APPENDIX C: SUPPORTING DOCUMENTS FOR THE CHLOROPHYLL A/PH (PHOSPHORUS) TMDL

APPENDIX C – 1 BACKGROUND DISCUSSION

In 1988 DEQ developed a TMDL designed to address the non-attainment of nuisance algal growth and pH water quality criteria. The initial phosphorus TMDL was in the form of instream compliance concentrations (OAR 340-041-0470 [9][a], Appendix C-2) and mass load allocations (TMDL Number 22M-02-004, Appendix C-3). The TMDL was approved by the USEPA in January 1994. The overall goal of the TMDL was to reduce the chlorophyll *a* concentration in the mainstem of the Tualatin River to a three-month average of .015 mg/L (15 ug/L) or less. (The concentration of chlorophyll *a* is considered to be an indicator of phytoplankton ["floating algae"] concentration.)

In order to achieve this chlorophyll *a* concentration, it was determined that the total phosphorus concentrations in the lower mainstem (below RM 33.3) of the Tualatin River would have to be reduced to a monthly median of 0.07 mg/L or less. The 0.07 mg/L or less concentration of phosphorus is the amount that was determined necessary to adequately reduce phytoplankton growth in the reservoir-like reaches of the mainstem upstream of the Lake Oswego Diversion Dam. In addition to this, the reduction of phosphorus was expected to reduce excessive periphyton growth observed in the faster flowing section downstream of the dam. This concentration is the basis for the 1988 phosphorus loading capacity.

As part of the TMDL development, allocations for various sources of phosphorus in the basin were determined. These allocations were set by performing modeling analyses to determine what concentrations, flows, and masses would be necessary to achieve the 0.07 mg/L concentration of phosphorus. The target concentrations were set for specific locations along the mainstem of the Tualatin, and at the mouths of the major tributaries.

Since the initial development of the Phosphorus TMDL, new information regarding the sources of phosphorus has been presented. In order to better examine this information, and with the goal of developing pertinent recommendations to DEQ, a technical advisory committee and a policy advisory committee were formed. The Tualatin Basin Policy Advisory Committee (TBPAC) reviewed the products of the technical advisory committee and presented its recommendations to DEQ in January 1998. The TBPAC provided nine recommendations specific to phosphorus (listed in Figure A, below).

While all of these recommendations pertain to the phosphorus TMDL, the first three of these are most directly related to the task of reviewing the TMDL and examining how its allocations address all phosphorus sources. Recommendation one is that appropriate loads are allocated to sources and that compliance is defined as implementing plans to meet the load allocations. Recommendation two is that the load allocation for background should be increased to account for all sources. Recommendation three is that the load allocations should be established to allow for human influence. All three of these recommendations are addressed by the TMDL.

Figure A: Tualatin Basin Policy Advisory Committee

Phosphorus Policy Recommendations
to Oregon Department of Environmental Quality

1. Designated Management Agency (DMA) compliance is defined as implementing a water quality management plan (WQMP) designed to meet load allocations and achieving that implementation under an established schedule. This recommendation is based on the following assumptions:
   - Load allocations are achievable
   - Load allocations will meet water quality standards
   - The plan is designed to meet load allocations
   - Load allocations (LAs) are the translations between water quality standards and the design of best management practices
   - DEQ will assure all of the assumptions listed above

2. The LA for background should be increased to account for high background (groundwater) concentrations

3. The LAs should be established above background to allow for some human influence.

4. DEQ should allow other control parameters to be substituted in a WQMP for TMDL parameters when such substitutions are accompanied by demonstration of a relationship between the control and TMDL parameters such that the substitute control criteria will provide reasonable assurance of achievement of the Wasteload Allocations or Load Allocations for the TMDL parameters.

5. TMDLs, permits and WQMPs should be reviewed in a coordinated manner in 1998 and at least every five years thereafter. This may require adjustment of permit renewal dates.

6. DEQ should consider allowing DMAs the ability to trade WLAs and LAs.

7. Trend monitoring should be continued to determine if improvements are being made.

8. The focus of monitoring should be balanced between trend/compliance monitoring and BMP effectiveness monitoring.

9. The DMAs and DEQ should work collaboratively to develop and support research needs.

APPENDIX C-2 – OAR 340-041-0470 (9) (A)

340-041-0470
Special Policies and Guidelines

(9) In order to improve water quality within the Tualatin River subbasin to meet the existing water quality standard for dissolved oxygen, and the 15 ug/1 chlorophyll a action level stated in OAR 340-041-0150, the following special rules for total maximum daily loads, waste load allocations, load allocations, and implementation plans are established:

(a) After completion of wastewater control facilities and implementation of management plans approved by the Commission under this rule and no later than June 30, 1993, no activities shall be allowed and no wastewater shall be discharged to the Tualatin River or its tributaries without the specific authorization of the Commission that cause the monthly median concentration of total phosphorus at the mouths of the tributaries listed below and the specified points along the main-stream of the Tualatin River, as measured during the low flow period between May 1 and October 31*, of each year, unless otherwise specified by the Department, to exceed the following criteria:

(A) Mainstream (RM) -- ug/1:

(i) Cherry Grove (67.8) -- 20;

(ii) Dilley (58.8) -- 40;

(iii) Golf Course Road (52.8) -- 45;

(iv) Rood Rd. (38.5) -- 50;

(v) Farmington (33.3) -- 70;

(vi) Elsner (16.2) -- 70;

(vii) Stafford (5.4) -- 70.

(B) Tributaries -- ug/1":

(i) Scoggins Creek -- 60;

(ii) Gales Creek -- 45;

(iii) Dairy Creek -- 45;

(iv) McKay Creek -- 45;

(v) Rock Creek -- 70;

(vi) Fanno Creek -- 70;

(vii) Chicken Creek -- 70.

APPENDIX C-3 – TMDL NUMBER 22M-02-004

NOTE: THE FOLLOWING IS A COMPUTER-SCANNED COPY OF THE ORIGINAL AND MAY CONTAIN TRANSCRIPTION ERRORS.

TOTAL MAXIMUM DAILY LOAD

WATER QUALITY MANAGEMENT PLAN COMPONENT

Department of Environmental Quality
811 Southwest Sixth Avenue, Portland, OR 97204
Telephone: (503) 229-5696

Developed pursuant to ORS 468.730 and The Federal Clean Water Act

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WATER QUALITY LIMITED SEGMENT:

Tualatin River (RM 0 - 58.8)

RECEIVING SYSTEM INFORMATION:

Basin: Willamette
Subbasin: Tualatin
County: Washington
Clackamas
Multnomah
Yamhill

WQ STANDARD NOT ATTAINED:

Nuisance Algal Growth, pH

APPLICABLE RULES:

OAR 340-41-442
OAR 340-41-150
OAR 340-41-445(2)(d)

OAR 340-41-006
OAR 340-41-470(3)

TMDL PARAMETER:

Total Phosphorus

STREAM SEGMENTS AND SOURCES COVERED BY THIS TMDL:

Source Number	Allocation Type	Source Description
001	LA	Tualatin River (upstream input)
002	LA	Scoggins Creek Sub-basin
003	LA	Mainstem and other streams above Dilley (58.8)
004	LA	Gales Creek Sub-basin
005	LA	Mainstem and other streams above Golf Course Road (RM 58.8 - 52.8)
006	LA	Dairy Creek Sub-basin
007	LA	Mainstem and other tributaries above Rood Rd. (RM 52.8 - 38.5)
008	WLA	USA Rock Creek WTP
009	LA	Rock Creek Sub-basin
010	LA	Mainstem and other tributaries above Farmington (RM 38.5 - 33.3)
011	LA	Mainstem and other tributaries above Elsner (RM 33.3 - 16.2)
012	WLA	USA Durham WTP
013	LA	Fanno Creek Sub-basin
014	LA	Mainstem, Chicken Creek, and other tributaries above Stafford (RM 16.2 - RM 5.4)
015	LA	Mainstem and other tributaries below Stafford (RM 5.4 - 0)
016	LA	Oswego Lake Sub-basin Draining to Oswego Lake

WATER QUALITY MANAGEMENT ACTIVITIES AND IMPLEMENTATION

Until this TMDL is modified, point source permits will be reissued as they are re-opened or expire to include limits for complying with the established waste loads. Compliance schedules will be specified within these permits for reaching identified limits where reduced limits are needed. Nonpoint sources will be addressed through specified schedules established in required program plans for developing and implementing needed control programs. All requirements, limitations, and conditions are set forth in the attached schedules as follows:

a. The loading capacity for total phosphorus in the Tualatin River is based on attaining a monthly median concentration of 70 ug/l of total phosphorus. Net load allocations are based on attaining measured concentrations of total phosphorus at specific locations as defined by OAR 340-41-470 and summarized below:

Cherry Grove (67.8)	20 ug/l
Dilley (58.8)	40 ug/l
Golf Course Rd. (52.8)	45 ug/l
Rood Rd. (38.5)	50 ug/l
Farmington (33.3)	70 ug/l
Elsner (16.2)	70 ug/l
Stafford (5.4)	70 ug/l

b. Loading capacity for the Oswego Lake sub-basin was calculated by the Vollenweider method and described in Lake Oswego Lake and Watershed Assessment 1986 - 1987. Diagnostic and Restoration Analysis. Scientific Resources Inc. Portland, Or.

c. Loading capacities are divided into four hydrologic categories based on typical flows observed between May and October in the Tualatin River and tributaries. The design flow for the lowest range is noted in parenthesis (XX). The design flow for determining loading capacity for the other hydrologic categories is the low end of the flow range.

d. Schedule A, section 1, describes "existing conditions" for phosphorus loads in the Tualatin Basin. Schedule A, section 1, lists the interim load limits not to be exceeded until the implementation of controls. Schedule A, section 2, provides estimated loads by land use required to achieve water quality standards in the Tualatin Basin. These load allocations provide guidance for developing the required program plans.

SCHEDULE A

Pollutant load limits not to be Exceeded

1. Pollutant load limits not to be exceeded until implementation of controls needed to meet condition 2, Schedule A., except as allowed by OAR 340-41-470(3) (existing conditions).

Source Number | Source Description | MONTHLY AVERAGE PHOSPHORUS LOADS May 1 to November 15 (pounds per day)

Source Number	Source Description					
001	LA Tualatin River Upstream Input		Tualatin River flow near Gaston (USGS)			
			less than 10 cfs (5)	10 to 20 cfs	20 to 30 cfs	greater than 30 cfs
	LOAD	lbs/d	0.54	1.08	2.16	3.24
002	LA Scoggins Creek		Scoggins Creek Flow (TVID)			
			less than 50 cfs (25)	50 to 100 cfs	100 to 150 cfs	greater than 150 cfs
	LOAD	lbs/d	8.10	16.2	32.4	48.6
003	LA Mainstem River and other tributaries above Dilley RM 68.8 - 58.8		Tualatin River flow near Dilley (USGS)			
			less than 60 cfs (30)	60 to 120 cfs	120 to 180 cfs	greater than 180 cfs
	LOAD		6.5	13.0	26.0	39.0
004	LA Gales Creek Sub-basin		Gales Creek Flow (TVID)			
			less than 10 cfs (5)	10 to 25 cfs	25 to 50 cfs	greater than 50 cfs
	LOAD		2.0	4.0	10.1	20.2
005	LA Mainstem River and other Tributaries above Golf Course Rd. RM 58.8 - 52.8		Tualatin River Below Pump Plant (TVID)			
			less than 50 cfs (25)	50 to 100 cfs	100 to 200 cfs	greater than 200 cfs
	LOAD		7.4	14.8	29.7	59.
006	LA Dairy Creek Sub-basin		Dairy Creek Flow (TVID)			
			less than 25 cfs (10)	25 to 50 cfs	50 to 100 cfs	greater than 100 cfs
	LOAD		6.7	16.8	33.7	67.5

007	LA	Mainstem River and other Tributaries above Rood Rd. RM 52.8 - 38.5	Tualatin River at Rood Rd. (TVID)			
			less than 100 cfs (75)	100 to 170 cfs	170 to 270 cfs	greater than 270 cfs
		LOAD	42.5	55.6	91.8	153.1
008	WLA	USA Rock Creek Sewage Treatment Plant.	Tualatin River at Farmington (USGS)			
			less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
		LOAD (2250 ug/l * 20 cfs)	245	245	245	245
009	LA	Rock Creek Sub-basin	Rock Creek Flow			
			less than 5 cfs(2.5)	5 to 10 cfs	10 to 25 cfs	greater than 25 cfs
		LOAD	4.3	8.7	17.2	43.2
010	LA	Mainstem River and other Tributaries above Farmington RM 38.5 - 33.3	Tualatin River at Farmington (USGS)			
			less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
		LOAD	200	245	405	610
011	LA	Mainstem River and other Tributaries above Elsner. RM 33.3 - 16.2	Tualatin River at Farmington (USGS)			
			less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
		load	135	162	324	400
012	WLA	USA Durham Sewage Treatment Plant.	Tualatin River at Farmington (USGS)			
			less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
		LOAD (2250 ug/l*20cfs)	245	245	245	245

013	LA Fanno Creek Sub-basin	Fanno Creek Flow			
		less than 5 cfs(2.5)	5 to 10 cfs	10 to 25 cfs	greater than 25 cfs
	LOAD	2.7	5.4	10.8	27.0
014	LA Mainstem River and other Tributaries above Stafford RM 38.5 - 16.2	Tualatin River at West Linn (USGS) Plus Flow in the Lake Oswego Diversion			
		less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	LOAD	190	225	380	570
015	LA Mainstem River and other Tributaries Below Stafford RM 38.5 - 16.2	Tualatin River at West Linn (USGS)			
		less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	LOAD	190	225	380	570
016	LA Oswego Lake sub-basin draining to Oswego Lake	Independent of flow in the Tualatin River			
	Background	650 lbs/year			
	Allocation	29850 lbs/year			
	TMDL	30500 lbs/year			

SCHEDULE A

Pollutant Load limits not to be Exceeded

2. Pollutant loads not to be exceeded after implementation of controls (Loads to use for development of program plans).

Source Number	Source Description	MONTHLY AVERAGE PHOSPHORUS LOADS May 1 to November 15 (pounds per day)			
001	LA Tualatin River Upstream Input	Tualatin River flow near Gaston (USGS)			
		less than 10 cfs (5)	10 to 20 cfs	20 to 30 cfs	greater than 30 cfs
	TMDL 20 ug/l lbs/d	0.54	1.08	2.16	3.23
	Allocations:				
	City of Gaston	0.02	0.04	0.07	0.11
	Washington County	0.02	0.03	0.06	0.09
	Yamhill County	0.01	0.01	0.01	0.01
	Agriculture	0.37	0.76	1.54	2.30
	Forestry	0.12	0.24	0.48	0.72
002	LA Scoggins Creek	Scoggins Creek Flow (TVID)			
		less than 50 cfs (25)	50 to 100 cfs	100 to 150 cfs	greater than 150 cfs
	TMDL 40 ug/l lbs/d	5.39	10.78	21.56	32.34
	Allocations:				
	Washington County	0.68	1.36	2.72	4.08
	Agriculture	1.80	3.59	7.18	10.77
	Forestry	2.91	5.83	11.66	17.49
003	LA Mainstem River and other tributaries above Dilley RM 68.8 - 58.8	Tualatin River flow near Dilley (USGS)			
		less than 60 cfs (30)	60 to 120 cfs	120 to 180 cfs	greater than 180 cfs
	Net Load (40 ug/l)	6.47	12.94	25.87	38.81
	TMDL	0.54	1.08	2.16	3.23
	Allocations:				
	Washington County	0.39	0.78	1.56	2.34
	Agriculture	0.13	0.26	0.53	0.79
	Forestry	0.02	0.04	0.07	0.10
004	LA Gales Creek Sub-basin	Gales Creek Flow (TVID)			
		less than 10 cfs (5)	10 to 25 cfs	25 to 50 cfs	greater than 50 cfs
	TMDL (45 ug/l)	1.21	2.43	6.06	12.13
	Allocations:				
	City of Forest Grove	0.19	0.38	0.96	1.91
	Washington County	0.54	1.09	2.72	5.45
	Agriculture	0.27	0.54	1.34	2.68
	Forestry	0.21	0.42	1.04	2.09

		Tualatin River Below Pump Plant (TVID)			
005	IA Mainstem River and other Tributaries above Golf Course Rd. RM 58.8 - 52.8	less than 50 cfs (25)	50 to 100 cfs	100 to 200 cfs	greater than 200 cfs
	Net Load (45 ug/l)	6.0	12.1	24.3	48.6
	TMDL	0.40	1.62	3.23	4.80
	Allocations:				
	City of Cornelius	0.02	0.10	0.18	0.27
	Washington County	0.32	1.32	2.65	3.98
	Agriculture	0.05	0.19	0.38	0.57
	Forestry	0.01	0.01	0.02	0.03

		Dairy Creek Flow (TVID)			
006	IA Dairy Creek Sub-basin	less than 25 cfs (10)	25 to 50 cfs	50 to 100 cfs	greater than 100 cfs
	TMDL (45 ug/l)	2.43	6.06	12.13	24.25
	Allocations:				
	City of Banks	0.02	0.05	0.09	0.19
	City of North Plains	0.06	0.16	0.32	0.65
	City of Cornelius	0.10	0.24	0.49	0.97
	City of Forest Grove	0.10	0.24	0.48	0.97
	City of Hillsboro	0.20	0.47	0.95	1.89
	Washington County	0.56	1.41	2.82	5.36
	Agriculture	1.11	2.80	5.61	11.21
	Forestry	0.21	0.54	1.07	2.41
	Department's Reserve	0.07	0.15	0.30	0.60

		Tualatin River at Rood Rd. (TVID)			
007	IA Mainstem River and other Tributaries above Rood Rd. RM 52.8 - 38.5	less than 100 cfs (75)	100 to 170 cfs	170 to 270 cfs	greater than 270 cfs
	Net Load (50 ug/l)	20.2	27.0	45.9	72.9
	TMDL	2.02	2.69	4.58	7.28
	Allocations:				
	City of Hillsboro	0.26	0.36	0.60	0.96
	Washington County	1.26	1.67	2.85	4.52
	Agriculture	0.42	0.56	0.97	1.55
	Forestry	0.01	0.01	0.01	0.02
	Department's Reserve	0.07	0.09	0.15	0.23

		Tualatin River at Farmington (USGS)			
008	WLA USA Rock Creek Sewage Treatment Plant.	less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Allocations:				
	outfall 001	15.63	18.32	25.87	36.65

		Rock Creek Flow			
009	IA Rock Creek Sub-basin	less than 5 cfs(2.5)	5 to 10 cfs	10 to 25 cfs	greater than 25 cfs
	TMDL (70 ug/l)	0.94	1.89	3.77	9.43
	Allocations:				
	City of Portland	0.03	0.06	0.11	0.28
	City of Beaverton	0.13	0.27	0.53	1.34
	City of Hillsboro	0.16	0.32	0.64	1.60
	Washington County	0.56	1.12	2.27	5.67
	Multnomah County	0.01	0.01	0.01	0.02
	Agriculture	0.01	0.02	0.03	0.05
	Forestry	0.01	0.01	0.02	0.86
	Department's Reserve	0.03	0.08	0.16	0.41

		Tualatin River at Farmington (USGS)			
010	IA Mainstem River and other Tributaries above Farmington RM 38.5 – 33.3	less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Loading Capacity	37.73	45.27	75.46	113.19
	TMDL	0.89	1.03	1.10	1.13
	Allocations:				
	City of Hillsboro	0.01	0.01	0.01	0.01
	Washington County	0.26	0.30	0.32	0.33
	Agriculture	0.18	0.21	0.22	0.23
	Department's Reserve	0.44	0.51	0.55	0.56

		Tualatin River at Farmington (USGS)			
011	IA Mainstem River and other Tributaries above Elsner. RM 33.3 – 16.2	less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Loading Capacity	37.73	45.27	75.46	113.19
	TMDL	8.05	8.55	8.80	9.12
	Allocations:				
	Washington County	0.17	0.18	0.19	0.20
	Agriculture	3.69	3.92	4.03	4.17
	Forestry	0.17	0.18	0.18	0.19
	Department's Reserve	4.03	4.27	4.40	4.56

012	WLA USA Durham Sewage Treatment Plant.	Tualatin River at Farmington (USGS) less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Allocation:				
	Outfall 001	9.13	9.52	10.71	12.28

013	LA Fanno Creek Sub-basin	Fanno Creek Flow less than 5 cfs(2.5)	5 to 10 cfs	10 to 25 cfs	greater than 25 cfs
	TMDL	0.94	1.89	3.77	9.43
	Allocation:				
	City of Portland	0.20	0.41	0.83	2.05
	City of Beaverton	0.16	0.32	0.63	1.58
	City of Tigard	0.27	0.56	1.12	2.81
	King City	0.01	0.01	0.01	0.02
	City of Durham	0.01	0.03	0.05	0.13
	City of Tualatin	0.01	0.02	0.04	0.11
	Multnomah County	0.01	0.01	0.01	0.02
	Washington County	0.23	0.46	0.93	2.32
	Department's Reserve	0.04	0.07	0.15	0.39

014	LA Mainstem River and other Tributaries above Stafford RM 38.5 - 16.2	Tualatin River at West Linn (USGS) Plus flow in the Lake Oswego Diversion less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Loading Capacity	37.73	45.27	75.46	113.19
	TMDL	3.69	4.62	7.40	11.08
	Allocations:				
	City of Sherwood	0.21	0.27	0.43	0.64
	King City	0.05	0.06	0.09	0.14
	City of Tigard	0.01	0.01	0.01	0.01
	City of Durham	0.01	0.01	0.01	0.01
	City of Tualatin	0.56	0.70	1.11	1.67
	City of Lake Oswego	0.03	0.04	0.07	0.10
	Washington County	0.58	0.73	1.17	1.75
	Yamhill County	0.03	0.04	0.07	0.10
	Clackamas County	0.04	0.05	0.07	0.11
	Agriculture	0.58	0.73	1.17	1.75
	Forestry	0.02	0.03	0.04	0.06
	Department's Reserve	1.56	1.95	3.16	4.74

		Tualatin River at West Linn (USGS)			
015	IA Mainstem River and other Tributaries Below Stafford RM 38.5 - 16.2	less than 120 cfs(100)	120 to 200 cfs	200 to 300 cfs	greater than 300 cfs
	Loading Capacity	37.73	45.27	75.46	113.19
	TMDL	1.56	1.51	1.28	0.98
	Allocations:				
	City of Lake Oswego	0.05	0.05	0.05	0.05
	City of West Linn	0.58	0.60	0.60	0.61
	Agriculture	0.14	0.15	0.15	0.15
	Department's Reserve	0.79	0.71	0.48	0.17

		Independent of flow in the Tualatin River
016	IA Oswego Lake sub-basin draining to Oswego Lake	
	Background	650 lbs/year
	Allocation	850 lbs/year
	TMDL	1500 lbs/year

SCHEDULE B

Minimum Monitoring and Reporting Requirements
(unless otherwise approved in writing by the Department)

1. Ambient Monitoring. The Department and USA shall operate a receiving water monitoring program to evaluate the effectiveness of the TMDL and to guide development of any additional control strategies. The ambient monitoring program shall consist of the following:

Stream	River Mile	Agency	Parameter	Minimum Frequency *	Type of Sample
Tualatin River	38.5	DEQ/USA	Basic/1 & Solids/2	Semimonthly	Grab
		"	Nutrients/3	Semimonthly	Grab
		"	Chloro. a	Semimonthly	Grab
Tualatin River	33.3	USA	Flow	Daily	Recording
		"	Basic/1 & Solids/2	Monthly	Grab
		"	Nutrients/3	Monthly	Grab
		"	Chloro. a	Monthly	Grab
Tualatin River	27.1	DEQ/USA	Basic/1 & Solids/2	Semimonthly	Grab
		"	Nutrients/3	Semimonthly	Grab
		"	Chloro. a	Semimonthly	Grab
Tualatin River	16.2	DEQ/USA	Basic/1 & Solids/2	Semimonthly	Grab
		"	Nutrients/3	Semimonthly	Grab
		"	Chloro. a	Semimonthly	Grab
Tualatin River	8.4	DEQ/USA	Basic/1 & Solids/2	Semimonthly	Grab
		"	Nutrients/3	Semimonthly	Grab
		"	Chloro. a	Semimonthly	Grab
Tualatin River	5.4	USA	Flow	Daily	Recording
		"	Basic/1 & Solids/2	Monthly	Grab
		"	Nutrients/3	Monthly	Grab
		"	Chloro. a	Monthly	Grab
Dairy - McKay Creek	5.0	USA	Basic/1 & Solids/2	Monthly	Grab
		"	Nutrients/3	Monthly	Grab
		"	Chloro. a	Monthly	Grab
Rock Creek	1.2	USA	Basic/1 & Solids/2	Monthly	Grab
		"	Nutrients/3	Monthly	Grab
		"	Chloro. a	Monthly	Grab
Chicken Creek	1.0	USA	Basic/1 & Solids/2	Bimonthly	Grab
		"	Nutrients/3	Bimonthly	Grab
		"	Chloro. a	Bimonthly	Grab
Fanno Creek	1.2	USA	Basic/1 & Solids/2	Monthly	Grab
		"	Nutrients/3	Monthly	Grab
		"	Chloro. a	Monthly	Grab

2. Source Monitoring. The following source monitoring program will be conducted by USA to describe wasteloads being discharged to the Tualatin River:

Source	Parameter	Minimum Frequency	Type of Sample
USA - Rock Creek WTP (Outfall 001)	Total Flow (mgd)	Continuous	Recording
	Ammonia Nitrogen	Daily	Composite
	Total Kjel. Nitrogen	Daily (Jun-Sep)	Composite
	"	Weekly (Oct-May)	"
	NO_2+NO_3-N	Daily (Jun-Sep)	Composite
	"	Weekly (Oct-May)	"
	Total Phosphorus	3 days per week	Composite
USA - Durham WTP (Outfall 001)	Total Flow (mgd)	Continuous	Recording
	Ammonia Nitrogen	Daily	Composite
	Total Kjel. Nitrogen	Daily (Jun-Sep)	Composite
	"	Weekly (Oct-May)	"
	NO_2+NO_3-N	Daily (Jun-Sep)	Composite
	"	Weekly (Oct-May)	"
	Total Phosphorus	3 days per week	Composite

Notes:

* May 1 - October 15 unless otherwise noted.

1. Basic: Water temperature, dissolved oxygen, conductivity, pH
2. Solids: Total solids, total suspended solids
3. Nutrients: NH_3-N, NO_2+NO_3-N, Total Kjeldahl Nitrogen, Total Phosphorus

3. Monitoring Procedures. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136 unless other test procedures have been approved by the Department.

4. Reporting Procedures. Monitoring results shall be reported on approved forms. The reporting period is the calendar month. Reports must be submitted to the Department by the 15th day of the following month.

SCHEDULE C

Compliance Conditions and Schedules

1. Within 90 days of adoption of implementation rules for the Tualatin River by the Environmental Quality Commission, the Unified Sewerage Agency shall submit a plan and time schedule to the Department describing how and when the Agency will modify its sewerage facilities to comply with this TMDL. This could result in a redistribution of wasteload and load allocations described in schedule A parts 1 and 2.

2. Within 90 days of adoptions of implementation rules for the Tualatin River by the Environmental Quality Commission, the Department will establish interim load allocations for guidance to nonpoint source program plans.

3. Within 18 months after the adoption of these rules, Washington, Clackamas, and Multnomah Counties, and all incorporated cities within the Tualatin River and Oswego Lake sub-basins shall submit to the Department a program plan for controlling the quality of urban storm water runoff within their respective jurisdictions. Review of program plans could result in a redistribution of allocations and modification of sampling requirements.

4. After July 1, 1989, Memorandums of Agreements between the Departments of Forestry and Agriculture and the Department of Environmental Quality shall include a time schedule for submitting a program plan. Review of program plans could result in a redistribution of allocations and modification of sampling requirements.

SCHEDULE D

Special Conditions

1. A biennial assessment report will be prepared by nonpoint source agencies responsible for program plans which describes the effectiveness of their control programs towards attaining water quality standards on the Tualatin Basin. This report will be submitted to the Department by January 1 on even numbered years for incorporation into the state-wide water quality status assessment Section 305(b) Report Required by the Federal Clean Water Act).

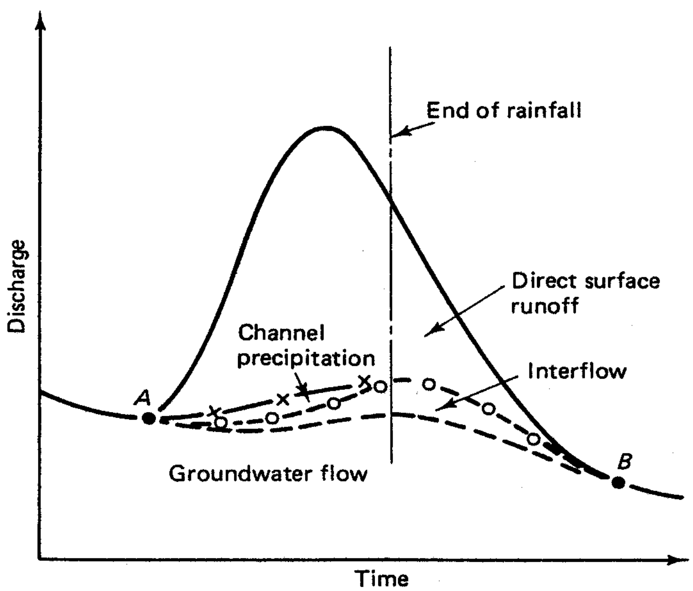
2. The Department, USA, and responsible nonpoint source agencies will use the assessment report and other information from the monitoring program to continually evaluate the effectiveness of this TMDL. If the data indicates adjustments are needed, the TMDL will be reopened. Waste load allocations and load allocations may be redistributed. The TMDL may exceed the Loading Capacity only under the conditions described by section 302 (b)(2)(A) of the Federal Clean Water Act.

APPENDIX C-4

ESTIMATION OF TRIBUTARY BACKGROUND PHOSPHORUS LEVELS

In order to approximate the impacts of groundwater on tributary phosphorus concentrations, DEQ has examined instream concentrations during non-runoff periods. During non-runoff periods (periods when there is not enough rainfall to generate surface run-off) the sources of phosphorus in the tributaries are considered to be primarily from groundwater. The median concentration of total phosphorus during these periods were determined for each major Tualatin tributary for several years. A similar, but less rigorous analysis (due to a lack of sufficient flow data) was completed for the chlorophyll *a* -listed streams that are not included in the analysis of the major tributaries (Nyberg, Burris, Bronson and Cedar creeks).[1]

Figure 1: Components of a hydrograph (after Viessman, et al)



DEQ's examination of non-runoff periods involved the analysis of hydrographs of the daily average flows for each of the major tributaries to separate runoff and groundwater flows. A schematic of an example runoff hydrograph is presented in **Figure 1**. The analysis of seasonal hydrographs gave specific time periods where runoff and the direct impact of associated pollutants could be considered negligible. An example of this is presented for 1992 Fanno Creek flows in **Figure 2**. The time periods and flows enclosed by the dashed lines and arrows in **Figure 2** are considered representative of non-runoff conditions.

For the time periods that were considered to represent non-runoff periods, the stream flows are predominately from natural (groundwater) sources. The median concentration of total phosphorus during these periods were determined for each major Tualatin tributary for several years. The median value, as opposed to the minimum value, has been chosen because the concentrations of phosphorus contributed by groundwater are expected to fluctuate throughout the season as different geologic strata, with differing phosphorus concentrations, contribute flows to the tributary stream. These results are presented in **Figure 3** below.

Possible non-runoff period sources other than groundwater are seepage from agricultural fields, releases from instream sediment, and anthropogenic sources such as illicit discharges. USGS data (Kelly, et al 1999) suggest that agricultural practices do not significantly impact phosphorus concentrations during low flow periods. In order to account for any influences by phosphorus laden sediments, phosphorus data were screened to eliminate samples with less than 3.0 mg/L of dissolved oxygen (DO). This was intended to address the possibility that the phosphorus concentrations were influenced by phosphorus released from iron oxides under anaerobic conditions.

While phosphorus input of other than natural origin were for the most part addressed, there remains the probability that the phosphorus concentrations measured during non-runoff period do reflect some anthropogenic input. This issue is addressed by the inclusion of a margin of safety as detailed in the main body of the TMDL.

[1] These creeks were analyzed by using rainfall data in place of flow data. Nyberg Creek had insufficient phosphorus data to complete this analysis and therefore the concentrations for Cedar Creek, which is the nearest creek with sufficient data, were used.

Figure 2 -Example of Non-Runoff Flow Periods for 1992 Fanno Creek at Durham Flow

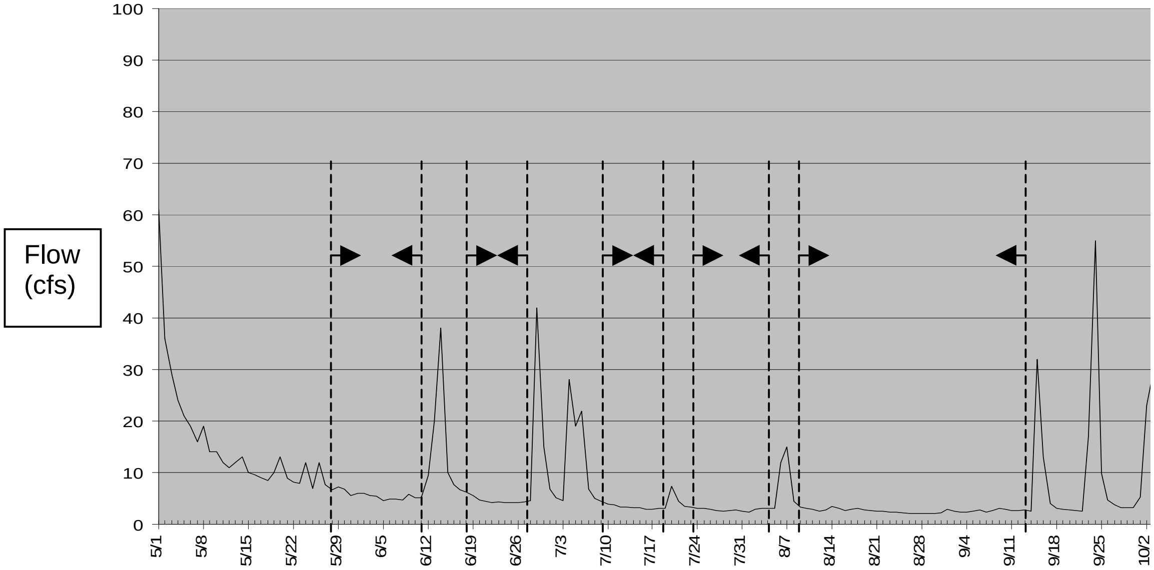


Figure 3: Non-Runoff Period Concentrations of Phosphorus											
Tributary	Summer Non-Runoff Median Total Phosphorus Concentrations (mg/L) (for monitoring sites nearest the mouth's of the tributaries)										Total Phosphorus Seasonal Median Concentration Range (mg/L)
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	
Gales		-	-	-	-	-	0.05	0.04	0.05	0.04	0.04 – 0.05
Dairy		-	-	-	-	0.12	-	0.10	0.09	0.11	0.09 – 0.12
Rock		-	-	-	-	0.25	-	0.19	0.20	0.23	0.19 – 0.25
Fanno		-	-	0.13	0.14	0.14	0.15	-	0.15	0.14	0.13 – 0.15
Burris							0.10	0.12	0.14	0.16	0.10 – 0.16
Cedar	0.15	0.14									0.14 – 0.15
Bronson							0.13	0.15	0.16	0.14	0.13 – 0.16
Nyberg	See Footnote on previous page										0.14 – 0.15

APPENDIX C-5
MASS BALANCE ANALYSIS OF TOTAL PHOSPHORUS CONCENTRATIONS ON THE MAINSTEM TUALATIN RIVER

As explained in the main portion of the TMDL, the pertinent water quality standard allows for modification of the chlorophyll *a* action level if the causes of the exceedances are found to be due to background conditions.

In order to estimate the concentrations that would result on the mainstem of the Tualatin River due to background conditions, a mass balance spreadsheet analysis was used that is similar to that used in the development of the initial TMDL in 1988. This analysis was accomplished by inserting known instream values of flow and total phosphorus concentrations for the mainstem into a spreadsheet. The spreadsheet uses simple mathematical functions to sum the flows and calculate loads. The spreadsheet was calibrated to account for unknown, but observed, sources and sinks of phosphorus and flows by inserting correction factors.

A phosphorus mass balance spreadsheet was developed for the "low flow" period (when typical summer flow patterns exist) for three of the last ten years: 1991, 1993, and 1994. These years are considered to cover the range of typical flow and precipitation patterns currently observed in the basin, with the exception of the withdrawals at Oswego Canal. Measured flow and total phosphorus concentrations for each of these years were inserted into the spreadsheet (with allowances made for travel time) and correction factors were introduced to calibrate the spreadsheets. These spreadsheets, which represent the base case scenarios, are presented below in **Figures 1, 2 and 3**.[1]

The next step in the analysis was to determine what the total phosphorus concentrations would be on the mainstem due to current flow patterns, with the removal of USA augmentation flows, and WWTP discharges and with the tributaries at the estimated background concentrations presented in Table 40 of the TMDL. In order to do this the following input values were modified (indicated in the spreadsheets by shaded cells):

- The tributary concentrations were modified to reflect the loading capacities given in the TMDL[2];
- The Tualatin River near Dilley flows were reduced by the median USA Hagg Lake augmentation for the actual periods used in the spreadsheets. These flows were 55 cfs for 1991, 34 cfs for 1993, and 43 cfs for 1994;
-

The wastewater treatment plants (WWTPs) discharges were set to a flow of zero. This is consistent with the goal of estimating phosphorus concentrations due to background conditions.

- Since it is anticipated that the flow withdrawals at Oswego Canal (RM 6.7) in the near future will be approximately 10cfs (seasonal median), this value was changed within the spreadsheet to reflect current flow conditions.

These spreadsheets are presented below in **Figures 4, 5, and 6**. The total phosphorus concentrations in the column labeled "10" in **Figures 4, 5, and 6** represent the estimated background concentrations for the mainstem Tualatin River.

A summary of the results is presented in **Table 1** below .

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[1] There are some differences between these three spreadsheets since sites with available measured values of flow and concentration varied between the three years.

[2] The concentrations for Baker, McFee and Christenson Creeks were input at 0.12 mg/L. This was the estimated background value for Burris Creek, which should have similar groundwater concentrations as the others.

Table 1. Tualatin Sub-Basin Estimated Total Phosphorus Background Condition Concentrations

Stream Segment	Total Phosphorus Concentrations (Summer Median - mg/L)		
	1991	1993	1994
Mainstem Tualatin River @ Stafford Rd. (RM 5.5)	0.13	0.10	0.12
Mainstem Tualatin River @ Hwy 99W (RM 11.6)	0.15	0.12	0.11
Mainstem Tualatin River @ Elsner (RM 16.2)	0.15	0.12	0.11
Mainstem Tualatin River @ Farmington (RM 33.3)	0.14	0.10	0.11
Mainstem Tualatin River @ Rood Rd. (RM 38.4)	0.13	0.10	0.09
Mainstem Tualatin River @ Golf Course Rd. (RM 51.5)	0.05	0.04	0.04

Figure 1

TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE

1991 SELECTED LOW FLOW PERIOD (7/1 - 10/21)

Base Case Scenario (Measured Values Used As Input Values)

1		2	3	4	5	6	9	10	11
SITE		**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
			Flow	Total Phos.	Flow	Total Phos.	Flow	Total Phos.	TP Mass
			(cfs)	(mg/L)	(cfs)	(mg/L)	(cfs)	(mg/L)	(lb/d)
Tualatin River near Dilley		58.8	167	0.025	167	0.025	167.0	0.03	22.5
	Gales Creek	56.7	15	0.035	15	0.035	182.0	0.03	25.3
	TVID and Joint Water Commission	56.1	-63.6		-63.6	0.026	118.4	0.03	16.5
	Other irrigation withdrawals		-5.4		-5.4	0.026	113.0	0.03	15.7
	Unknown (Correction)				**8.5**	**0.21**	121.5	0.04	25.3
Tualatin River at Golf Course Rd.		51.5	121.5	0.039			121.5	0.04	25.3
	Dairy Creek	44.8	19	0.119	19	0.119	140.5	0.05	37.5
Tualatin River at Highway 219		44.4					140.5	0.05	37.5
	Jackson Slough	43.8	0.3	0.8	0.3	0.8	140.8	0.05	38.8
	Miller Swale	43.5	0.7	2.62	0.7	2.62	141.5	0.06	48.7
	Irrigation withdrawals		-10.2		-10.2	0.05	131.3	0.06	46.0
	Unknown (Correction)				**0.7**	**5.1**	132.0	0.09	65.2
Tualatin River at Rood Road		38.4	132	0.092			132.0	0.09	65.2
	Rock Creek	38.1	11	0.241	11	0.241	143.0	0.10	79.5
	Rock Creek WWTP	38.1	21.5	0.02	21.5	0.02	164.5	0.09	81.8
Tualatin River at Meriwether		36.8					164.5	0.09	81.8
	Unknown (Correction)				**6.5**	**0.092**	171.0	0.09	85.1
Tualatin River at Farmington		33.3	171				171.0	0.09	85.1
	Christensen Creek	31.9	0.2	0.43	0.2	0.43	171.2	0.09	85.5
	Burris Creek	31.6	0.5	0.83	0.5	0.83	171.7	0.09	87.8
	Baker Creek	28.2	1.1	0.12	1.1	0.12	172.8	0.10	88.5
	McFee Creek	28.2	1.3	0.14	1.3	0.14	174.1	0.10	89.5
Tualatin River at Scholls		26.9					174.1	0.10	89.5
Tualatin River at Neal's		23.2					174.1	0.10	89.5
	Unknown (Correction)				**+8.5 lbs.**		174.1	0.10	98.0
Tualatin River at Elsner		16.2		0.10			174.1	0.10	98.0
	Chicken Creek	15.2	2.6	0.12	2.6	0.12	176.7	0.10	99.6
	Rock Creek South	15.2	0.7	0.14	0.7	0.14	177.4	0.10	100.2
Tualatin River at Highway 99W		11.6					177.4	0.10	100.2
	Durham WWTP	9.3	21.8	0.44	21.8	0.44	199.2	0.14	151.9
	Fanno Creek	9.3	4.4	0.167	4.4	0.167	203.6	0.14	155.8
Tualatin River at Boone's Ferry		8.7					203.6	0.14	155.8
	Nyberg Creek	7.5	1.0	0.18	1.0	0.18	204.6	0.14	156.8
	Oswego Canal	6.7	-57.5		-57.5	0.14	147.1	0.14	112.8
	Irrigation withdrawals		-14.0		-14.0	0.14	133.1	0.14	102.1
	Unknown (Correction)				**-8.7 lbs.**		133.1	0.13	93.4
Tualatin River at Stafford Rd.		5.5		0.13			133.1	0.13	93.4
	Unknown (Correction)				**6.4**	**-10.5 lbs**	139.5	0.11	82.9
Tualatin River at West Linn		0.2	139.5	0.11			139.5	0.11	82.9

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.
The primary data source was USGS Open-File Report 96-173

Figure 2

TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE

1993 SELECTED LOW FLOW PERIOD (7/1 - 10/31)

Base Case Scenario (Measured Values Used As Input Values)

1		2	5	6	3	4	9	10	11
SITE		**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
			Flow	Total Phos.	Flow	Total Phos.	Flow	Total Phos.	TP Mass
			(cfs)	(mg/L)	(cfs)	(mg/L)	(cfs)	(mg/L)	(lb/d)
Tualatin River near Dilley		58.8	127	0.031	127	0.031	127	0.03	21
	Gales Creek	56.7	21.5	0.048	21.5	0.048	149	0.03	27
	TVID and Joint Water Commission	56.1	-58		-58	0.03	91	0.03	16
	Other irrigation withdrawals		-4.4		-4.4	0.03	86	0.03	16
	Unknown (Correction)				**15**	**0.075**	101	0.04	22
Tualatin River at Golf Course Rd.		51.5	101	0.042			101	0.04	22
	Dairy Creek	44.8	31.5	0.102	31.5	0.102	133	0.05	39
Tualatin River at Highway 219		44.4					133	0.05	39
	Jackson Slough	43.8	0.60	0.67	0.60	0.67	133	0.06	41
	Miller Swale	43.5	0.80	0.76	0.80	0.76	134	0.06	44
	Irrigation withdrawals		-8.6		-8.6	0.05	125	0.06	42
	Unknown (Correction)				**10**	**0.36**	135	0.08	61
Tualatin River at Rood Road		38.4	135	0.084			135	0.08	61
	Rock Creek	38.1	13.0	0.208	13.0	0.208	148	0.09	76
	Rock Creek WWTP	38.1	23.2	0.05	23.2	0.05	172	0.09	82
Tualatin River at Meriwether		36.8					172	0.09	82
	Irrigation withdrawals		-4.1		-4.1	0.09	168	0.09	80
	Unknown (Correction)				**19.0**	0.09	187	0.09	89
Tualatin River at Farmington		33.3	187				187	0.09	89
	Christensen Creek	31.9	0.4	0.19	0.4	0.19	187	0.09	90
	Burris Creek	31.6	1.1	0.255	1.1	0.255	188	0.09	91
	Baker Creek	28.2	1.8	0.145	1.8	0.145	190	0.09	93
	McFee Creek	28.2	2.4	0.164	2.4	0.164	192	0.09	95
	Unknown (Correction)				**+ 9 lbs.**		192	0.10	104
Tualatin River at Scholls		26.9		0.10			192	0.10	104
Tualatin River at Elsner		16.2		0.10			192	0.10	104
	Chicken Creek	15.2	4.50	0.12	4.50	0.12	197	0.10	107
	Rock Creek South	15.2	1.4	0.22	1.4	0.22	198	0.10	108
Tualatin River at Highway 99W		11.6					198	0.10	108
	Durham WWTP	9.3	24.5	0.47	24.5	0.47	223	0.14	170
	Fanno Creek	9.3	4.70	0.14	4.70	0.14	227	0.14	174
Tualatin River at Boone's Ferry		8.7					227	0.14	174
	Oswego Canal	6.7	-53.0		-53.0	0.14	174	0.14	133
	Irrigation withdrawals		-12.0		-12.0	0.14	162	0.14	124
	Unknown (Correction)				**-10 lbs.**		162	0.13	114
Tualatin River at Stafford Rd.		5.5		0.13			162	0.13	114
	Unknown (Correction)				**11**	**0.28**	173	0.14	131
Tualatin River at West Linn		0.2	173	0.14			173	0.14	131

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.
The primary data source was USGS Open-File Report 96-173

Figure 3

TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE

1994 SELECTED LOW FLOW PERIOD (7/7 - 10/25)

Base Case Scenario (Measured Values Used As Input Values)

1		2	3	4	5	6	9	10	11
SITE		**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
			Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	TP Mass (lb/d)
Tualatin River near Dilley		58.8	172	0.03	172	0.03	172	0.03	27.8
	Gales Creek	56.7	8.4	0.06	8.4	0.06	180	0.03	30.5
	TVID and Joint Water Commission	56.1	-61.5		-61.5	0.03	119	0.03	20.6
	Other irrigation withdrawals		-10.3		-10.3	0.03	109	0.03	18.9
	Unknown (Correction)				**2.4**	**0.40**	111	0.04	24.1
Tualatin River at Golf Course Rd.		51.5	111	0.04			111	0.04	24.1
	Dairy Creek	44.8	12.9	0.12	12.9	0.12	124	0.05	32.4
	Irrigation withdrawals		-4.7		-4.7	0.04	119	0.05	31.4
	Unknown (Correction)					**+7 lb/d**	119	0.06	38.4
Tualatin River at Highway 219		44.4		0.06			119	0.06	38.4
	Jackson Slough	43.8	0.06	0.52	0.06	0.52	119	0.06	38.6
	Miller Swale	43.5	0.17	0.40	0.17	0.40	119	0.06	39.0
	Irrigation withdrawals		-8.9		-8.9	0.06	111	0.06	36.1
	Unknown (Correction)				**-13.5**	**+0.5 lb/d**	97	0.07	36.6
Tualatin River at Rood Road		38.4	97	0.07			97	0.07	36.6
	Rock Creek	38.1	5.9	0.26	5.9	0.26	103	0.08	44.9
	Rock Creek WWTP	38.1	28.7	0.04	28.7	0.04	132	0.07	51.0
Tualatin River at Meriwether		36.8					132	0.07	51.0
	Irrigation withdrawals		-5.3		-5.3	0.07	126	0.07	49.0
	Unknown (Correction)				**18.7**	**0.135**	145	0.08	62.6
Tualatin River at Farmington		33.3	145	0.08			145	0.08	62.6
	Irrigation withdrawals		-5.7		-5.7	0.08	139	0.08	60.1
Tualatin River at Scholls		26.9		0.08			139	0.08	60.1
	Irrigation withdrawals		-5.5		-5.5	0.08	134	0.08	57.8
Tualatin River at Neal's		23.2					134	0.08	57.8
	Irrigation withdrawals		-3		-3	0.08	131	0.08	56.5
Tualatin River at Elsner		16.2		0.08			131	0.08	56.5
	Chicken Creek	15.2	1.3	0.11	1.3	0.11	132	0.08	57.2
	Irrigation withdrawals		-1.7		-1.7	0.08	130	0.08	56.5
Tualatin River at Highway 99W		11.6					130	0.08	56.5
	Durham WWTP	9.3	26	0.04	26	0.04	156	0.07	62.1
	Fanno Creek	9.3	3.9	0.15	3.9	0.15	160	0.08	65.3
	Irrigation withdrawals		-0.5		-0.5	0.08	160	0.08	65.0
Tualatin River at Boone's Ferry		8.7					160	0.08	65.0
	Oswego Canal	6.7	-50.1		-50.1	0.08	110	0.08	44.7
	Irrigation withdrawals		-0.23		-0.2	0.08	110	0.08	44.6
	Unknown (Correction)					**+ 2.5 lbs**	110	0.08	47.1
Tualatin River at Stafford Rd.		5.5		0.08			110	0.08	47.1
	Unknown				**12.5**	**0.08**	122	0.08	52.5
Tualatin River at West Linn		0.2	122	0.08			122	0.08	52.5

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.

Figure 4
TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE
1991 SELECTED LOW FLOW PERIOD (7/1 - 10/21)

Values Modified From Base Case Are Shaded

1		2	3	4	5	6	9	10	11
SITE		**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
			Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	TP Mass (lb/d)
Tualatin River near Dilley		58.8	167	0.025	112	0.025	112	0.03	15.1
	Gales Creek	56.7	15	0.035	15	0.04	127	0.03	18.3
	TVID and Joint Water Commission	56.1	-63.6		-63.6	0.027	63	0.03	9.1
	Other irrigation withdrawals		-5.4		-5.4	0.027	58	0.03	8.4
	Unknown (Correction)				**8.5**	**0.21**	67	0.05	18.0
Tualatin River at Golf Course Rd.		51.5	121.5	0.039			67	0.05	18.0
	Dairy Creek	44.8	19	0.119	19	0.09	86	0.06	27.2
Tualatin River at Highway 219		44.4					86	0.06	27.2
	Jackson Slough	43.8	0.3	0.8	0.3	0.8	86	0.06	28.5
	Miller Swale	43.5	0.7	2.62	0.7	2.62	87	0.08	38.4
	Irrigation withdrawals		-10.2		-10.2	0.06	76	0.09	35.1
	Unknown (Correction)				**0.7**	**5.1**	77	0.13	54.4
Tualatin River at Rood Road		38.4	132	0.092			77	0.13	54.4
	Rock Creek	38.1	11	0.241	11	0.19	88	0.14	65.6
	Rock Creek WWTP	38.1	21.5	0.02	0.0	0.02	88	0.14	65.6
Tualatin River at Meriwether		36.8					88	0.14	65.6
	Unknown (Correction)				**6.5**	**0.092**	95	0.14	68.9
Tualatin River at Farmington		33.3	171				95	0.14	68.9
	Christensen Creek	31.9	0.2	0.43	0.2	0.12	95	0.14	69.0
	Burris Creek	31.6	0.5	0.83	0.5	0.12	95	0.14	69.3
	Baker Creek	28.2	1.1	0.12	1.1	0.12	96	0.13	70.0
	McFee Creek	28.2	1.3	0.14	1.3	0.12	98	0.13	70.9
Tualatin River at Scholls		26.9					98	0.13	70.9
Tualatin River at Neal's		23.2					98	0.13	70.9
	Unknown (Correction)				**+8.5 lbs.**		98	0.15	79.4
Tualatin River at Elsner		16.2		0.10			98	0.15	79.4
	Chicken Creek	15.2	2.6	0.12	2.6	0.14	100	0.15	81.3
	Rock Creek South	15.2	0.7	0.14	0.7	0.14	101	0.15	81.9
Tualatin River at Highway 99W		11.6					101	0.15	81.9
	Durham WWTP	9.3	21.8	0.44	0.0	0.44	101	0.15	81.9
	Fanno Creek	9.3	4.4	0.167	4.4	0.13	105	0.15	84.9
Tualatin River at Boone's Ferry		8.7					105	0.15	84.9
	Nyberg Creek	7.5	1.0	0.18	1.0	0.14	106	0.15	85.7
	Oswego Canal	6.7	-57.5		-10.0	0.15	96	0.15	77.6
	Irrigation withdrawals		-14.0		-14.0	0.15	82	0.15	66.3
	Unknown (Correction)				**-8.7 lbs.**		82	0.13	57.6
Tualatin River at Stafford Rd.		5.5		0.13			82	0.13	57.6
	Unknown (Correction)				**6.4**	**-10.5 lbs**	89	0.10	47.1
Tualatin River at West Linn		0.2	139.5	0.11			89	0.10	47.1

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.
The primary data source was USGS Open-File Report 96-173

Figure 5
TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE
1993 SELECTED LOW FLOW PERIOD (7/1 - 10/31)
Values Modified From Base Case Are Shaded

1	2	5	6	3	4	9	10	11
SITE	**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
		Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	TP Mass (lb/d)
Tualatin River near Dilley	58.8	127	0.031	93	0.031	93	0.03	16
Gales Creek	56.7	21.5	0.048	21.5	0.04	115	0.03	20
TVID and Joint Water Commission	56.1	-58		-58	0.03	57	0.03	10
Other irrigation withdrawals		-4.4		-4.4	0.03	52	0.03	9
Unknown (Correction)				**15**	**0.075**	67	0.04	15
Tualatin River at Golf Course Rd.	51.5	101	0.042			67	0.04	15
Dairy Creek	44.8	31.5	0.102	31.5	0.09	99	0.06	31
Tualatin River at Highway 219	44.4					99	0.06	31
Jackson Slough	43.8	0.60	0.67	0.60	0.67	99	0.06	33
Miller Swale	43.5	0.80	0.76	0.80	0.76	100	0.07	36
Irrigation withdrawals		-8.6		-8.6	0.06	91	0.07	33
Unknown (Correction)				**10**	**0.36**	101	0.10	53
Tualatin River at Rood Road	38.4	135	0.084			101	0.10	53
Rock Creek	38.1	13.0	0.208	13.0	0.19	114	0.11	66
Rock Creek WWTP	38.1	23.2	0.05	0.0	0.05	114	0.11	66
Tualatin River at Meriwether	36.8					114	0.11	66
Irrigation withdrawals		-4.1		-4.1	0.11	110	0.11	64
Unknown (Correction)				**19.0**	0.09	129	0.10	73
Tualatin River at Farmington	33.3	187				129	0.10	73
Christensen Creek	31.9	0.4	0.19	0.4	0.12	130	0.10	73
Burris Creek	31.6	1.1	0.255	1.1	0.12	131	0.10	74
Baker Creek	28.2	1.8	0.145	1.8	0.12	133	0.10	75
McFee Creek	28.2	2.4	0.164	2.4	0.12	135	0.11	77
Unknown (Correction)				**+ 9 lbs.**		135	0.12	86
Tualatin River at Scholls	26.9		0.10			135	0.12	86
Tualatin River at Elsner	16.2		0.10			135	0.12	86
Chicken Creek	15.2	4.50	0.12	4.50	0.14	140	0.12	89
Rock Creek South	15.2	1.4	0.22	1.4	0.14	141	0.12	90
Tualatin River at Highway 99W	11.6					141	0.12	90
Durham WWTP	9.3	24.5	0.47	0	0.47	141	0.12	90
Fanno Creek	9.3	4.70	0.14	4.70	0.13	146	0.12	93
Tualatin River at Boone's Ferry	8.7					146	0.12	93
Oswego Canal	6.7	-53.0		-10.0	0.12	136	0.12	87
Irrigation withdrawals		-12.0		-12.0	0.12	124	0.12	79
Unknown (Correction)				**-10 lbs.**		124	0.10	69
Tualatin River at Stafford Rd.	5.5		0.13			124	0.10	69
Unknown (Correction)				**11**	**0.28**	135	0.12	86
Tualatin River at West Linn	0.2	173	0.14			135	0.12	86

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.
The primary data source was USGS Open-File Report 96-173

1		2	3	4	5	6	9	10	11
Figure 6									
TUALATIN RIVER TOTAL PHOSPHORUS MASS BALANCE									
1994 SELECTED LOW FLOW PERIOD (7/7 - 10/25)									
Values Modified From Base Case Are Shaded									
SITE		**RM**	**MEASURED VALUES**		**INPUT VALUES**		**MAINSTEM PREDICTED VALUES**		
			Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	Flow (cfs)	Total Phos. (mg/L)	TP Mass (lb/d)
Tualatin River near Dilley		58.8	172	0.03	129	0.03	129	0.03	20.9
	Gales Creek	56.7	8.4	0.06	8.4	0.04	137	0.03	22.7
	TVID and Joint Water Commission	56.1	-61.5		-61.5	0.03	76	0.03	12.7
	Other irrigation withdrawals		-10.3		-10.3	0.03	66	0.03	11.1
	Unknown (Correction)				**2.4**	**0.40**	68	0.04	16.2
Tualatin River at Golf Course Rd.		51.5	111	0.04			68	0.04	16.2
	Dairy Creek	44.8	12.9	0.12	12.9	0.09	81	0.05	22.5
	Irrigation withdrawals		-4.7		-4.7	0.04	76	0.05	21.4
	Unknown (Correction)					**+7 lb/d**	76	0.07	28.4
Tualatin River at Highway 219		44.4		0.06			76	0.07	28.4
	Jackson Slough	43.8	0.06	0.52	0.06	0.52	76	0.07	28.5
	Miller Swale	43.5	0.17	0.40	0.17	0.40	76	0.07	28.9
	Irrigation withdrawals		-8.9		-8.9	0.07	68	0.07	25.6
	Unknown (Correction)				**-13.5**	**+0.5 lb/d**	54	0.09	26.1
Tualatin River at Rood Road		38.4	97	0.07			54	0.09	26.1
	Rock Creek	38.1	5.9	0.26	5.9	0.19	60	0.10	32.1
	Rock Creek WWTP	38.1	28.7	0.04	0.0	0.04	60	0.10	32.1
Tualatin River at Meriwether		36.8					60	0.10	32.1
	Irrigation withdrawals		-5.3		-5.3	0.10	55	0.10	29.3
	Unknown (Correction)				**18.7**	**0.135**	73	0.11	42.9
Tualatin River at Farmington		33.3	145	0.08			73	0.11	42.9
	Irrigation withdrawals		-5.7		-5.7	0.11	68	0.11	39.6
Tualatin River at Scholls		26.9		0.08			68	0.11	39.6
	Irrigation withdrawals		-5.5		-5.5	0.11	62	0.11	36.3
Tualatin River at Neal's		23.2					62	0.11	36.3
	Irrigation withdrawals		-3		-3	0.11	59	0.11	34.6
Tualatin River at Elsner		16.2		0.08			59	0.11	34.6
	Chicken Creek	15.2	1.3	0.11	1.3	0.14	60	0.11	35.6
	Irrigation withdrawals		-1.7		-1.7	0.11	59	0.11	34.6
Tualatin River at Highway 99W		11.6					59	0.11	34.6
	Durham WWTP	9.3	26	0.04	0	0.04	59	0.11	34.6
	Fanno Creek	9.3	3.9	0.15	3.9	0.13	63	0.11	37.3
	Irrigation withdrawals		-0.5		-0.5	0.11	62	0.11	37.0
Tualatin River at Boone's Ferry		8.7					62	0.11	37.0
	Oswego Canal	6.7	-50.1		-10.0	0.11	52	0.11	31.1
	Irrigation withdrawals		-0.23		-0.2	0.11	52	0.11	30.9
	Unknown (Correction)					**+ 2.5 lbs**	52	0.12	33.4
Tualatin River at Stafford Rd.		5.5		0.08			52	0.12	33.4
	Unknown				**12.5**	**0.08**	64	0.11	38.8
Tualatin River at West Linn		0.2	122	0.08			64	0.11	38.8

Notes: All values are "low flow period" medians. Irrigation withdrawals were estimated.

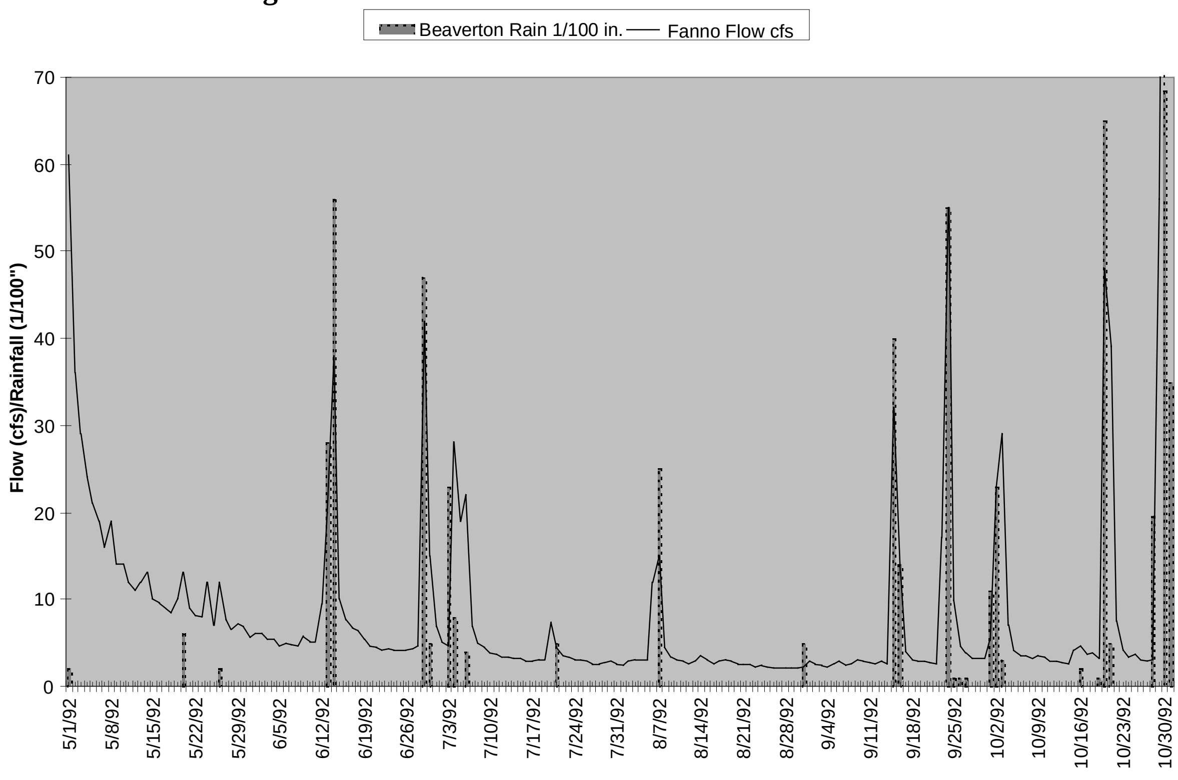
APPENDIX C-6

ANALYSIS OF URBAN RUNOFF CONTRIBUTIONS TO TOTAL PHOSPHORUS LOADINGS

The amount of runoff from urban lands during the TMDL (or summer) season has been a topic of much debate. Examination of hydrographs (plots of stream flow vs. time) over the last several years for urbanized watersheds in the Tualatin Sub-Basin show distinct runoff curves over the course of the TMDL period.

Comparing tributary hydrographs with hyetographs (plots of rainfall vs. time) shows a strong relationship between rainfall and runoff. **Figure 1** gives an example of a hydrograph and hyetograph for an urban creek in 1992.

Figure 1: 1992 Fanno Creek at Durham Rd. Flow & Rainfall



Due to the fact that not all precipitation results in runoff, a correction factor is usually applied when determining the amount of runoff that occurs. In estimating runoff for its 1993 Municipal Separate Storm Sewer System (MS4) permit application, USA corrected for non-runoff precipitation events by using only storm events that resulted 0.1 inches or more of rain.[1] The examination of the hydrographs and hyetographs for Rock and Fanno Creeks tend to support the procedure that USA used.

[1] Another method would be to multiply the total precipitation by a correction factor (a value of 0.9 is typical).

Examination of rainfall data for the Beaverton station (Beaverton 2 SSW) over a period of 25 years (1973 – 1997) shows that 15% of the days between May 1 and October 31 have 0.1 inches of rain or greater. The percent of days between August 1 and October 31 with 0.1 inches of rain or greater is also 15%. Thus, an average of approximately one in seven days in the Beaverton area during the TMDL season sees enough rainfall to produce runoff from urban areas.

The total loadings from runoff sources may be estimated by utilizing any of a variety of acceptable procedures. One that is commonly used is referred to as the "simple method". In this procedure the amount of runoff for a specific time period is multiplied by the estimated pollutant concentration to give a total loading for that time period. The runoff is a function of the total rainfall, the correction factor mentioned above, and a runoff coefficient that is specific to the land uses in the basin being examined. The estimated pollutant concentration usually used is the event mean concentration.

The pollutant concentration of runoff due to a single storm event is generally characterized by the event mean concentration (EMC). EMCs are the average pollutant concentrations of the total volume of runoff from a storm event. If several storm events are sampled at a particular site, then the median value of the EMCs is usually calculated to give a value that is considered to be representative of that site. Since monitoring sites are usually selected to collect runoff from one general land use, the median EMC value is considered to be representative of the runoff from that type of land use.

Using data from the USA storm monitoring program, USA's 1999 Stormwater Annual Report (USA, 1999b) and from ACWA's 1997 report (ACWA, 1997), a list of median EMC values for the Tualatin Sub-Basin has been developed (**Table 1**). These estimated values are provided solely for comparison purposes and were not used to determine loads, etc. More accurate EMC's will need to be developed as part of the TMDL Implementation Plan(s).

Table 1. : Estimated Tualatin Sub-Basin Total Phosphorus Concentrations (mg/L) by Land Use

	Commercial[a]	Industrial[a]	Single Family Residential[a]	Multi-Family Residential[b]	Rural[c]	Parks and Open Space[b]	Trans-portation (Roads)[b]	Vacant Lands[c]
Annual Median	.25	.55	.17	.48	.16	.17	.27	.17
TMDL Period Median	.43	-	.54	-	-	-	-	-

[a] Values are from USA 1999b.
[b] Values are from ACWA 1997.
[c] Rural and Vacant values are the same as Single-Family Residential

Since stormwater pollutant concentrations may vary seasonally, it would be ideal to have concentrations based on sampling from the TMDL period. Unfortunately, most sampling has occurred in the basin during the winter season when the wet weather patterns better facilitate sampling. For two of the land uses (commercial and single family residential) both an annual median and a TMDL period median are presented since EMCs for these two land uses were available for the TMDL period from USA data. It should be noted that these two values are higher than the corresponding values that represent data from the entire year.

APPENDIX C-7

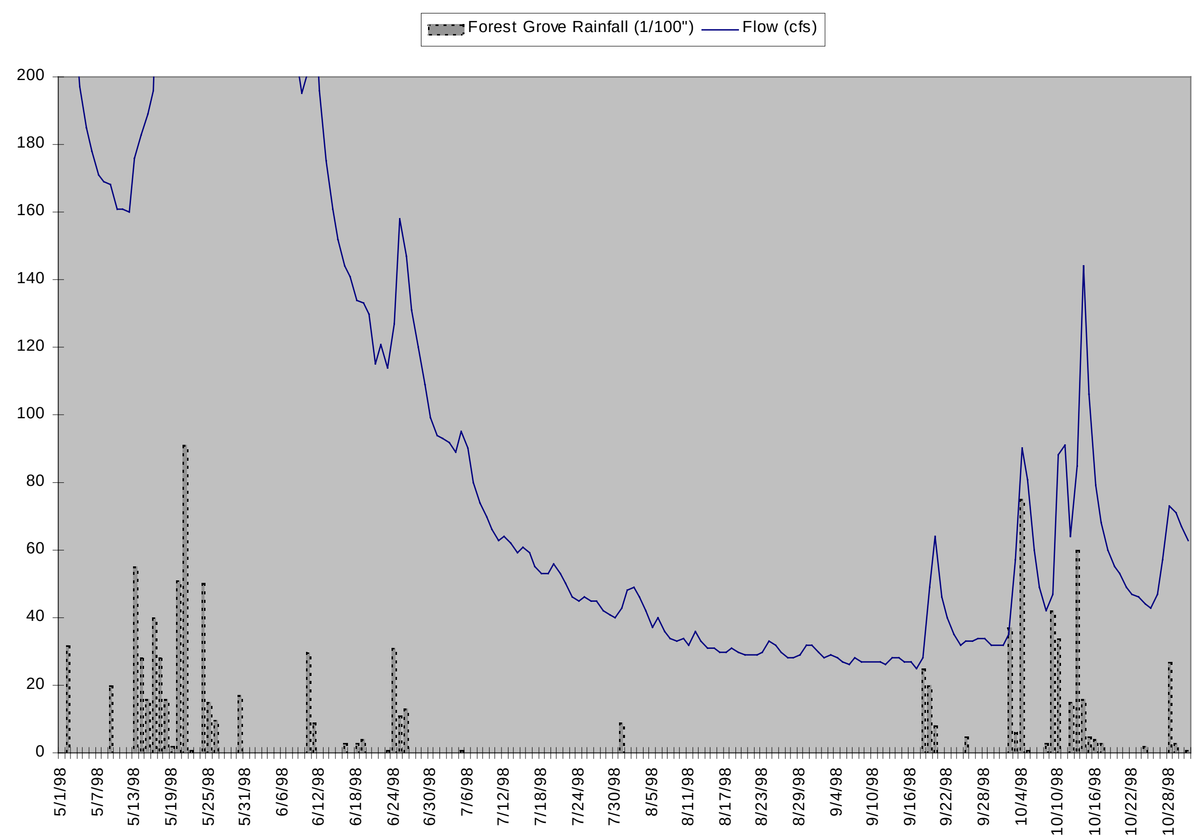
ANALYSIS OF RUNOFF CONTRIBUTIONS FROM RURAL, AGRICULTURAL, AND FORESTED LANDS TO TOTAL PHOSPHORUS LOADINGS

While runoff from rural, agricultural and forested lands differs from runoff from urban areas, much of the discussion above applies to these land uses as well. The main differences between the two broad source categories is that the volume of runoff from non-urbanized watersheds is generally less for an equal amount of rain and land area methods, and that the pollutant concentrations are different.

Figure 1, below, shows the hydrograph and hyetograph for a predominantly agricultural, rural and forested watershed. From inspection of this figure, the relationship between precipitation and runoff is still apparent, but the amount of precipitation to cause runoff is greater than for the urbanized watersheds and the relationship is more dependent on the antecedent rainfall.

Data on total phosphorus concentrations for agricultural and forested land runoff specific to the Tualatin Sub-Basin is lacking. An event mean concentration (EMC) derived for general agricultural lands in another area gave a total phosphorus concentration of 1.3 mg/L (Quenzer, 1998). This estimate seems rather high and may be offset by the phosphorus control strategies already in place. As is the case with urban runoff, runoff with these concentrations (or even at one-tenth of these concentrations) would exceed the background concentration of 0.10 mg/L of Dairy Creek. It has been estimated that rural residential sources of phosphorus typically have the same concentrations as single family residential, though the amount of runoff from rural sites is less (USA, 1999a).

Figure 1: 1998 Dairy Creek at Hwy 8 Flow and Forest Grove Rainfall



APPENDIX C-8

DETERMINATION OF ALLOCATIONS FOR RUNOFF SOURCES

To estimate the load allocation (or wasteload allocation) for runoff from a specific land area, the total volume of runoff due to typical seasonal precipitation is multiplied by an appropriate target concentration (described below). The resulting allocation will be in the form of a seasonal load, which may then be divided by the number of days per season to give an average daily load. To determine the total loading that a designated management agency is responsible for, the allocations for all land areas within an agency's jurisdiction are then summed. Basically:

Load (or Wasteload) Allocation = (Lb. of Total Phosphorus/Season)
= Allocation (mg/L Total Phosphorus) x Runoff Volume (ft^3) x Conversion Factor
(Where the runoff volume is the seasonal total)

Target Allocation Concentrations

In order to provide appropriate allocations (in the form of concentrations) for each land area in the basin, specific allocations were determined for each Tualatin Subbasin or group of sub-basins. These allocations were selected to meet the loading capacities (see main body of phosphorus TMDL).

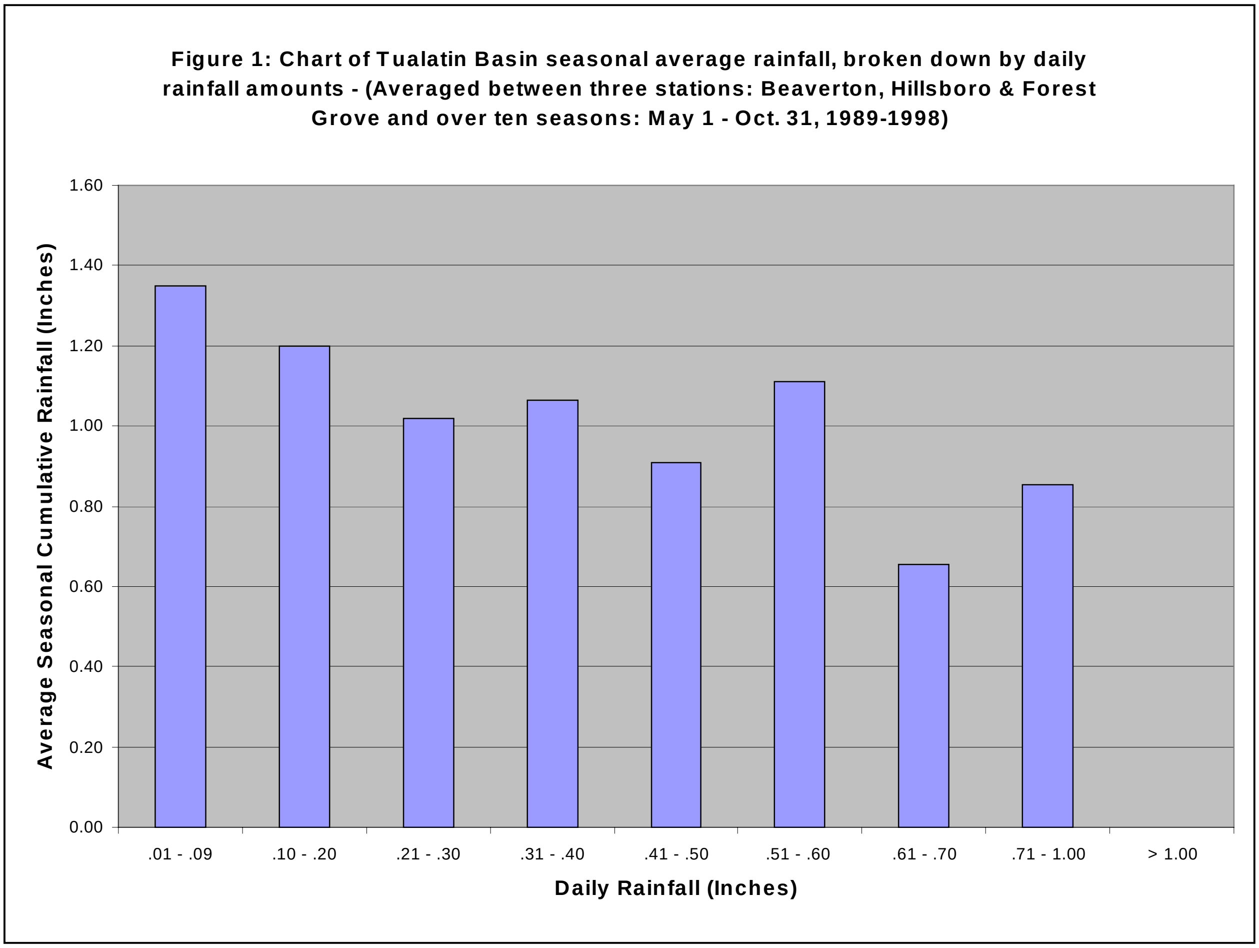
The allocations the Tualatin Sub-Basin are given in **Table 1**, below.

Table 1. Tualatin Sub-Basin Total Phosphorus Allocations (in the form of concentrations)

Subbasin	Total Phosphorus Concentrations (Summer Median - mg/L)
All Sources to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14
All Sources to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04
Bronson Creek	0.13
Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.	0.12
Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr.	0.14
Dairy Creek	0.09
Fanno Creek	0.13
Gales Creek	0.04
Rock Creek	0.19

Precipitation

In order to estimate the total volume of water to runoff of land in the Tualatin Sub-Basin, typical seasonal precipitation within the basin was determined. This was done by performing an analysis of the daily rainfall records from the May 1 through October 31 period of the last ten years for three stations in the basin. This analysis basically consisted of determining the number of rainfall events that occurred for a series of storm sizes at each station. A synthetic seasonal record for rainfall was then produced that reasonably well represents mean values of each of the stations (**Figure 1**). The total seasonal rainfall for the synthetic record is 8.17 inches.



This synthetic seasonal record was used as an input to a GIS-based spreadsheet model to predict runoff. The rainfall is adjusted within the model to account for spatial variations due to elevation, etc. as predicted by PRISM, the Parameter-elevation Regressions on Independent Slopes Model developed at Oregon State University.

Runoff Volume

The spreadsheet model utilizes two different runoff equations to determine runoff volumes. For urbanized areas (in this case, within the urban growth boundary) the “simple” method was used. This method, which is appropriate for areas with high percentages of impervious surfaces, uses a specific runoff coefficient for each land use type (commercial, industrial, etc.) to predict the amount of runoff for a specific precipitation amount and land area. As explained in **Appendix C-6**, runoff is expected to occur in urban areas when the daily rainfall is greater than or equal to 0.1 inches. The synthetic rainfall record gives a total seasonal rainfall of 6.82 inches for daily rainfall in this range. For non-urbanized areas the SCS Curve Method was selected as the most appropriate to estimate runoff. The same synthetic rainfall record is applied for this method, but since forested and some agricultural lands are at higher elevations, PRISM-corrected rainfall values are appropriate. (The rainfall gauges are all in the lower elevations of the basin. By applying PRISM to the records [and the synthetic record], estimated average values for higher elevations may be derived).

Allocations

Once runoff volume for the input precipitation was determined, the spreadsheet model simply multiplies this volume by the given allocation in the form of concentration to give loads. These loads were segregated to give allocations for each DMA.

The determination of which management agency is responsible for specific loads was based on six separate parameters: city boundary, county boundary, land use designation, Unified Sewerage Agency (USA) boundary, ODOT roads, and urban growth boundary. A geographical information system (GIS) was used in this determination. The data used was from Metro's database, USGS land use information (outside the UGB), ODOT and USA. Every reasonable attempt was made to ensure that this data was as accurate and up-to-date as possible. However, if future corrections regarding DMA designations of loadings are necessary, the TMDL contains allocation language that will make this possible.

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