GSI
Water Solutions, Inc.

November 14, 2008

Dorothy Pederson
Water Rights Transfer Specialist
Oregon Water Resources Department
North Mall Office Building
725 Summer Street NE, Suite A
Salem, OR 97301-1266

RECEIVED
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WATER RESOURCES DEPT
SALEM, OREGON

Re: Transfer T-10464

Based on our correspondence and discussions, please find enclosed a reconfiguration of the original transfer proposed in T-10464. We are not considering this a new transfer application, but a clarification or reconfiguration of the originally proposed transfer in T-10464. The reconfigured transfer seeks to rectify a discrepancy between the original South Spring surface water POD and the pit well/collector well groundwater POA that now exists at the South Spring. Enclosed are new application materials meant to provide clarification to the originally proposed transfer in T-10464. Because the location of the South Spring POD and the collector well POA are within 500 feet of each other, a geologist report is no longer necessary (ORS 540.531(D)) and is not included. An evaluation of "similar" impact of the collector well on South Spring is attached and the methodology is described below.

An analytical spreadsheet (Wozniak, 2003) utilizing the Jenkins, 1970 and Hunt, 1999 methodologies was utilized to evaluate the impact of pumping the collector well on what has been identified as the South Spring. Assumptions for use of this methodology included the following:

- The collector well is located in the same location as South Spring based on anecdotal information provided by the applicant. To utilize the model, and assumed perpendicular distance from the collector well to the spring of 1 foot was used to allow analysis (zero results in unstable results)
- Aquifer hydraulic conductivity and specific yield were estimated based on geologic descriptions in nearby wells UMAT 50301 (approximately 1,200 feet east) and UMAT 55804 (approximately 2,700 feet southeast), which indicated the local shallow geology consists of sand, course gravel, and some silt. Hydraulic conductivity and specific yield were assumed to be 300 feet/day and 0.15, respectively, and were based on EPA, 1986 and Johnson, 1967.
- The parameter "streambed hydraulic conductivity" was assumed to be the same as aquifer hydraulic conductivity because no streambed is present at the spring.

- The parameter "streambed thickness and width" were assumed to be 1 foot based on the size of the collector well and for analytical stability (thickness likely should be zero since no streambed is present at the spring).
- Aquifer thickness was assumed to be 50 feet based on the geology described in nearby well log UMAT 1335 and also based on the relatively shallow depth of the aquifer that is developed by the collector well.

Results of the analysis are presented on the following attachment and indicate that use of the collector affects what has been identified as South Spring and results in stream depletion of 99.9% of the rate of appropriation after 10 days of continuous pumping of the collector well. This indicates that the collector well will affect the South Spring POD similarly, as described in ORS 540.531(2)(C) and (7)(b).

If you have any questions, please call me at 503-239-8799 ext. 104.

Sincerely,

Jason Melady, RG, CWRE
Project Hydrogeologist
GSI Water Solutions, Inc.

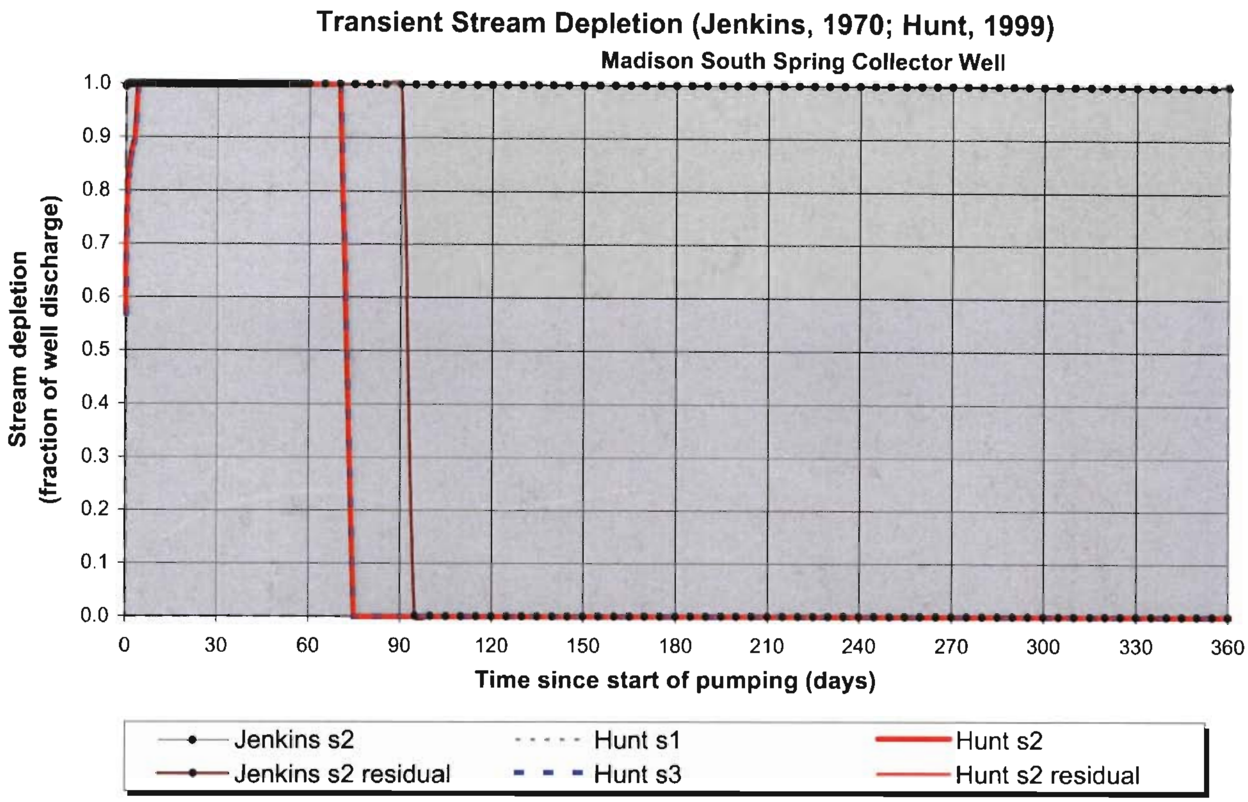
References:
Hunt, B., 1999. Unsteady stream depletion from ground water pumping: Ground Water, v. 37, no. 1, p. 98-102.

Jenkins, C.T., 1968. Techniques for computing rate and volume of stream depletion by wells: Ground Water, v. 6, no. 2, p. 37-46.

Johnson, A.I., 1967. Specific yield — compilation of specific yields for various materials. U.S. Geological Survey Water Supply Paper 1662-D. 74 p.

US EPA, 1986. Saturated Hydraulic Conductivity, Saturated Leachate Conductivity and Intrinsic Permeability. In: Test Methods for Evaluating Solid Waste. SW846, Method 9100. Office of Solid Waste and Emergency Response. U.S. Environmental Protection Agency. Washington D.C.

Wozniak, K.C., 2003. Analytical Spreadsheet to Calculate Transient Stream Depletion using Methods of Jenkins, 1970, and Hunt, 1999. Oregon Water Resources Department, Salem, Oregon.

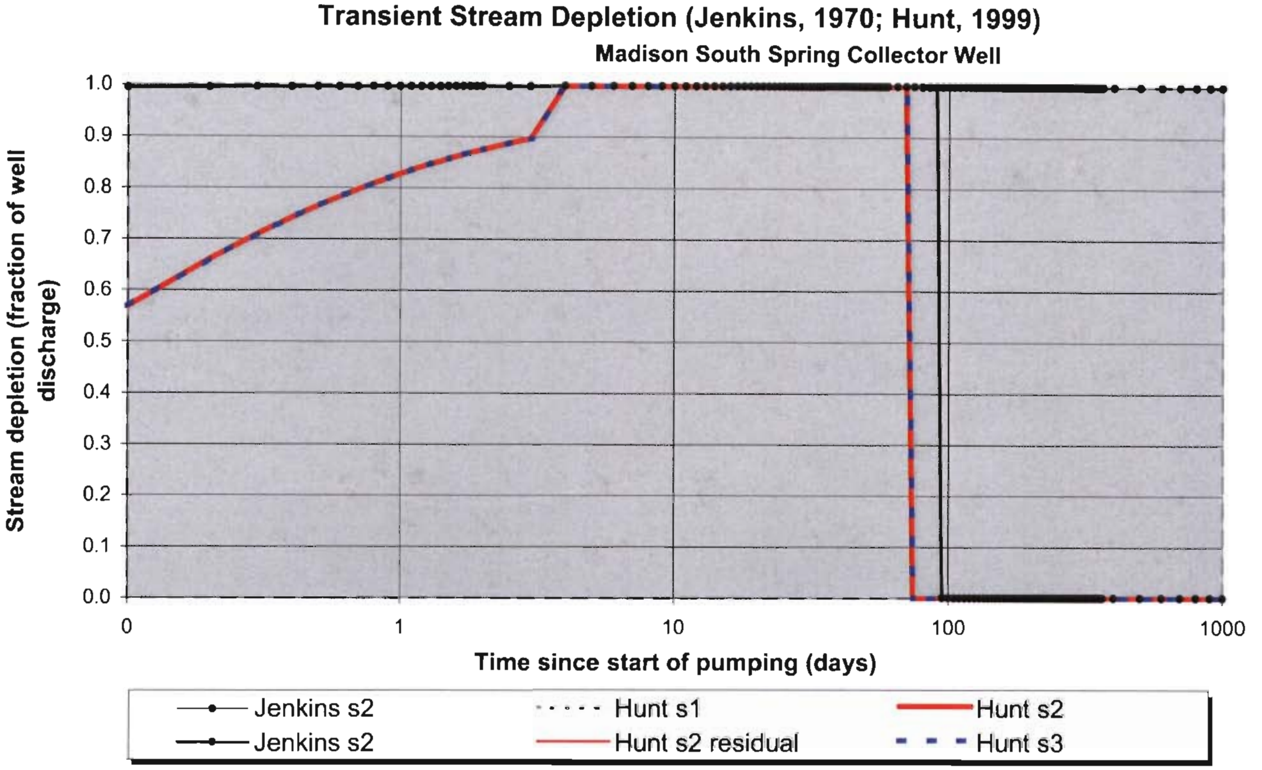

Transient Stream Depletion (Jenkins, 1970; Hunt, 1999)

Madison South Spring Collector Well

Output for Hunt Stream Depletion, Scenerio 2 (s2): **Time pump on = 90 days**

Days	30	60	90	120	150	180	210	240	270	300	330	360
Hunt SD s2	0.9997	0.9998	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Qw, cfs	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
H SD s2, cfs	0.280	0.280	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Parameters:		**Scenario 1**	**Scenario 2**	**Scenario 3**	**Units**
Net steady pumping rate	Qw	0.28	0.28	0.28	cfs
Distance to stream	a	1	1	1	ft
Aquifer hydraulic conductivity	K	300	300	300	ft/day
Aquifer thickness	b	50	50	50	ft
Aquifer transmissivity	T	15000	15000	15000	ft*ft/day
Aquifer storage coefficient	S	0.15	0.15	0.15	
Stream width	ws	1	1	1	ft
Streambed hydraulic conductivity	Ks	300	300	300	ft/day
Streambed thickness	bs	1	1	1	ft
Streambed conductance	sbc	300	300	300	ft/day
Stream depletion factor (Jenkins)	sdf	0.00001	0.00001	0.00001	days
Streambed factor (Hunt)	sbf	0.02	0.02	0.02	



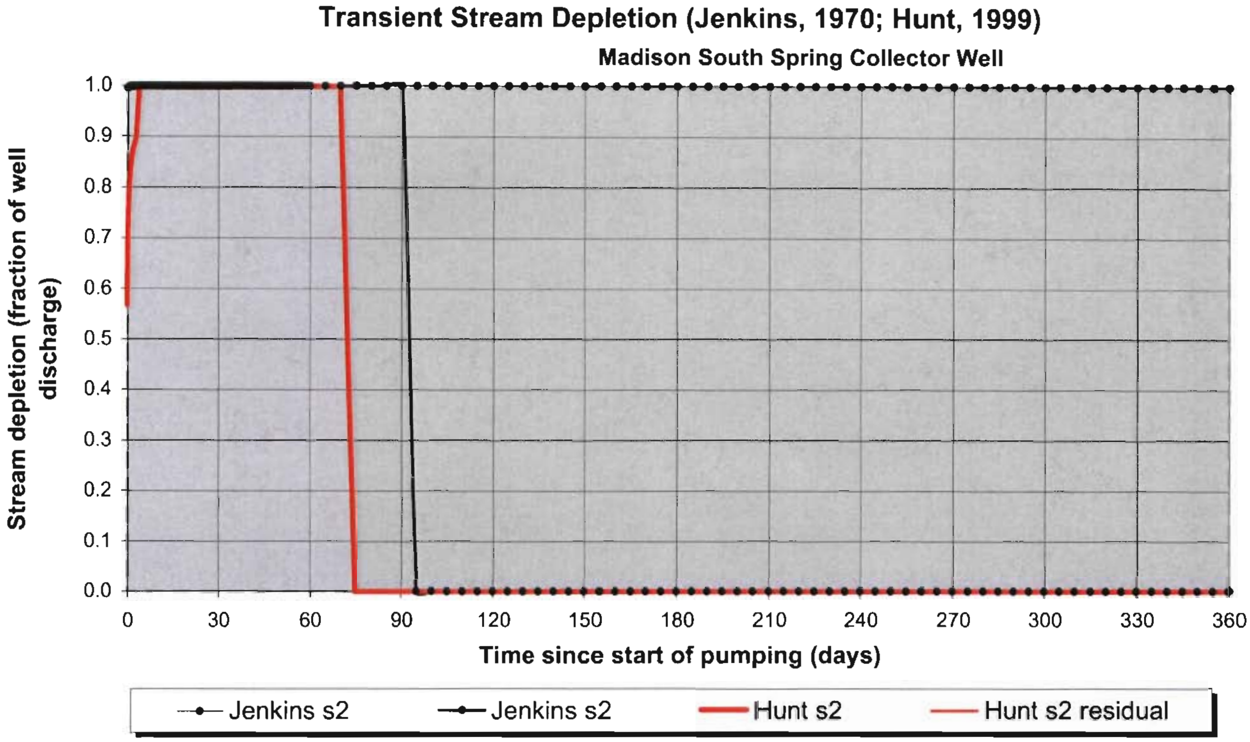
Transient Stream Depletion (Jenkins, 1970; Hunt, 1999)

Madison South Spring Collector Well

Output for Hunt Stream Depletion, Scenerio 2 (s2):

Days	30	60	90	120	150	180	210	240	270	300	330	360
Hunt SD s2	0.9997	0.9998	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Qw, cfs	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
H SD s2, cfs	0.280	0.280	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Parameters:		**Scenario 1**	**Scenario 2**	**Scenario 3**	**Units**
Net steady pumping rate	Qw	0.28	0.28	0.28	cfs
Distance to stream	a	1	1	1	ft
Aquifer hydraulic conductivity	K	300	300	300	ft/day
Aquifer thickness	b	50	50	50	ft
Aquifer transmissivity	T	15000	15000	15000	ft*ft/day
Aquifer storage coefficient	S	0.15	0.15	0.15	
Stream width	ws	1	1	1	ft
Streambed hydraulic conductivity	Ks	300	300	300	ft/day
Streambed thickness	bs	1	1	1	ft
Streambed conductance	sbc	300	300	300	ft/day
Stream depletion factor (Jenkins)	sdf	0.00001	0.00001	0.00001	days
Streambed factor (Hunt)	sbf	0.02	0.02	0.02	



Output for Hunt Stream Depletion, Scenerio 2 (s2):

Days	30	60	90	120	150	180	210	240	270	300	330	360
Hunt SD s2	0.9997	0.9998	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Qw, cfs	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
H SD s2, cfs	0.280	0.280	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Parameters:		**Scenario 1**	**Scenario 2**	**Scenario 3**	**Units**
Net steady pumping rate	Qw	0.28	0.28	0.28	cfs
Distance to stream	a	1	1	1	ft
Aquifer hydraulic conductivity	K	300	300	300	ft/day
Aquifer thickness	b	50	50	50	ft
Aquifer transmissivity	T	15000	15000	15000	ft*ft/day
Aquifer storage coefficient	S	0.15	0.15	0.15	
Stream width	ws	1	1	1	ft
Streambed hydraulic conductivity	Ks	300	300	300	ft/day
Streambed thickness	bs	1	1	1	ft
Streambed conductance	sbc	300	300	300	ft/day
Stream depletion factor (Jenkins)	sdf	0.00001	0.00001	0.00001	days
Streambed factor (Hunt)	sbf	0.02	0.02	0.02	

General Output:	Name	Scenario 1	Scenario 2	Scenario 3	Unit	
a	a_ft		1		ft	
	a_m		0.304878049		m	
Qw	Qw_cfs		0.28		cfs	
	Qw_gpm		125.66		gpm	
	Qw_lps		7.93		lps	
b	b_ft		50		ft	
	b_m		15.24390244		m	
d	d_ft		30		ft	
	d_m		9.146341463		m	
Hydraulic conductivity	K_ft	300.00	300.00	300.00	ft/day	= K
	K_gal	2244.00	2244.00	2244.00	gpd/ft*ft	
	K_m	91.46	91.46	91.46	m/day	
Transmissivity	T_ft	15000.00	15000.00	15000.00	ft*ft/day	= K*b
	T_gal	112200.00	112200.00	112200.00	gpd/ft	
	T_m	1394.26	1394.26	1394.26	m*m/day	
Streambed hydraulic conductivity	Ks_ft	300.00	300.00	300.00	ft/day	= Ks
	Ks_gal	2244.00	2244.00	2244.00	gpd/ft*ft	
	Ks_m	91.46	91.46	91.46	m/day	
Stream width	ws_ft		1		ft	
	ws_m		0.304878049		m	
Stream thickness	bs_ft	1	1	1	ft	
	bs_m	0.304878049	0.304878049	0.304878049	m	
Streambed conductance	sbc_ft	3.00E+02	3.00E+02	3.00E+02	ft/day	= Ks*ws/bs
	sbc_gal	2.24E+03	2.24E+03	2.24E+03	gpd/ft*ft	
	sbc_m	9.15E+01	9.15E+01	9.15E+01	m/day	
Stream depletion factor 1 (intermediate calc)	sdf_1	2.50E-06	2.50E-06	2.50E-06	days	= (a^2*S)/(4T)
Stream depletion factore 2 (intermediate calc)	sdf_2	10	10	10		= sbc^2/(4ST)
Stream depletion factor (Jenkins)	sdf	1.00E-05	1.00E-05	1.00E-05	days	= (a^2*S)/(T)
Streambed factor (Hunt)	sbf	2.00E-02	2.00E-02	2.00E-02		= sbc*a/T
Hunt exponential stream depletion term	hsdt	#NUM!	#NUM!	#NUM!		

Transient Stream Depletion Output:		Scenario 1	Scenario 2	Scenario 3		
Transient Stream Depletion (Jenkins) at time, tp	sdj	0.9998	0.9998	0.9998		= erfc SQRT(sdf)
Transient Stream Depletion (Hunt) at time, tp	sdh	#NUM!	#NUM!	#NUM!		= erfc SQRT(sdf)-hsdt

Plot labels:
#NUM!

Data for Transient Stream Depletion Chart:

Time Since Pump Started [days]	Time Since Pump Stopped [days]	Stream Depletion Hunt s1 sdj s1	Stream Depletion Jenkins s2 sdj s2	Residual Str Depletion Jenkins s2 sdjr s2	Stream Depletion Hunt s2 sdh s2	Residual Str Depletion Hunt s2 sdhr s2	Stream Depletion Hunt s3 sdh s3
0.10	0.0	0.568147296	0.994358151	0.994358151	0.568147296	0.568147296	0.568147296
0.20	0.0	0.660437058	0.996010594	0.996010594	0.660437058	0.660437058	0.660437058
0.30	0.0	0.709787227	0.996742659	0.996742659	0.709787227	0.709787227	0.709787227
0.40	0.0	0.742051692	0.997179058	0.997179058	0.742051692	0.742051692	0.742051692
0.50	0.0	0.765351434	0.997476872	0.997476872	0.765351434	0.765351434	0.765351434
0.60	0.0	0.783228183	0.997696709	0.997696709	0.783228183	0.783228183	0.783228183
0.70	0.0	0.797519671	0.997867566	0.997867566	0.797519671	0.797519671	0.797519671
0.80	0.0	0.809291037	0.998005291	0.998005291	0.809291037	0.809291037	0.809291037
0.90	0.0	0.819209291	0.99811937	0.99811937	0.819209291	0.819209291	0.819209291
1.00	0.0	0.827716897	0.998215877	0.998215877	0.827716897	0.827716897	0.827716897
1.10	0.0	0.835120744	0.998298906	0.998298906	0.835120744	0.835120744	0.835120744
1.20	0.0	0.841641425	0.998371326	0.998371326	0.841641425	0.841641425	0.841641425
1.30	0.0	0.847442184	0.998435221	0.998435221	0.847442184	0.847442184	0.847442184
1.40	0.0	0.852646819	0.998492141	0.998492141	0.852646819	0.852646819	0.852646819
1.50	0.0	0.857351168	0.99854327	0.99854327	0.857351168	0.857351168	0.857351168
1.60	0.0	0.861630751	0.998589527	0.998589527	0.861630751	0.861630751	0.861630751
1.70	0.0	0.865546005	0.99863164	0.99863164	0.865546005	0.865546005	0.865546005
1.80	0.0	0.869145956	0.998670193	0.998670193	0.869145956	0.869145956	0.869145956
1.90	0.0	0.872470845	0.998705661	0.998705661	0.872470845	0.872470845	0.872470845
2.00	0.0	0.875554043	0.998738434	0.998738434	0.875554043	0.875554043	0.875554043
2.50	0.0	0.888186481	0.998871621	0.998871621	0.888186481	0.888186481	0.888186481
3.00	0.0	0.897109259	0.998969936	0.998969936	0.897109259	0.897109259	0.897109259
4.00	0.0	0.999107938	0.999107938	0.999107938	0.999107938	0.999107938	0.999107938
5.00	0.0	0.999202116	0.999202116	0.999202116	0.999202116	0.999202116	0.999202116
6.00	0.0	0.999271634	0.999271634	0.999271634	0.999271634	0.999271634	0.999271634
7.00	0.0	0.999325665	0.999325665	0.999325665	0.999325665	0.999325665	0.999325665
8.00	0.0	0.999369217	0.999369217	0.999369217	0.999369217	0.999369217	0.999369217
9.00	0.0	0.999405292	0.999405292	0.999405292	0.999405292	0.999405292	0.999405292
10.00	0.0	0.99943581	0.99943581	0.99943581	0.99943581	0.99943581	0.99943581

11.00	0.0	0.999462066	0.999462066	0.999462066	0.999462066	0.999462066	0.999462066
12.00	0.0	0.999484968	0.999484968	0.999484968	0.999484968	0.999484968	0.999484968
13.00	0.0	0.999505173	0.999505173	0.999505173	0.999505173	0.999505173	0.999505173
14.00	0.0	0.999523173	0.999523173	0.999523173	0.999523173	0.999523173	0.999523173
15.00	0.0	0.999539341	0.999539341	0.999539341	0.999539341	0.999539341	0.999539341
16.00	0.0	0.999553969	0.999553969	0.999553969	0.999553969	0.999553969	0.999553969
17.00	0.0	0.999567286	0.999567286	0.999567286	0.999567286	0.999567286	0.999567286
18.00	0.0	0.999579478	0.999579478	0.999579478	0.999579478	0.999579478	0.999579478
19.00	0.0	0.999590694	0.999590694	0.999590694	0.999590694	0.999590694	0.999590694
20.00	0.0	0.999601058	0.999601058	0.999601058	0.999601058	0.999601058	0.999601058
21.00	0.0	0.999610672	0.999610672	0.999610672	0.999610672	0.999610672	0.999610672
22.00	0.0	0.999619623	0.999619623	0.999619623	0.999619623	0.999619623	0.999619623
23.00	0.0	0.999627984	0.999627984	0.999627984	0.999627984	0.999627984	0.999627984
24.00	0.0	0.999635817	0.999635817	0.999635817	0.999635817	0.999635817	0.999635817
25.00	0.0	0.999643175	0.999643175	0.999643175	0.999643175	0.999643175	0.999643175
26.00	0.0	0.999650104	0.999650104	0.999650104	0.999650104	0.999650104	0.999650104
27.00	0.0	0.999656645	0.999656645	0.999656645	0.999656645	0.999656645	0.999656645
28.00	0.0	0.999662832	0.999662832	0.999662832	0.999662832	0.999662832	0.999662832
29.00	0.0	0.999668696	0.999668696	0.999668696	0.999668696	0.999668696	0.999668696
30.00	0.0	0.999674265	0.999674265	0.999674265	0.999674265	0.999674265	0.999674265
31.00	0.0	0.999679562	0.999679562	0.999679562	0.999679562	0.999679562	0.999679562
32.00	0.0	0.999684608	0.999684608	0.999684608	0.999684608	0.999684608	0.999684608
33.00	0.0	0.999689424	0.999689424	0.999689424	0.999689424	0.999689424	0.999689424
34.00	0.0	0.999694025	0.999694025	0.999694025	0.999694025	0.999694025	0.999694025
35.00	0.0	0.999698428	0.999698428	0.999698428	0.999698428	0.999698428	0.999698428
36.00	0.0	0.999702646	0.999702646	0.999702646	0.999702646	0.999702646	0.999702646
37.00	0.0	0.999706692	0.999706692	0.999706692	0.999706692	0.999706692	0.999706692
38.00	0.0	0.999710577	0.999710577	0.999710577	0.999710577	0.999710577	0.999710577
39.00	0.0	0.999714312	0.999714312	0.999714312	0.999714312	0.999714312	0.999714312
40.00	0.0	0.999717905	0.999717905	0.999717905	0.999717905	0.999717905	0.999717905
41.00	0.0	0.999721367	0.999721367	0.999721367	0.999721367	0.999721367	0.999721367
42.00	0.0	0.999724704	0.999724704	0.999724704	0.999724704	0.999724704	0.999724704
43.00	0.0	0.999727924	0.999727924	0.999727924	0.999727924	0.999727924	0.999727924
44.00	0.0	0.999731033	0.999731033	0.999731033	0.999731033	0.999731033	0.999731033
45.00	0.0	0.999734038	0.999734038	0.999734038	0.999734038	0.999734038	0.999734038
46.00	0.0	0.999736945	0.999736945	0.999736945	0.999736945	0.999736945	0.999736945
47.00	0.0	0.999739759	0.999739759	0.999739759	0.999739759	0.999739759	0.999739759
48.00	0.0	0.999742484	0.999742484	0.999742484	0.999742484	0.999742484	0.999742484
49.00	0.0	0.999745125	0.999745125	0.999745125	0.999745125	0.999745125	0.999745125
50.00	0.0	0.999747687	0.999747687	0.999747687	0.999747687	0.999747687	0.999747687
51.00	0.0	0.999750173	0.999750173	0.999750173	0.999750173	0.999750173	0.999750173
52.00	0.0	0.999752587	0.999752587	0.999752587	0.999752587	0.999752587	0.999752587
53.00	0.0	0.999754932	0.999754932	0.999754932	0.999754932	0.999754932	0.999754932
54.00	0.0	0.999757211	0.999757211	0.999757211	0.999757211	0.999757211	0.999757211
55.00	0.0	0.999759429	0.999759429	0.999759429	0.999759429	0.999759429	0.999759429
56.00	0.0	0.999761586	0.999761586	0.999761586	0.999761586	0.999761586	0.999761586
57.00	0.0	0.999763687	0.999763687	0.999763687	0.999763687	0.999763687	0.999763687
58.00	0.0	0.999765733	0.999765733	0.999765733	0.999765733	0.999765733	0.999765733
59.00	0.0	0.999767727	0.999767727	0.999767727	0.999767727	0.999767727	0.999767727
60.00	0.0	0.999769671	0.999769671	0.999769671	0.999769671	0.999769671	0.999769671
65.00	0.0	0.999778707	0.999778707	0.999778707	0.999778707	0.999778707	0.999778707
70.00	0.0	0.999786756	0.999786756	0.999786756	0.999786756	0.999786756	0.999786756
75.00	0.0	#NUM!	0.999793987	0.999793987	#NUM!	#NUM!	#NUM!
80.00	0.0	#NUM!	0.999800529	0.999800529	#NUM!	#NUM!	#NUM!
85.00	0.0	#NUM!	0.999806485	0.999806485	#NUM!	#NUM!	#NUM!
90.00	0.0	#NUM!	0.999811937	0.999811937	#NUM!	#NUM!	#NUM!
95.00	5.0	#NUM!	0.999816953	0.000614837	#NUM!	#NUM!	#NUM!
100.00	10.0	#NUM!	0.999821588	0.000385777	#NUM!	#NUM!	#NUM!
105.00	15.0	#NUM!	0.999825887	0.000286546	#NUM!	#NUM!	#NUM!
110.00	20.0	#NUM!	0.99982989	0.000228833	#NUM!	#NUM!	#NUM!
115.00	25.0	#NUM!	0.99983363	0.000190454	#NUM!	#NUM!	#NUM!
120.00	30.0	#NUM!	0.999837132	0.000162867	#NUM!	#NUM!	#NUM!
125.00	35.0	#NUM!	0.999840423	0.000141995	#NUM!	#NUM!	#NUM!
130.00	40.0	#NUM!	0.999843522	0.000125617	#NUM!	#NUM!	#NUM!
135.00	45.0	#NUM!	0.999846447	0.000112409	#NUM!	#NUM!	#NUM!
140.00	50.0	#NUM!	0.999849214	0.000101527	#NUM!	#NUM!	#NUM!
145.00	55.0	#NUM!	0.999851837	9.24078E-05	#NUM!	#NUM!	#NUM!
150.00	60.0	#NUM!	0.999854327	8.46563E-05	#NUM!	#NUM!	#NUM!
155.00	65.0	#NUM!	0.999856696	7.79891E-05	#NUM!	#NUM!	#NUM!
160.00	70.0	#NUM!	0.999858953	7.21962E-05	#NUM!	#NUM!	#NUM!
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170.00	80.0	#NUM!	0.999863164	6.26351E-05	#NUM!	#NUM!	#NUM!
175.00	85.0	#NUM!	0.999865133	5.86483E-05	#NUM!	#NUM!	#NUM!
180.00	90.0	#NUM!	0.999867019	5.50824E-05	#NUM!	#NUM!	#NUM!

185.00	95.0	#NUM!	0.999868829	5.18759E-05	#NUM!	#NUM!	#NUM!
190.00	100.0	#NUM!	0.999870566	4.89784E-05	#NUM!	#NUM!	#NUM!
195.00	105.0	#NUM!	0.999872236	4.63489E-05	#NUM!	#NUM!	#NUM!
200.00	110.0	#NUM!	0.999873843	4.39529E-05	#NUM!	#NUM!	#NUM!
205.00	115.0	#NUM!	0.999875391	4.17618E-05	#NUM!	#NUM!	#NUM!
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220.00	130.0	#NUM!	0.999879714	3.61924E-05	#NUM!	#NUM!	#NUM!
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290.00	200.0	#NUM!	0.999895233	2.13893E-05	#NUM!	#NUM!	#NUM!
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305.00	215.0	#NUM!	0.999897841	1.95176E-05	#NUM!	#NUM!	#NUM!
310.00	220.0	#NUM!	0.999898669	1.89542E-05	#NUM!	#NUM!	#NUM!
315.00	225.0	#NUM!	0.999899476	1.84176E-05	#NUM!	#NUM!	#NUM!
320.00	230.0	#NUM!	0.999900264	1.79061E-05	#NUM!	#NUM!	#NUM!
325.00	235.0	#NUM!	0.999901035	1.7418E-05	#NUM!	#NUM!	#NUM!
330.00	240.0	#NUM!	0.999901787	1.69519E-05	#NUM!	#NUM!	#NUM!
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340.00	250.0	#NUM!	0.999903242	1.60802E-05	#NUM!	#NUM!	#NUM!
345.00	255.0	#NUM!	0.999903946	1.56722E-05	#NUM!	#NUM!	#NUM!
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360.00	270.0	#NUM!	0.999905968	1.45467E-05	#NUM!	#NUM!	#NUM!
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400.00	310.0	#NUM!	0.999910794	1.21252E-05	#NUM!	#NUM!	#NUM!
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800.00	710.0	#NUM!	0.999936922	3.87867E-06	#NUM!	#NUM!	#NUM!
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1000.00	910.0	#NUM!	0.999943581	2.72418E-06	#NUM!	#NUM!	#NUM!

Stream Depletion Analysis
sd_hunt (stream depletion hunt)

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Last modified: 8/11/2003
Version: 1.10

Function of model:
Calculates transient stream depletion using methods of Jenkins, 1970, and Hunt, 1999.

References:

1. Environment Canterbury, 2000, Guidelines for the assessment of groundwater abstraction effects on stream flow: New Zealand Environment Canterbury Regional Council.
2. Glover, R.E. and Balmer, C.G., 1954, river depletion from pumping a well near a river: American Geophysical Union Transactions, v. 35, no. 3, p. 468-470.
3. Hunt, B., 1999, Unsteady stream depletion from ground water pumping: Ground Water, v. 37, no. 1, p. 98-102.
3. Jenkins, C.T., 1968, Techniques for computing rate and volume of stream depletion by wells: Ground Water, v. 6, no. 2, p. 37-46.
4. Jenkins, C.T., 1970, Computation of rate and volume of stream depletion by wells: U.S. Geol. Survey Techniques of Water-Resources Investigations of the Unites States Geological Survey, Chapter D1, Book 4,17 p.
5. Theis, 1941, The effect of a well on the flow of a nearby stream: American Geophysical Union Trans., v. 22, pt. 3, p. 734-738.

Model Assumptions:
1. The ratio of vertical to horizontal velocity components is small (the Dupuit approximation)
2. The aquifer is of infinite extent and is homogenous and isotropic in all horizontal directions.
3. Drawdowns are small enouth compared with saturated aquifer thicknesses to allow the governing equations to be linearized.
4. The streambed cross section has horizontal and vertical dimensions that are small compared to the saturated aquifer thickness, and the steam extends from y = -infinity to y = infinity along x = 0.
5. The well flow rate, Qw, is constant for 0 < t < infinity (t = time pumped)
6. Changes in water surface elevation in the river created by pumping are small compared with changes created in the water table elevation on the aquifer side of the semipervious layer.
7. Seepage flow rates from the river into the aquifer are linearly proportional to the change in piezometric head across the semipervious layer.