENSES	8030	_____	200.75	_____
Less Depreciation (Worksheet 2)	1116	_____	27.90	_____
Inventory Change (+ or -)	~		~	
ADDITIONAL NET INCOME	6914	_____	172.85	_____

Notes: If the irrigation system is used for another purpose (e.g. manure disposal), depreciation, interest, and insurance should be pro-rated among the alternative uses.

WORKSHEET 6
IMPACT ON CASH FLOW

	TOTAL		PER ACRE	
ADDITIONAL INCOME				
Income (Worksheet5)	12000	_____	300.00	_____
Less reduced income (e.g. interest on savings)	-378	_____	-9.45	_____
Total Additional Inflow	11622	_____	390.55	_____
ADDITIONAL CASH OUTFLOW (Worksheet 3)				
Electricity	324	_____	8.00	_____
Fuel, Oil, Lubrication	~	_____	~	_____
Repairs and Maintenance	460	_____	11.60	_____
Labour	800	_____	20.00	_____
Additional Harvesting	1040	_____	26.00	_____
_____				
_____				
Insurance	160	_____	4.00	_____
Water License or Taxes	80	_____	2.00	_____
Loan Payments (see example)	1678	_____	41.95	_____
Miscellaneous	~	_____	~	_____
_____	~	_____	~	_____
Less reduced expenses	~	_____	~	_____
Total Additional Outflow	4542	_____	113.55	_____
ADDITIONAL NET CASHFLOW	7080	_____	177.00	_____

Notes: (1) If the irrigation system is used for another purpose (e.g. manure disposal), depreciation, interest, and insurance should be pro-rated among the alternative uses.

(2)There may also be some Income Tax considerations

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