

Appendix A. Example of Input File to the EDT Analytical Model

The following is an example of the output file format that will be generated from the Roza-Prosser Reach water-temperature model for input to the EDT analytical model. The first column is the identifier code for the output site, the second column is the output data code

(MAX_WATER_TEMP_C is daily maximum simulated water temperature in degrees Celsius [°C]), the third column is the date (in Afrikaans date format), and the fourth column is the simulated daily maximum water temperature in °C.

H-2C	MAX_WATER_TEMP_C	1984/04/01	12.02
H-2C	MAX_WATER_TEMP_C	1984/04/02	12.62
H-2C	MAX_WATER_TEMP_C	1984/04/03	11.91
H-2C	MAX_WATER_TEMP_C	1984/04/04	11.03
H-2C	MAX_WATER_TEMP_C	1984/04/05	11.46
H-2C	MAX_WATER_TEMP_C	1984/04/06	12.72
H-2C	MAX_WATER_TEMP_C	1984/04/07	11.25
H-2C	MAX_WATER_TEMP_C	1984/04/08	12.29

Appendix B. Method for Deriving Daily Mean Flow for Sites Used to Define Flow for the Roza-Prosser Reach Water-Temperature Model

Tables B1 and B2 show methods used to derive values for daily mean flow for sites used to define flow for the Roza–Prosser Reach water-temperature model. Sites at Hydromet gaging stations used daily mean flow measurements from

those stations. Sites between Hydromet stations were assigned a percentage of the difference in flow between the stations. The assigned percentages were based on flow measurements made by the USGS during field trips in September 2005.

Table B1. Method used to assign daily mean flow to sites used to define flow for the Roza–Prosser Reach water-temperature model.

[Flow calculation abbreviations are listed in table B2; SUM1 = All inflow between Roza Dam and Parker, Washington, minus flow to diversions. Abbreviations: Reclamation, Bureau of Reclamation; NA, not applicable]

Location	Flow calculation	Decimal percent used in calculations
Yakima River below Roza Dam, near Roza	Used daily values measured at RBDW	NA
Selah-Moxee Canal	Used daily values measured at SEXW	NA
Selah Creek at Canyon Road Crossing, near Pomona	Set daily values equal to percent of PARW - (SUM1)	0.003
Wenas Creek near mouth on Reclamation land, near Selah	Set daily values equal to percent of PARW - (SUM1)	.031
Taylor Ditch at Harrison Road Bridge, near Selah	Set daily values equal to percent of SEXW	.080
Golf Course and Selah Sewage Outflow Creek, near Selah	Set daily values equal to percent of PARW - (SUM1)	.197
Naches River near North Yakima, near mouth at Reclamation gaging site 12499900	Used daily values measured at NRYW	NA
Moxee Canal	Set daily values equal to percent of UNGW	.050
Hubbard Canal	Set daily values equal to percent of UNGW	.200
Union Gap Canal	Set daily values measured at UNGW	NA
Richartz Ditch	Set daily values equal to percent of UNGW	.000
Roza Wasteway No. 2 (at Reclamation)	Set daily values equal to RZCW-ROZW	NA
Moxee Drain at Thrope Road	Use daily values measured at BICW	NA
Wide Hollow Creek near mouth	Set daily values equal to percent of PARW - (SUM1)	.658
Ahtanum Creek at Union Gap, Station No. 12502500	Use daily values measured at AUGW	NA
Union Gap Canal Wasteway	Set daily values equal to percent of PARW - (SUM1)	.111
New Reservation Canal Headworks (Wapato Canal)	Use daily values measured at RSCW	NA
Sunnyside Canal near Parker	Use daily values measured at SNCW	NA
Yakima River at Parker, Station No. 1250500	Use daily values measured at PARW	NA
Roza Canal Wasteway No. 3	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0174
Snipes and Allen Ditch Diversion	Set daily values equal to percent of SEXW	.2065
Lateral 1 near the Donald-Wapato Road, near Wapato	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0161
Roza Canal Wasteway No. 4	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0039
Roza-Sunnyside Joint Drain 19.9	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0011
Roza-Sunnyside Joint Drain 20.8	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0017
East Toppenish Drain at Wilson Road, Station No 12505350	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0592
DID Drain 27 at mouth	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0026
Sub-Drain No. 35 at Parton Road, Station No. 12505410	Set daily values equal to percent of (YGVW-SUCW)-PARW	.1073
Granger Drain at Sheep Barns, Station No. 12505460?	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0584
Marion Drain at Indian Church Road, at Granger, Station No. 12505510	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0392
Coulee Drain near Satus Road Crossing (2 Drains?)	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0327

Table B1. Method used to assign daily mean flow to sites used to define flow for the Roza-Prosser Reach water-temperature model.—Continued

[Flow calculation abbreviations are listed in table B2; SUM1 = All inflow between Roza Dam and Parker, Washington, minus flow to diversions.
Abbreviations: Reclamation, Bureau of Reclamation; NA, not applicable]

Location	Flow calculation	Decimal percent used in calculations
Toppenish Creek at Indian Church Road, Station 12507508	Set daily values equal to percent of (YGVW-SUCW)-PARW	0.1122
DID 16 Drain	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0364
Satus Creek at Satus (at gage), Station No. 12508620	Set daily values equal to percent of (YGVW-SUCW)-PARW	.1402
South Drain near Satus, Station No. 12508630	Set daily values equal to percent of (YGVW-SUCW)-PARW	.1205
Satus No. 2 Drain	Set daily values equal to percent of (YGVW-SUCW)-PARW	0.00
DID No. 7 Drain	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0085
Satus No. 3 Drain	Set daily values equal to percent of (YGVW-SUCW)-PARW	.039
Sulphur Creek Wasteway	Use daily values measured at SUCW	NA
Satus Drain 303 + Mabton West Wasteway at Highway 22	Set daily values equal to percent of (YGVW-SUCW)-PARW	.1135
DID Drain 31 (Frazier Drain at Chase-Frasier Road)	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0436
Joint DID 2 Drain	Set daily values equal to percent of (YGVW-SUCW)-PARW	.0465
Outlet for DID No. 10	Set daily values equal to percent of (YRPW+CHCW)-YGVW	.5075
Drain near Grandview-Prosser Highway 8/24-2B	Set daily values equal to percent of (YRPW+CHCW)-YGVW	.0374
Roza-Sunnyside Joint Drain	Set daily values equal to percent of (YRPW+CHCW)-YGVW	.4551
Chandler Canal at Prosser Dam, Station No. 12509499	Use daily values measured at CHCW	NA
Yakima River at Prosser	Use daily values measured at YRPW	NA

Table B2. U.S. Bureau of Reclamation gaging stations used in calculations for the Roza-Prosser Reach water-temperature model.

[Data obtained from Hydromet database]

Station identification	Station description
RBDW	Yakima River below Roza Dam
RZCW	Roza Canal at Headworks
SEXW	Selah Moxee Canal
NRYW	Naches River near Yakima
UNGW	Union Gap Canal
BICW	Moxee Drain at Birchfield Road
AUGW	Ahtanum Creek at Union Gap
ROZW	Roza Canal at 11.0 mile
RSCW	New Reservation Canal
SNCW	Sunnyside Canal
PARW	Yakima River near Parker
SUCW	Sulphur Creek at Holiday Road, near Sunnyside
YGVW	Yakima River at Euclid Road Bridge, near Grandview
CHCW	Chandler-Prosser Power Canal
YRPW	Yakima River near Prosser

Appendix C. Regression Equations Used to Estimate Water Temperature for Each Surface-Water Source of the Roza–Prosser Reach, Washington.

Table C1. Regression equations used to estimate water temperature for each surface-water source of the Roza–Prosser Reach, Washington.

[Abbreviations: NA, Water temperature is not assigned to diversions; T_w , daily mean water temperature in degrees Celsius; m^3/s , cubic meter per second]

Location	Water temperature calculation
Yakima River below Roza Dam, near Roza	$T_w = 4.0 + 0.2991*(45\text{-day moving average of daily mean air temperature}) + 0.3448*(\text{daily mean average of air temperature})$
Selah-Moxee Canal	NA
Selah Creek at Canyon Road Crossing, near Pomona	$T_w = T_w$ at Wide Hollow Creek near mouth
Wenas Creek near mouth on Reclamation land, near Selah	$T_w = T_w$ at Wide Hollow Creek near mouth
Taylor Ditch at Harrison Road Bridge, near Selah	$T_w = T_w$ at Wide Hollow Creek near mouth
Golf Course and Selah Sewage Outflow Creek near Selah	$T_w = T_w$ at Wide Hollow Creek near mouth
Naches River near North Yakima, near mouth at Reclamation gaging station 12499900	$T_w = 2.4 + 0.4635*(45\text{-day moving average of daily mean air temperature}) + 0.2992*(\text{daily mean average of air temperature}) - 0.002*(\text{flow } (m^3/s) \text{ at the Naches River at Yakima gaging station})$
Moxee Canal	NA
Hubbard Canal	NA
Union Gap Canal	NA
Richartz Ditch	$T_w = T_w$ at Wide Hollow Creek near Mouth
Roza Wasteway No. 2 (at Reclamation)	$T_w = T_w$ at Wide Hollow Creek near Mouth
Moxee Drain at Thrope Road	$T_w = T_w$ at Wide Hollow Creek near Mouth
Wide Hollow Creek near mouth	$T_w = (0.5768*\text{daily mean air temperature}) + 20.8$
Ahtanum Creek at Union Gap, Station No. 12502500	$T_w = T_w$ at Wide Hollow Creek near Mouth
Union Gap Canal Wasteway	$T_w = T_w$ at Wide Hollow Creek near Mouth
New Reservation Canal Headworks (Wapato Canal)	NA
Sunnyside Canal near Parker	NA
Yakima River at Parker, Station No. 1250500	NA
Roza Canal Wasteway No. 3	$T_w = T_w$ at Lateral 1 near the Donald-Wapato Road near Wapato
Snipes and Allen Ditch Diversion	NA
Lateral 1 near the Donald-Wapato Road, near Wapato	$T_w = (1.1037*\text{daily mean air temperature}) + 26.4$
Roza Canal Wasteway No. 4	$T_w = T_w$ at Lateral 1 near the Donald-Wapato Road near Wapato
Roza-Sunnyside Joint Drain 19.9	$T_w = T_w$ at Lateral 1 near the Donald-Wapato Road near Wapato
Roza-Sunnyside Joint Drain 20.8	$T_w = T_w$ at Lateral 1 near the Donald-Wapato Road near Wapato
East Toppenish Drain at Wilson Road, Station No 12505350	$T_w = (0.5567*\text{daily mean air temperature}) + 20.6$
DID Drain 27 at mouth	$T_w = T_w$ at Sub-Drain No. 35 at Parton Road, Station No. 12505410
Sub-Drain No. 35 at Parton Road, Station No. 12505410	$T_w = (0.5074*\text{daily mean air temperature}) + 20.1$
Granger Drain at Sheep Barns, Station No. 12505460	$T_w = T_w$ at Sub-Drain No. 35 at Parton Road, Station No. 12505410
Marion Drain at Indian Church Road, at Granger, Station No. 12505510	$T_w = (0.7477*\text{daily mean air temperature}) + 23.1$
Coulee Drain near Satus Road Crossing	$T_w = (0.7312*\text{daily mean air temperature}) + 22.8$
Toppenish Creek at Indian Church Road, Station 12507508	$T_w = (1.0704*\text{daily mean air temperature}) + 22.0$
DID 16 Drain	$T_w = T_w$ at Coulee Drain near Satus Road Crossing
Satus Creek at Satus (at gage), Station No. 12508620	$T_w = (0.8225*\text{daily mean air temperature}) + 23.4$
South Drain near Satus, Station No. 12508630	$T_w = (0.915*\text{daily mean air temperature}) + 24.5$
Satus No. 2 Drain	$T_w = T_w$ at South Drain near Satus, Station No. 12508630
DID No. 7 Drain	$T_w = (0.9929*\text{daily mean air temperature}) + 24.3$
Satus No. 3 Drain	$T_w = T_w$ at DID No. 7 Drain
Sulphur Creek Wasteway	$T_w = T_w$ at DID No. 7 Drain
Satus Drain 303 + Mabton West Wasteway at Highway 22	$T_w = (1.1977*\text{daily mean air temperature}) + 27.5$
DID Drain 31 (Frazier Drain at Chase-Frasier Road)	$T_w = T_w$ at Satus Drain 303 + Mabton West Wasteway at Highway 22
Joint DID 2 Drain	$T_w = T_w$ at Satus Drain 303 + Mabton West Wasteway at Highway 22
Outlet for DID No. 10	$T_w = T_w$ at Satus Drain 303 + Mabton West Wasteway at Highway 22
Drain near Grandview-Prosser Highway 8/24-2B	$T_w = T_w$ at Satus Drain 303 + Mabton West Wasteway at Highway 22
Roza-Sunnyside Joint Drain	$T_w = T_w$ at Satus Drain 303 + Mabton West Wasteway at Highway 22
Chandler Canal at Prosser Dam, Station No. 12509499	NA
Yakima River at Prosser	NA

Appendix D. Example of the Shading Effects Field Sheet.

Shading Effects Field Sheet

Location _____

Date: _____ Time: _____ Hydrographer(s) _____

GPS Coordinates: N _____° _____' _____" accuracy +/- _____ ft

(at center of river) W _____° _____' _____"

Stream Azimuth (-90° to 90°) _____° Magnetic or True North?

Stream Width _____ ft

	West Bank	East Bank
Topographic Altitude	_____°	_____°
Vegetation height (Vh)	_____ ft	_____ ft
Vegetation crown (Vc)	_____ ft	_____ ft
Vegetation offset (Vo)	_____ ft	_____ ft
Vegetation density (Vd)	_____ %	_____ %
Maximum light	_____ Fc	_____ Fc
Shaded light	_____ Fc	_____ Fc

Remarks _____

Appendix E. Regression Equations Used to Estimate Daily Mean Water Temperature in Outflow from Five Reservoirs in the Yakima River Basin

The following section shows regression equations that were used to estimate daily mean water temperature in outflow from five reservoirs in the Yakima River basin. The equations were originally intended for generating input to the Roza–Prosser Reach water-temperature model but were not included in the final version of the model. The equations are included here for documentation purposes.

Regression equations were examined by using S-PLUS (Insightful Corp., 2002) and TableCurve 3D (Systat Software, Inc., 2002) for the purpose of estimating stream water temperatures downstream of five reservoirs. The process of variable selection for the regressions was identical to the process used in Roza Dam and Naches River regression development.

Bumping: (Linear Robust LTS, S-PLUS)

$$\text{BUM} = -1.809 + \text{AT} * 0.1449 + \text{AT45dav} * 0.7177$$

Robust multiple $R^2 = 0.89$, Scale estimate of residual = 1.5 (°C), N = 1620

Cle Elum: (Linear Robust LTS, S-PLUS)

$$\text{CLE} = 16.28 + \text{AT} * 0.0518 - \text{J}' * 0.09 - \text{Q} * 0.004$$

Robust multiple $R^2 = 0.89$, Scale estimate of residual = 2.56, N = 1279

Kachess: (Linear OLS, S-PLUS)

$$\text{KAC} = -2.1 + \text{AT} * 0.1729 + \text{AT45dav} * 0.7995$$

Multiple $R^2 = 0.95$, Residual Standard Error = 1.0 (°C), N = 460

Keechelus: (Linear OLS, S-PLUS)

$$\text{KEE} = 3.5 + \text{AT} * 0.2028 + \text{AT45dav} * 0.4633$$

Multiple $R^2 = 0.91$, Residual Standard Error = 1.4 (°C), N = 742

Rimrock: (Linear Robust LTS, S-PLUS)

$$\text{RIM} = 15.85 - \text{AT45dav} * 0.1071 - \text{J}' * 0.073 + \text{Q} * 0.004$$

Robust multiple $R^2 = 0.98$, Scale estimate of residual = 0.90, N = 360

Explanation of variables:

AT = Air temperature at Yakima Air Terminal as provided from NOAA (°C).

AT45dav = 45 day moving average of air temperature at Yakima Air Terminal (°C).

Q = Flow downstream of dam (cubic meters per second).

J' = Number of days from warmest average water day (for CleElum J' = ABS(Julian day – 233), for Rimrock, J' = ABS(Julian day – 258).

(°C) = degree Celsius.

N = Number of data sets used in regression development.

Appendix F. Daily Maximum, Mean, and Minimum Water Temperature for Sites in the Yakima River Basin, Washington

As a part of this project, water temperature data were collected at 20 sites within the Yakima River basin. Data were collected from May 27, 2005, to December 6, 2006, but the actual period of record for individual sites varies during this period. The data have been entered into the U.S. Geological Survey database (Automated Data Processing System, ADAPS) and are available in an Excel spreadsheet at the USGS Washington Water Science Center Yakima River Temperature Model project website at <http://wa.water.usgs.gov/projects/yakimatemp/data.htm>.

Several sites were located in the upper parts of the watershed and were not used in the development of the model, but they are included here for possible use in other studies. Water temperatures were recorded by Onset StowAway TidbiT thermistors or Onset Optic StowAway thermistors set in enclosures, usually a 1- x 3-inch PVC pipe, tied to something solid on the river bank and placed on the bottom of the river- or creek-channel. Either 30- or 60-minute recording cycles were used to log the data. Recorded values were checked with field measurements during visits to the gaging station.

Table F1. U.S. Geological Survey gaging stations where daily maximum, mean, and minimum water temperature data were collected, Yakima River basin, Washington.

[Data are available at <http://wa.water.usgs.gov/projects/yakimatemp/data.htm>. NAD27, North American Datum of 1927; NAD83, North American Datum of 1983]

Gaging station name	Gaging station No.	Latitude	Longitude	Datum
Gold Creek above Keechelus Lake near Hyak	12473980	47° 23' 25"	121° 22' 54"	NAD27
Box Canyon Creek near Hyak	12473985	47° 21' 32.4"	121° 14' 44.4"	NAD83
Cle Elum River above Cle Elum Lake, near Roslyn	12478300	47° 21' 19"	121° 06' 22"	NAD27
American River near Nile	12488500	46° 58' 40"	121° 10' 03"	NAD27
Tieton River below Oak Creek, near Naches	12493005	46° 43' 39"	120° 8' 35.5"	NAD83
Naches River above Divrsion Dam, near Yakima	12498690	46° 37' 56"	120° 35' 15"	NAD27
Cowiche Creek near Yakima	12498986	46° 37' 38"	120° 34' 52"	NAD83
Wide Hollow Creek near Union Gap	12500447	46° 32' 20"	120° 28' 22"	NAD27
Yakima River above Ahtanum Creek, at Union Gap	12500450	46° 32' 04"	120° 27' 58"	NAD27
Yakima River near Wapato	12505050	46° 29' 09"	120° 25' 49"	NAD27
East Toppenish Drain at Wilson Road, near Toppenish	12505350	46° 22' 04"	120° 15' 00"	NAD27
Sub 35 Drain at Connie Road, near Granger	12505410	46° 20' 11"	120° 13' 48"	NAD27
Lateral 1 Drain near Wapato	1250547010	46° 27' 45"	120° 24' 31"	NAD83
Marion Drain at Indian Church Road and Highway 223	12505510	46° 19' 52"	120° 11' 54"	NAD27
Toppenish Creek at Indain Church Road, near Granger	12507508	46° 18' 52"	120° 11' 53"	NAD27
Coulee Drain at North Satus Road, near Satus	12507560	46° 17' 49"	120° 08' 42"	NAD27
South Drain near Satus	12508630	46° 15' 35"	120° 07' 57"	NAD27
Satus Creek below North Drain, near Satus	1250862050	46° 16' 32"	120° 08' 16"	NAD27
DID 7 Drain near Mabton	12508670	46° 15' 32"	120° 03' 56"	NAD83
Satus Drain 303 near Mabton	12508694	46° 13' 00"	120° 01' 14.5"	NAD83