APPENDIX E NITRATE SENSITIVITY ANALYSIS

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Site Name:	Circle WWTP, Pre-Upgrade Loading			
County:	McCone			
Notes:	Public, Two-celled System, constructed 1954			
Eff	luent Seepage Rate from Pond System	Value	Units	Notes
Pond Seepage D	ischarge (Q) = KIA = 99.3 m ³ /day ~ 11,601 ft ³ /day	99.3	m ³ /day	(3,507 ft ³ /day)
Where:				·
K = hydraulic co	nductivity of clay liner = 10^{-9} m/sec	2.34E-09	m/sec	From estimated seepage rate of 9,611,500 gal/yr (Interstate Engineering 2004)
I = Hydraulic gra=6+1 ft/1 ft	adient = pond operating depth+liner thickness/liner thickness	7	NA	(Interstate Engineering 2004)
A = Pond area 1'	7.34 acres (70,173 m^2)	70173.000	m^2	(Interstate Engineering 2004)
	Nitrogen Concentration of Effluent-Affected	l Groundwa	ter Reac	hing the Redwater River
VARIABLES	Description	Value	Units	Notes
К	Aquifer Hydraulic Conductivity	0.283	ft/day	Silty Sand at 10 ⁻⁵ cm/s (Freeze and Cherry 1979)
Ι	Hydraulic Gradient	0.003	ft/ft	From local wells U/S of system
D	Mixing Zone Thickness (usually constant)	15.000	ft	Assumed mixing depth in the alluvial aquifer
L	Mixing Zone Length (see ARM 17.30.517(1)(d)(viii)	300.000	ft	Measured median distance from edge of pond system to Redwater River bank
Y	Width of Source Perpendicular to Ground Water Flow	1000.000	ft	Per system plan map
Ng	Background Nitrate (as Nitrogen) Concentration in Ground Water	1.600	mg/L	Average for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.
Nr	Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)	1.000	mg/L	Default
Ne	Nitrate (as Nitrogen) Concentration in Effluent	10.600	mg/L	Circle DMR mean for TN
#1	Facility Operated as a single system discharge	1.000		
Ql	Effluent Seepage Rate	3,507	ft ³ /day	
Р	Precipitation	13.380	in/year	Circle weather station mean annual precipitation
V	Percent of Precipitation Recharging Ground Water (usually constant)	0.200		
EQUATIONS	Description	Value	Units	Notes
W	Width of Mixing Zone Perpendicular to Ground Water Flow $= (0.175)(L)+(Y)$	1052.500	ft	Assumes 5° dispersion angle from each side of the source
Am	Cross Sectional Area of Aquifer Mixing Zone = (D)(W)	15787.500	ft^2	
As	Surface Area of Mixing $Zone = (L)(W)$	315750.000	ft^2	

Table E-1. Nitrogen Loading Analysis Before Waste Water Treatment Plant Upgrade

Qg	Ground Water Flow Rate = $(K)(I)(Am)$	13.404	ft ³ /day	
Qr	Precipitation Recharge Flow Rate = $(As)(P/12/365)(V)$	192.910	ft ³ /day	
Qe	Effluent Flow Rate = (#1)(Q1)	3,507	ft ³ /day	
SOLUTION	Description	Value	Units	Notes
Nt	Nitrate (as Nitrogen) Concentration entering Redwater	10.069	mg/L	
	River			
	=((Ng)(Qg)+(Nr)(Qr)+(Ne)(Qe)) / ((Qg)+(Qr)+(Qe))			
	Surface Water-Effl	uent Seepag	<u>e Mixing</u>	
	Description	Value	Units	Notes
Nsw	Background Nitrate (as Nitrogen) Concentration in Surface	1.241	mg/L	Average growing season concentration for stations
	Water		23/1	MCNREDW-01, MCNREDW-02 & 6177500
Qsw	Baseflow Surface Water Discharge Rate	28912.000	ft ³ /day	Baseflow average (0.335 cfs)
Ngw	Concentration of Effluent-affected Groundwater	10.073	mg/L	C45Above
	Cross Sectional Area of Aquifer Mixing $Zone = (D)(W)$	15787.500	ft ²	C38 Above
	Aquifer Gradient	0.003	NA	C22 Above
	Aquifer Hydraulic Conductivity	0.283	ft/day	Silty Sand at 10 ⁻⁵ cm/s (Freeze and Cherry 1979)
Qgw		13.404	ft ³ /day	
Qsw		28912.000	ft ³ /day	
	Concentration of mixed surface water and effluent	2.527	mg/L	
	Loading Contributions From Trea	tment Syste	em vs Ups	stream Sources
	Baseflow Surface Water Discharge Rate (cfs)	0.335	cfs	Growing season baseflow average
	Upstream Nitrogen Concentration in Surface Water (mg/L)	1.241	mg/L	Mean of upstream growing season TN concentration
				Flow (cfs)*concentration (mg/L*conversion factor
	Upstream Nitrogen Loading rate (lbs/day)	2.245	lbs/day	(5.4)
	Effluent Discharge Rate (cfs)	0.041	cfs	C42/86400 sec/day
	Effluent Nitrogen Concentration (mg/L)	10.600	mg/L	
	Treatment System Loading Rate (lbs/day)	2.3	lbs/day	
	Treatment System Percentage of Total Load	51		
	Upstream Percentage of Nitrogen Load	49		

Table E-1. Nitrogen Loading Analysis Before Waste Water Treatment Plant Upgrade

County:McConeNotes:Public, Three-celled System, constructed 2009Effluent Scepage Rate from Pond SystemValueUnitsNotesPond Scepage Discharge (Q) = KIA = 0.152 ³ /day ~ 5.4 ft ³ /day0.152 m^3/day $(5.4 ft^3/day)$ Where:	Site Name:	Circle WWTP, Post Upgrade Loading			
Notes: Public, Three-celled System, constructed 2009 Image: Funct: Secage Rate from Pond System Value Units Notes Pond Seepage: U; = KIA = 0.152 ² /day ~ 5.4 ft ³ /day 0.12 m ³ /day (5.4 ft ³ /day) Where: (Interstate Engineering 2004) I = Hydraulic conductivity of clay liner = 10 ⁻¹¹ m/sec 4.600E-11 m/sec (Interstate Engineering 2004) A = Pond area 7.9 arcs (31970 m ³) 31970.000 m ² (Interstate Engineering 2004) A = Pond arca 7.9 arcs (31970 m ³) 31970.000 m ² (Interstate Engineering 2004) YARIABLES Description Value Units Notes YARIABLES Aquifer Hydraulic Conductivity 0.233 ft/day Silty Sand at 10 ³ cm/s (Freeze and Cherry 1979) I Hydraulic Gradient 0.003 ft Assumed mixing depth in the alluvial aquifer I Hydraulic Gradient 0.003 ft System to Redwater River bank Y Mixing Zone Ength (see ARM 17.30.517(1/d)(viii) 900.000 ft System to Redwater River bank	County:	McCone			
Filture Sepage Rate from Pond SystemValueValueUnitsNotesPond Sepage Jurg (0) = KLA = 0.152 ¹ /day ~ 5.4 f ¹ /day0.152m ³ /day(5.4 f ³ /day)Where:KK </th <th>Notes:</th> <th>Public, Three-celled System, constructed 2009</th> <th></th> <th></th> <th></th>	Notes:	Public, Three-celled System, constructed 2009			
Pond Seepage Discharge (Q) = KIA = $0.152^3/day \sim 5.4 ft^3/day$ 0.152 m^3/day $(5.4 ft^3/day)$ Where:K = hydraulic conductivity of clay liner = 10^{-11} m/sec4.600E-11m/secI = Hydraulic gradient = 1.2 m operating depth 1.200 NA(Interstate Engineering 2004)A = Pond area 7.9 acres (31,970 m ³)31970.000m ² (Interstate Engineering 2004)Vitrogen Concentration of Effluent-Affected Groundwater ReachingVARIABLESDescriptionValueUnitsNotesKAquifer Hydraulic Conductivity 0.283 ft/daySilty Sand at 10^{-5} cm/s (Freeze and Cherry 1979)IHydraulic Gradient 0.003 ft/ftFrom local wells U/S of systemDMixing Zone Thickness (usually constant) 15.000 ftAssumed mixing depth in the alluvial aquiferLMixing Zone Length (see ARM 17.30.517(1)(d)(viii) 900.000 ftSystem to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow 750.000 ftPer system plan mapNgWater 1.600 mg/LDefaultNrconstant) 1.000 mg/LDefaultNrconstant) 1.000 mg/LDefaultNeNitrate (as Nitrogen) Concentration in Effluent 10.000 mg/LCircle DMR mean for TNMater 1.000 mg/LDefaultCircle DMR mean for TNMitFacility Operated as a single system discharge 1.000 mg/LCircle DMR mean for TN <t< th=""><th></th><th>Effluent Seepage Rate from Pond System</th><th>Value</th><th>Units</th><th>Notes</th></t<>		Effluent Seepage Rate from Pond System	Value	Units	Notes
Where:Image: Constraint of the second s	Pond Seepage D	ischarge (Q) = KIA = 0.152^3 /day ~ 5.4 ft ³ /day	0.152	m ³ /day	$(5.4 \text{ ft}^3/\text{day})$
K = hydraulic conductivity of clay liner = 10 ⁻¹¹ m/sec 4.600E-11 m/sec I = Hydraulic gratient = 1.2 m operating depth 1.200 NA (Interstate Engineering 2004) A = Pond area 7.9 acres (31.970 m ²) 3197.000 m ² (Interstate Engineering 2004) VARIABLES Description Value Units Notes VARIABLES Description Value Units Notes K Aquifer Hydraulic Conductivity 0.283 f/day Silty Sand at 10 ⁻⁵ cm/s (Freeze and Cherry 1979) I Hydraulic Gradient 0.003 ft/ft From local wells U/S of system D Mixing Zone Thickness (usually constant) 15.000 ft Assumed mixing depth in the alluvial aquifer L Mixing Zone Length (see ARM 17.30.517(1)(d)(viii) 900.000 ft system to Redwater River bank Y Width of Source Perpendicular to Ground Water Flow 750.000 ft Per system plan map Mage Mater 1.600 mg/L Average for 53 wells "MCN" GWIC, WQ, Total Ng Nitrate (as Nitrogen) Concentration in Precipitation (usually mg/L Default Nr constant) 1.000 <t< td=""><td>Where:</td><td></td><td></td><td></td><td></td></t<>	Where:				
I = Hydraulic gradient = 1.2 m operating depth1.200NA(Interstate Engineering 2004)A = Pond are 7.9 acres (31,970 m²)31970.000m²(Interstate Engineering 2004)Nitrogen Concentration of Effluent-Affected Groundwater Reaching the Redwater RiverVARIABLESDescriptionValueUnitsNotesKAquifer Hydraulic Conductivity0.283ft/daySilty Sand at 10 s² cm/s (Freeze and Cherry 1979)IHydraulic Gradient0.003ft/ftFrom local wells U/S of systemDMixing Zone Thickness (usually constant)15.000ftAssumed maixing depth in the alluvial aquiferLMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftsystem to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapNgWater1.600mg/LDepth < 150 ft.	K = hydraulic co	onductivity of clay liner = 10^{-11} m/sec	4.600E-11	m/sec	
A = Pond area 7.9 acres (31,970 m²) 31970.000 m² (Interstate Engineering 2004) Nitrogen Concentration of Effluent-Affected Groundwater Reaching the Redwater River VARIABLES Description Value Units Redwater River VARIABLES Aquifer Hydraulic Conductivity 0.283 ft/day Silty Sand at 10 ⁵ cm/s (Freeze and Cherry 1979) I Hydraulic Gradient 0.003 ft/ft From local wells U/S of system D Mixing Zone Thickness (usually constant) 15.000 ft Assumed mixing depth in the alluvial aquifer L Mixing Zone Length (see ARM 17.30.517(1)(d)(viii) 900.000 ft system to Redwater River bank Y Width of Source Perpendicular to Ground Water Flow 750.000 ft Per system plan map Background Nitrate (as Nitrogen) Concentration in Ground mg/L Depth < 150 ft. Percent of Precipitation fully Nr constant) Inter (as Nitrogen) Concentration in Effluent 1.000 mg/L Default Nitrate (as Nitrogen) Concentration in Effluent 10.600 mg/L Default Nr constant) Inter (is Nitrogen) Concentration in Effluent 1.000 mg/L Circ	I = Hydraulic gra	adient = 1.2 m operating depth	1.200	NA	(Interstate Engineering 2004)
Nitrogen Concentration of Effluent-Affected Groundwater Reaching the Redwater RiverVARIABLESConcentration of Effluent-Affected Groundwater Reaching the Redwater RiverKAquifer Hydraulic Conductivity0.283ft/daySilty Sand at 10 ⁵ cm/s (Freeze and Cherry 1979)IHydraulic Gradient0.003ft/ftFrom local wells U/S of systemDMixing Zone Thickness (usually constant)15.000ftAssumed mixing depth in the alluvial aquiferDMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftMeasured media distance from edge of pondYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapNgBackground Nitrate (as Nitrogen) Concentration in Groundmg/LDepth < 150 ft.	A = Pond area 7.	.9 acres (31,970 m ²)	31970.000	m^2	(Interstate Engineering 2004)
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I IHydraulic Gradient0.003ft/ftFrom local wells U/S of systemDMixing Zone Thickness (usually constant)15.000ftAssumed mixing depth in the alluvial aquiferLMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftMeasured median distance from edge of pond system to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapMacground Nitrate (as Nitrogen) Concentration in Precipitation (usually watermg/LDepth < 150 ft.	К	Aquifer Hydraulic Conductivity	0.283	ft/day	Silty Sand at 10 ⁻⁵ cm/s (Freeze and Cherry 1979)
DMixing Zone Thickness (usually constant)15.000ftAssumed mixing depth in the alluvial aquiferLMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftMeasured median distance from edge of pond system to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapMaxing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftAverage for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.	Ι	Hydraulic Gradient	0.003	ft/ft	From local wells U/S of system
LMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftMeasured median distance from edge of pond system to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapBackground Nitrate (as Nitrogen) Concentration in Ground WaterAverage for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.	D	Mixing Zone Thickness (usually constant)	15.000	ft	Assumed mixing depth in the alluvial aquifer
LMixing Zone Length (see ARM 17.30.517(1)(d)(viii)900.000ftsystem to Redwater River bankYWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapBackground Nitrate (as Nitrogen) Concentration in Ground WaterAverage for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.					Measured median distance from edge of pond
YWidth of Source Perpendicular to Ground Water Flow750.000ftPer system plan mapBackground Nitrate (as Nitrogen) Concentration in Ground WaterAverage for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.	L	Mixing Zone Length (see ARM 17.30.517(1)(d)(viii)	900.000	ft	system to Redwater River bank
Background Nitrate (as Nitrogen) Concentration in Ground WaterAverage for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.NgWater1.600mg/LDepth < 150 ft.	Y	Width of Source Perpendicular to Ground Water Flow	750.000	ft	Per system plan map
NgWater1.600mg/LDepth < 150 ft.Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)1.000mg/LDefaultNeNitrate (as Nitrogen) Concentration in Effluent10.600mg/LCircle DMR mean for TN#1Facility Operated as a single system discharge1.000mg/LCircle DMR mean for TN#1Facility Operated as a single system discharge1.000QlEffluent Seepage Rate5.385ft³/dayPPrecipitation Recharging Ground Water (usually constant)0.200Circle weather station mean annual precipitationVconstant)0.200Notes		Background Nitrate (as Nitrogen) Concentration in Ground		_	Average for 53 wells "MCN" GWIC, WQ, Total
Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)mDefaultNrconstant)1.000mg/LDefaultNeNitrate (as Nitrogen) Concentration in Effluent10.600mg/LCircle DMR mean for TN#lFacility Operated as a single system discharge1.000QlEffluent Seepage Rate5.385ft³/dayPPrecipitation Recharging Ground Water (usually constant)in/yearCircle weather station mean annual precipitationVOnstant)0.200EQUATIONSDescriptionValueUnitsNotes	Ng	Water	1.600	mg/L	Depth < 150 ft.
Ni Constant/ Constant/ Default Ne Nitrate (as Nitrogen) Concentration in Effluent 10.600 mg/L Circle DMR mean for TN #1 Facility Operated as a single system discharge 1.000 mg/L Circle DMR mean for TN QI Effluent Seepage Rate 5.385 ft ³ /day circle weather station mean annual precipitation P Precipitation Recharging Ground Water (usually constant) 0.200 Circle weather station mean annual precipitation V constant) 0.200 Mathematical State Notes Width of Mixing Zone Perpendicular to Ground Water Value Units Notes	Nr	Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)	1 000	mg/I	Default
Net Nutrate (as Nutrogen) Concentration in Efficient 10.000 Ing/L Circle DMR mean for TN #1 Facility Operated as a single system discharge 1.000 Ql Effluent Seepage Rate 5.385 ft³/day P Precipitation 13.380 in/year Circle weather station mean annual precipitation V Percent of Precipitation Recharging Ground Water (usually constant) 0.200 EQUATIONS Description Value Units Notes	INI No	Nitrote (og Nitrogen) Concentration in Effluent	10,600	mg/L	Circle DMD mean for TN
#I Facility Operated as a single system discharge 1.000 Ql Effluent Seepage Rate 5.385 ft ³ /day P Precipitation 13.380 in/year Circle weather station mean annual precipitation V Percent of Precipitation Recharging Ground Water (usually constant) 0.200 Image: Constant (Usually constant) EQUATIONS Description Value Units Notes	ine		10.000	IIIg/L	
Ql Effluent Seepage Rate 5.385 ft³/day P Precipitation 13.380 in/year Circle weather station mean annual precipitation V Percent of Precipitation Recharging Ground Water (usually constant) 0.200 Circle weather station mean annual precipitation EQUATIONS Description Value Units Notes	#1	Facility Operated as a single system discharge	1.000	. 2	
P Precipitation 13.380 in/year Circle weather station mean annual precipitation V Percent of Precipitation Recharging Ground Water (usually constant) 0.200 0.200 0.200 EQUATIONS Description Value Units Notes	Ql	Effluent Seepage Rate	5.385	ft³/day	
Percent of Precipitation Recharging Ground Water (usually constant) 0.200 EQUATIONS Description Value Units Width of Mixing Zone Perpendicular to Ground Water 0.200	Р	Precipitation	13.380	in/year	Circle weather station mean annual precipitation
V Constant) 0.200 EQUATIONS Description Value Units Width of Mixing Zone Perpendicular to Ground Water Image: Constant State	¥7	Percent of Precipitation Recharging Ground Water (usually	0.000		
EQUATIONS Description Value Units Notes Width of Mixing Zone Perpendicular to Ground Water		constant)	0.200	T T •4	N. 4
Width of Willing Zone Perpendiciliar to Exclining Water	EQUATIONS	Description	Value	Units	Notes
Flow		Flow			Assumes 5° dispersion angle from each side of
W = $(0.175)(L)+(Y)$ 907 500 ft the source	W	= (0.175)(L) + (Y)	907 500	ft	the source
AmCross Sectional Area of Aquifer Mixing Zone = (D)(W)13612.500ft²	Am	$\frac{-(0.175)(D)(1)}{Cross Sectional Area of Aquifer Mixing Zone = (D)(W)}$	13612.500	ft ²	
As Surface Area of Mixing Zone = $(L)(W)$ 816750.000 ft ²	As	Surface Area of Mixing Zone = $(L)(W)$	816750.000	ft ²	
Og Ground Water Flow Rate = $(K)(I)(Am)$ 11.557 ft^3/day	Og	Ground Water Flow Rate = $(K)(I)(Am)$	11.557	ft ³ /dav	

Table E-2. Nitrogen Loading Analysis After Waste Water Treatment Plant Upgrade

Qr	Precipitation Recharge Flow Rate = $(As)(P/12/365)(V)$	499.001	ft ³ /day	
Qe	Effluent Flow Rate = $(1\#)(Q1)$	5.385	ft ³ /day	
SOLUTION	Description	Value	Units	Notes
	Nitrate (as Nitrogen) Concentration entering Redwater River			
Nt	=((Ng)(Qg)+(Nr)(Qr)+(Ne)(Qe)) / ((Qg)+(Qr)+(Qe))	1.114	mg/L	
	Surface Water-Eff	luent Seepa	ge Mixing	
	Description	Value	Units	Notes
Nsw	Background Nitrate (as Nitrogen) Concentration in Surface Water	1.231	mg/L	Mean of upstream growing season TN concentration
Qsw	Baseflow Surface Water Discharge Rate	28912.000	ft ³ /day	Baseflow average-0.335 cfs
Ngw	Concentration of Effluent-affected Groundwater	1.114	mg/L	C47Above
	Cross Sectional Area of Aquifer Mixing Zone = (D)(W)	13612.500	ft ²	C37 Above
	Aquifer Gradient	0.003	NA	C19 Above
	Aquifer Hydraulic Conductivity	0.283	ft/day	Silty Sand at 10 ⁻⁵ cm/s (Freeze and Cherry 1979)
Qgw		11.557	ft ³ /day	
Qsw		28912.000	ft ³ /day	
	Concentration of mixed surface water and effluent	1.233	mg/L	
	Loading Contributions From Trea	atment Syst	em vs Upstrea	am Sources
	Baseflow Surface Water Discharge Rate (cfs)	0.335	cfs	Growing season baseflow average
	Upstream Nitrogen Concentration in Surface Water (mg/L)	1.200	mg/L	C49 above
	Unstroom Nitrogon Loading rate (lbs/day)	2 171	lbs/day	Flow (cfs)*concentration (mg/L*conversion
	Effluent Discharge Data (afc)	2.171	10s/day	Tactor (3.4)
	Effluent Discharge Rate (Cfs)	0.00006	CIS	
-	Effluent Nitrogen Concentration (mg/L)	10.600	mg/L	
	Treatment System Loading Rate (lbs/day)	0.004	lbs/day	
	Treatment System Percentage of Total Load	0.1641		
	Upstream Percentage of Nitrogen Load	100		

	Table E-2	. Nitrogen	Loading	Analysis	After	Waste Water	Treatment	Plant U	pgrade
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Site Name:	Circle WWTP							
County:	McCone							
Notes:	Loading from Sludge Disposal Area of Former Two-Celled System							
Eff	luent Seepage Rate from Sludge Disposal Area	Value	Units	Notes				
Annual precipitation	$n = (0.20)^* (13.38) = 2.68 \text{ in/year} (0.223 \text{ ft/year})$	13.380	inches	Circle weather station				
Sludge disposal are	ea is 500,000 ft2	500000.000	ft ²	GIS area measurement tool				
Volume of annual	precipitation within disposal area	557500.000	ft ³					
Precipitation infiltr	ation fraction	0.200						
Mean daily volume	e of precipitation entering local aquifer from disposal area	305.479	ft ³ /day					
	Nitrogen Concentration of Effluent-Affected G	roundwater R	Reaching the l	Redwater River				
VARIABLES	Description	Value	Units	Notes				
К	Aquifer Hydraulic Conductivity	2.830	ft/day	Silty Sand at 10-5 cm/s (Freeze and Cherry 1979)				
Ι	Hydraulic Gradient	0.003	ft/ft	From local wells U/S of system				
D	Mixing Zone Thickness (usually constant)	15.000	ft	Default				
L	Mixing Zone Length (see ARM 17.30.517(1)(d)(viii)	800.000	ft	Median distance from edge of sludge disposal area to Redwater River bank				
Y	Width of Drainfield Perpendicular to Ground Water Flow	1000.000	ft	Per system plan map				
Ng	Background Nitrate (as Nitrogen) Concentration in Ground Water	1.600	mg/L	Average for 53 wells "MCN" GWIC, WQ, Total Depth < 150 ft.				
Nr	Nitrate (as Nitrogen) Concentration in Precipitation (usually constant)	1.000	mg/L	Default				
Ne	Nitrate (as Nitrogen) Concentration in Effluent	10.600	mg/L	Circle DMR mean for TN				
#1	Number of Single Family Homes on the Drainfield	1.000		Source is a single system				
Ql	Quantity of Affected Seepage Entering Local Groundwater	305.479	ft ³ /day	Calculated for clay-lined cell				
Р	Precipitation	13.380	in/year					
V	Percent of Precipitation Recharging Ground Water (usually constant)	0.200						
EQUATIONS	Description	Value	Units	Notes				
W	Width of Mixing Zone Perpendicular to Ground Water Flow = $(0.175)(L)+(Y)$	1140.000	ft					
Am	Cross Sectional Area of Aquifer Mixing Zone = (D)(W)	17100.000	ft ²					
As	Surface Area of Mixing Zone = $(L)(W)$	912000.000	ft ²					
Qg	Ground Water Flow Rate = $(K)(I)(Am)$	145.179	ft ³ /day					

Table E-3. Nitrogen Loading Analysis Sludge Disposal Loading

Qr	Precipitation Recharge Flow Rate = $(As)(P/12/365)(V)$	557.195	ft ³ /day	
Qe	Effluent Flow Rate = (#I)(QI)	305.479	ft ³ /day	
SOLUTION	Description	Value	Units	Notes
Nt	Nitrate (as Nitrogen) Concentration at end of Mixing Zone = $((Ng)(Qg)+(Nr)(Qr)+(Ne)(Qe)) / ((Qg)+(Qr)+(Qe))$	3.996	mg/L	
	Surface Water-Eff	luent Mixing		
	Description	Value	Units	Notes
Nsw	Background Nitrate (as Nitrogen) Concentration in Surface Water	1.241	mg/L	Average growing season concentration for stations MCNREDW-01, MCNREDW-02 & 6177500
Qsw	Baseflow Surface Water Discharge Rate	28912.000	ft ³ /day	Baseflow average-0.3 cfs
Ngw	Concentration of Effluent-affected Groundwater	3.996	mg/L	C41 Above
	Cross Sectional Area of Aquifer Mixing $Zone = (D)(W)$	17100.000	ft ²	C34 Above
	Aquifer Gradient	0.003	NA	C19 Above
	Aquifer Hydraulic Conductivity	2.830	ft/day	Silty Sand at 10-5 cm/s (Freeze and Cherry 1979)
Qgw		145.179	ft ³ /day	
Qsw		28912.000	ft ³ /day	
	Concentration of mixed surface water and effluent	1.353		
	Loading Contributions From Treatme	ent System vs	Upstream So	ources
	Baseflow Surface Water Discharge Rate (cfs)	0.330		
	Upstream Nitrogen Concentration in Surface Water (mg/L)	1.241		
	Upstream Nitrogen Loading rate (lbs/day)	2.211		
	Effluent Discharge Rate (cfs)	0.004		
	Effluent Nitrogen Concentration (mg/L)	10.600		
	Treatment System Loading Rate (lbs/day)	0.202		
	Treatment System Percentage of Total Load	8.385		
	Upstream Percentage of Nitrogen Load	91.615		

Table E-3.	Nitrogen	Loading	Analysis	Sludge	Disposal	Loading
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