STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

PROTESTED
REPORT OF EXAMINATION
Temporary Change of: Point of Withdrawal, Place of Use, Purpose of Use
WRTS File No. CG1-*00671C@2

PRIORITY DATE	CLAIM NO.	PERMIT NO.	CERTIFICATE NO.
November 22, 1947			330 Record (B)

NAME

Washington Department of Corrections *(water right leased to Cadman, Inc.)*

ADDRESS/STREET	CITY/STATE	ZIP CODE
P.O. Box 41112 *(P.O. Box 97038)*	Olympia, WA *(Redmond, WA)*	98504 *(98073)*

PUBLIC WATERS TO BE APPROPRIATED

SOURCE

Two wells

TRIBUTARY OF (IF SURFACE WATERS)

MAXIMUM CUBIC FEET PER SECOND	MAXIMUM GALLONS PER MINUTE	MAXIMUM ACRE-FEET PER YEAR
	600	232.4*

QUANTITY, TYPE OF USE, PERIOD OF USE

* 108 afy to be used consumptively for industrial purposes – all uses associated with operation of a gravel mine, 124.4 afy to be used non-consumptively for mitigation

Continuously – year round

LOCATION OF DIVERSION/WITHDRAWAL

APPROXIMATE LOCATION OF DIVERSION--WITHDRAWAL

Both wells approximately 300 feet south and 1,200 feet west from the northeast corner of Section 15

LOCATED WITHIN (SMALLEST LEGAL SUBDIVISION)	SECTION	TOWNSHIP	RANGE	WRIA	COUNTY
NE1/4 NE1/4	15	27 N.	9 E. W.M.	7	Snohomish

PARCEL NUMBER	LATITUDE	LONGITUDE	DATUM
270915-001-001-00	47.834079°	-121.635445°	NAD83 HARN

LEGAL DESCRIPTION OF PROPERTY ON WHICH WATER IS TO BE USED
[Attachment 1 shows location of the authorized place of use and point(s) of diversion or withdrawal.]

NE¼ SE¼, NW¼ NE¼, and E½ NE¼ of Section 15, Township 27 North, Range 9 East, W.M. lying south of State Route 2, and

SW¼ NW¼ and NW¼ SW¼ of Section 14, Township 27 North, Range 9 East, W.M

DESCRIPTION OF WATER SYSTEM

Two wells will be utilized at the site. The existing well (AKY991) is 6 inches in diameter and 69.5 feet in depth. The second well has not yet been drilled. It is anticipated to be a larger diameter well completed at a similar depth. Both wells will serve wheel washing facilities, dust abatement vehicles, gravel washing facilities and associated storage pond, and a possible concrete batch plant.

DEVELOPMENT SCHEDULE		
BEGIN PROJECT BY THIS DATE	COMPLETE PROJECT BY THIS DATE	WATER PUT TO FULL USE BY THIS DATE
December 31, 2013	December 31, 2018	December 31, 2023

PROVISIONS

WELLS, WELL LOGS AND WELL CONSTRUCTION STANDARDS

In accordance with WAC 173-160, wells shall not be located within certain minimum distances of potential sources of contamination. These minimum distances shall comply with local health regulations, as appropriate. In general, wells shall be located at least 100 feet from sources of contamination. Wells shall not be located within 1,000 feet of the boundary of a solid waste landfill.

All wells constructed in the state shall meet the construction requirements of WAC 173-160 titled “Minimum Standards for the Construction and Maintenance of Wells” and RCW 18.104 titled “Water Well Construction”. Any well which is unusable, abandoned, or whose use has been permanently discontinued, or which is in such disrepair that its continued use is impractical or is an environmental, safety or public health hazard shall be decommissioned.

All wells shall be tagged with a Department of Ecology unique well identification number. If you have an existing well and it does not have a tag, please contact the well-drilling coordinator at the regional Department of Ecology office issuing this decision. This tag shall remain attached to the well. If you are required to submit water measuring reports, reference this tag number.

Required installation and maintenance of an access port as described in WAC 173-160- 291(3).

MEASUREMENTS, MONITORING, METERING AND REPORTING

An approved measuring device shall be installed and maintained for each of the sources authorized by this water right in accordance with the rule "Requirements for Measuring and Reporting Water Use", WAC 173-173. http://www.ecy.wa.gov/programs/wr/measuring/measuringhome.html

Water use data shall be recorded weekly and maintained by the property owner for the duration of the temporary change authorization. The maximum rate of diversion/withdrawal and the annual total volume shall be submitted to the Department of Ecology by January 31st of each calendar year.

Recorded water use data shall be submitted via the Internet. To set up an Internet reporting account, contact the Northwest Regional Office. If you do not have Internet access, you can submit hard copies by contacting the Northwest Regional Office for forms to submit your water use data.

WAC 173-173 describes the requirements for data accuracy, device installation and operation, and information reporting. It also allows a water user to petition Ecology for modifications to some of the requirements.

In order to distinguish between consumptive and non-consumptive uses authorized under the temporary change authorization, Cadman must meter both the amount of water withdrawn from the source wells and the amount of water released for mitigation.

An annual report with a description of and supporting data for monitoring, management, and mitigation from the previous year shall be submitted to Ecology each year along with metering data. Failure to comply with the mitigation/management plan will result in cancellation of the change authorization. If a failure event occurs, a review will take place to determine if cancellation is warranted.

SCHEDULE AND INSPECTIONS

Department of Ecology personnel, upon presentation of proper credentials, shall have access at reasonable times, to the project location, and to inspect at reasonable times, records of water use, wells, diversions, measuring devices and associated distribution systems for compliance with water law.

The water right will not proceed to superseding certificate while used by Cadman, Inc. The proposal is for a temporary lease of the water right for the life of the gravel pit, anticipated to be 25 years. On January 1, 2036, the water right will revert back to Department of Corrections. If the gravel pit is still active on this date and water continues to be beneficially used, Cadman, Inc. may apply for an extension of the change authorization.

The development schedule on page 2 will be a measure of Cadman’s diligent pursuit of the proposed change. If these dates are not met, Cadman must submit an extension request with an explanation.

QUANTITY LIMITS, FLOW AND REGULATION

Cadman, Inc. shall calculate and monitor flows in the Skykomish River (as described in the Management Plan in Appendix A) for the Monroe control station (12.1411.00) and may only withdraw water from the authorized wells when flows in the Skykomish River are greater than 100 cubic feet per second above the instream flow values given for this location in WAC 173-507. During the period from June through September, the flow calculation must be made during the lowest flow of the day between 6 and 10 am.

Cadman, Inc. shall monitor all required meters (source and mitigation release) and shall discontinue pumping its source well(s) for the calendar year if either reaches its authorized annual quantity – 232.4 acre feet for the well(s) and 124.4 for mitigation release. Additionally, at the end of each calendar year the difference between the total annual quantity for each must be less than or equal to 108 acre-feet and will represent the annual consumptive use.

The proposed mitigation plan contains several factors of safety that ensure instream flows will not be impaired. This includes the method for calculating flows at the non-existent Monroe control station (12.1411.00). Should an active gage be installed at this location during the life of Cadman's lease of the water right, the flow calculation currently authorized may only be abandoned if a new, equally protective plan is developed .

FINDINGS OF FACT AND ORDER

Upon reviewing the investigator's report, I find all facts relevant and material to the subject application have been thoroughly investigated. Furthermore, I find the subject right to be in good standing and the change of water right as recommended will not be detrimental to existing rights.

Therefore, I ORDER the requested change of Certificate 330 Record (B) be approved subject to existing rights and the provisions specified above.

You have a right to appeal this action to the Pollution Control Hearing Board (PCHB) within 30 days of the date of receipt of this document. The appeal process is governed by Chapter 43.21B RCW and Chapter 371-08 WAC. "Date of receipt" is defined in RCW 43.21B.001(2).

To appeal, you must do the following within 30 days of the date of receipt of this document:

- File your appeal and a copy of this document with the PCHB (see addresses below). Filing means actual receipt by the PCHB during regular business hours.
- Serve a copy of your appeal and this document on Ecology in paper form - by mail or in person. (See addresses below.) Email is not accepted.

You must also comply with other applicable requirements in Chapter 43.21B RCW and Chapter 371-08 WAC.

Street Addresses	Mailing Addresses
Department of Ecology Attn: Appeals Processing Desk 300 Desmond Drive SE Lacey, WA 98503 Pollution Control Hearings Board 1111 Israel Rd SW Ste 301 Tumwater WA 98501	Department of Ecology Attn: Appeals Processing Desk PO Box 47608 Olympia, WA 98504-7608 Pollution Control Hearings Board PO Box 40903 Olympia, WA 98504-0903

Please also send a copy of your appeal to:
Jacqueline Klug
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue WA 98008

For additional information visit the Environmental Hearings Office Website: http://www.eho.wa.gov . To find laws and agency rules visit the Washington State Legislature Website: http://www1.leg.wa.gov/CodeReviser .

Signed at Bellevue, Washington, this _____ day of _____, 2011.

_____
Jacqueline Klug, Section Manager
Water Resources Program
Northwest Region Office

INVESTIGATOR'S REPORT
by Jay Cook – Hydrogeologist

BACKGROUND

Proposed change

Washington Department of Corrections (DOC) is requesting to remove water from temporary trust under the Washington State Trust Water Rights Program. The water right has been leased by and is proposed to be transferred to Cadman, Inc. for use at the Cadman Longview mining operation located near Gold Bar, Washington. Thus, DOC and Cadman are requesting a change in point of withdrawal, place of use, and purpose of use of the water right. Please see Figure 1 in the September 2010 Technical Memorandum (Aspect, 2010 C) in Appendix A for locations of existing and proposed points of withdrawal.

Cadman's proposal is to use 600 gallons per minute (gpm) and 232.4 acre-feet per year (afy) at the Gold Bar facility. Note the instantaneous quantity proposed for use is less than the 676 gpm currently held in temporary trust, thus only 600 gpm will be transferred with the remaining 76 gpm remaining in temporary trust.

Attributes of the existing water right and proposed changes

Table 1 Existing and Proposed Attributes

Attributes	Documented	Proposed
Name	Washington State Trust Water Rights Program	Washington State Department of Corrections leased to Cadman, Inc.
Priority Date	November 22, 1947	November 22, 1947
Date of Application for Change	September 8, 2008	--
Instantaneous Rate	676 gallons per minute (gpm)	600 gpm
Annual Volume	232.4 acre-feet per year (afy)	232.4 afy
Point of Withdrawal	NA	Two wells within NE¼ NE¼ Section 15, T27N, R9E W.M.
Period of Use	Year-round	Year-round
Place of Use	None – in trust	See bottom of Page 1

Statutory authorities

RCW 90.03.380(1) provides that a water right may be changed if the change can be made without detriment or injury to existing rights, and to the extent the right is valid and has been beneficially exercised without a break of more than five consecutive years without sufficient cause for nonuse.

Legal requirements for the proposed change

The following is a list of requirements that must be met prior to processing the proposed change:

- **Public Notice**
  Public notice of the application was published in *Monroe Monitor-Valley News* on June 9 and June 16, 2009. Three written protests were received during the statutory 30-day protest period. The protests were from the Big Bend Landowners Association, Greenwater Meadows, and the City of Gold Bar. Additionally, the Tulalip Tribe commented on the proposed change. The concerns given in each of these submittals will be summarized and addressed in this report.

- **State Environmental Policy Act (SEPA)**
  The subject application is categorically exempt under SEPA WAC 197-11-305 and WAC 197-11-800(4) because the instantaneous rate requested to be changed is less than 2,250 gallons per minute.

INVESTIGATION

History of the water right

Much of the following was taken from Dunn (2005):

On November 22, 1947, the Department of Conservation and Development (predecessor to the Department of Ecology) received an application from the Washington State Reformatory for a groundwater right to appropriate 1,000 gpm for domestic use and other requirements of Washington State Reformatory at Monroe, Wash. – year round. The water right application was assigned number 671.

On February 25, 1948, Groundwater Permit 625 was issued to the Washington State Reformatory. The permit was approved for withdrawal of 1,000 gpm and 336 afy from wells in the SW¼ SE¼, Section 11, T27N, R6E, W.M.

On July 25, 1949, Earl H. Lee signed the proof of appropriation form indicating that the date when water was completely applied to proposed use was June 27, 1949.

On August 14, 1949, the State Supervisor of Hydraulics issued Groundwater Certificate 330 to Washington State Reformatory. The certificate was issued for domestic supply and other requirements of Washington State Reformatory, at an instantaneous rate of 1,000 gpm and an annual rate of 336 acre-feet per year.

On February 2, 1998, the Department of Ecology accepted a change application from the Washington State Department of Corrections for Groundwater Certificate 330. This change application eventually requested to place the water right into temporary trust under the Trust Water Rights Program to potentially be pulled out at a future date and put to beneficial use. The change application was assigned Water Right Tracking Number CG1-*00671C.

On December 5, 2002, the Department of Ecology approved the proposed transfer, placing a portion of the right (300 gpm and 100 afy) into permanent trust and the remainder (700 gpm and 236 afy) into temporary trust under the Trust Water Rights Program.

On April 20, 2005, the Department of Ecology accepted an application from the Washington Department of Corrections (DOC) to change Groundwater Certificate 330. This application requested to remove a portion of the right that had been placed temporarily in the Trust Water Rights Program and to begin using it for rainwater catchment and use at the facility. This change application was assigned Water Right Tracking Number CG1-*00671C@1.

The result of that change was that the water right was split into two records – Certificate 330 Record (A), Water Right Tracking Number CG1-*00671C@1 (A), which authorized use of rainwater at the correctional facility at a rate of 24 gpm and 3.6 afy; and Certificate 330 Record (B), Water Right Tracking Number CG1-*00671C@1 (B), which remained in the Trust Program with quantities of 976 gpm and 332.4 afy (of which 676 gpm and 232.4 afy was in temporary trust and 300 gpm and 100 afy is in permanent trust).

On September 8, 2008, the Department of Ecology accepted a change application from the Washington Department of Corrections and Cadman, Inc., requesting a change to Certificate 330 Record (B). The application, which is the subject of this report, was given a tracking number of CG1-*00671C @2. The request is to remove 600 gpm and 232.4 afy from temporary trust and transfer it to Cadman's Longview gravel-mining facility near Gold Bar, Washington for the life of the gravel pit, approximately 25 years. Upon completion of mining, the lease will expire and the water right will revert back to DOC. The 76 gpm not transferred will remain in trust and remain identified as Certificate 330 Record (B). The quantity transferred to Cadman will become Certificate 330 Record (B1).

Table 2 Certificate 330 - Current Water Rights Records as of Issuance of this Report of Examination

Water Right Number	Stage	Purpose of Use	Change App. Date (m-d-y)	Qi (gpm)	Qa (afy)	Source
Cert. 330 Record (A) *CG1-*00671C@1(A)*	change authorization	Domestic	4-20-2005	24	3.6	Rooftop catchment
Cert. 330 Record (B) *CG1-*00671C@1(B)*	change authorization	Temp. Trust	2-2-1998	76	--	None
Super. Cert. 330 Record (C) G1-*00671C(C)	superseding certificate	Perm. Trust	2-2-1998	300	100	None
Cert. 330 Record (B1)* *CG1-*00671C@2*	change authorization	Gravel Pit Operations	9-9-2008	600	232.4	Wells

*Subject of this investigation.

Historic Water Use and Quantity Available for Change

Groundwater Certificate 330 has been investigated twice since 2002. Both investigations were for proposed changes to the water right and included tentative determinations of extent and validity.

The report completed in 2002 found that the entire water right (1,000 gpm, 336 afy) had been perfected. Of the total annual quantity, 108 afy was found to have been used consumptively and the remaining 224 afy was found to have been used non-consumptively. For priority processing of the water right, DOC donated 300 gpm and 100 afy into permanent trust, leaving 700 gpm and 236 afy available to be removed from trust.

In 2005 DOC requested to remove 24 gpm and 3.6 afy of the water from temporary trust for use within the prison, leaving 676 gpm and 232.4 available in temporary trust.

In 2011 DOC leased the entire water right remaining in temporary trust to Cadman for possible transfer to the mine. With no need for a portion of the instantaneous quantity, 76 gpm will remain in temporary trust.

The quantities available to be transferred to Cadman's Gold Bar facility are 600 gpm and 232.4 afy (108 afy consumptive + 124.4 afy non-consumptive) and, as a consequence of being in the Trust Program since 2002, are tentatively considered valid and eligible for change.

Proposed Use

Cadman, Inc. proposes to use the consumptive portion of the transferred water at its gravel mining facility. Uses of water will be for dust abatement, wheel washing, general plant cleanup, a proposed gravel washing facility, and a possible concrete batching plant. All of these uses fall under the industrial purpose of use, with water to be used for mining operations.

An exempt well currently supplies less than 5,000 gallons of water per day for existing activities at the mine for wheel washing and dust abatement. All of the water produced from this well is used consumptively. The wheel wash is a closed-loop system that recaptures wash water for later use, with none flowing onto the ground and infiltrating. Water leaves the site on the wheels of the vehicles and by direct evaporation from the holding facility. Dust abatement is also completely consumptive.

The immediate proposal is to add a second well to supply water for a proposed gravel washing plant, though both wells may be used interchangeably. The new well and the existing well will be used to supply water to a lined storage pond that will be about 5 acres in area and capable of storing about 50 acre-feet of water. Water will be pumped from the storage pond as needed into a separate vault, sent from that vault through the gravel washing plant, and returned to the vault in a closed loop system. Fines will be mechanically removed from the wash water, collected and pressed into "filter cakes" that will be placed in areas concurrently being reclaimed. Water will leave the site via evaporation from the storage pond, from filter cakes, and from product stockpiles and on product that leaves the site. No water will be returned to the groundwater system via infiltration. All water used for industrial purposes at the Gold Bar facility will be considered consumptive. Cadman estimates that consumptive use at the gravel washing plant will range from 60,000 gallons per day (gpd) up to 156,000 gpd (Aspect, 2009). The 108 afy in consumptive use would allow an average of about 96,000 gpd, suggesting the gravel washing facility and other on-site uses will require the full requested quantity.

A concrete batching plant is possible at the site and, if constructed, would consumptively use an estimated 12 afy of water. It should be noted that if the batching plant is put into operation, a reduction in consumptive use elsewhere would likely be necessary to ensure total consumptive use remains below 108 afy. Over the life of the site water may also be used for reclamation requirements.

The non-consumptive portion of the water right also will be used at the site for mitigation of impacts to the Skykomish River (see "*Mitigation / Management Plan*" portion of the "Impairment" section of this report). Some of the water pumped from the production wells into the storage pond will be released from the storage pond into an infiltration pond and returned to the same aquifer.

Site Descriptions

The State Reformatory property is located within Section 11, Township 27 North, Range 6 East, approximately one-half mile west-southwest of the City of Monroe in western Snohomish County, Washington. DOC owns several hundred acres, a portion of which is agricultural and abuts the Skykomish River. The reformatory's buildings are located on a topographic terrace north of the Skykomish River and approximately 80 to 100 feet higher in elevation. The river is at an elevation of about 35 feet above mean sea level (MSL) at this location, approximately 3½ miles upstream of the confluence with the Snoqualmie River. The wells originally authorized

under this water right were located within the NW¼ SW¼ SE¼ of Sec. 11, T27N, R6E, W.M. See Attachment 1. The proposed place of use is Cadman's Longview Gravel Mine, which is located approximately 21 miles east (upstream) of DOC's Monroe Reformatory and about 3 miles east of the Town of Gold Bar in Snohomish County, WA. The mining operation has been active since 2006 and will eventually excavate and process gravel on 230 acres. The site generally slopes up from north to south and is characterized by upper and lower terraces separated by steep slopes. Elevations at the site range from approximately 900 feet above mean sea level (MSL) along the south site boundary to about 305 feet MSL at the northern boundary (Aspect, 2008). The two proposed wells will be situated on the lower terrace and will be within the NE¼ NE¼ Section 15, T27N, R9E W.M.

Site Visits

The original water right location, Monroe Correctional Facility, was visited May 2, 2002, by Jay Cook, geologist, and Janet Jorg, permit writer, as part of the investigation to place the water right into the Washington State Trust Water Rights Program. The plant manager at the Monroe facility provided information regarding water use at the facility and gave a tour of existing water supply facilities.

A site visit was performed at the Longview Mine on August 20, 2009. Jay Cook of Ecology met on-site with Mr. Gabe Morelli (Cadman) and Mr. Owen Reese (Aspect Consulting), both representing Cadman, Inc. During the site visit, current and future operations of the mine were discussed and a tour of the mine was given. Active mining on the site was occurring on the upper terrace with stockpiles of materials situated on the lower terrace. Current water use on the site for wheel washing, dust abatement, and general plant cleanup was noted to be supplied by an exempt well (well tag number AKY 991). Typical pumping rate from the well is 25 gpm. Static water level within the well was obtained using a sonic well probe and was found to be 40.6 feet below ground surface. Also during the visit a GPS (global positioning system) reading was taken of the existing well and gave a latitude of 47.834079° and a longitude of -121.635445°.

Additionally, during the August 20 site meeting, a neighboring development, the Big Bend community (formal protestors of the change application), was visited. This meeting at the Big Bend wells site was hosted by Ms. Colleen Bleifuss, President of Big Bend Landowners Association (BBLA), Mr. Dave Clark, BBLA board member, and Ms. Kim Peterson, who operates the BBLA water system. During the meeting, operation of the BBLA system was discussed along with concerns of potential impacts to the BBLA system by the proposed withdrawal and use of water at the Cadman facility. It was noted that BBLA's system is served by 2 wells located approximately 20 feet apart that operate simultaneously, each pumping approximately 35 gallons per minute. One of the wells is 8 inches in diameter and has a well tag number of ABR046. The second well was not viewed due to inaccessibility, and no static water levels were taken in either well due to inaccessibility. A single GPS reading was taken near both wells and gave a latitude of 47.835605° and a longitude of -121.635445°.

Topographic and Local Area Maps

The Monroe (USGS, 1953, revised 1968), Maltby (USGS, 1953, revised 1968), and Gold Bar (USGS, 1989, provisional edition) 7.5-minute Quadrangles were used to discern the locations and elevations of the original and proposed points of withdrawal/diversion as well as to examine the general topography of the area and basin characteristics.

General Hydrology and Physiography

Much of the following information was derived from PGG (1995) and Thomas et al (1997), referenced at the end of this report.

Water Resources Inventory Area (WRIA) 7 is located in the north-central Puget Sound region and includes portions of King and Snohomish County. The watershed encompasses 1,867 square miles, of which 1,780 square miles is drained by the Snohomish River (PGG, 1995). The Snohomish River, which discharges to Puget Sound, carries the combined flow of the Skykomish and Snoqualmie Rivers. Major tributaries to these rivers include the Tolt, Sultan, and Pilchuk Rivers. The Snohomish River main stem is about 20 miles in length.

The Skykomish River basin drains 844 square miles of the northern portion of the WRIA, accounting for about 43 percent of the total WRIA area. The Snoqualmie River basin drains 693 square miles of the southern portion of the WRIA, accounting for about 35 percent of the total WRIA area.

Two distinct physiographic provinces exist within the WRIA as defined in the Initial Basin Assessment (PGG, 1995). The Puget Sound Lowland occupies the far-western portion of the watershed and is characterized by upland plateaus dissected by broad river valleys. The major plateaus typically range in elevation between 200 and 600 feet above mean sea level (MSL). Along the eastern edge of the Lowland, the plateaus form the transitional foothills into the Cascade Mountains. The Cascade uplands occupy the eastern and southeastern portions of the

watershed, and are characterized by rugged mountainous terrain and outcropping bedrock. Summit elevations are typically 6,000 to 7,000 feet MSL.

The climate is characterized by warm, dry summers and cool, wet winters with about 70 percent of total annual rainfall occurring between October and March and 10 percent of annual rainfall occurring in June, July, and August. Temperatures within the basin are moderated by marine air from the west. Rainfall is usually light to moderate in intensity and continuous over extended periods during the wet season (PGG, 1995). Mean annual precipitation throughout the WRIA is about 87 inches but varies from 25 inches in the northwestern portion of the watershed to 180 inches in the eastern, mountainous region.

A large portion of the Snohomish River Basin drains high-elevation areas of the Cascade Mountains. Due to this, spring and early summer snowmelt strongly influence streamflow patterns in the basin. All of the major rivers of the Snohomish basin – the Snohomish, Snoqualmie, and Skykomish rivers – exhibit two distinct periods of high monthly flows. November, December and January feature high flows due to rainfall, while May and June have high flows as a result of snowmelt at high elevations. The low-flow month at almost all gages in the basin is August, due to the fact that snow has melted and little rainfall usually occurs at this time of year (Pentec, 1998).

Regional Geologic Setting

Much of the following summary is compiled from work by Turney and others (1995), Pentec (1998), PGG and others (1995), and Thomas (1997).

Puget Sound Lowland has been in existence since Tertiary times (about 66 to 2.2 million years before present) when sedimentary and volcanic basement rocks were folded downward between the Olympic and Cascade ranges. The resulting basin provided an avenue for several episodes of piedmont or ice sheet-type glacial flow from southwestern Canada, with concurrent sedimentary deposition during the Pleistocene (2 million to 10,000 years before present). Recent post-glacial topographic modifications by erosion and deposition have been minor, occurring primarily along river floodplains.

The Cascade Mountains in the Snohomish Basin are generally underlain by Tertiary-age bedrock which is composed of intrusive igneous rocks (granite, granodiorite, and tonalite), small amounts of volcanic rocks (andesite and basalt), and older Tertiary-age sedimentary and metamorphic rock (Pentec, 1998).

Tertiary bedrock, consisting of consolidated rocks such as volcanics, conglomerate, sandstone, limestone, and others, is the basal unit underlying the Puget Sound Lowland. The mantle of debris overlying the bedrock units in the Puget Sound Lowland and reaching thicknesses in excess of 800 feet typically is composed of Pleistocene-aged, glacially derived sediments. These sediments were deposited during four (possibly 5) periods of glaciation during which the Puget Lowland was overridden by continental glaciers advancing from the north. The most recent glacial event and the source of most shallow glacial sediments in the Lowland and foothills of the Cascades was the Vashon Stade of the Fraser Glaciation, which receded from the area approximately 13,000 years ago.

Vashon-aged glacial sediments found within the Puget Sound Lowland and Cascade foothills consist of (from oldest to youngest): advance outwash (Qva) – typically compact and composed primarily of gravels with discontinuous sand lenses and local lenses of silt and clay deposited by meltwater streams as the glacier advanced; glacial till (Qvt) – very compact, also known as hardpan, composed of clay, silt, and gravel deposited at the base of the advancing glacier; and recessional outwash (Qvr) – not compact, deposits composed primarily of well-sorted gravels, sand, silt and clay deposited by meltwater streams as the glacier retreated.

Subsequent to the deposition of the glacial sediments, alluvial sediments (Qal) of the Holocene age (10,000 years ago to the present) were deposited. These alluvial sediments are predominantly fluvial deposits of sand with some small gravel that also includes lenses of fine-grained overbank deposits, coarse gravel, and cobbles which were deposited in stream and river valleys. Typical thickness is about 40 feet, and deposits within the Skykomish River Valley are some of the most areally extensive in the Snohomish basin.

Concurrent with deposition of alluvium, still-water bog and marsh deposits were formed in low-lying areas. These deposits are composed of peat interbedded with organic rich mud (Thomas, 1997).

Local Geology

Driller's logs from the subject wells and wells in their vicinity were examined along with reports and publications of geologic research performed in the area.

Original Points of Withdrawal
The Thomas (1997) geologic map shows alluvial deposits at the surface of the two-mile-wide Skykomish River floodplain near Monroe, and a cross section within the report shows these deposits reaching a thickness of approximately 50 feet near the Department of Corrections wellfield, which is situated about 1,300 feet from the Skykomish River. The depths of the production wells, Wells 1 and 2, are 52 and 54 feet, respectively (Cook, 2002). Considering the location and depths of the wells, it is likely both wells are completed within the alluvial deposits (Qal) of the Skykomish River.

Proposed Points of Withdrawal
The Thomas (1997) geologic map shows alluvial (Qal) deposits at the surface in Skykomish River valley near Gold Bar, WA, but no geologic cross section near the Longview Mine was constructed for the report. A geologic map and cross sections prepared by Aspect Consulting (2004) as part of Cadman's Longview Mine Environmental Impact Statement (EIS) also shows alluvial deposits present at the surface, but suggests these deposits are thin in the valley bottom in and around the Cadman site. The Aspect report shows that in the valley bottom, the surficial alluvial deposits are underlain immediately by undifferentiated Vashon glacial deposits, termed Qvu, which contain a higher fraction of fine-grained materials. Immediately below Qvu, Aspect suggests, are Pre-Vashon fluvial deposits (Qpff), composed of high-energy sands and gravels.

The Qvu unit is not present in all locations in the valley bottom. Notably it generally appears to pinch out and not be present near the Skykomish River. Where Qvu is absent, alluvial deposits directly overlie the Qpff unit, which is compositionally similar to the Qal and the two create a thick, unconfined aquifer near the river. The geologic interpretation presented in the EIS report is based on a detailed and comprehensive review of geologic information for the area surrounding the Cadman site. The geologic map and associated cross section prepared by Aspect (2004) can be found in Appendix B of this report.

Based on this geologic interpretation, Aspect suggests that Cadman's existing water well (permit exempt), located about 1,700 feet from the Skykomish River and screened between 55 and 70 feet below ground surface, penetrates surface alluvium and Qvu and is completed within the underlying Qpff unit. The additional proposed well will also tap a similar production zone.

Aspect used their 2004 geologic interpretation to generate the geologic/hydrogeologic framework for a three dimensional, numerical groundwater model that was used to assess potential impacts of the proposed pumping and mitigation. For stratigraphic simplicity in the model, Aspect combined the alluvial deposits (Qal) with other shallow aquifer deposits including Vashon recessional outwash (Qvr) and Vashon fluvial (Qvf) to create a single shallow aquifer termed the "unconfined aquifer". This is irregularly underlain in the model by the Qvu unit described above. The bottom layer of the model is the Qpff aquifer described above. All of these materials are underlain by Tertiary bedrock. The modeling memorandum (Aspect, 2010B) is included in Appendix A of this report.

Ecology's finding is that Aspect's interpretation of site geology and their use of this geology in the groundwater model is reasonable.

Local Hydrogeology

Original Points of Withdrawal
The Monroe facility wells take water from the alluvial aquifer (Qal) of the Skykomish River. The high-permeability sands and gravels in the Skykomish alluvial aquifer suggests that the Monroe facility wells are in direct hydraulic connection to the Skykomish River. With typical groundwater gradients toward the river and downstream, it is expected that all water withdrawn from these wells would have ultimately discharged to the Skykomish River.

Proposed Points of Withdrawal
Cadman has not yet constructed the primary production well, but its location will be restricted to the area given in the water right application publication, which is the NE¼ NE¼ of Section 15. The proposed well location will be further restricted, by site topography and easy access to shallow water, to a flat area situated near Highway 2. As described above, this location is underlain by a thin veneer of alluvial material, discontinuous Qvu deposits (confining to semi-confining unit), and Qpff deposits (see Figure 1on page 13 of this report and Appendix B).

An existing well, actively used for permit exempt withdrawals, currently occupies this area and will likely be used as one of two points of withdrawal for the site. This well is interpreted by Aspect as drawing water from the unconfined to semi-confined Qpff unit and is likely in direct continuity with the Skykomish River. As with the Monroe wells, the groundwater gradient at Cadman's well suggests that all water withdrawn from this well would have discharged to the Skykomish River.

Aspect Consulting, carrying out hydrogeologic work for Cadman, Inc., performed pumping tests on the exempt well in April 2005 in order to determine production capability of the well and aquifer and to determine aquifer parameters. The pumping test memorandum, submitted to Cadman on May 2, 2005, was included as an appendix in a report produced in September 2008 and submitted to Ecology for informational purposes in support of the proposed water right change (Aspect, 2008).

Soon after completion of the pumping test, raw data from the pumping test and the pumping test report were shared with BBLA and their hydrogeological consultants, Pacific Groundwater Group (PGG), for use in creating a numerical model for assessing wellhead protection of BBLA's groundwater sources. PGG's May 18, 2005 modeling report with wellhead protection area recommendations was submitted by BBLA to Ecology in 2009 for informational purposes regarding their formal protest of the subject water right change application.

Ecology's review of the pumping test report as part of this investigation found flaws with the pumping test data and interpretation. Most notable was that the water level in the nearest monitoring well began to rise after about 200 minutes of pumping the production well. After discussion with Aspect it was concluded that the discharge water, released in a swale about 300 feet from the well, had infiltrated and affected the pumping test. Thus, the pumping test data are considered questionable.

On December 9, 2010, Aspect Consulting submitted a memorandum to Ecology on behalf of Cadman that describes and gives results from a three-dimensional groundwater model of the Cadman site. The memorandum can be found in Appendix A of this report. Aspect states the model was developed to assess lag effects on the Skykomish River and replace estimates of lag effects from previous technical memorandums based on Jenkins and Hunt analytical models, which are simplified and do not consider many site-specific conditions. The objective in doing so is to support the effectiveness of Cadman's proposed mitigation and management strategy.

The model was developed using available topography, surface and subsurface geology, historical river stage and flow data, and groundwater monitoring data from the site. The top of the model is based on the aerial topographic survey within the mine site and USGS digital elevation model (DEM) for surrounding areas. The bottom of the model represents inferred bedrock elevation based on well logs and geophysical measurements (Aspect, 2010 B).

The model recognizes the three geologic layers described above. Due to its confining properties, the second layer, Qvu, has significant influence on model results. The extent and thickness of the finer-grained second layer was determined from stratigraphic contacts present in borings and from geostatistical methods. The layer was inferred to be thin (about 15 feet) and relatively uniform where no subsurface data were available. Where borings indicate the layer is absent, it is simulated as 1 foot thick to avoid issues with layer discontinuity (Aspect, 2010 B).

Aquifer parameters were determined through manual adjustment during model calibration and are given in the following table taken from Aspect's 2010 modeling report.

Table 3 Aquifer Parameters Derived from Model Calibration (from Aspect, 2010 B in Appendix A)

Hydrostratigraphic Unit	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity	Confined Storage Coefficient, Specific Storage	Unconfined Storage Coefficient, Specific Yield
Qvf (Layer 1)	1000 ft/d	100 ft/d	3×10^{-4} /ft	0.2
Qvu (Layer 2)	10 ft/d	1 ft/d	1×10^{-5} /ft	0.1
Qpff (Layer 3)	1000 ft/d	100 ft/d	1×10^{-5} /ft	0.2

The aquifer parameters derived from the model fall within typical ranges for these types of sedimentary deposits (Freeze and Cherry, 1979). The groundwater model presented by Aspect appears to be a reasonable representation of the hydrogeology at the Cadman site.

Protests and Comments

Three formal protests were received within the statutory 30-day protest period. The protests are summarized below. Please note that Ecology received a number of letters and supporting information from protestors and from project proponents subsequent to the original protest letters. All of these documents have been reviewed and considered for this report.

Big Bend Landowners Association (Received July 14, 2009)

1. The proposed well is not in the same body of public groundwater. "…simply because the proposed well and existing well draw water out of an aquifer connected to the Skykomish River does not mean that the water is within the 'same body of public groundwater.' The two groundwater basins are separated by over 21 miles of rugged terrain and located in starkly different settings."

   "In this case, not only is there a stark contrast in the physical nature of the two basins, the two stretches of river are also under different management frameworks. The upper stretch of the Skykomish River, and specifically the 14 mile stretch downstream of the confluence between the North Fork and South Fork to the junction of the Sultan River is one of only two rivers designated by the State of Washington as Scenic Rivers. RCW 79A.55.040. As a designated state scenic river, Ecology is directed by statute 'to pursue policies with regard to its activities, functions, powers and duties which are designed to conserve and enhance the conditions of the rivers which have been included in the system…' RCW 79A.55.040. Allowing transfer of a water right 21 miles upstream from a slow flowing agricultural stretch of river to a stretch of scenic river fails Ecology's statutory duty."

2. The proposed transfer will impair existing rights. "The transfer will impair the quantity of BBLA's water right. The BBLA well is approximately 1000 feet away from the proposed well, clearly within the zone of influence Cadman's new well system." BBLA suggests the pumping test was flawed due to the return of pumped water and due to rising aquifer levels before the start of the pumping test.

   "The transfer will impair the quality of BBLA's water right. Operation of the Cadman facility has the potential to impact BBLA's water quality through spills, by increasing the turbidity of our water and increasing pH and pH-sensitive parameters particularly if expanded site development includes gravel washing of aggregate and a new concrete batch plant. Concrete plants produce very high pH water which can enter the ground and cause changes to groundwater chemistry, smell, and taste. Aspect's [Cadman's consultant's] calculated average linear seepage velocity of 0.4 ft/min within the vadose zone is very high and likely indicates large pores that could easily transmit turbidity" from infiltrating stormwater. Hydrogeologic modeling performed by Pacific Groundwater Group (PGG) "demonstrated that the location of the Cadman's proposed well is directly within the capture pathway for the BBLA well. Cadman's proposed well lies within the three month zone of the BBLA wellhead protection area."

3. The transfer will impair instream flows. "The applicant proposes to transfer this water right upstream approximately 21 miles from the original point of withdrawal. In order for this to be approved Ecology has to show…that the change won't impair the instream flows established for the Skykomish River under WAC 173-507. Relocating the point of impact upstream on a regulated reach of water increases the number of stream miles that would suffer from reduced flows." BBLA states that instream flows are not met during all months of the year, and for some periods flows are not met more than 60% of the time. BBLA goes on to state concerns with the management by Cadman of any system utilized to mitigate impacts to instream flow. BBLA also raises concerns about potential impacts to Proctor Creek that has "an important contribution to the anadromous fishery of the Skykomish…"

4. The application fails to completely quantify the amount of water. "The Application for Change and supporting work prepared by Aspect fail to quantify both the amount needed for consumption and the amount that will be put to beneficial use."

5. The water may not be put to beneficial use. "Some of the water proposed for transfer is intended to be used for concrete production. In reviewing the SEPA documents related to this project, we do not find mention of a concrete batch plant. If a concrete plant was not approved through the SEPA process Ecology has no grounds to allocate water for that purpose. Aspect has estimated the amount of consumptive water use for the concrete plant to be 12 acre-feet per year, the change authorization needs to consider the entire amount of water needed."

6. The transfer is not in the public interest. "For many of the above stated reasons, this application will indeed be detrimental [to the public interest] and should be denied."

City of Gold Bar (Received July 15, 2009)

1. The aquifer being utilized services many districts between the original point of withdrawal and the proposed point of withdrawal [21 miles apart]. Some of the water users are: Big Bend Community, Gold Bar Nature Trails Community, City of Gold Bar, Washington Fish and Wildlife Hatchery, Startup Water District, various private wells.

2. The Gold Bar Wellhead Study indicated that the aquifer feeds May Creek, a salmon spawning stream.

Greenwater Meadows Landowners Association (Received July 15, 2009)

1. The water rights transfer to enable use of water at 600 gpm at the gravel pit and potential concrete batch plant "would have severe impacts on our water rights and quality and availability of our water." Additionally, Mr. Udd expresses concern for the same water users as the City of Gold Bar protest.

2. "If any approval is considered there needs to be tough, independent mechanisms to monitor the operations at Cadman; to monitor aquifer quantity, quality and safety; to compel Cadman to shut down all operations that compromise, reduce or destroy the water supply to our homes; and to specify mitigation measures, compensation, and penalties."
3. Mr. Udd also mentions the upper Skykomish designation as a scenic river, and states, "This violates the Water Resources Act of 1971 that protects stream flows as well as adversely affecting fish runs, salmon and steelhead spawning grounds and endangered species."

One formal comment letter was received and is summarized below.

Tulalip Tribes (Received electronically November 14, 2008)

1. "The Tribes do not support a change of place of use from one source to another."
2. What is the reason that aggregate from the Gold Bar mine cannot be processed at another site?
3. "Currently, without a stream gauge on the Skykomish River, Ecology can monitor neither instream flows nor the impairment of junior water rights. As Aspect Consulting has demonstrated, only coarse estimates of flow can be calculated for the Skykomish River using existing gauge data scaled for basin area. This method of monitoring instream flows and impacts to junior water uses is not scientifically robust… Tribes encourage the State to seriously consider the amount of monitoring, reporting and enforcement that will become necessary if Ecology continues to issue complicated water rights and water rights changes in basins which do not meet their designated minimum instream flows and which have inadequate monitoring instrumentation."

FINDINGS

Impairment of Other Rights

Impairment means to 1) adversely impact the physical availability of water for a beneficial use that is entitled to protection, and/or 2) to prevent the beneficial use of the water to which one is entitled, and/or 3) to adversely affect the flow of a surface water course at a time when the flows are at or below instream flows levels established by rule (POL-1200), and/or 4) degrade the quality of the source to the point that water is unsuitable for use by existing water right holders (WAC 173-150). Demonstration of impairment would require evidence of a substantial and lasting or frequent impact reflecting such conditions.

Appropriative Rights and Claims

There are 7 probable water rights in the four sections (10, 11, 14, 15) nearest the proposed points of withdrawal. Of these, 2 are claims and 5 are certificates.

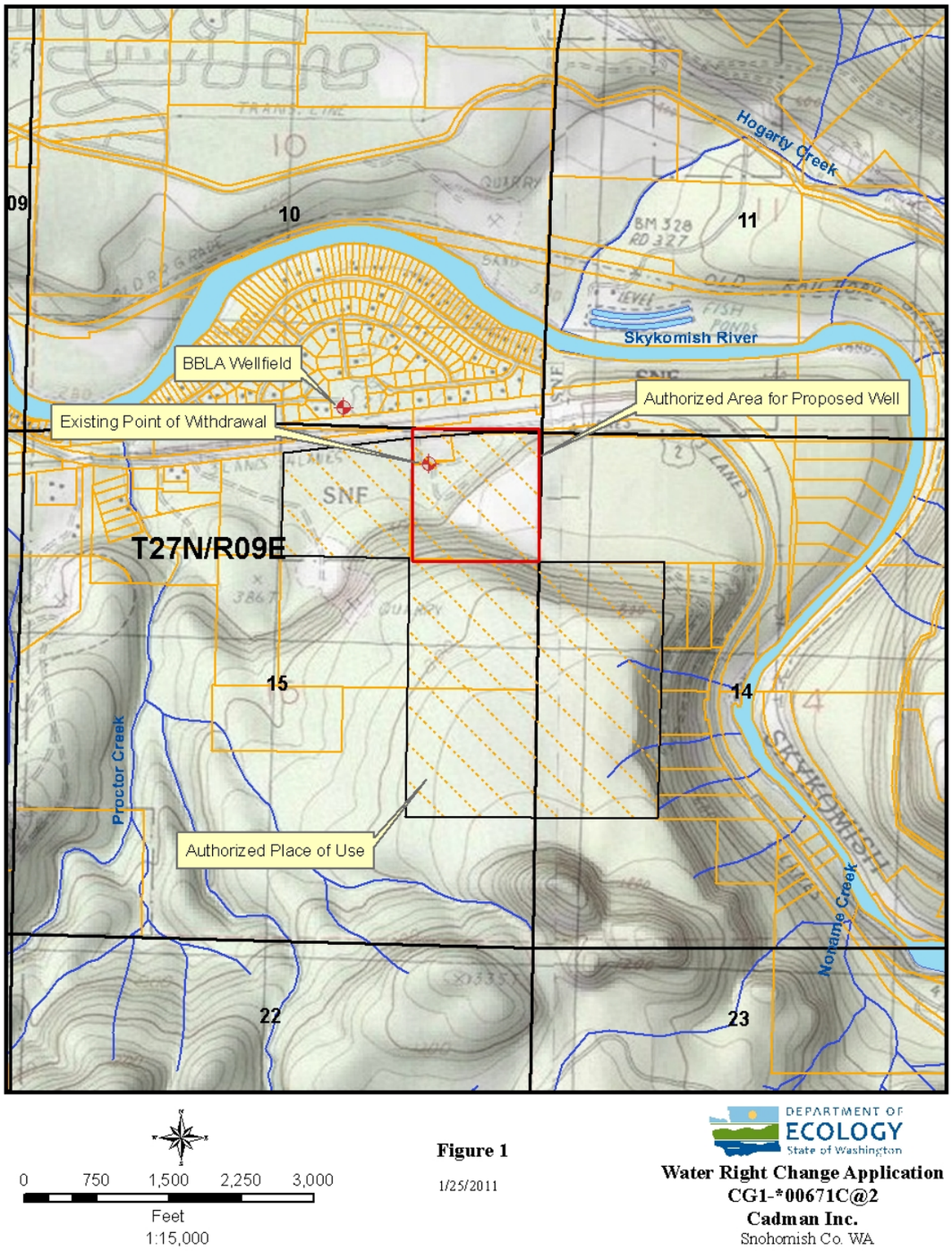
One of the claims is for groundwater withdrawal for domestic use at a Department of Fish and Wildlife Facility (filed by predecessor agency – Dept. of Game), and the other is a surface diversion from a spring for irrigation and general domestic use. Validity of claims in Snohomish County can only be evaluated in an adjudication by Snohomish County Superior Court. Of the 5 certificated water rights in this four-section area, 2 are for ground water withdrawals and 3 authorize surface water diversions from nearby creeks: Austin Creek, Hogarty Creek, and Proctor Creek.

Considering the hydrogeology and the proposed pumping rate, a radius of ½ mile was chosen for closer examination of potential impairment. One water right was found in this area. The groundwater certificate was issued to Peterson Investment Co. for 200 gpm and 134 afy for multiple domestic supply. This water right is now held by Big Bend Landowners Association (BBLA - formal protestors), a community of about 400 residents located across Highway 2 from the Cadman site. BBLA utilizes two wells, 69 and 91 feet deep, that are located approximately 1,100 feet northwest of Cadman's proposed wells. See Figure 1, following page.

Research indicates 8 water wells within ½-mile of Cadman's proposed wells. Most (6) of these wells do not have a corresponding water right. It is likely that these 6 wells are exempt from the permitting process pursuant to RCW 90.44.050 and are authorized to each withdraw a maximum of 5,000 gallons of groundwater per day. The remaining 2 wells are associated with BBLA.

BBLA's wells are the nearest water wells to the proposed points of withdrawal. Hydrogeologic principles suggest that if BBLA's wells are not impaired, it is very unlikely that any more-distant wells will be impaired. The groundwater model, produced by Aspect consulting, was run to evaluate potential impacts at the BBLA well during a worst-case pumping event at the proposed Cadman wells. The worst case pumping event that was modeled represents 24 days of continuous pumping at 600 gpm, which would fill a 50 acre-foot pond plus make-up water used in the washing facility for a total of 63 acre-feet. The model found the maximum expected drawdown

Figure 1 Proposed points of withdrawal, site topography, hydrologic features and nearest groundwater withdrawal



at the BBLA well to be less than 0.2 feet, which would not constitute impairment. This finding is supported by the accepted hydrogeologic concept that highly transmissive aquifers (thick and permeable) promote a large radius of influence with a small amount of drawdown.

Being the water body nearest the proposed points of withdrawal and in direct continuity with the tapped aquifer, the Skykomish River is the only surface water body that will be impacted by the proposed pumping (i.e. once the radius of influence reaches the Skykomish River, the radius should grow no larger). If all the water being pumped from the proposed wells (600 gpm or 1.34 cfs) were to come directly from the Skykomish at its lowest measured daily flow of about 800 cfs, it would account for less than 0.2% of total flow and would not physically impair any water rights that take water from the Skykomish River.

Water Quality

BBLA has expressed concerns that the proposed use of water at the Cadman Site could impair their water right by degrading water quality. BBLA's wells are situated downgradient of the proposed gravel-washing plant and the possible batching plant. BBLA has stated concerns that the gravel washing activities could increase turbidity in their well and that a concrete batching plant, if constructed, could chemically alter their water quality. Ecology's Water Quality Program was consulted regarding these concerns. An internal memorandum from the Water Quality Program was received in response and is included as Appendix C. In summary, the Water Quality memorandum states that groundwater contamination by turbidity is extremely rare and suggests that the proposed use of a lined

process pond will serve to further protect the groundwater. Note that subsequent to the Water Quality memo Cadman altered its plans and now will install a vault for its gravel washing processes, which should perform as well or better than the process pond considered by the Water Quality program. The memo goes on to state that the existing Sand and Gravel Permit requires protection of groundwater, and it states that installation of a batch plant (concrete or asphalt) will require a full SEPA review and significant additional permitting actions that will assess potential for groundwater contamination.

During the Snohomish County process for authorization of a new gravel pit, the Snohomish County Hearings Examiner required Cadman to prepare and implement a groundwater-monitoring plan to confirm that measures for protecting groundwater quality are effective.

In consideration of the Department of Ecology Water Quality memorandum and the groundwater monitoring already required by Snohomish County, it is unlikely that BBLA's wells will suffer from degraded groundwater quality due to the proposed mining activities. Additionally, a Contingency Plan (Aspect, 2006) is in place for Cadman to secure a safe water supply for BBLA in the event that groundwater quality is compromised.

Cadman's proposed management/mitigation plan calls for use of the non-consumptive portion of the water right to release large volumes of water from their lined storage pond into their stormwater infiltration pond. The storage pond is not a process or settling pond and will receive water only from Cadman's production wells, thus only clean groundwater will be infiltrated as mitigation. Ecology's Water Quality program was consulted with regard to this proposal and stated that the release into the infiltration pond does not violate the terms of Cadman's Longview Mine National Pollutant Discharge Elimination System (NPDES) permit.

As above, with BBLA's wells being nearest to and downgradient of the proposed project, a finding of no likely degradation of water quality at BBLA suggests the same for other water users at a greater distance.

Instream Flow for Skykomish River
The Skykomish River has been assigned instream flows under chapter 173-507 WAC. These discharge values, measured at a specific "control station", are considered a water right for the river and may not be impaired by junior water rights. When flows fall below the prescribed levels, appropriators with rights subject to instream flows must cease pumping or diverting ("turn off") in priority order until the prescribed flow is restored or until there are no rights to turn off that are subject to flows.

The original water right held by the Department of Corrections (DOC) is senior to the Instream Resources Protection Program (chapter 173-507 WAC) established in 1979 for the Snohomish River system (Water Resources Inventory Area 7) and was never subject to instream flows. However, the original point of withdrawal at the DOC facility was downstream of the Skykomish River control station given in the rule, and the water use never affected the Skykomish River's discharge at the control station. The proposed point of withdrawal is upstream of the control station and will now affect flow at that location. To avoid impairment of the river and of any water rights subject to flows at that control station, the right must become subject to flows at the Skykomish River control station in Monroe. Note that no active continuous-data gage exists at the location prescribed in chapter 173-507 WAC. A daily-measurement gage was present there only for about 9 months from 1968 to 1969. Ecology's Environmental Assessment Program (EAP) has manually measured Skykomish River discharge on a monthly basis for a number of years at this location, but this is not effective for monitoring instream flows for the purpose of regulation.

When an appropriator diverting surface water is subject to instream flows, it is simple to regulate – simply turn off when flows are not met. This proves much more difficult with groundwater withdrawals. As described earlier in this report, all water taken from the Cadman wells ultimately would have discharged to the Skykomish River. Removing water from the aquifer sometimes results in actual discharge of river water into the aquifer, but more often results in long-lasting reductions in aquifer discharge to the river known as "lag effects". Analyzing the timing of lag effects is necessary for crafting a management scheme that will not impair instream flows.

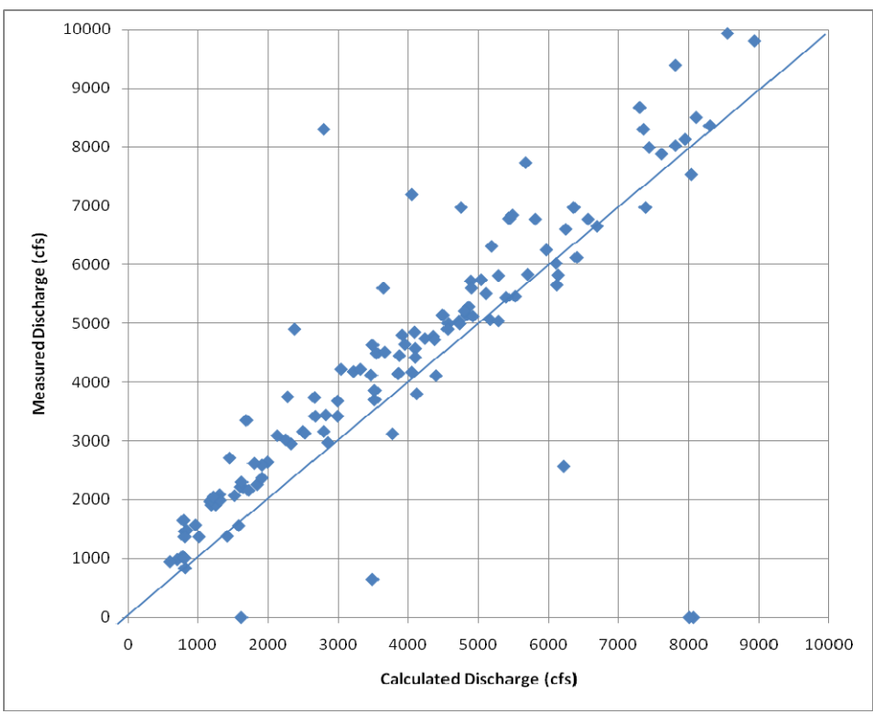
Mitigation / Management Plan
Cadman's consultant, Aspect Consulting, has submitted a management plan and supporting technical memorandum (modeling report) to protect instream flows at the Skykomish River control station in Monroe. Both of these documents can be found in Appendix A of this report. Key aspects of the plan include:

- Calculating flow (discharge) at missing gage in Monroe
- Adding a 100 cfs buffer to the instream flow assigned in WAC 173-507-020
- Turning off production wells and releasing water into infiltration pond when calculated flow is below instream flow plus buffer

Discharge Calculation
WAC 173-500-060 authorizes Ecology to change a control station location or to add new control stations to improve management capability for use in regulating water rights that are subject to flow limitations. Aspect has proposed using a formula to calculate flow at the non-existent Monroe control station (12.1411.00) by utilizing the nearest active gages on the Snoqualmie and Snohomish Rivers. Since the Snoqualmie and Skykomish Rivers meet to form the Snohomish, Skykomish flows can be estimated by subtracting the flow at the most downstream Snoqualmie gage from the flow at the most upstream Snohomish River gage. Aspect (2010 A) has proposed multiplying this difference by a factor of 0.89 to recognize flow accretion between the missing Skykomish gage at Monroe and the upper Snohomish gage. Aspect compared their calculations to the flow records from 1968-1969 and found that the formula predicts flow reasonably well with an error toward predicting flows that are lower than actual flows during low-flow periods. See Figures 1 and 2 in Sept. 2010 (Aspect, 2010 C) technical memorandum in Appendix A.

Ecology performed the same exercise using monthly flow data from Ecology's Water Quality Program website for the Skykomish River. The data are for the period from 1997 through 2009 and were collected using manual methods. The flow data were compared to calculated flows for the same date range using Aspect's formula and daily data from the USGS gages on the Snohomish and Snoqualmie Rivers. Figure 2 below confirms that Aspect's calculation consistently under-predicts flows at Monroe, particularly during periods when flow is below 5,000 cfs. The highest minimum instream flow for the Skykomish is 4,900 cfs. Thus, when the river is near its instream flow, the actual flow of the river will consistently be greater than the flow calculated by Cadman. Figure 2 suggests that the difference between calculated and actual flows will often be several hundred cubic feet per second, adding a significant safety factor that is protective of instream flows.

Figure 2 X-Y Plot of Calculated Flows vs. Measured Flows in Skykomish River



Buffer
The proposed 100-cfs buffer is designed to give a 1 to 3 day period (window) during which Cadman will negate lag impacts to the Skykomish River before the minimum instream flow is reached. Based on historical data, Aspect in the September 2010 supporting document (2010 C, found in Appendix A) suggests that in late summer and early fall when flows are lowest (August to October) the 100-cfs buffer will give a 1-day window 93% of the time, a 2-day window 83% of the time, and a 3-day window 75% of the time (i.e. if Cadman turns off at 100 cfs above the minimum instream flow between August and October, 75% of the time it will take more than 3 days for the river to reach the minimum instream flow; 93% of the time it will take more than 1 day). Evaluating the data for the entire year reduces the reliability of the buffer due to the large discharge fluctuations that occur during the rainy season. The 100-cfs buffer year-round offers a 1-day window 77% of the time, a 2-day window 60% of the time, and a 3-day window 50% of the time.

Strategy
In the proposed Management Plan prepared by Aspect Consulting (in Appendix A), Cadman has proposed a mitigation strategy to quickly negate pumping impacts on the river. The proposal is that Cadman will observe flows each morning that pumping is planned (using real-time flow data and the calculation described above) and may pump freely to fill its storage pond or supply process water when (calculated) flows in the Skykomish River

are above the instream flow plus the 100 cfs buffer. When flows decline to the instream flow plus the buffer, Cadman will immediately cease pumping the production well and will begin releasing water from their lined storage pond into a stormwater infiltration pond located about 1,000 feet west of the pumping wells (nearer the river in the downstream direction). If not actively pumping when flows are below the instream flow plus the buffer, Cadman will not begin pumping and will discharge mitigation water as necessary.

Water will be discharged into the infiltration pond continuously at a rate of 1,200 gpm until a calculated total volume is reached. The total volume to be released is based on the summed volume of water that has been pumped from the production wells over the previous 20 days. Twenty days was chosen based on Aspect's modeling, which shows residual impacts after 20 days are minimal (see Aspect, 2010 B in Appendix A). Note that the volumes to be released for each day range from 99.7% of the volume of water pumped one day prior down to 49.0% of the volume of water pumped 20 days prior to the mitigation event.

The groundwater model shows that residual cumulative impacts for the 20-day period after one day of continuous pumping at 600 gpm are significantly smaller than the volumes to be released, ranging from 76.4% after one day to 2.2% after 13 days. This suggests that the volume of water being released for mitigation will exceed the outstanding impact and will likely benefit flows in the Skykomish River once overcoming the impacts from withdrawals.

Given the buffer above, if Cadman's mitigation releases can completely offset pumping impacts within 1 day, 93% of the time there will be no impairment of Skykomish flows in late summer and 77% of the time there will be no impairment year-round. Using the groundwater model, Aspect ran a 90-day simulation of pumping and mitigation releases based on a single year's (1978) flow data for the Skykomish. The simulation found that in all cases requiring release of mitigation water, the pumping-induced impacts to the river were negated within one day. Additionally, the model simulation substantiates that the large-volume mitigation releases result in slight benefits to the river during periods when the river is near its minimum instream flow.

The above in combination with the conservatism built into the flow calculation suggests that actual impairment of instream flows is very unlikely. If impairment does occur it will occur infrequently and will be very minor, of very short duration (hours), and will likely only occur during winter months.

Impairment Finding
Aspect's groundwater model along with application of accepted hydrogeological principles indicate minor, if any, interference drawdown will be experienced in BBLA wells, and no other appropriative rights should experience any interference drawdown. Measures are in place from the Snohomish County Hearings Examiner's decision and from Ecology's NPDES permit to protect the water quality in the aquifer and in BBLA's wells. In consideration of the mitigation plan, the proposed water right change will not impair instream flows.

Public Interest

With the Skykomish River located approximately 1,700 feet from the proposed well and in direct continuity with the aquifer that will be tapped, the radius of influence created by the pumping well will not extend beyond this distance (1,700 feet) in any direction. There are no wetlands or other closed water bodies within this distance. The protestors of this application assert that Proctor Creek and May Creek, two nearby streams, will be affected by the proposed withdrawal. However, both of these creeks are more distant than the Skykomish River and will not be affected.

The upper reach of the Skykomish River, from the junction of the north and south forks of the Skykomish downstream approximately fourteen miles to its junction with the Sultan River, has been designated under RCW 79A.55.070 as a scenic river system of the state of Washington. Under RCW 79A.55.005, rivers designated as being scenic "shall be preserved in as natural a condition as practical." However, the same statute states, "*The purpose of this chapter is to establish a program for managing publicly owned land on rivers included in the state's scenic river system, to indicate the river segments to be initially included in that system, to prescribe a procedure for adding additional components to the system, and to protect the rights of private property owners.*" RCW 79.55.040(2) states, "*Nothing in this chapter shall grant to the commission* [State Parks and Recreation] *the power to restrict the use of private land without either the specific written consent of the owner thereof…*" While the statute places restrictions on uses of public land that may negatively impact this stretch of river, the statute specifically states that these restrictions are not to affect private property. Additionally, the proposed wells which will be greater than 1,500 feet from the Skykomish River will not diminish its natural condition, and the mitigation plan will protect instream flows.

The Skykomish River has a section listed under Section 303(d) of the Clean Water Act as having low dissolved oxygen and high temperatures. The mitigation measures offered to protect instream flows for the river will also offer protection for (not harm) this limited section of river.

Water Availability at the New Point of Withdrawal

Pumping test information supplied by the applicant's consultant indicates that water in adequate quantities is available from the proposed wells at the Cadman facility. The 6-inch well currently being used under the groundwater exemption produced 309 gpm for the pumping test with only 7 feet of drawdown after about 2 hours of pumping before the discharge water affected the test. This suggests that a second 6-inch well could pump at the same rate, reaching a total of 600 gpm. With 7 feet of drawdown in the 6-inch well pumping at 309 gpm and considering the hydrogeologic setting of a sand and gravel aquifer, it is likely that a larger-diameter production well could produce the proposed 600 gpm as a standalone.

Same Body of Public Groundwater

RCW 90.44.100 states that for authorization of a change in point of withdrawal, the original and proposed points of withdrawal must tap the same body of public groundwater. The change proposed in the subject application requests moving the point of withdrawal approximately 21 miles upstream within the Skykomish River basin.

Ecology's Policy 2010 states that the "same body of public groundwater" is defined as having a common recharge area and a common flow regime, and the body must not itself be divided by an effective barrier but must be separable from other bodies by effective barriers for the purpose of water rights administration.

The original wellfield at the Department of Corrections site is located approximately 1,300 feet from the Skykomish River and taps the Skykomish Alluvial Aquifer, while the proposed wells at the Cadman facility are situated about 1,700 feet from the river and tap pre-Vashon fluvial deposits in contact with Skykomish alluvial deposits. Both sets of wells are intimately connected to the river. All water removed from either wellfield would have discharged directly to the Skykomish River and would have affected flow in the river above its confluence with the Snohomish River. Thus, both locations are within a common flow regime.

There are no effective barriers to flow. Aquifer materials, alluvial, fluvial and glacial, are present along the river continuously from Gold Bar to Monroe. For most of the 21-mile reach the river communicates freely with the valley aquifer, likely losing and gaining water at locations throughout.

The body of public ground water is separated from other bodies by effective barriers. Groundwater divides found laterally up-gradient from the valley aquifer (i.e. ridges) separate it from other groundwater bodies.

Both locations have a recharge area in common. During high-flow periods in the Skykomish River, the river's stage is higher in elevation than the valley aquifer's potentiometric surface, thus the river recharges the valley aquifer during high-flow periods and the common recharge is the snowpack or precipitation feeding the Skykomish River in its upper reaches.

Responses to Protestors Comments

Big Bend Landowners Association (Received July 14, 2009)

1. <u>The proposed well is not in the same body of public groundwater.</u> This concern is addressed in the "Same Body of Public Groundwater" section. A change in terrain and topographic setting is not a consideration in making this determination.

   The second part of this comment regarding the designation of the upper Skykomish as scenic under chapter 79A.55 RCW is responded to in the "Public Interest" section.

2. <u>The proposed transfer will impair existing rights.</u> Please see "Impairment of Other Rights" section.

3. <u>The transfer will impair instream flows.</u> Please see "Impairment of Other Rights" section. The proposal will not impair instream flows. Impacts from pumping will be negated through mitigation while flows in the Skykomish are above the instream flows set in chapter 173-507 WAC. Additionally, Proctor Creek will not be affected. See "Public Interest" section.

4. <u>The application fails to completely quantify the amount of water.</u> Documentation provided through the investigation has adequately quantified the amount of water to be used at the Cadman site. It is evident that all of the 108 afy consumptive quantity will be used in most years and that most or all of the non-consumptive quantity will be used in many years.

5. <u>The water may not be put to beneficial use.</u> The facility will likely use all allocated water without the concrete batch plant. If the batch plant is constructed and put to use, Cadman must still operate within the quantities authorized. As noted in the "Impairment of Other Water Rights" section, prior to construction and use of a concrete batching plant, the proposal must pass through SEPA review and other permitting.

6. <u>The transfer is not in the public interest.</u> Please see "Public Interest" section.

City of Gold Bar (Received July 15, 2009)

1. The aquifer being utilized services many districts between the original point of withdrawal and the proposed point of withdrawal [21 miles apart]. Some of the water users are: Big Bend Community, Gold Bar Nature Trails Community, City of Gold Bar, Washington Fish and Wildlife Hatchery, Startup Water District, various private wells. Please see "Impairment of Other Rights" section of this report. It has been determined that the Big Bend Community will not be impaired. All the other water users listed are more distant and also will not be impaired.

2. The Gold Bar Wellhead Study indicated that the aquifer feeds May Creek, a salmon spawning stream. May Creek is located approximately 1½ miles from the proposed wells on the other side of the Skykomish River. While both the wells and May Creek interact with the valley aquifer, May Creek will not be affected by the proposed withdrawals.

Greenwater Meadows Landowners Association (Received July 15, 2009)

1. The water rights transfer to enable use of water at 600 gpm at the gravel pit and potential concrete batch plant "would have severe impacts on our water rights and quality and availability of our water." Additionally, Mr. Udd expresses concern for the same water users as the City of Gold Bar protest. Please see "Impairment of Other Rights" section. Greenwater Meadows and the other water users listed, being more distant than the Big Bend Community, will not be impaired by the proposed withdrawals.

2. "If any approval is considered there needs to be tough, independent mechanisms to monitor the operations at Cadman; to monitor aquifer quantity, quality and safety; to compel Cadman to shut down all operations that compromise, reduce or destroy the water supply to our homes; and to specify mitigation measures, compensation, and penalties." As described in the "Impairment of Other Rights" section of this report, there is little chance that any water rights will be negatively affected by the proposed pumping at the Cadman site. Measures are in place to monitor and protect groundwater quality from the actual use of the water.

3. Mr. Udd also mentions the upper Skykomish designation as a scenic river, and states, "This violates the Water Resources Act of 1971 that protects stream flows as well as adversely affecting fish runs, salmon and steelhead spawning grounds and endangered species." Please see the "Public Interest" section of this report. The scenic river designation does not apply to private property. The proposed use with the management/mitigation plan will not reduce flows during periods when instream flows are not being met.

Tulalip Tribes

1. "The Tribes do not support a change of place of use from one source to another." Nothing in statute or rule precludes a change in place of use from one source to another. In addition, a finding has been made that both sites, the Monroe Correctional Facility and the Cadman Gold Bar site, produce water from the same body of groundwater.

2. What is the reason that aggregate from the Gold Bar mine cannot be processed at another site? This comment does not fall under any test that is to be considered when investigating a proposed water right change. A decision is to be made based on the proposal at hand and whether it meets the statutory requirements for a water right change authorization. The option of performing the proposed activities at other locations is not a consideration for Ecology to make.

3. "Currently, without a stream gauge on the Skykomish River, Ecology can monitor neither instream flows nor the impairment of junior water rights. As Aspect Consulting has demonstrated, only coarse estimates of flow can be calculated for the Skykomish River using existing gauge data scaled for basin area. This method of monitoring instream flows and impacts to junior water uses is not scientifically robust… Tribes encourage the State to seriously consider the amount of monitoring, reporting and enforcement that will become necessary if Ecology continues to issue complicated water rights and water rights changes in basins which do not meet their designated minimum instream flows and which have inadequate monitoring instrumentation." As shown in the "Impairment of Other Rights" section of this report, flow estimates that will be used for the management/mitigation plan for the most part underestimate flows, resulting in Cadman turning off earlier and more often than they would if a gage were present. This Report of Examination is provisioned to retain this safety factor, and it is provisioned for long-term reporting and oversight to ensure that mitigation measures are followed for the duration of use of this water right at the Cadman facility. Water is available in basins with instream flows when designated instream flows are met. The State's lack of funding to support instream flow monitoring should not be to the detriment of potential water rights, especially when reasonable measures (i.e. substituting nearby gages) can be taken to assure that instream flows are not impaired.

CONCLUSIONS

I conclude the quantities of water proposed to be changed are in good standing and are eligible for change. I also conclude there will be no impairment of existing rights, no detriment to the public interest, water is physically available at the proposed point of withdrawal, and the original and proposed point of withdrawal are within the same body of public groundwater.

RECOMMENDATIONS

Based on the above investigation and conclusions, I recommend the request for change be approved in the amounts and within the limitations listed below and subject to the provisions beginning on page 3.

Water right attributes (Certificate 330B)

600 gpm
108 afy to be used consumptively for all gravel pit activities
124.4 afy to be used non-consumptively for mitigation of impacts to Skykomish River instream flows

For a total of 232.4 afy

Point of diversion

Two wells within NE¼ NE¼ Section 15, T27N, R9E W.M.

Place of use

NE¼ SE¼, NW¼ NE¼, and E½ NE¼ of Section 15, Township 27 North, Range 9 East, W.M. lying south of State Route 2, and

SW¼ NW¼ and NW¼ SW¼ of Section 14, Township 27 North, Range 9 East, W.M.

Report by: _____ _____
Jay Cook, Hydrogeologist Date
Water Resources Program

_____
Licensed Geologist/Hydrogeologist No. 1598

If you need this publication in an alternate format, please call the Water Resources Program at (425) 649-7000. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

REFERENCES

Aspect Consulting, 2004, Final Earth and Water Resources, Cadman Longview Mining Project EIS: Prepared for Snohomish County Planning and Development Services.

Aspect Consulting, 2006, Water Supply Contingency Plan, Big Bend Landowners Association Wells: Prepared for Cadman, Inc.

Aspect Consulting, 2008, Water Right Evaluation, Temporary Transfer of DOC Water Right to Longview Mining Operation: Consulting Report prepared for Cadman, Inc.

Aspect Consulting, 2009, Response to BBLA Protest of Cadman-DOC Water Right Transfer: Letter to Ecology prepared for Cadman, Inc.

Aspect Consulting, 2010 A, Management Plan for Groundwater Withdrawals at Cadman's Gold Bar Mining Operation

Aspect Consulting, 2010 B, Memorandum Regarding Revised Groundwater Model Results for Lag Effects of Pumping at Cadman's Gold Bar Mining Operation: Technical Memorandum prepared for Cadman, Inc.

Aspect Consulting, 2010 C, Supporting Information for Proposed Management Plan for Groundwater Withdrawals at Cadman's Gold Bar Facility: Technical Memorandum prepared for Cadman, Inc.

Cook, J.C., 2002, Hydrogeology Review for Application CG1-*00671C (Certificate No. 330A): Internal Memorandum, Washington State Department of Ecology.

Dunn, A.B., 2005, Report of Examination for Change CG1-*00671C@1 (Certificate No. 330A): Published Report, Washington State Department of Ecology

Freeze, R. A., and Cherry, J. A., 1979, Groundwater: Englewood Cliffs, Prentice-Hall Inc.

Liesh, B.A., Price, C.E., and Walters, K.I., 1963, Geology and Ground Water Resources of Northwestern King County, Washington: Water Supply Bulletin No. 20, Department of Conservation.

Pacific Groundwater Group, Washington Department of Ecology, Northwest Hydraulic Consultants, Inc., Beak Consultants Incorporated, and Marshall & Associates, 1995, Initial Watershed Assessment, Water Resources Inventory Area 7, Snohomish River Watershed: Open File Technical Report, Washington Department of Ecology.

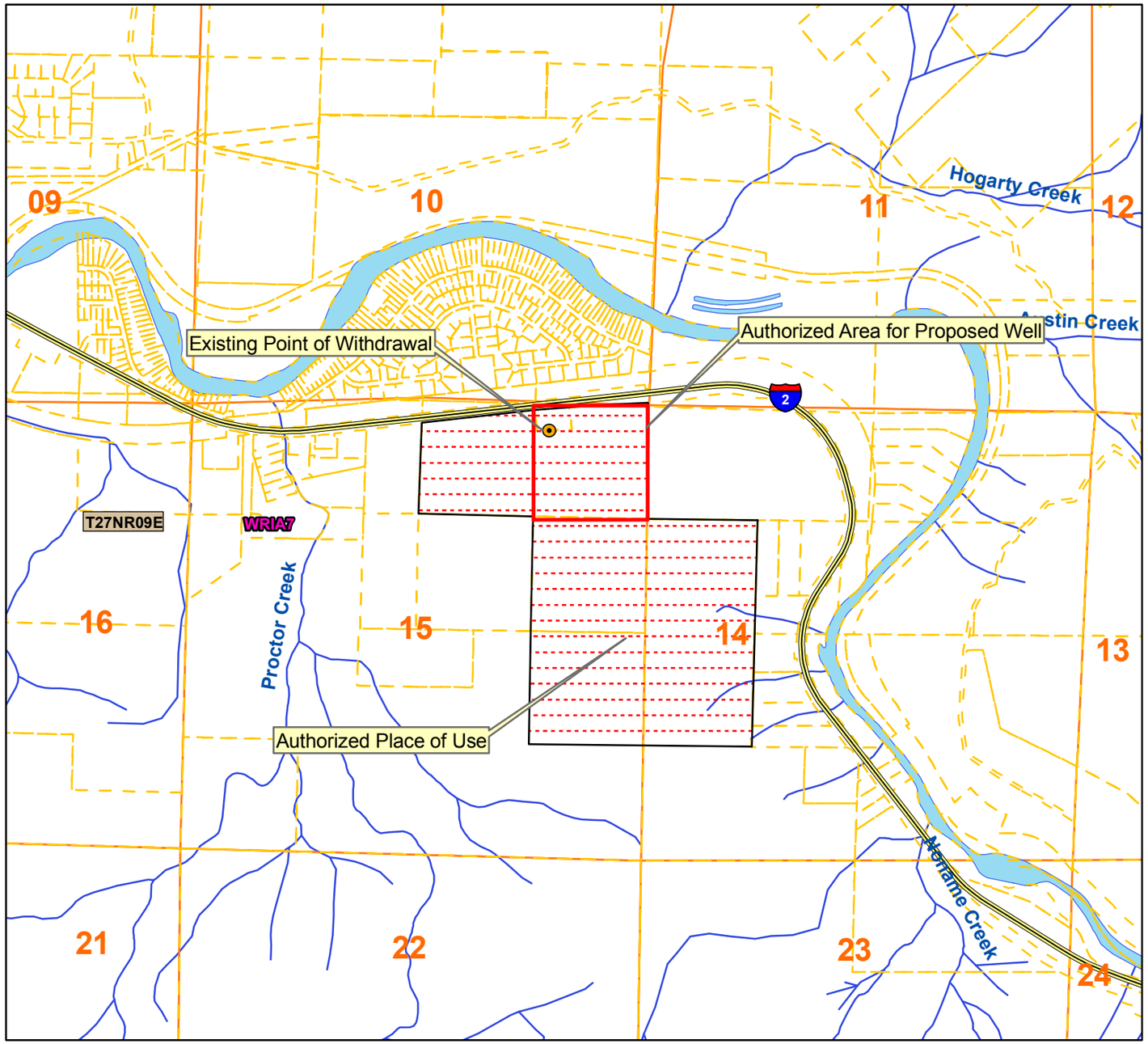
Pentec Environmental, Inc., 1998, Snohomish River Basin Conditions and Issues Report: Prepared for the Snohomish Work Group.

Thomas, B.E., Wilkinson, J.M., and Embrey, S.S., 1997, The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington: Water-Resources Investigations Report 96-4312, United States Geological Survey in cooperation with Snohomish County PUD No. 1 and Washington State Department of Ecology.

Turney, G.L., Kahle, S.C., and Dion, N.P., 1995, Geohydrogy and Ground-Water Quality of East King County, Washington: Water-Resources Investigations Report 94-4082, United States Geological Survey in cooperation with Seattle-King county Department of Public Health.

Cadman Inc
Water Right Number CG1-*00671C@2
Sec.15, T 27N, R 09E W.M.
WRIA 7 - Snohomish County

DEPARTMENT OF ECOLOGY
State of Washington



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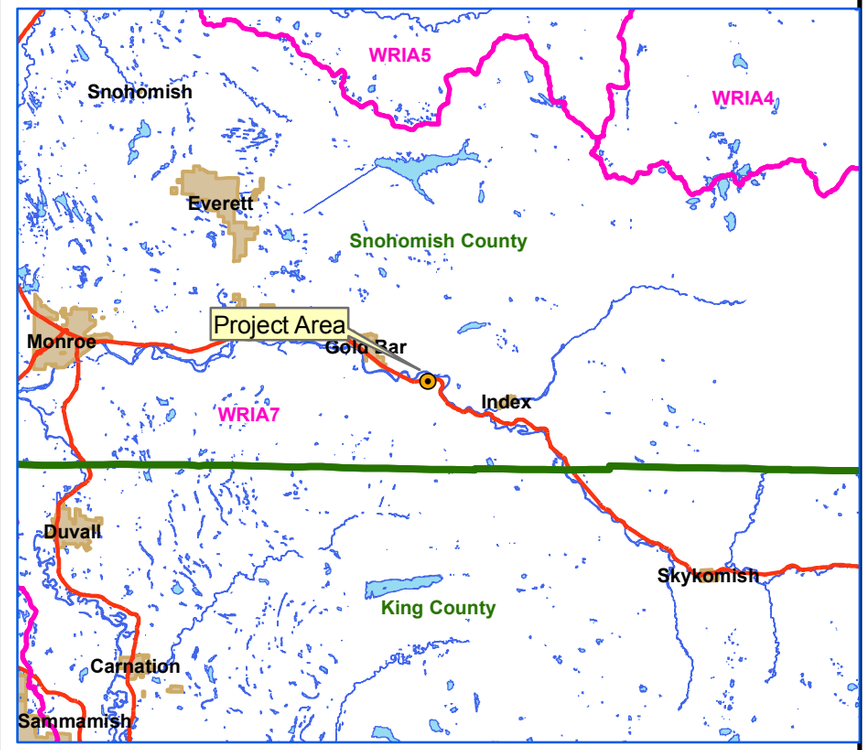

5 2.5 0 5 10 Miles

Legend

- County
- WRIA
- Highways
- Townships
- cities
- Sections
- Authorized Point of Withdrawal
- Authorized Place of Use

Place of use and point(s) of diversion/withdrawal are as defined on the cover sheet under the headings, 'LOCATION OF DIVERSION/WITHDRAWAL' and 'LEGAL DESCRIPTION OF PROPERTY ON WHICH WATER IS TO BE USED.'

Attachment 1

Appendix A

Management Plan
(Apect, 2010 A)

December 9, 2010 - Three-Dimensional Modeling Memorandum in Support of Management Plan
(Aspect, 2010 B)

September 14, 2010 - Supporting Technical Memorandum
(Aspect, 2010 C)

Management Plan for Groundwater Withdrawals at Cadman's Gold Bar Mining Operation

Purpose: Protect against reducing flow in the Skykomish River as a result of groundwater withdrawal when flows are below the minimum instream flow (MIF) established in the Skykomish River IRPP (WAC 173-507) at the Skykomish River at Monroe control point.

Approach: Withdraw water from a storage pond instead of pumping groundwater during periods when flows are below the MIF plus a buffer. Release water from the storage pond to an infiltration pond on the day that flows go below the MIF plus buffer to offset lag effects from recent pumping.

Details:

1. **Construct Storage Pond** – Cadman will construct a lined pond with at least 30-acre feet of storage capacity near the processing area.
2. **Monitor Streamflow During Operations** –
    a. During any day that withdrawals from groundwater are planned, Cadman will check streamflows at the following USGS gages at least once per day:
        i. Skykomish River at Monroe (USGS 12141100), when re-established; or
        ii. Snohomish River near Monroe (USGS 12150800), and Snoqualmie River near Carnation (USGS 12149000), and Skykomish River at Gold Bar (USGS 12134500).
    b. Until the Skykomish River at Monroe gage is re-established, Cadman will predict streamflow at the missing gage location as follows:

        Flow = 0.89 x (flow at Snohomish R. near Monroe – flow at Snoqualmie R. near Carnation).

    c. During June through September, perform the calculation between 6am and 10am to reflect the daily minimum flow during snowmelt season.
    d. If necessary gage data is not available, Cadman will use weather conditions, recent flows, current flow at the Skykomish R. at Gold Bar gage (if available), and historic data during that time of year to assess if flows are above the MIF.
    e. Cadman may elect to withdraw from storage for extended periods in lieu of daily calculations of streamflow.
3. **Pump only when flows are above the MIF plus a 100 cfs buffer** – Cadman will operate the groundwater withdrawal only when flows are above the MIF plus a 100 cfs buffer.
4. **Filling and Refilling the Storage Pond** – Cadman may fill or refill the storage pond by pumping groundwater on days when the streamflow is calculated (using the methodology described in item 2) to be above the MIF plus the buffer. All groundwater withdrawals will adhere to the maximum instantaneous rate and annual quantity of the water right.

Cadman will have significant flexibility in its operation of the storage pond, but generally anticipates operating the pond as follows:

a. Cadman will initially fill the pond prior to the start of wash plant operations. Initial filling is anticipated to require several weeks.
b. When streamflows allow, Cadman will attempt to keep the pond near full, particularly entering the summer dry season.
c. If the pond has been drawn down, Cadman will refill it quickly once streamflows are above the MIF plus the buffer.

5. **Release Water from the Storage Pond to an Infiltration Pond to Counter Lag Effects from Pumping** – Each time that flow drops below the MIF plus the buffer, Cadman will release a quantity of water that has been calculated to offset the lag effects of recent pumping. The water shall be released from the storage pond into an infiltration pond to recharge the aquifer.

The total quantity to be released shall be calculated by as the sum of the volume of water pumped on each of the previous 20 days multiplied by the corresponding lag offset factor from Table 1 for that day.

Table 1 - Offset Factors for Prior Pumping

Days Prior	Lag Offset Factor	Days Prior	Lag Offset Factor
1	99.7%	11	62.5%
2	96.3%	12	60.4%
3	91.1%	13	58.5%
4	85.9%	14	56.8%
5	81.2%	15	55.3%
6	77.0%	16	53.8%
7	73.4%	17	52.5%
8	70.2%	18	51.2%
9	67.3%	19	50.0%
10	64.8%	20	49.0%

Once the lag offset volume for a specific day has been released, no further mitigation for lag effects from that day is required should the flow go below the MIF plus the buffer again within 20 days.

The total quantity to be released will be pumped from the storage pond to the infiltration pond at 1,200 gpm, which allows for the release of 5.3 acre feet in a single day. In some cases, it may require multiple days to release the full volume from a single event.

If river flow rises above the MIF plus the buffer before the full volume from an event has been released, Cadman may cease releasing mitigation water. However, Cadman must calculate which days have been offset (by assuming that released water offsets lag impacts from the oldest days first), and which remain to be offset. If flows subsequently fall below the MIF plus the buffer, the calculation

for that new event must include any unmitigated days from the prior event that are still within the 20-day window.

6. **Reporting –** Cadman will provide an annual report to Ecology and BBLA. The report will provide a table of daily values for the following:
    a. Estimated flow at the missing gage
    b. Minimum Instream Flow
    c. Maximum pumping rate
    d. Duration of pumping in hours
    e. Volume pumped from groundwater
    f. Volume released to offset lag effects

    The report will also include the annual maximum pumping rate, the annual volume pumped from groundwater, and the annual volume of water released to offset lag effects.

7. **Updating the Management Plan –** Cadman may elect to update the management plan based on changing conditions or new information such as changes to the gage network, or revised aquifer parameters derived from a new pumping test. Prior to implementation, Cadman will submit the suggested revisions to the management plan along with supporting documentation to Ecology for review and approval. Cadman will inform BBLA of any changes to the management plan.

Aspect CONSULTING

MEMORANDUM

Project No.: 020050-005-03

December 9, 2010

To: Jay Cook, LHG Ecology NWRO

cc: Bill Sayer, Cadman, Inc.

From: Peter Bannister, P.E. and Owen G. Reese, P.E.

12/9/10

Re: **Revised Groundwater Model Results for Lag Effects of Pumping at Cadman's Gold Bar Mining Operation**

This memorandum presents results from a revised version of the site-specific, three dimensional, groundwater model developed for Cadman's Gold Bar Mining Operation (Figure 1). The model was developed to evaluate the lag effects on the Skykomish River (River) from pumping at Cadman's well. The model was revised from the earlier version (Aspect Consulting 2010a) to modify the thickness and extent of the finer grained layer present over portions of the site. The revised model was recalibrated and used to perform the same analyses as presented in the original memorandum and an additional analysis simulating 90 days of pumping and mitigation operations.

The revised version of the model, and the original model, were developed to replace earlier provided estimates of lag effects based on the Jenkins and Hunt models (Aspect Consulting 2010b), which are simplified analytical solutions that do not consider many site specific conditions. For example, the Jenkins and Hunt models assume that the aquifer is of infinite extent, the aquifer is flat, the river is straight and perpendicular to groundwater flow, and the river is the only source of recharge for the aquifer.

The groundwater model presented in this memorandum was developed to better represent the site by using available topography, surface and subsurface geology, historical river stage and flow data, and groundwater monitoring data from the site. The goal was to develop a model that is site specific, but still conservative.

Before discussing model results, this memorandum summarizes the model construction and calibration. The calibrated model was used to evaluate three scenarios: 1) a one-day pumping scenario at 600gpm, 2) a hypothetical worst-case pumping scenario of 24 days of continuous

pumping at 600 gpm, which represents rapid refilling of 50-acre foot storage pond while keeping up with August water supply demands and 3) a 90-day scenario of pumping and mitigation operations representing a that includes a typical mitigation release (median event).

The model results were evaluated to estimate the change in water levels at the BBLA well and provide information on the lag of river response to pumping and the adequacy of the proposed mitigation plan. The water level at the BBLA was drawn down less 0.2 feet during the worst case scenario, indicating that the BBLA well would not be impaired. The model results also demonstrate that the 20-day period considered in the proposed groundwater management plan is sufficient to mitigate significant lag effects. Finally the model results indicate that the mitigation plan is adequate and would overcompensate for impact to the river resulting in a slight benefit to flows during some periods when flows are below the MIF.

Model Construction

This groundwater model was constructed to evaluate the effects of lag time due to pumping the proposed Cadman well. This section describes the model code, model structure, model boundaries and aquifer parameters.

Model Code

This groundwater model was developed using Groundwater Vistas as a pre- and post-processor, and used MODFLOW-SURFACT code, capable of simulating partially-saturated groundwater flow. The groundwater flow equations were solved iteratively using the PCG5 solver, with a closure criterion of 0.01 feet. This resulted in a reasonably low mass-balance error of less than 0.03 percent.

Model Structure

The lateral extent of the model is shown at the top of Figure 2. The model area was approximately centered around the Cadman pumping well to evaluate the effects of pumping on the River. The grid spacing was uniformly set to 50 feet, and was aligned with the Washington State Plane – NAD 83 coordinate system. Cross sections A-A’ and B-B’ on Figure 2 provide an illustration of the vertical model structure. The top of the model is based on topography from the aerial topographic survey within the mine site and the USGS digital elevation model (DEM) for surrounding areas (Figure 1). The bottom of the model represents the inferred bedrock elevation based on well logs and geophysical measurements.

The model includes three layers to simply the hydrostratigraphy. Each of the three layers in the model represents partially or totally saturated hydrostratigraphic units identified in earlier documents (EIS; Snohomish County 2004). The top layer represents the unconfined aquifer, and includes the following deposits with similar hydrogeologic characteristics: Younger alluvial (Qyal), Older alluvium (Qoal), Vashon recessional (Qvr) and Vashon-fluvial (Qvf). The second layer represents a finer grained unit observed in some borings, described as the Vashon-undifferentiated deposits (Qvu) in the EIS. The bottom layer represents coarser grained deposits including the pre-Frasier-fluvial deposits (Qpff).

The extent and thickness of the second layer is one of the key differences between this model and the earlier results, and is shown in Figure 2. The extent and thickness of the second layer was determined from stratigraphic contacts present in the borings, and geostatistical methods (i.e.,

kriging as implemented in Surfer, a contour and surface mapping software). The layer was inferred to be thin (about 15 feet) and relatively uniform in areas where no borings or other subsurface information are available. Where borings indicate the layer is not present, it is simulated as 1 foot thick in the groundwater model to avoid issues with layer discontinuity.

Model Boundaries

The only major boundary condition included in the model is the Skykomish River channel. Other potential sources of water to the valley aquifer, such as precipitation recharge or mountain front recharge, were not included.

The Skykomish River was simulated using head-dependent "river" cells that allow both leakage to and discharge from the aquifer. The river bottom elevation was assumed to linearly increase between the 250-foot and 350-foot elevation contours along the path of the river. The river bottom conductance was set so that the aquifer vertical hydraulic conductivity was the limiting factor on the leakance rate. For the model calibration, river stage was assumed to be the monthly average stage for the Skykomish River near Goldbar (USGS station 12134500) during the calibration period (10/1/2003 through 12/31/2009). For scenario evaluation, the river stage was assumed to be the average median daily stage.

The Big Bend wellfield was simulated by assuming that the primary well (10Q1) was pumping continuously at the maximum instantaneous rate allowed (200 gpm [PGG 2005]). This well was active in the model calibration and scenario evaluation.

The proposed Cadman water supply well (LV05-1) is located at the intersection of the cross sections on Figure 2. This well was not active during the model calibration, but was simulated as pumping during some scenarios.

An alternate location for Cadman's water supply well is also shown on Figure 2 and was simulated as pumping in some scenarios. This well has not yet been constructed, but may be installed if the water right is approved.

Aquifer Parameters

Aquifer parameters, including hydraulic conductivity and storage, were assumed to be horizontally uniform. These parameters were manually adjusted during the model calibration. Table 1 below provides the calibrated parameter values.

Table 1 – Stream Depletion Results for the 24-day Pumping Scenario

Hydrostratigraphic Unit	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity	Confined Storage Coefficient, Specific Storage	Unconfined Storage Coefficient, Specific Yield
Qvf (Layer 1)	1000 ft/d	100 ft/d	3×10^{-4} /ft	0.2
Qvu (Layer 2)	10 ft/d	1 ft/d	1×10^{-5} /ft	0.1
Qpff (Layer 3)	1000 ft/d	100 ft/d	1×10^{-5} /ft	0.2

Model Calibration

The groundwater model was calibrated to the 294 observed groundwater levels collected from 2003 to 2009 as part of Cadman's ongoing groundwater monitoring at the site. The locations of the five monitoring wells are shown on Figures 1 and 2. The groundwater model was calibrated using trial and error, starting with reasonable estimates of aquifer parameters based on the observed material types. Calibration results are shown in Figure 3.

Overall, the calibrated model generally matches the magnitude, range, and seasonal patterns of observed groundwater levels in the five monitoring wells. The top graph in Figure 3 shows the observed groundwater levels (points) and calculated groundwater levels (dashed lines), as well as the observed River stage (solid line) over the calibration period. The model is most accurate at predicting groundwater levels in wells PC97-32, LV-05-2 and PC03-3. The model calculates high groundwater elevations at PC03-2 and PC03-1, perhaps because of local heterogeneity in the aquifer not simulated in the model. Generally, the calibration results in a better fit to observed data then attained with the previous model, as it better simulates gradient and has a lower mean square error.

Figure 3 also includes calibration statistics and an x-y plot of calculated and observed groundwater levels. Based on the calibration statistics, the model is sufficiently calibrated to simulate groundwater conditions for lag evaluation. In particular, the scaled standard deviation is about 8 percent, meeting the target of less than 15 percent. The x-y plot confirms that the model is most accurate at predicting groundwater elevations in the main portion of the site and on the higher bench (PC97-3). Modeled groundwater elevations are higher than observed at lower elevations (PC03-1).

Pumping Scenarios

The model was used to evaluate three pumping scenarios: 1) a simple case of one day (24 hours) of continuous pumping at 600 gpm, 2) a worst-case of 24 days of continuous pumping at 600 gpm and 3) a 90-day simulation of pumping and mitigation reflecting that includes a medium-sized mitigation event and several larger ones.

The one day scenario was simulated to evaluate aquifer recovery in a scenario directly comparable to those used in the Jenkins model to develop the groundwater management plan. This scenario used LV05-1 as the point of withdrawal, and only the lag effect was analyzed.

The worst case scenario was simulated to provide an upper bound on the potential impact to the Big Bend Landowners Association (BBLA) well and the lag effects to the Skykomish River. The worst

case scenario results in a total pumped volume of 63 acre feet, sufficient to completely fill a large storage pond while meeting water supply demands during peak summer production. This intensity of pumping is a theoretical worst case, the simulation model of how the water supply (built on 44-years of historical data) would operates indicates that a scenario this severe is unlikely to occur. The worst case scenario was simulated for two possible pumping well locations: the existing pumping well LV05-1, and a possible alternate well location (shown in Figure 2) closer to the storage pond.

The pumping and mitigation scenario simulates actual operations of the well and mitigation plan over a 90-day period. The pumping volumes and mitigation releases were predicted by the simulation model of how the water supply would operate. The particular 90-day period evaluated was selected from 44 years simulated because it includes a median mitigation volume (i.e. represents a typical event). It also includes several larger mitigation events. This scenario was simulated for the alternate well location, which had slightly greater lag effects from the worst case scenario simulations.

Model Results

Model results were used to evaluate the effects of pumping on two locations: the BBLA water supply well, and the Skykomish River.

Effect on BBLA Well

Drawdown from the worst-case pumping scenario at either well location reached a maximum of less than 0.2 feet and recovered rapidly following cessation of pumping (Figure 4). The two pumping well locations resulted in very similar predictions of maximum drawdown, though recovery was marginally slower at the alternate well location.

Lag Effect on Skykomish River

The calibrated model was used to evaluate the time-lag between the point the Cadman pumping stopped, and the time the cone of depression around the Cadman well was filled. In this model, only water from the river can contribute to fill the cone of depression. As such, this model is considered a “conservative” evaluation of lag.

One Day of Pumping at 600gpm. As an initial analysis of lag effect, the model was used to simulate the effect on the river from pumping for 24 hours at 600 gpm from LV05-1, followed by an extended period of no pumping. The model calculates the effects of this one day of pumping on aquifer discharge to the river over time. Results are shown in Figure 5, with the top graph showing pumping and stream depletion in units of cubic feet per second (cfs) and the bottom graph showing instantaneous stream depletion as a percent of the pumped volume. Stream depletion is a net reduction in river flow resulting from either a reduction in aquifer discharge to the river or an increase in river discharge to the aquifer.

The model results (shown in Figure 5) indicate that pumping would have a rapid effect on the river with the river experiencing a reduction in inflow of 23.6 percent of the pumped volume on the same day pumping occurs. Five days after pumping ceases (i.e. Day 6) the stream depletion impact has reduced to less than 7 percent of the volume pumped, and at 10 days the impact is less than 4 percent. By 20 days the impact has decreased to 2 percent.

Numerical accuracy is an important consideration when evaluating these (or any) groundwater model results. The model error is shown as the solid green line in Figure 5. Model run parameters were adjusted to minimize the mass balance error in the model. The accuracy for the model is 0.03 cfs or 0.5 percent of the volume pumped. Model results near or below the model error are not as accurate as higher magnitude results and should be treated as estimates. In particular, this affects the stream depletion results for this scenario after about Day 25.

Figure 6 shows the cumulative stream depletion and its complement, the remaining cumulative stream depletion. The remaining cumulative stream depletion results are analogous to the factors included in the groundwater management plan. These results indicate that the groundwater management plan is conservative – releasing more water than necessary to offset lag impacts. For example, when flow first drop below the MIF plus the buffer, the groundwater management plan calls for infiltrating 99.7 percent of the volume of water pumped 1 day prior. According to Figure 5, the remaining cumulative impact is actually only 76.4 percent, since 23.6 percent of the impact occurred on the same day as pumping. For pumping that occurred 13 days ago, the model predicts the remaining cumulative depletion to be 2.2 percent, but the groundwater management plan requires release of 58.5 percent of the volume pumped.

Twenty Four Days of Pumping at 600 gpm. After completion of the initial one day analysis, the effect of pumping on the river was simulated by assuming that the pumping well is pumped continuously at 600 gpm for 24 days, followed by a long period with no pumping. Results for both potential well locations are shown in Figure 7. Both graphs in Figure 7 show the same data with the top graph using a linear scale for the vertical axis and the bottom graph using a logarithmic scale.

The model results shown in Figure 7 indicate that pumping would have a rapid effect on the river with the river experiencing close to a 600 gpm (1.34 cfs) reduction while pumping is occurring, then recovering rapidly after pumping ceases. The lag impacts from pumping at the alternate well location are predicted to be slightly greater than pumping at the existing well. This discussion is based on results for the alternate well location. Five days after pumping ceased stream depletion had decreased to 0.54 cfs, and by 10 days after pumping it had dropped to 0.26 cfs. At twenty days after pumping ceased stream depletion was 0.09 cfs or 6.8 percent of the maximum pumping rate. The specific data values at key time points from Figure 7 are shown in Table 2.

Table 2 – Stream Depletion Results for the 24-day Pumping Scenario

Day	Days Since Pumping Ceased	LV05-1		Alternate Well Location	
		Stream Depletion in cfs	Stream Depletion as % of Max Pumping Rate	Stream Depletion in cfs	Stream Depletion as % of Max Pumping Rate
24	0	1.28	95.4%	1.27	94.7%
25	1	0.97	72.6%	1.05	78.4%
26	2	0.79	59.4%	0.88	66.0%
27	3	0.66	49.5%	0.75	55.9%
28	4	0.56	41.6%	0.64	47.7%
29	5	0.47	35.2%	0.54	40.7%
34	10	0.22	16.4%	0.26	19.4%

39	15	0.12	9.3%	0.15	10.9%
44	20	0.08	5.7%	0.09	6.8%
49	25	0.05	3.6%	0.06	4.4%
54	30	0.03	2.5%	0.04	2.9%
59	35	0.02	1.8%	0.03	2.1%

The data presented in Table 2 and Figure 7 indicate that the two well locations have similar effects on the river, with the alternate well location having a marginally greater impact that the existing well.

As with the one day scenario, numerical accuracy is an important consideration when evaluating model results for the 24-day scenario. The model error for the 24-day scenario varied over time but was generally less than 0.01 cfs or 0.8 percent of the maximum pumping rate (shown as the solid green line in Figure 7). For this scenario, the key model results approach, but are generally above, the accuracy of the model.

Figure 8 focuses on the recovery period starting immediately after pumping ceases. It shows the remaining stream depletion for pumping from each well location, with the top graph presenting results in cfs and the bottom graph presenting results relative to the total volume pumped (i.e. 63 acre feet). One day after pumping ceases, the cumulative remaining stream depletion would be 516,000 to 594,000 cubic feet (depending on which well was used). This volume is 18.6 to 21.4 percent of the total volume pumped. Recovery occurs steadily, and by 20 days after pumping ceased the remaining stream depletion is about 72,000 cubic feet (2.5 percent of the total volume pumped).

The top graph also Figure 8 also includes the remaining stream depletion calculated using the factors incorporated in the groundwater management plan. The groundwater management plan greatly overestimates the remaining stream depletion, and would result in release of many times the volume of water that the groundwater model predicts is necessary for aquifer recovery.

Ninety Day Simulation of Pumping and Mitigation. The final analysis conducted was an example of the pumping and mitigation that would occur if the water right is approved. This example simulates 90 days of operations and is based on the model used to simulate water supply operations on a daily basis over a 44 year period. This analysis assumed pumping occurred from the alternate well location, which is conservative as lag effects are slightly greater from this location. The example period (June 9 to September 6, 1978) was selected because it contains a medium-sized mitigation event (as well as several larger ones). The medium-sized event requires a mitigation release of 5.2 acre feet, which is equal to the median release required from all mitigation events over the 44 year period. The median event occurs on day 31 of the simulation.

Figure 10 shows the pumping (blue line), mitigation releases (dashed purple line), and the model results for predicted net effect on the river (red line). Where the net effect on the river is a negative number it indicates an increase in flow in the river.

At the start of the period the storage pond is full, and the water supply well is pumped at a lower rate (~80 gpm) just to keep up with daily water use. On the seventh day of the simulation, flow drops

below the MIF plus buffer triggering a mitigation release. Flows are below the MIF plus buffer for two days. The mitigation release has a rapid effect on the river, and slightly increases flows for throughout the 2 day duration that flows are below the MIF plus buffer. Pumping resumes at a higher rate of 600 gpm to refill the pond, then shuts down again when flows drop below the MIF plus buffer triggering another mitigation release. This pattern continues through a series of 5 mitigation events.

Overall, flow is below the MIF plus buffer for 42 of the 90 days simulated, and the river would experience a slight benefit during much of this period. In fact there are only 3 days when the river would be below the MIF plus buffer and experience a reduction in flow. These instances all occur on the first day after pumping ceases, when the buffer would provide protection (i.e., flows are not likely to be below the MIF).

Conclusions

We draw the following conclusions based on the model results and analysis presented in this memo:

1) The model calibrated well to observed monitoring data for 2003 to 2009 as is suitable for use in evaluating the effects of Cadman's proposed withdrawal on the aquifer and Skykomish River.

2) The BBLA will not be impaired by Cadman's pumping as drawdown is predicted to be less than 0.2 feet even for the worst-case scenario.

3) It is appropriate that the groundwater management plan tracks, and mitigates for, pumping over the last 20 days. Pumping on an earlier day would have a remaining cumulative impact less than 5.7 to 6.8 percent of the volume pumped, consistent with the 4 to 8 percent range accepted by Ecology NWRO for the City of North Bend water right.

4) The groundwater management plan is very conservative and requires the release of more water than necessary to mitigate pumping in the last 20 days. Simulation results indicate that the mitigation plan would offset the impact, and in fact create a slight benefit, during periods when flows are below the MIF.

5) The aquifer is not particularly sensitive to the location of the pumping well, and either the existing well or alternate location produced very similar results.

6) Model error is variable over time, and generally low, but was significant enough to affect interpretation of cumulative depletion results for the one day scenario after Day 25.

Limitations

Work for this project was performed and this memorandum prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Cadman for specific application to the referenced property. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Figure 7. Model Results for Instantaneous Stream Depletion – 24 Day Scenario
Figure 8. Model Results for Remaining Stream Depletion – 24 Day Scenario
Figure 9. Model Results for 90 Day Pumping and Mitigation Scenario

References

Aspect Consulting, 2008. Water Right Evaluation, Temporary Transfer of DOC Water Right to Longview Mining Operation. Prepared for: Cadman, Inc. September 16, 2008.

Aspect Consulting, 2010a. Memorandum Re: Groundwater Model Results for Lag Effects of Pumping at Cadman's Gold Bar Mining Operation. November 8, 2010.

Aspect Consulting, 2010b. Memorandum Re: Supporting Information for Proposed Management Plan for Groundwater Withdrawals at Cadman's Gold Bar Facility. September 14, 2010.

Pacific Groundwater Group, 2005. Memorandum Re: Wellhead Protection Area Recommendation. May 18, 2005.

Snohomish County, 2004. Final Environmental Impact Statement, Cadman Longview Mining Operation, February.

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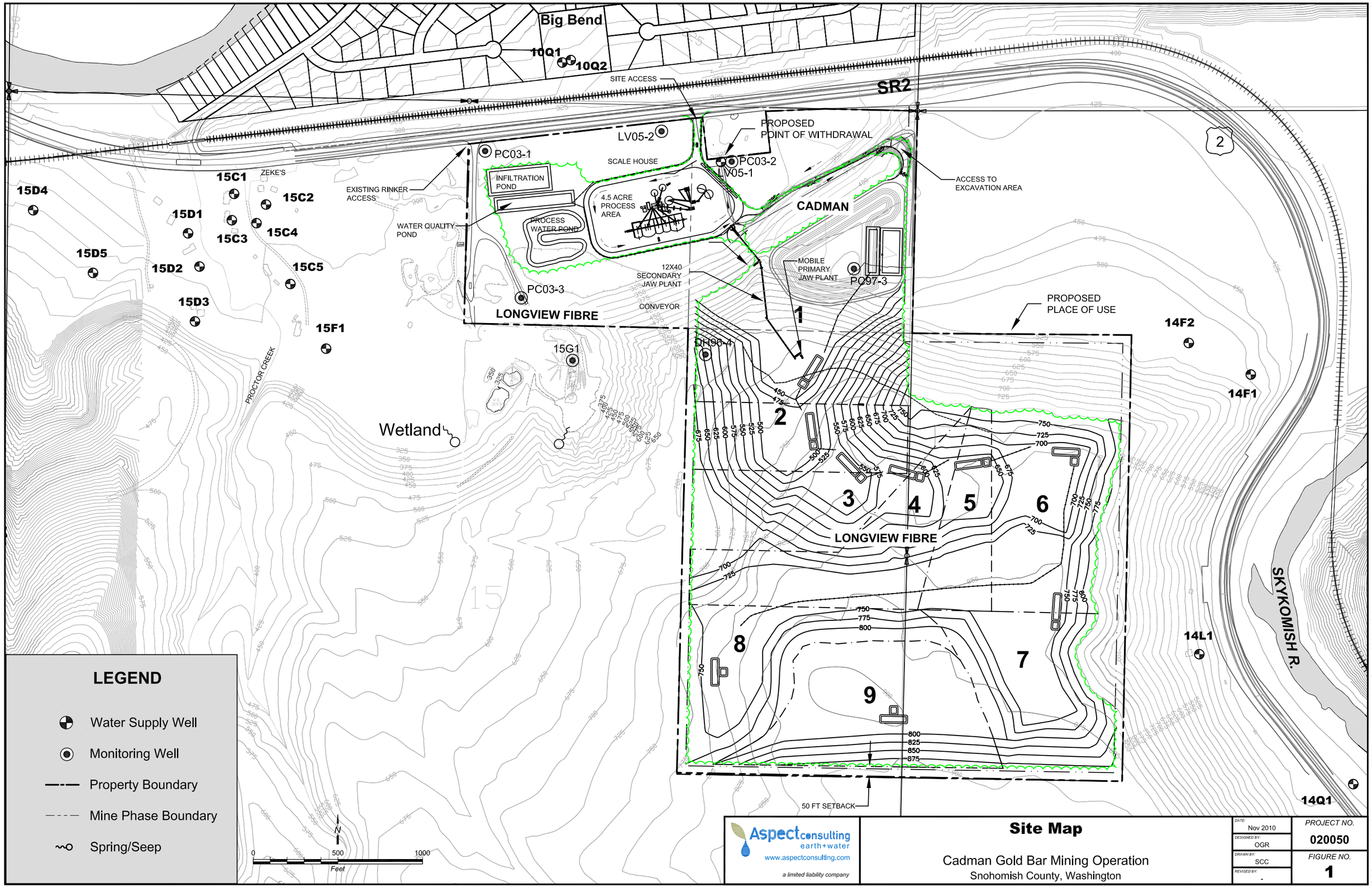

Aspect consulting
earth+water
www.aspectconsulting.com
a limited liability company

Site Map

Cadman Gold Bar Mining Operation
Snohomish County, Washington

DATE: Nov 2010	PROJECT NO. 020050
DESIGNED BY: OGR	
DRAWN BY: SCC	FIGURE NO. 1
REVISED BY: -	

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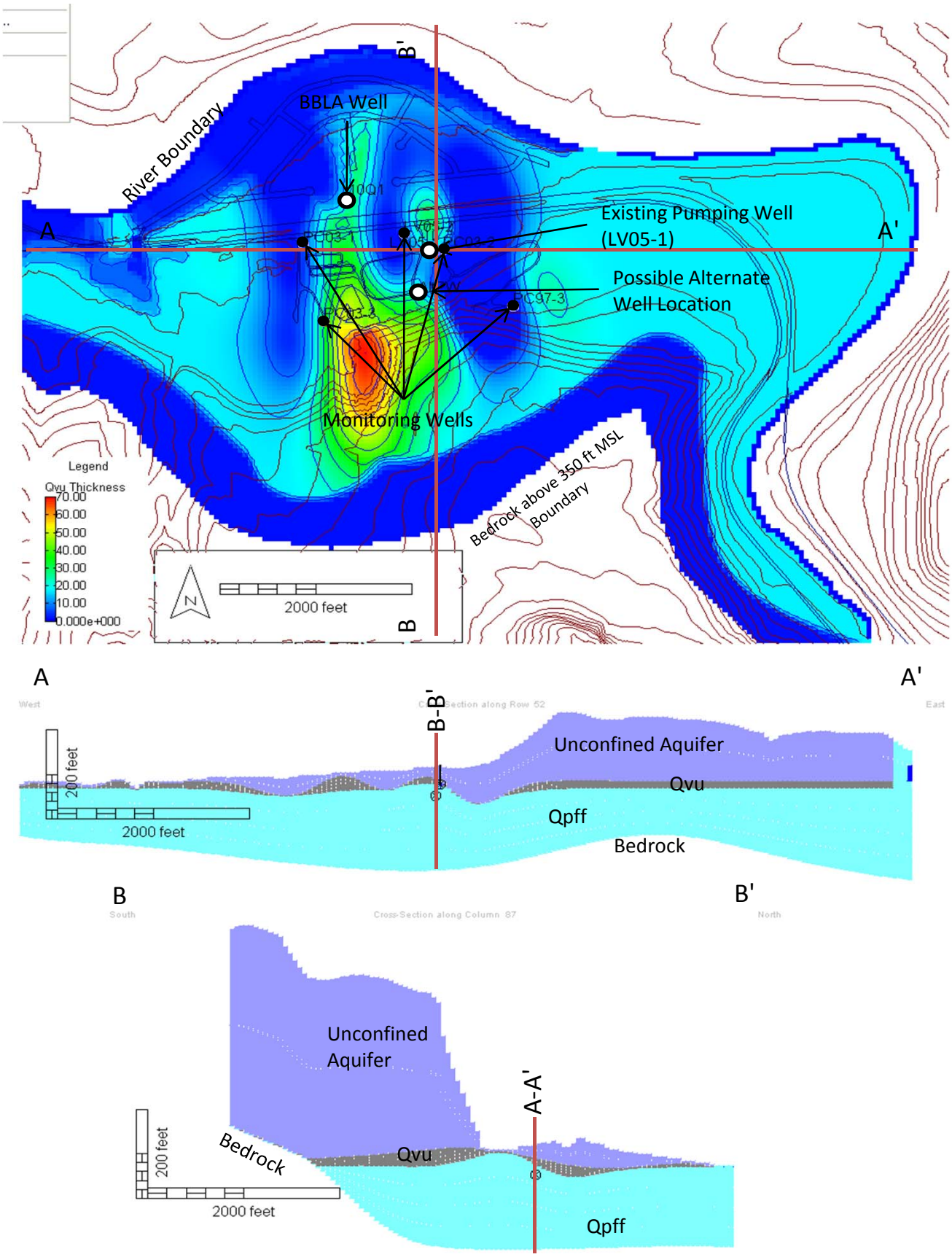

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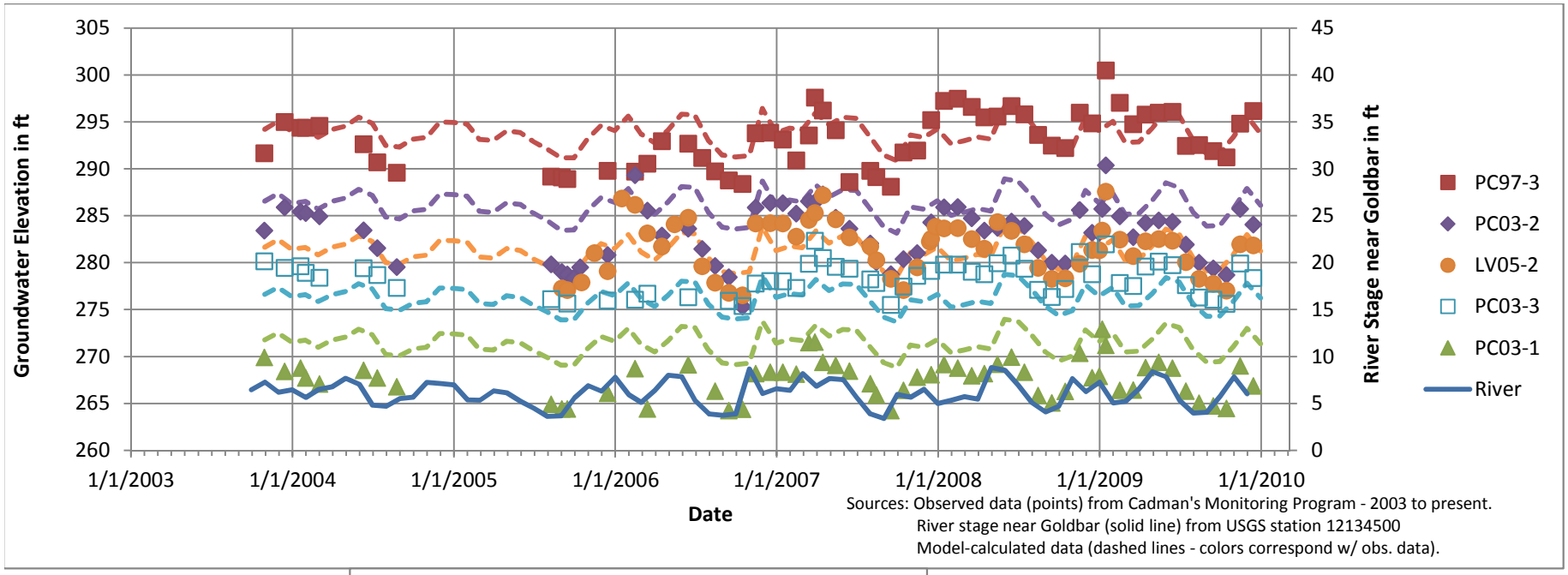
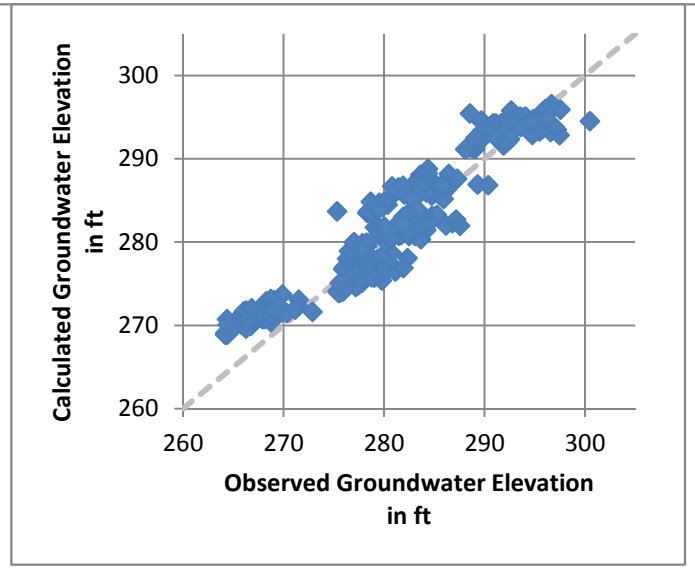
Figure 2
Groundwater Model Structure
Cadman Gold Bar Mining Operation





Calibration Statistic	Value	Units
Residual Mean	-1.01	ft
Abs. Res. Mean	2.55	ft
Res. Std. Dev.	2.83	ft
Sum of Squares	2,656	
RMS Error	3.01	ft
Min. Residual	-8.34	ft
Max. Residual	5.97	ft
Number of Observations	294	
Range in Observations	36.28	ft
Scaled Std. Dev.	8%	(Target <15%)
Scaled Abs. Mean	7%	
Scaled RMS	8%	

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Figure 3
Groundwater Model Calibration
Cadman Gold Bar Mining Operation

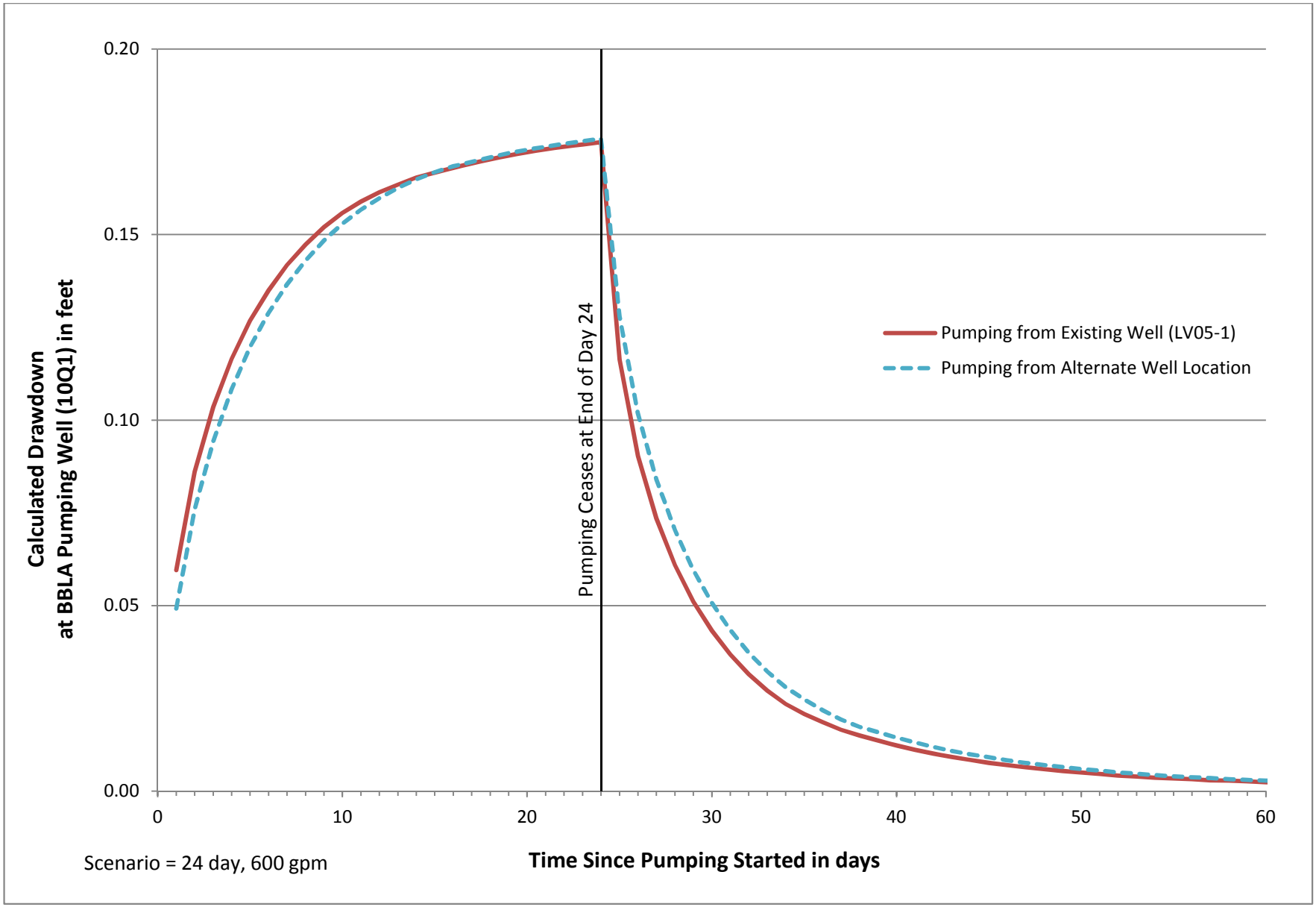

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Figure 4
Drawdown at BBLA Well
Cadman Gold Bar Mining Operation

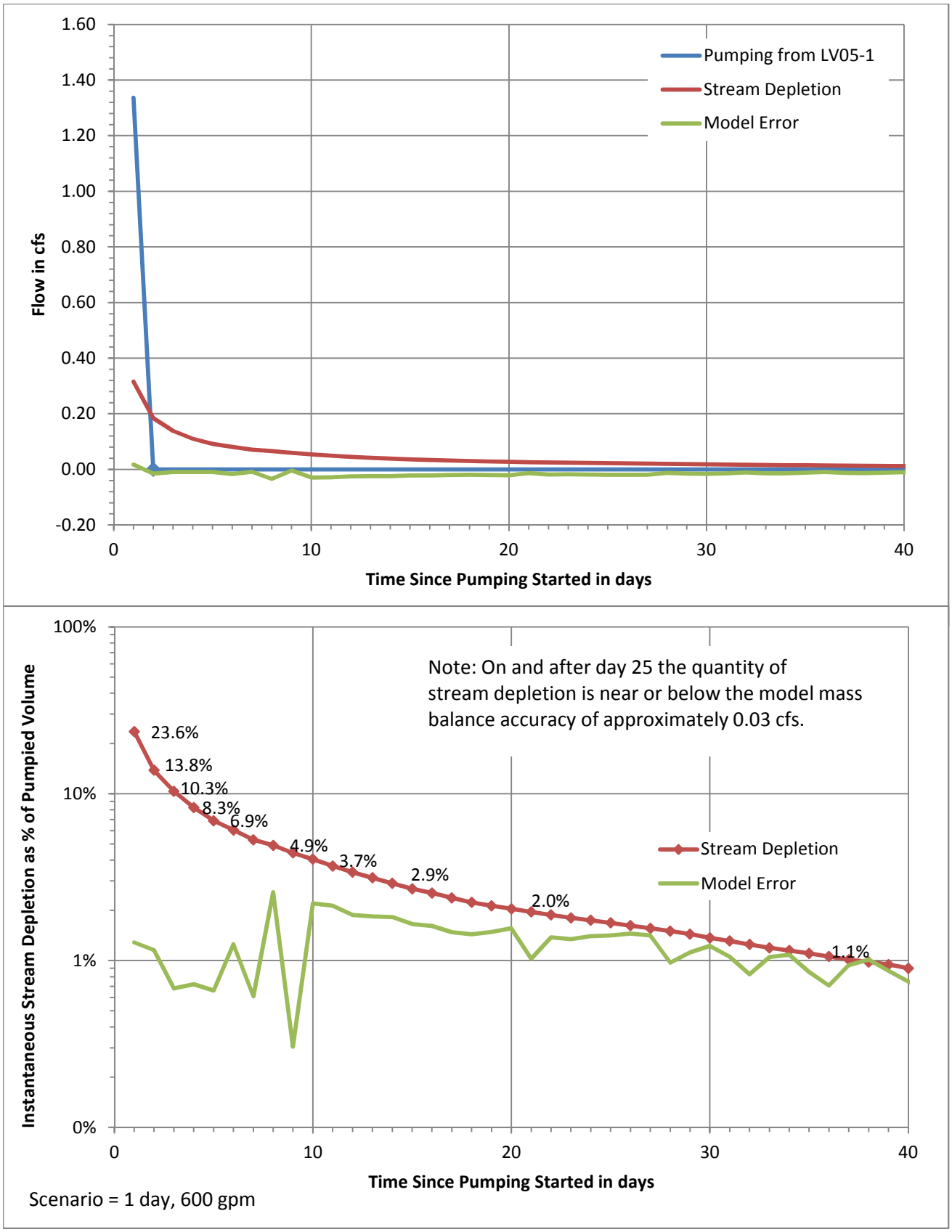

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Figure 5
Model Results for Instantaneous Stream Depletion - 1 Day Scenario
Cadman Gold Bar Mining Operation

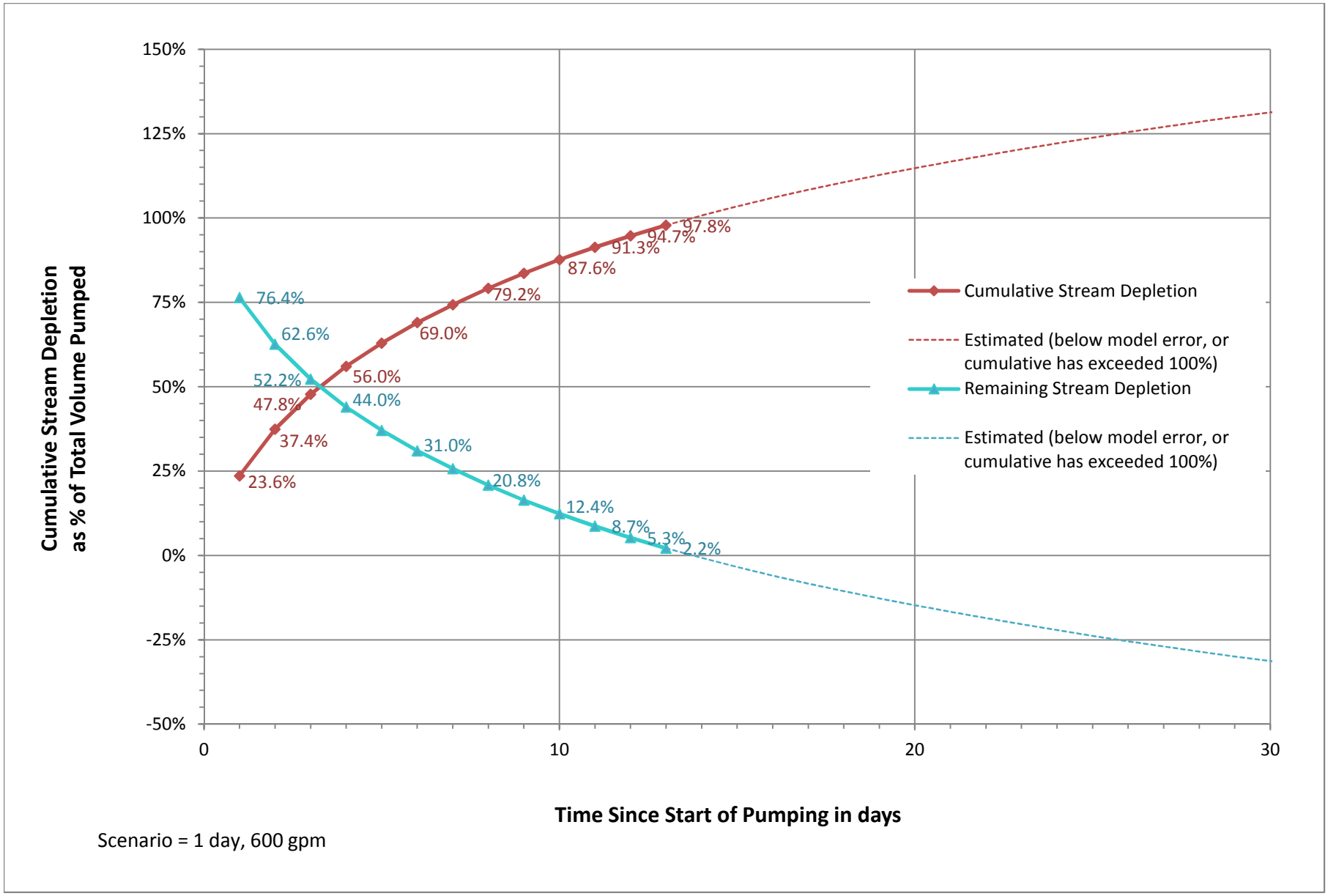

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Figure 6
Model Results for Cumulative Stream Depletion - 1 Day Scenario
Cadman Gold Bar Mining Operation

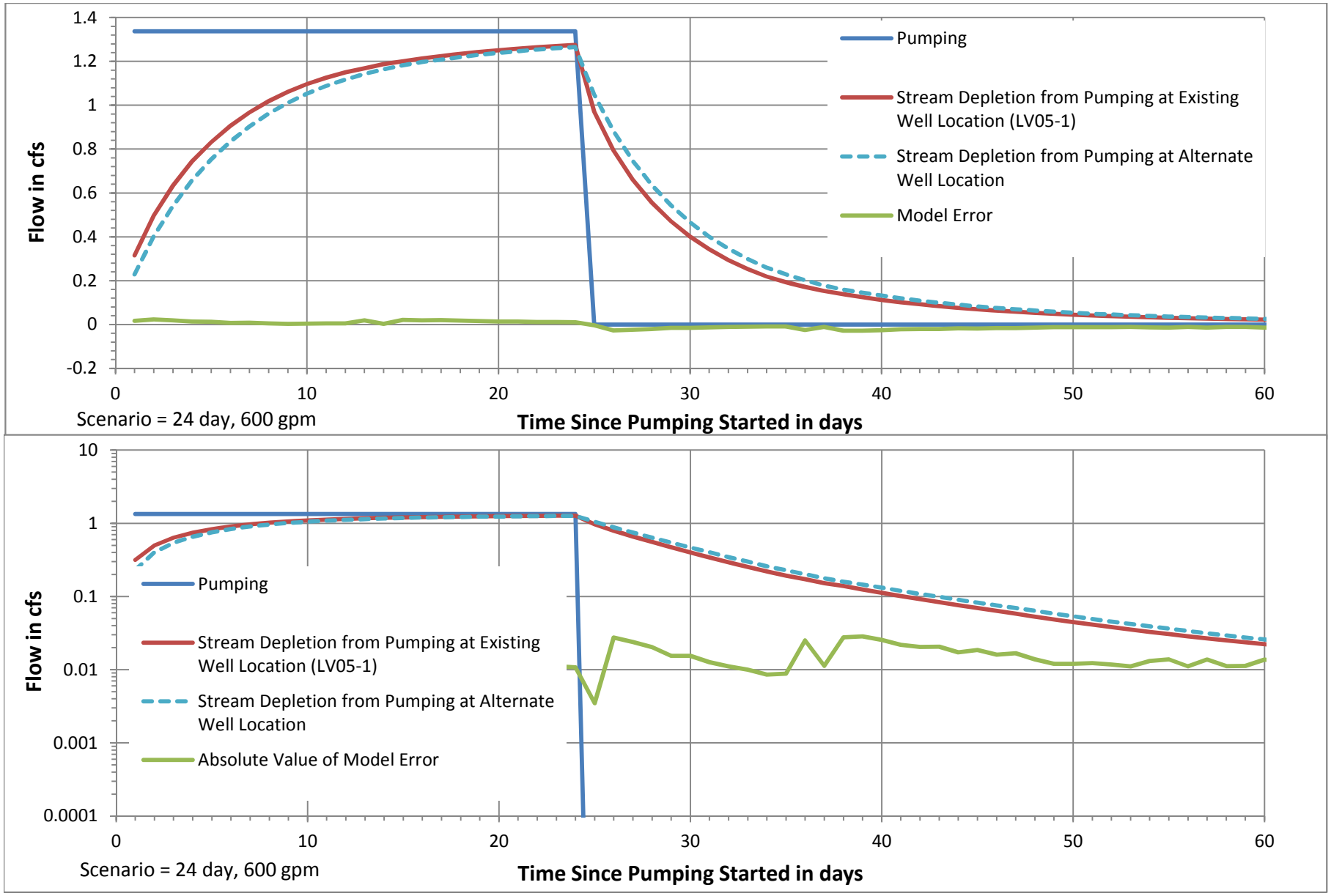

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Figure 7
Model Results for Instantaneous Stream Depletion - 24 Day Scenario
Cadman Gold Bar Mining Operation

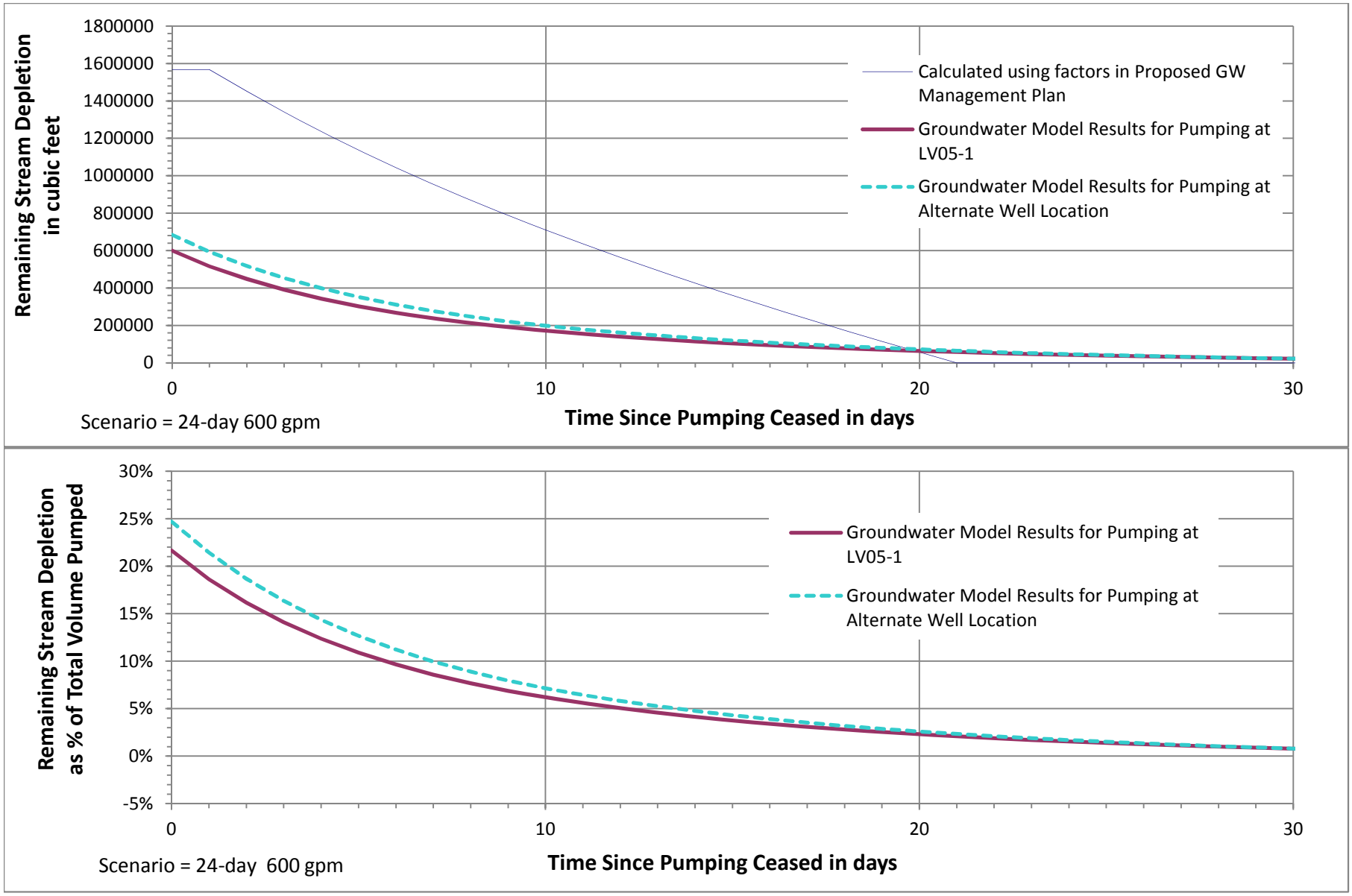

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Figure 8
Model Results for Remaining Stream Depletion - 24 Day Scenario
Cadman Gold Bar Mining Operation

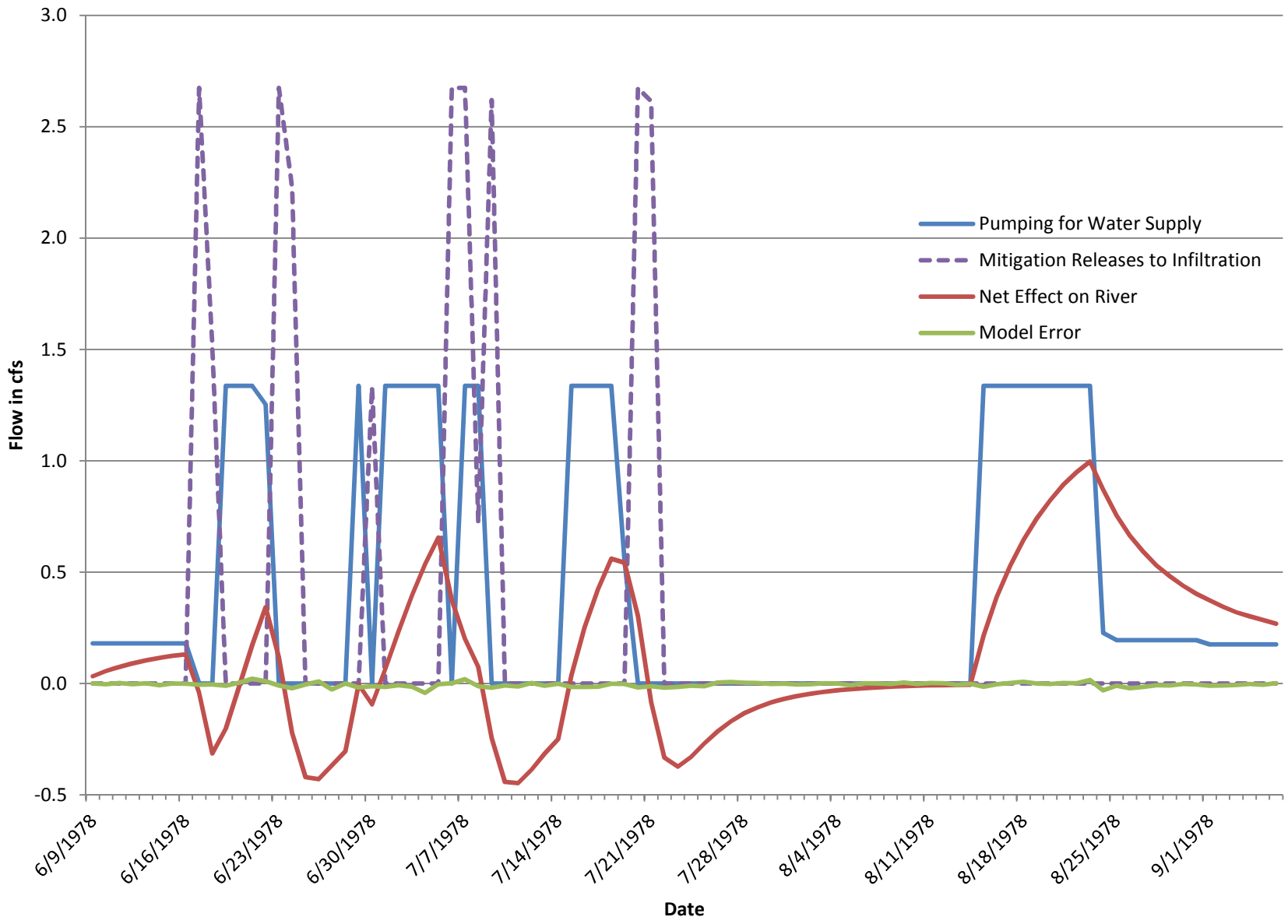

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Figure 9
Results for 90 Day Pumping and Mitigation Scenario
Cadman Gold Bar Mining Operation

MEMORANDUM

Project No.: 020050

September 14, 2010

To:	Jay Cook, LHG, Ecology
cc:	Bill Sayer, Cadman
From:	Owen G. Reese, P.E.
Re:	**Supporting Information for Proposed Management Plan for Groundwater Withdrawals at Cadman's Gold Bar Facility.**

This memorandum presents supporting information used in the development of the management plan for groundwater withdrawals at Cadman's Gold Bar Mining Operation. The management plan has recently been modified to require the release of water from storage to offset lag effects from pumping.

Cadman has submitted a change application for Groundwater Certificate 330, held by the Washington State Department of Corrections for their Monroe Correctional Facility. If approved, the water right change would transfer an instantaneous quantity of 600 gpm and an annual consumptive quantity of 108 acre feet per year to Cadman's Gold Bar Mining Operation. Cadman would also transfer a portion of the DOC's non-consumptive water for use in offsetting lag effects of pumping; the necessary quantity of non-consumptive water is discussed in this memorandum. The transfer would be temporary, lasting only 20 to 22 years, and Cadman would transfer the water right back to the Monroe facility upon completion. Cadman would withdraw water from an existing well and\or a second well yet to be installed.

Description of the Management Plan

Cadman has proposed a plan for managing groundwater withdrawals to protect the Minimum Instream Flow ("MIF") for the Skykomish River. The MIF is measured at the Skykomish River at Monroe gage, which has been missing since 1969. The plan includes the following key components:

1) Each day, Cadman will estimate flows at the missing Skykomish River at Monroe using a conservative approach based on other gages in the basin.

2) Cadman will cease pumping groundwater whenever the estimated flows are below the MIF plus a 100 cubic feet per second ("cfs") buffer. Cadman will continue operations during these periods by using water from a storage pond for water supply.

3) On each day that flow first drops below the MIF plus the buffer, Cadman will release water from the storage pond to an infiltration pond to recharge the aquifer. The amount of water released will be calculated based on conservative model results to offset completely any potential lag effects to the river from pumping in previous days.

Development of the Management Plan

This section presents the supporting documentation for the key components of Cadman's management plan: the streamflow prediction methodology, the 100 cfs buffer, and the calculation of the volume of water to offset lag effects.

Streamflow Prediction Methodology

Cadman's proposed methodology for predicting flows at the missing Skykomish River at Monroe gage conservatively under predicts flows. The methodology calculates the flow as the flow at the missing gage location estimated according to the following formula:

Skykomish River at Monroe = 0.89 x (Snohomish River at Monroe - Snoqualmie River at Carnation)

The gage locations are shown in Figure 1 (originally presented as Figure 1 in Aspect Consulting 2008). The basin represented by subtracting the Snoqualmie River at Carnation from the downstream Snohomish River at Monroe gage is larger than the contributing basin to the missing Skykomish River near Monroe. The larger basin includes portions of the Snoqualmie River downstream of the Carnation gage, and the Skykomish River downstream of the missing gage. The correction factor of 0.89 in the above formula corrects for the additional basin area.

To check the validity of this approach, the formula was used to predict flows during the one year period from 1968 to 1969 when Skykomish River at Monroe gage was functioning. The calculated flows are compared with the observed flows in Figure 2 (originally presented as Figure 7 in Aspect Consulting 2010a). The diagonal line across the figure marks the ideal 1 to 1 relationship (i.e., the calculated flows exactly match the predicted flows). Where the data points are left of the line it indicates that the calculated flows are lower than the observed flows. This is a conservative result because it means that Cadman would predict lower flows then are actually occurring, essentially adding an additional buffer on the MIF.

A linear trendline was added to Figure 2 to indicate the magnitude of the conservatism built into the prediction methodology. The trendline indicates that, on average, the predicted flows are 300 to 500 cfs less than observed flows, when observed flows are in the range of 2,000 to 3,000 cfs. The trendline also indicates that the formula is more conservative at lower flows, than at higher flows. However, in 1968 and 1969 there were no observed flows below 1,900 cfs, so we are not able to evaluate the prediction methodology at the lowest flow levels. These lowest flows levels are expected to occur in August through October.

Buffer

The 100 cfs buffer was developed based on the change in flow in the Skykomish River, using instantaneous gage data from the Skykomish River at Gold Bar (USGS Gage No 12134500) from water year 1988 to 2008 (the full period of record for instantaneous data). We calculated change in daily minimum flows for over one, two, and three days periods on days when the flow at Gold Bar was at or below the assigned MIF at Monroe. The distribution of the changes in flow is shown in Figure 3 for the August to October period and the entire year.

As shown in Figure 3, the 100 cfs buffer provides between at least one day of protection 94% of the time in August to October, and 75% of the time for the entire year. It also provides a 3-day buffer at least 50 percent of the time year round, and 75 percent of the time in August to October.

These results are summarized in Table 1.

Table 1 – Change in Skykomish River daily minimum flow when flow is below the MIF

	Change in Flow in cfs for given percent exceedance					
	August to October			All Year		
Period	50%	75%	90%	50%	75%	90%
1 day change	-14	-36	-76	-29	-100	-200
2 day change	-29	-70	-146	-64	-200	-410
3 day change	-42	-101	-219	-100	-300	-620

Calculation of the Volume of Water to Offset Lag Effects

The volume of water to be released to the infiltration pond to offset lag effects was calculated based on conservative use of a stream deletion model. The approach used to calculate the volume of water that needs to be released to offset lag effects from recent pumping is based on model results from STRMDEPL08 version 1.1, published by the U.S. Geological Service ("USGS"). A range of aquifer and stream characteristics were used to represent the uncertainty in site conditions. Model results provided stream depletion curves for each set of parameters. A worst-case stream depletion curve was developed as the maximum impact from the suite of stream depletion curves. The worst-case curve would then be used in real time to calculate the potential future impact on stream flows from from recent pumping. On the day flows drop below the MIF plus the buffer, Cadman would infiltrate a volume of water equal to total potential impact.

The following sections provide more detail on each step of this methodology.

Aquifer and stream parameters

Six sets of stream and aquifer parameters were developed to represent a range of possible aquifer and streambed characteristics. The following sections discuss the estimates and range used for the five key parameters: transmissivity, storativity, distance to the stream, streambed conductance, and whether the stream fully or only partially penetrates the aquifer.

Transmissivity – 24,000 gpd/ft or 0.2778 ft^2/sec; based on results from the pumping test (Aspect Consulting 2009).

Storativity – 0.14; based on results from the pumping test (Aspect Consulting 2009).

Diffussivity – 170,000 gpd/ft or 1.98 ft^2/sec; calculated from the transmissivity and storativity measured in the pumping test.

Distance to Stream – 200 or 1,720 feet; the shorter distance is based on the location of the possible boundary condition identified during the pumping test, the longer distance is measured from the well location to the bank of the Skykomish River.

Fully or Partially Penetrating Stream – analyzed with the stream fully penetrating the aquifer without streambed resistance (Jenkins 1968) and partially penetrating the aquifer with streambed resistance (Hunt 1999).

Streambed Conductance – 2 or 0.2 feet per second ("fps"); based on the formula $\lambda = K'w/m$ (Hunt 1999); where λ is streambed conductance, K' is the hydraulic conductivity of the streambed (assumed to be 1 to 0.1 times the hydraulic conductivity of the aquifer which was estimated at 0.008 fps from the pumping test), w is the width of the stream (measured from aerial photographs at about 250 ft), and m is the thickness of the streambed (assumed to be 1 foot).

Six combinations of these parameters were analyzed, shown in Table 2. Of these cases, we believe Case 1 to be the best representation of actual conditions based on the results of the pumping test, the thickness of the aquifer, and the coarse nature of the streambed in a high gradient river system. However, all cases were treated equally in generating the stream depletion curve.

Table 2 – Aquifer Parameters Used in Stream Depletion Model

Parameter	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Diffusivity in ft^2/sec	1.98	1.98	--	--	--	--
Transmissivity in ft^2/sec	--	--	0.2778	0.2778	0.2778	0.2778
Storativity (dimensionless)	--	--	0.14	0.14	0.14	0.14
Distance to Stream in feet	200	1720	200	1720	200	1720
Stream Penetration of Aquifer	Full	Full	Partial	Partial	Partial	Partial
Streambed Conductance in fps	--	--	2	2	0.2	0.2

Note: -- indicates parameter not applicable for given scenario.

Stream depletion curves

The Skykomish River and the aquifer beneath the processing area are hydraulically connected; therefore pumping the aquifer will reduce groundwater discharge to the river. We have assumed 100 percent of the water pumped would have discharged to the river. The timing of stream depletion was calculated using the STRMDEPL08 model, version 1.1, published by the U.S. Geological Survey (Reeves 2008).

The STRMDEPL08 model uses the Jenkins (1968) approach for calculating stream depletion in fully penetrating with no streambed resistance, and the Hunt (1999) approach for partially penetrating streams with streambed resistance. These equations are linear, so they can be scaled by the pumping rate on any particular day to calculate the lag effects of that day's pumping. Using the principal of superposition, the lag effects from multiple days can be calculated by adding the effects of each days pumping. We modeled the effects of one day of continuous pumping with the intention of developing a stream depletion curve that could be used to predict impacts from any pumping scenario through use of scaling and superposition.

The STRMDEPL08 model was run for each of the six cases that represent the range of possible aquifer and stream characteristics. The primary model output is a time series of the reduction in

streamflow that would occur during pumping, and following cessation of pumping. The resulting stream depletion curves, expressed as a percentage of the one day pumping rate, are shown in Figure 4. These curves were calculated over a 21 day period (one day of pumping, and 20 days of no pumping). For most scenarios, most of the stream depletion occurs on the day of pumping and in the first few non-pumping days. The 21-day period was selected based on the greatest length of time between the 6 scenarios until stream depletion was 1 percent of the pumping rate on day 1.

As shown in Figure 4, the six cases resulted in two groups of results with cases 1, 3 and 5 forming one group of similar results, and cases 2, 4, and 6 forming the other. These groupings indicate that the results are not particularly sensitive to stream penetration of the aquifer and the stream conductance for the range of values evaluated; but are sensitive to the distance from the well to the stream.

"Lag offset factors" were calculated using the results for cases 2, 4 and 6, which were the worst case in that they resulted in greater lasting effects on the river. The lag offset factors were calculated as the cumulative remaining impact to the stream depending on how long ago pumping ceased. For example, the lag offset factor for day 1 was calculated as the sum of the remaining stream depletion curve after day 0, resulting in a factor of 99.7%. Similar factors were calculated for the remaining days and are shown in Table 3.

Table 3 – Lag Offset Factors

Days Prior	Lag Offset Factor	Days Prior	Lag Offset Factor
1	99.7%	11	62.5%
2	96.3%	12	60.4%
3	91.1%	13	58.5%
4	85.9%	14	56.8%
5	81.2%	15	55.3%
6	77.0%	16	53.8%
7	73.4%	17	52.5%
8	70.2%	18	51.2%
9	67.3%	19	50.0%
10	64.8%	20	49.0%

These lag offset factors are used to calculate how much water must be released to completely offset the potential stream depletion from pumping on a particular day. For example, if pumping occurred one day ago, 99.7% of the volume pumped must be released to offset the impact. If pumping occurred 20 days ago, 49% of the volume pumped 20 days ago must be released.

The management plan would use the lag offset factors in combination with pumping records to continuously track the effect on streamflow. On the day that flows first drop below the MIF plus the buffer, the total volume (calculated as the sum of each the last 20 days pumping multiplied by the corresponding offset factor) would be released to an infiltration pond to recharge the aquifer.

Evaluation of Management Plan

The effect of the management plan was evaluated using a spreadsheet-based system model to simulate operation of Cadman's groundwater withdrawal. The model was based on the common historical data from 1963 to 2006, the common period of record for the gages used to estimate flow at the missing gage. On each day, the model does the following:

- Calculates the flow at the missing gage and compares it to the MIF plus the buffer.
- Determines if pumping groundwater is allowed, and at what rate and duration (from August 1 to October 31)
- Determines the need for pumping groundwater based on the amount of water in the storage pond, and the amount consumptively used in Cadman's operations.
- Calculates the lag effects from the previous 20 days of pumping operations, and releases that volume to infiltrate each time the river flow dips below the MIF plus the buffer.
- Calculates the effects on the storage pond from Cadman's water use (consumptive) and releases to the infiltration pond (non-consumptive).

This results in a 44-year simulation of pumping volumes, releases to offset lag effects, and amount of water stored in the water supply pond. These results provide useful information about the frequency that releases would be necessary to offset lag effects, and the amount of water that would need to be released.

The systems model indicates that Cadman would need to cease pumping and release water to the infiltration pond on an average of 9.3 times per year. The median volume released per event would be 5.2 acre feet, with a range from 2.6 acre feet in the smallest event up to 33.4 acre feet in the largest. On average, the volume released would be about 59 percent of the total pumped over the prior 20 days. For the larger required releases, Cadman would release water at 1,200gpm over several days. Should flows rise above the MIF plus the buffer before the release has been completed, Cadman would be able to cease releasing water, but would need to track which days had not been mitigated in case flows dip below the MIF plus the buffer again.

The results of the systems model were used with a stream depletion model (using the case 2 assumptions) to simulate individual scenarios of pumping and recharge. Examples for four scenarios representing the range from normal to worst case conditions are shown in Figures 5, 6, 7 and 8.

Figure 5 shows a normal scenario, representing 20 days of consecutive pumping at 90 gpm, which is sufficient to keep up with water supply demand in August. Flows drop below the MIF plus buffer on the 21st day, triggering release of 1,200 gpm for 1.02 days. The total volume pumped is about 8 acre feet, of which 5.4 is released to offset stream depletion.

Figure 6 shows a moderate scenario based on results of the water systems model. It was selected because the total quantity released is in the middle of the potential range. In this case, pumping occurs for 10 consecutive days at 600 gpm to refill the water supply pond, followed by another 10

days at 79 gpm to keep up with consumptive use in September for a total of 26 acre feet. Flow drops below the MIF plus the buffer on day 21, triggering release of 1,200 gpm for 3.06 days or 16.2 acre feet.

Figure 7 shows the results for the worst possible case, 20 days of consecutive pumping at 600 gpm. This equals a total withdrawal of 53 acre feet, enough to fill a large pond while keeping up with water supply consumption. Assuming flows drop below the MIF plus buffer on the 21st day, a release of 36 acre feet is released to offset stream depletion.

Finally, Figure 8 shows a more complicated scenario from the systems model with a double dip below the MIF plus buffer.

In each of these scenario, the management plan is protective of the MIF, and often results in a benefit to streamflows lasting for weeks.

Quantity of Non-Consumptive Water Use

Implementing the management plan would require non-consumptive use of water to offset the lag impacts. All water released to the infiltration pond should be considered non-consumptive use, because that water was pumped recently, stored very briefly, and released to an infiltration pond to benefit instream flows. The annual volume of releases to the infiltration pond would range from 5 acre feet (in 1997, a wet year) up to 129.6 acre feet in 1973 as shown in Figure 9. On average, Cadman would need to release 63.2 acre feet from storage.

The water right has a non-consumptive quantity of 124.4 acre feet, which would be sufficient to provide for the non-consumptive releases in all but one of the 44 years evaluated. In this case, the difference (5.2 acre feet) could be made up by using water that would otherwise be allocated to consumptive uses (either from water stored in the pond, or by reducing consumptive demand that year).

Timing of Effects of Released Water

One of the key considerations in evaluating this strategy for offsetting the lag effects is the timing of pumping versus releases. Cadman's management plan includes several components to ensure that any lag effects are offset before any change in streamflow occurs:

1) The 100 cfs buffer is designed to trigger the cessation of pumping 1 to 3 or more days before the flow is actually below the MIF.

2) The conservatism in the methodology for estimating flows at the missing gage provides additional protection for ensuring early cessation of pumping.

3) The total volume of water required to completely offset any lag effects would be released quickly at the start of the event, allowing for rapid recharge of the aquifer and providing a benefit to streamflow after a couple days.

4) The existing infiltration pond is located in the northwest corner of the site. This location is downgradient of the existing pumping well and is closer to the river than the well.

Adequacy of the Existing Infiltration Pond

This section presents information about the existing infiltration pond to evaluate its adequacy to infiltrate the releases to offset lag effects, and to evaluate the potential travel time for water to reach the aquifer.

The existing infiltration pond is a trapezoidal pond about 5 feet deep, with 1 additional foot of freeboard. The pond bottom is 80 feet wide by 310 feet long with 3H:1V side slopes. The infiltration pond was designed to infiltrate 100 percent of the 100 year design storm (peak flow of about 50 cfs). Therefore the pond can easily infiltrate any releases to offset lag effects, which would occur at a maximum rate of 1,200 gpm (or 2.67 cfs).

The bottom of the pond is at an elevation of 300 feet. The groundwater elevation in the vicinity of the pond ranges from 264.2 feet to 271 feet in seven years of monitoring. (Aspect Consulting 2010b). The bottom of the infiltration pond is approximately 36 feet above the lowest observed water level.

The travel time to the aquifer is estimated to be about 106 minutes based on Darcy's law with a gradient (dh/dl) equal to 1 and a vertical hydraulic conductivity of 68.5 feet per day (10 times lower than the horizontal conductivity observed in the pumping test of 685 fpd or 0.008 fps), and effective porosity assumed equal to storativity of 0.14.

Attachments

Figure 1 – Skykomish River Gages and Withdrawal Points

Figure 2 – Relationship between Observed and Calculated Flow at Skykomish River at Monroe, 1968-1969

Figure 3 – Change in Flow in the Skykomish River when Flow is Below MIF

Figure 4 – Stream Depletion Curves

Figure 5 – Effect of Management Plan on Streamflow – Normal Case

Figure 6 – Effect of Management Plan on Streamflow – Moderate Case

Figure 7 – Effect of Management Plan on Streamflow – Worst Case

Figure 8 – Effect of Management Plan on Streamflow – Complex Case

Figure 9 – Annual Volumes of Water Released to Offset Lag Effects

References

Aspect Consulting, 2008. Water Right Evaluation, Temporary Transfer of DOC Water Right to Longview Mining Operation. September 16, 2008.

Aspect Consulting, 2009. Memorandum Re: Supplemental Information on Projected Water Use and Pumping Test Data for Cadman's Water Right Transfer Application. May 7, 2009.

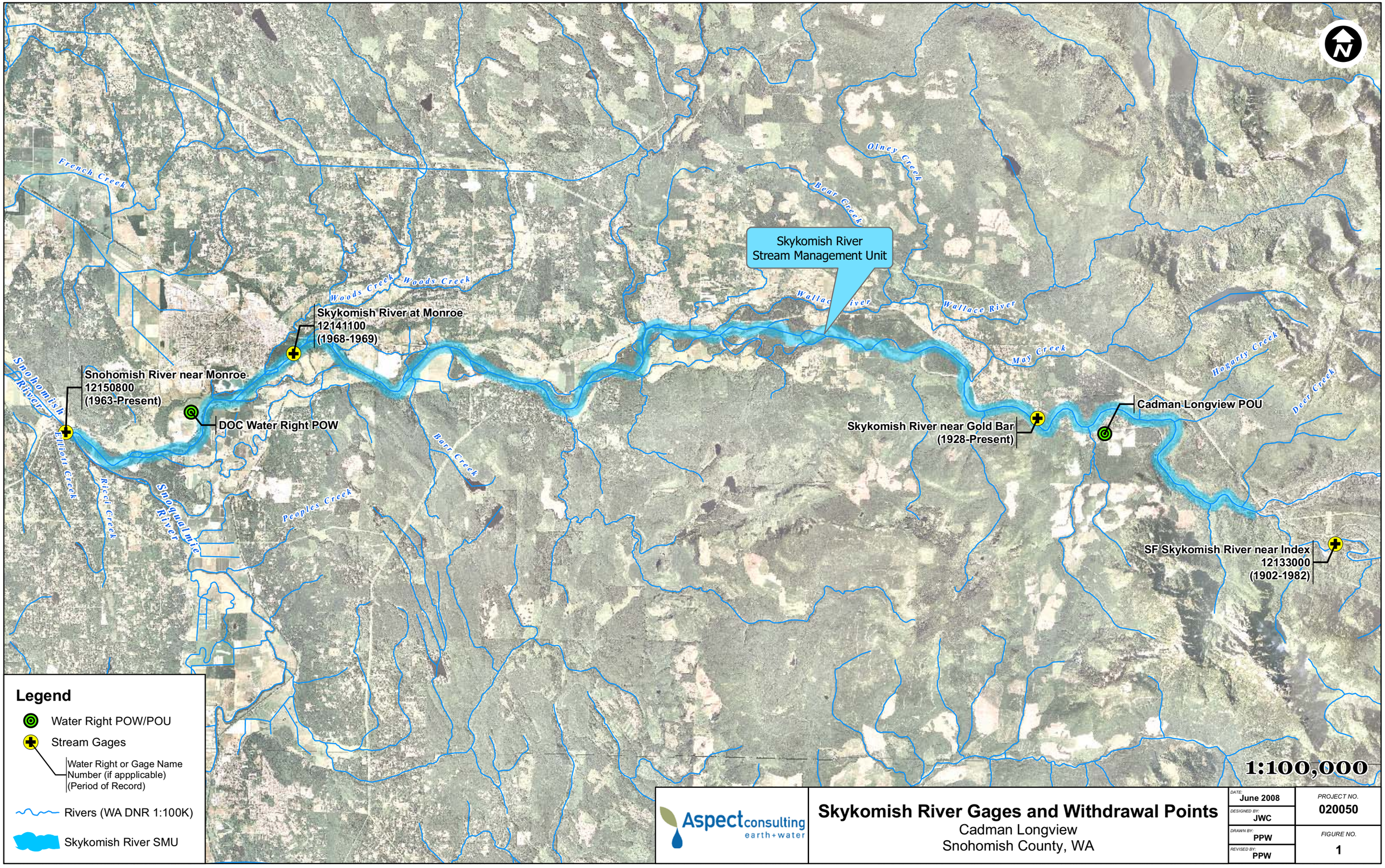
Aspect Consulting, 2010a. Memorandum Re: Evaluation of lag effects from proposed groundwater withdrawals at Cadman's Gold Bar Mining Operation. April 5, 2010.

Aspect Consulting, 2010b. 2009 Groundwater Monitoring Report, Cadman Longview Mining Operation. March 30, 2010.

Hunt, B., 1999. Unsteady Stream Depletion from Ground Water Pumping. Ground Water 37(1):98-102.

Jenkins, C.T., 1968. Techniques for computing rate and volume of stream depletion by wells. Ground Water 6(2)37-46.

Reeves, H.W., 2008. STRMDEPL08—An extended version of STRMDEPL with additional analytical solutions to calculate streamflow depletion by nearby pumping wells. U.S. Geological Survey Open-File Report 2008–1166, 22 p.



Aspect consulting
earth+water

Skykomish River Gages and Withdrawal Points

Cadman Longview
Snohomish County, WA

DATE: June 2008	PROJECT NO. 020050
DESIGNED BY: JWC	
DRAWN BY: PPW	FIGURE NO. 1
REVISED BY: PPW	

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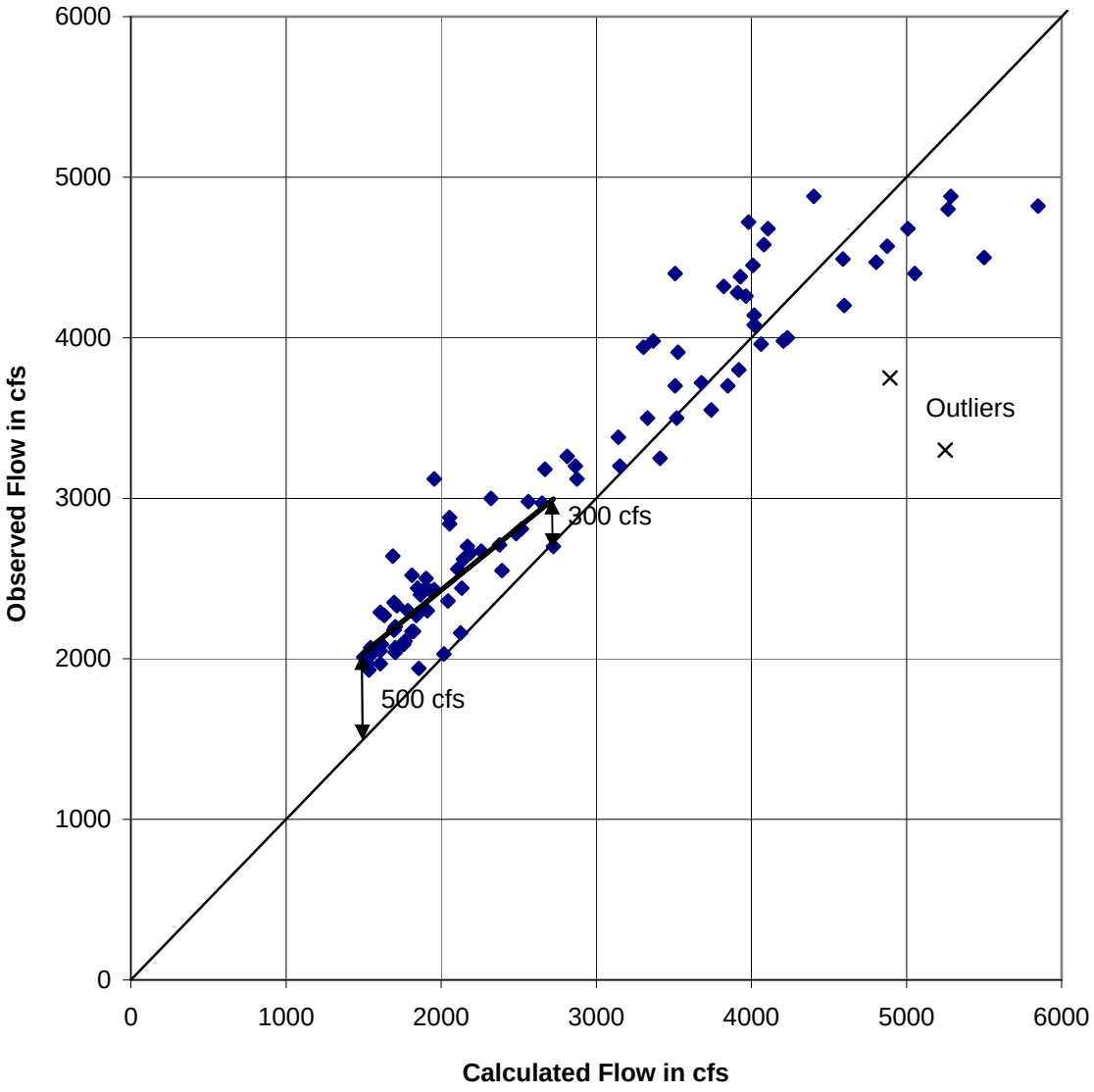
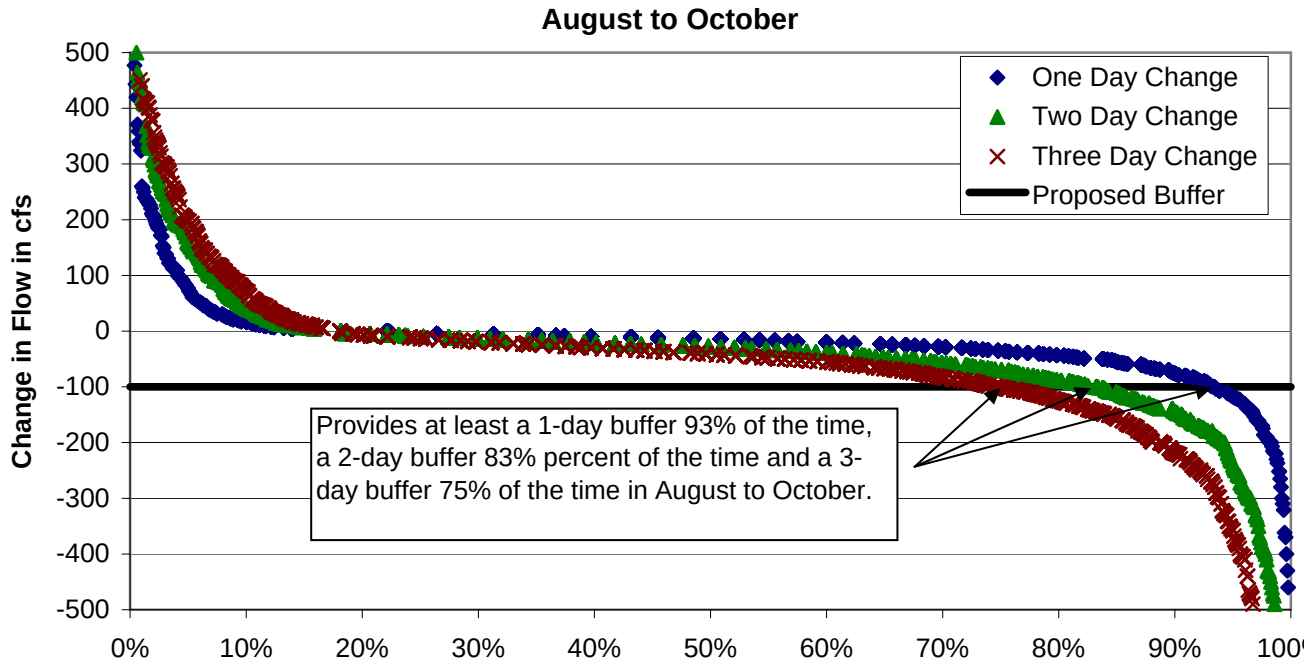


Figure 2
Relationship between Observed and Calculated Flow at Skykomish River at Monroe, 1968-1969

Aspect Consulting
April 5, 2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Flow Prediction.xls



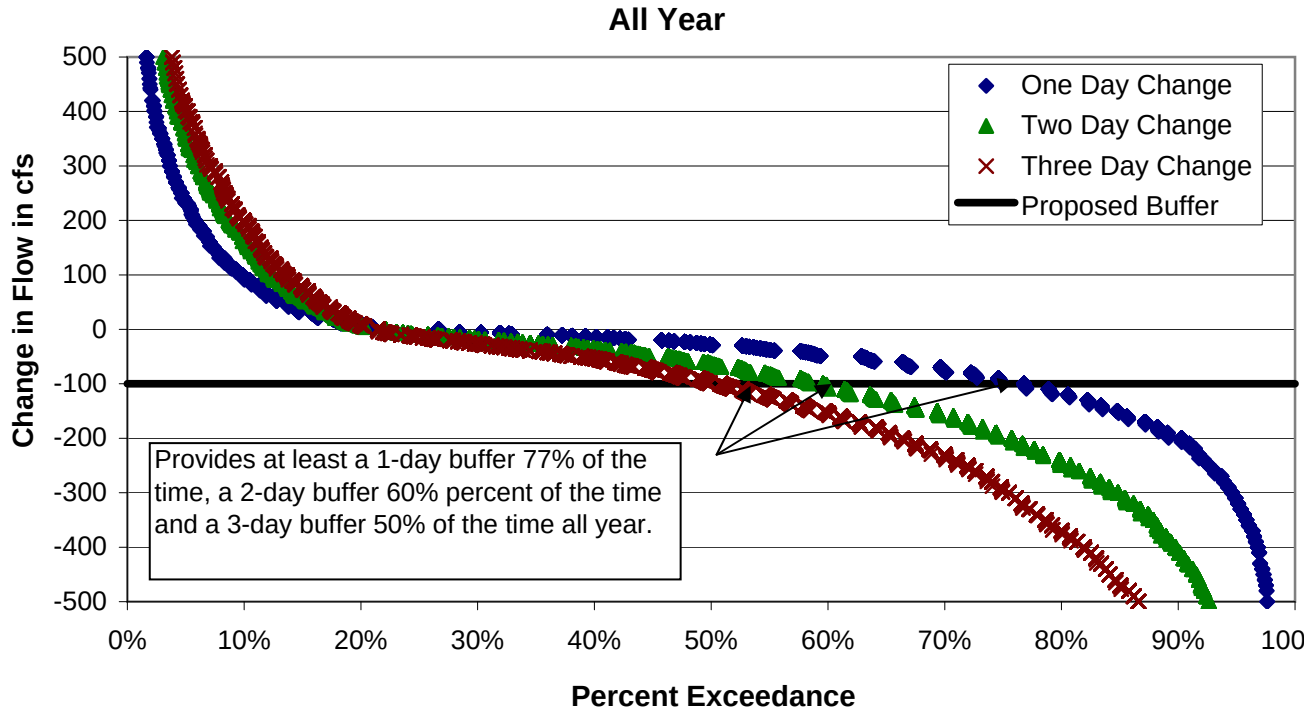
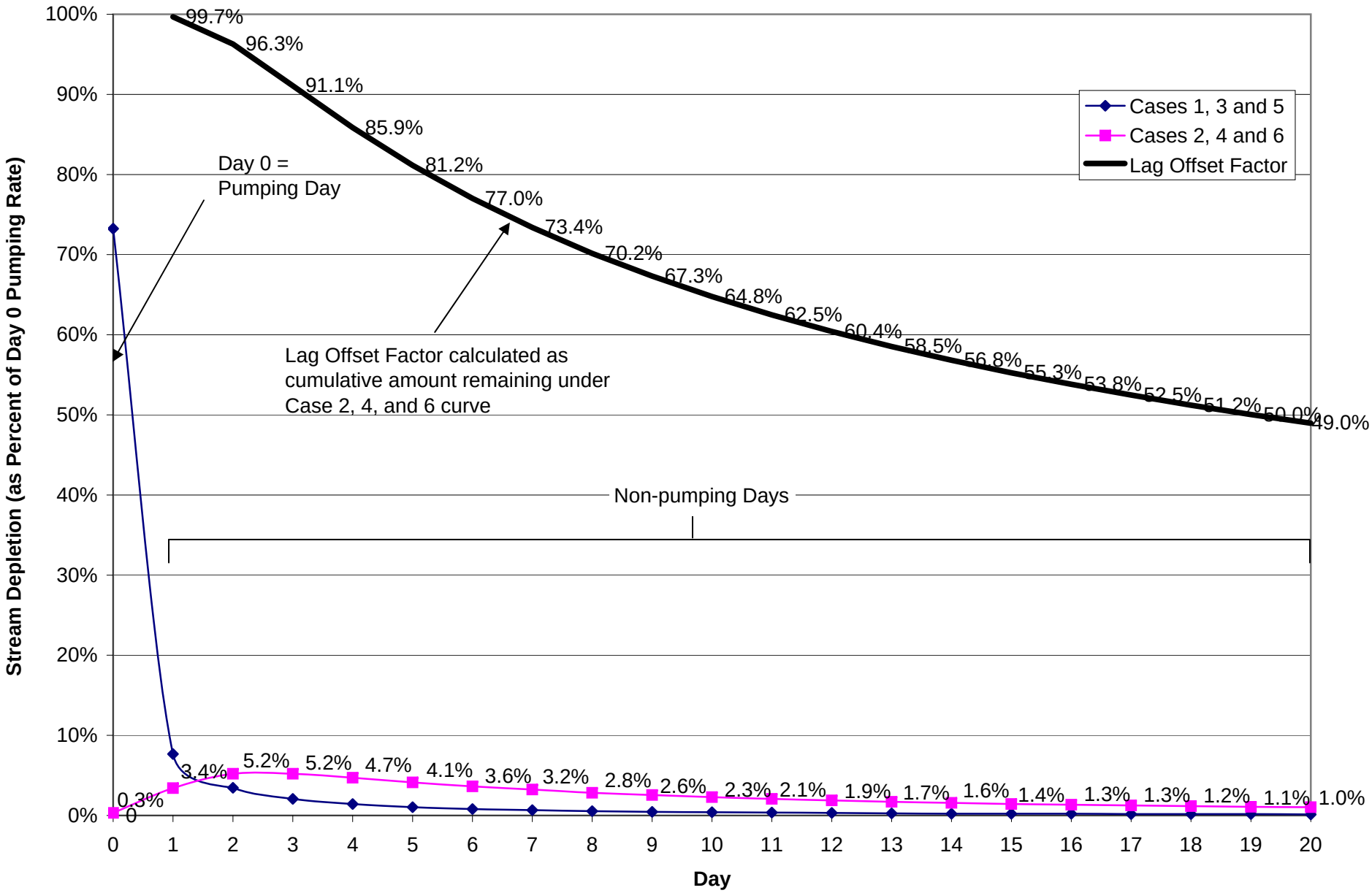


Figure 3
Change in Flow in the Skykomish River when Flow is Below MIF
Gold Bar Mining Operation

Aspect Consulting
9/14/2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Cadman Goldbar Instantaneous Flow Data.xls



Aspect Consulting
9/14/2010
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Figure 4
Stream Depletion Curves
Gold Bar Mining Operation, WA

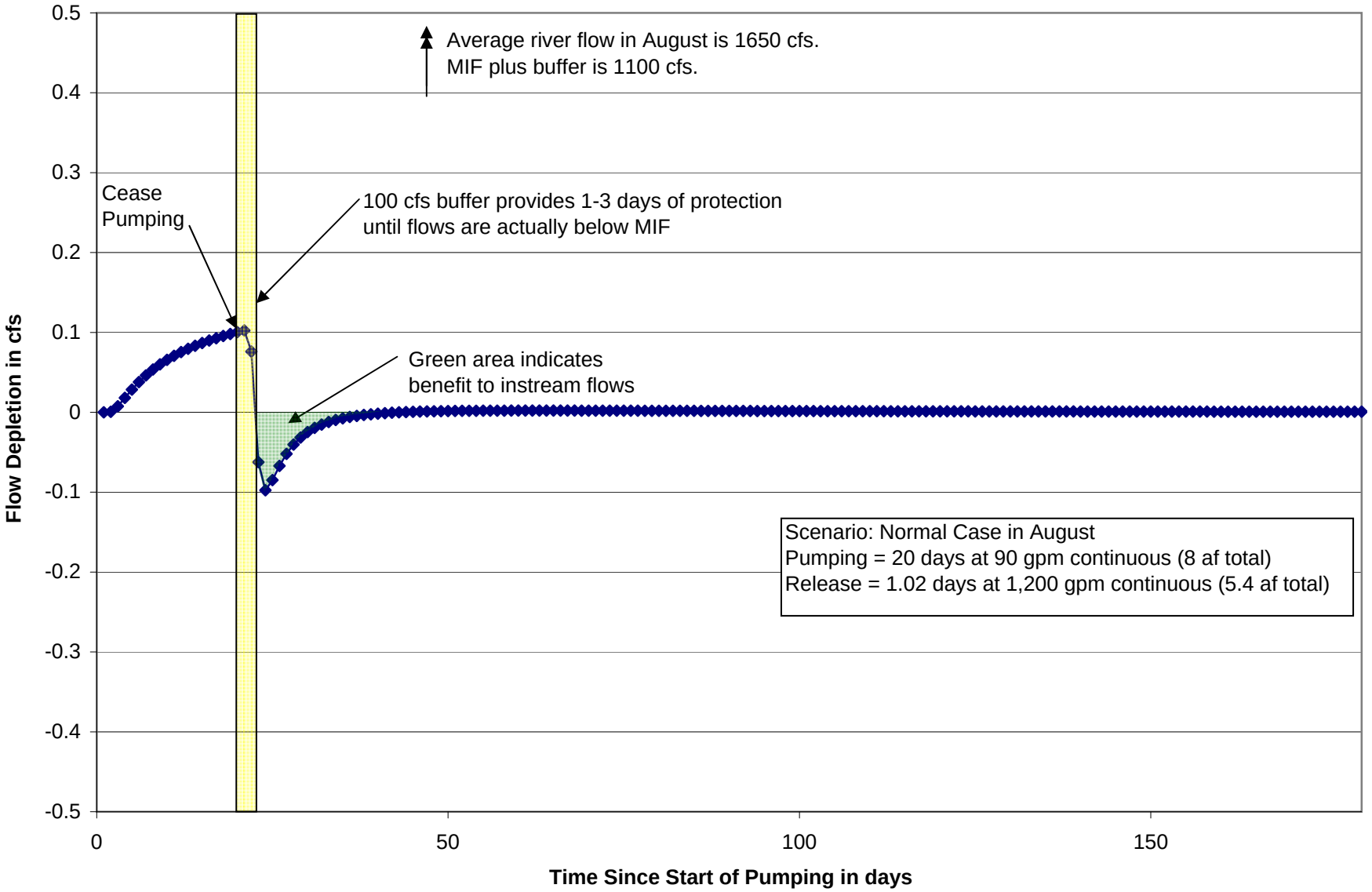

Figure 5

Effect of Management Plan on Streamflows - Normal Case

Gold Bar Mining Operation

Aspect Consulting
9/14/2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Analyses\Jenkins Streamflow Depletion model - normal case.xls

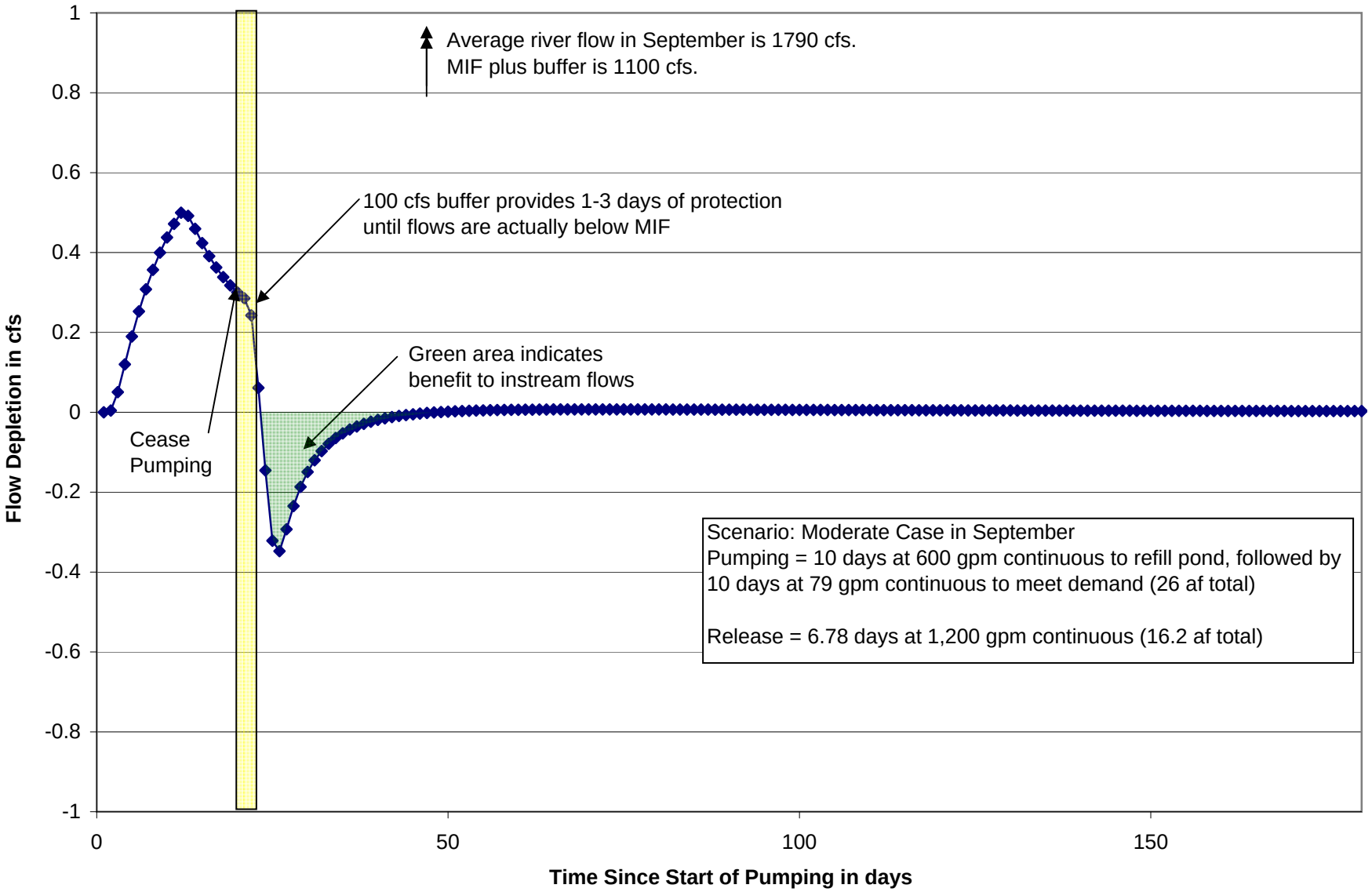

Figure 6

Effect of Management Plan on Streamflow - Moderate Case

Gold Bar Mining Operation

Aspect Consulting
9/14/2010
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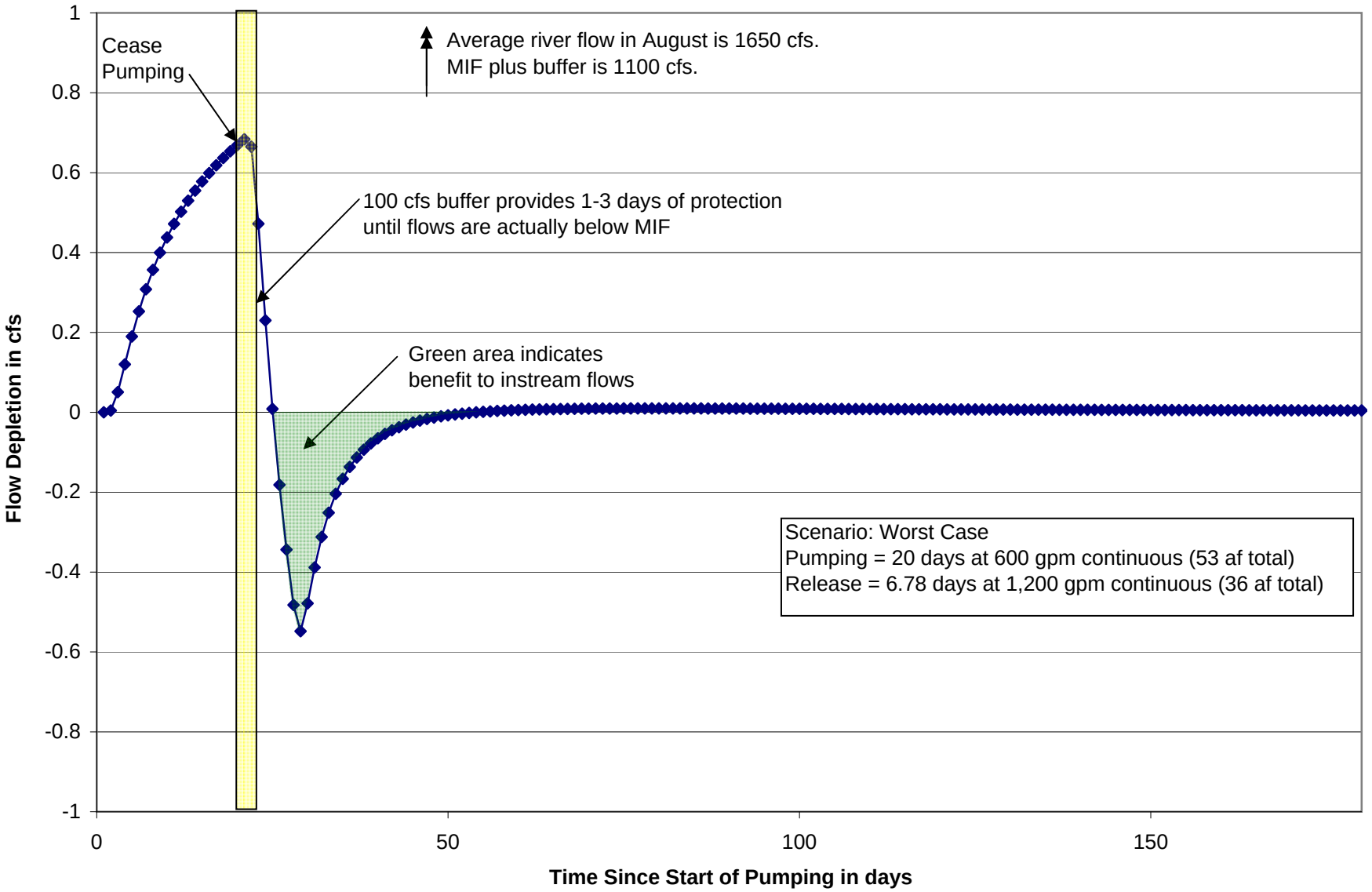
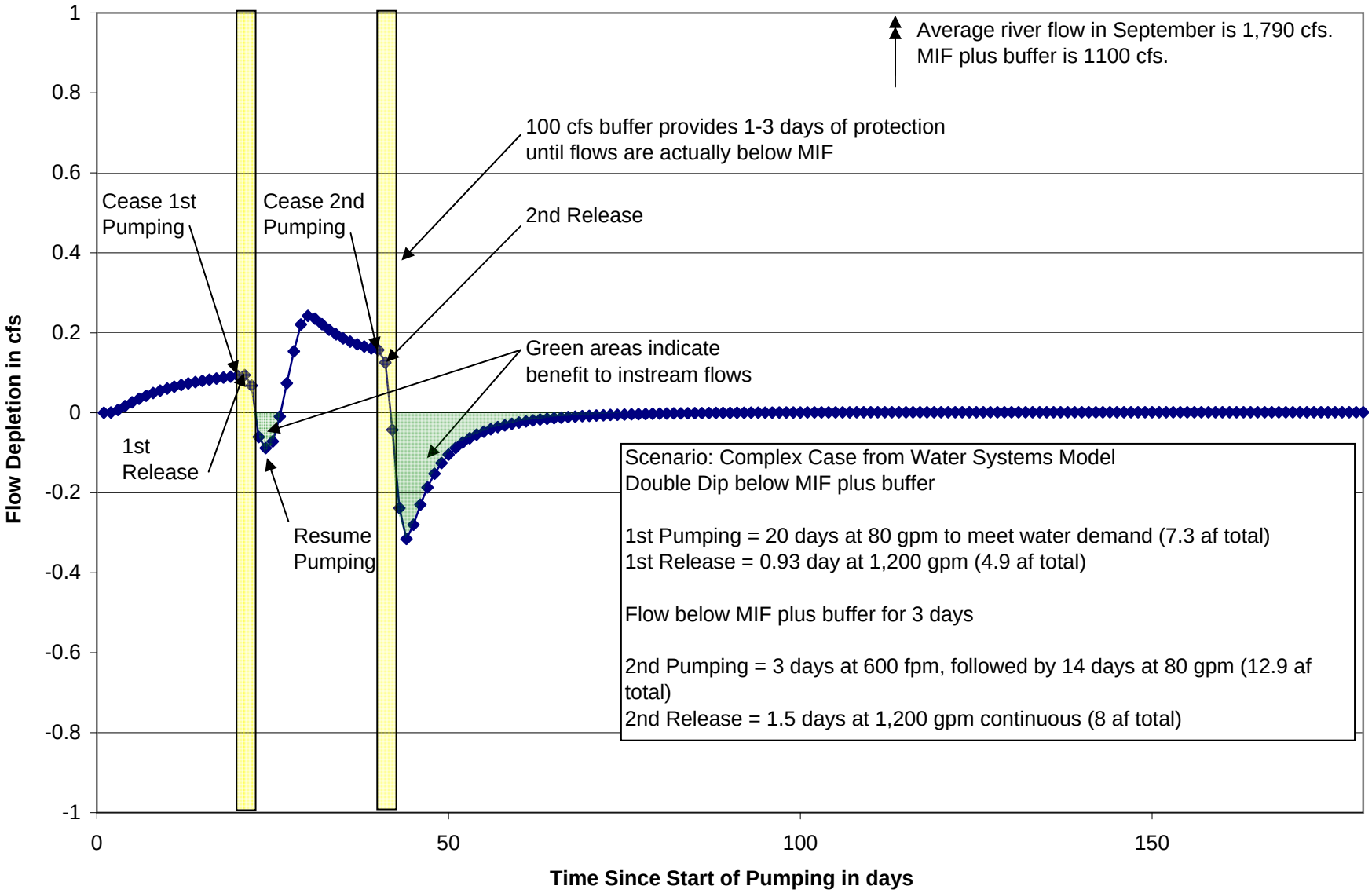


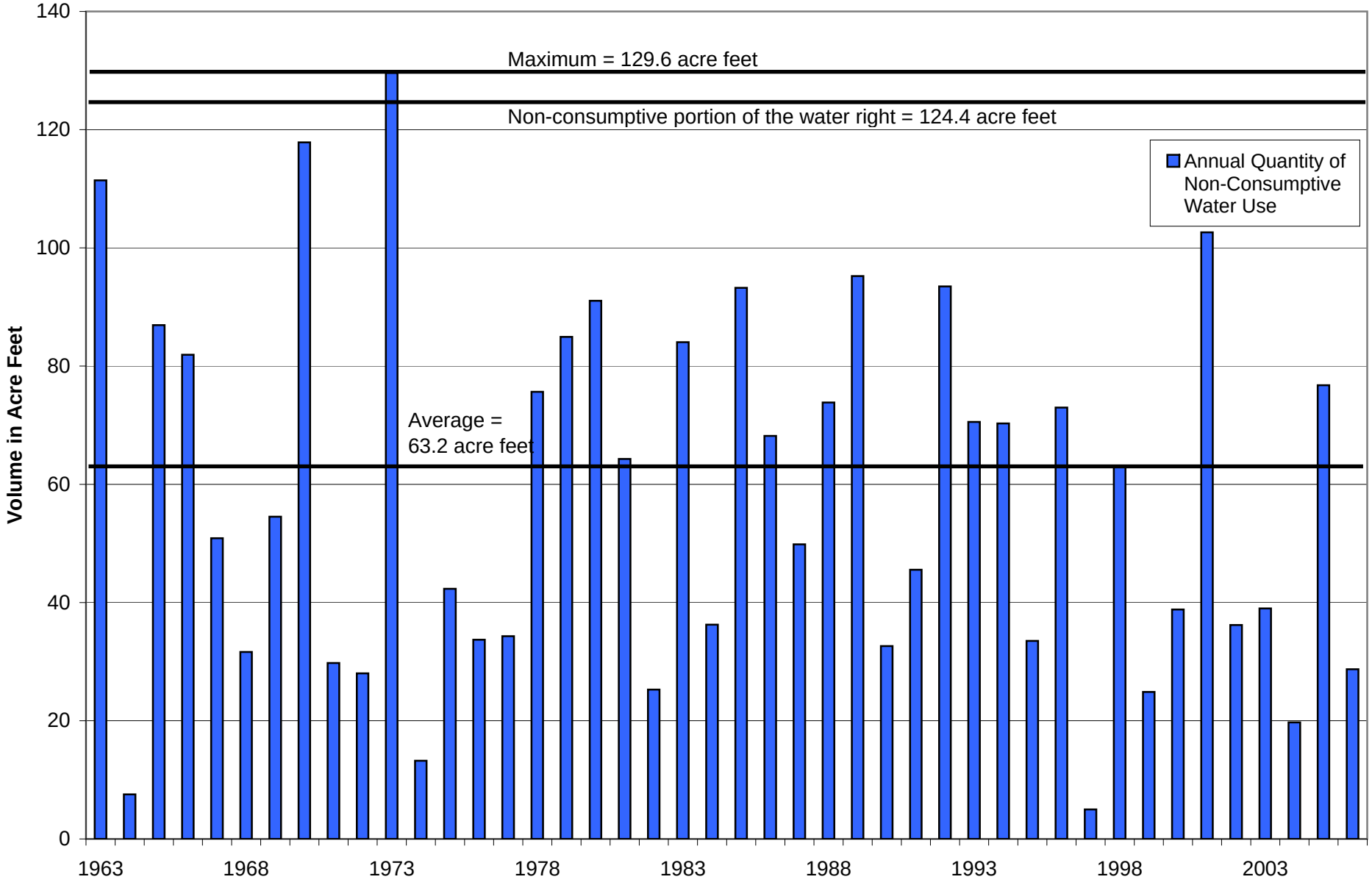
Aspect Consulting
9/14/2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Analyses\Jenkins Streamflow Depletion model - worst case.xls

Figure 7
Effect of Management Plan on Streamflow - Worst Case
Gold Bar Mining Operation



Aspect Consulting
9/14/2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Analyses\Jenkins Streamflow Depletion model - complex case.xls

Figure 8
Effect of Management Plan on Streamflow - Complex Case
Gold Bar Mining Operation

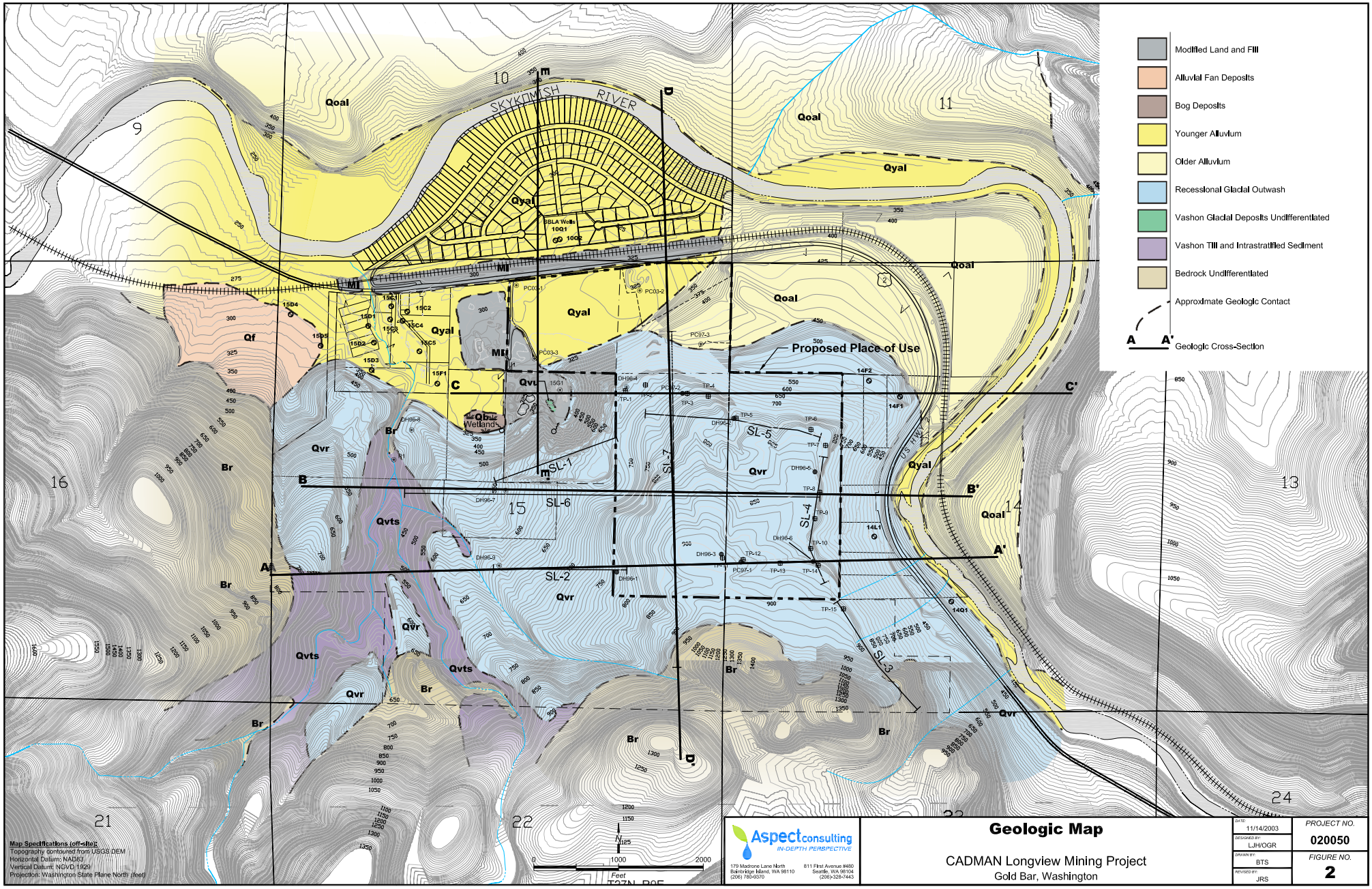


Aspect Consulting
9/14/2010
S:\Cadman\Gold Bar Longview\Water Rights\DOC Water Right Change\Data\Analyses\Water Supply Model.xls

Figure 9
Annual Volumes of Water Released to Offset Lag Effects
Gold Bar Mining Operation, WA

Appendix B

Geologic Map and Cross Section from (Aspect, 2004)


Modified Land and Fill
Alluvial Fan Deposits
Bog Deposits
Younger Alluvium
Older Alluvium
Recessional Glacial Outwash
Vashon Glacial Deposits Undifferentiated
Vashon Till and Intrastratified Sediment
Bedrock Undifferentiated
Approximate Geologic Contact
Geologic Cross-Section
SKYKOMISH RIVER
Proposed Place of Use
Wetlands
BBLA Wells
Qoal
Qyal
Qvr
Qvts
Qf
Br
SL-1
SL-2
SL-3
SL-4
SL-5
SL-6
SL-7
Map Specifications (off-site):
Topography contoured from USGS DEM
Horizontal Datum: NAD83
Vertical Datum: NGVD 1929
Projection: Washington State Plane North (feet)
Feet
Aspect consulting
IN-DEPTH PERSPECTIVE
179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-6570
811 First Avenue #480
Seattle, WA 98104
(206)-328-7443
Geologic Map
CADMAN Longview Mining Project
Gold Bar, Washington
DATE: 11/14/2003
DESIGNED BY: LJH/OGR
DRAWN BY: BTS
REVISED BY: JRS
PROJECT NO. 020050
FIGURE NO. 2
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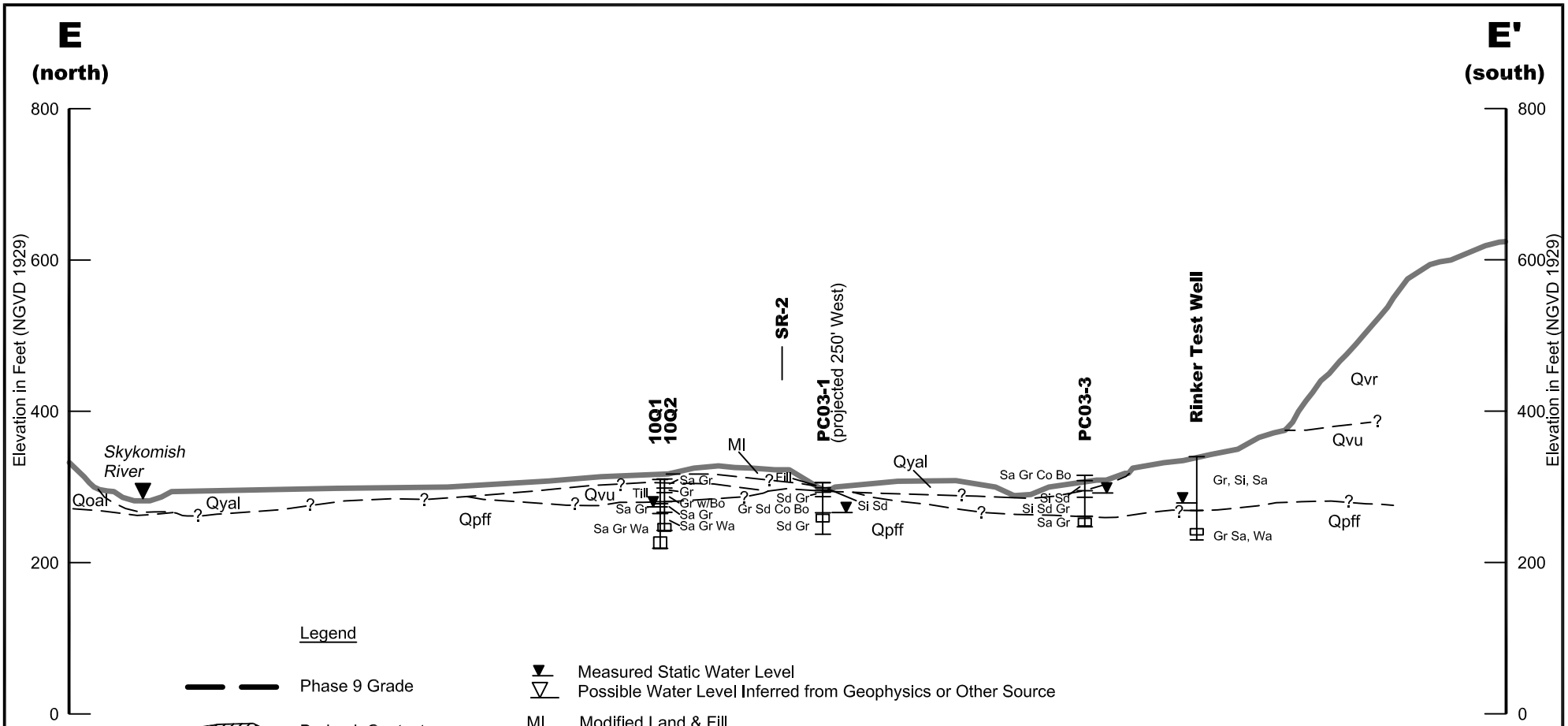

Legend

Phase 9 Grade

Bedrock Contact from Geophysics

Inferred Contact

Speculative Contact

Sa Gr
Sa, Si, Gr
Well Screened Zone

Borehole with Lithologic Notes:

Cl	- Clay	f.	- fine
Si	- Silt	m.	- Medium
Sa	- Sand	c.	- Coarse
Gr	- Gravel	w/	- with
Co	- Cobbles	&	- and
Bo	- Boulder	int.	- interbeds
Wa	- Water Bearing		

Example: Sa Gr - Sandy Gravel
Sa, Si, Gr - Sand, Silt, and Gravel

Measured Static Water Level
Possible Water Level Inferred from Geophysics or Other Source

Ml	Modified Land & Fill
Qyal	Younger Alluvium
Qoal	Older Alluvium
Qvr	Recessional Glacial Outwash Deposits
Qvts	Vashon Till and Intrastratified Sediments
Qvf	Vashon Fluvial Deposits Undifferentiated
Qvu	Vashon Glacial Deposits Undifferentiated
Qpff	Pre-Fraser Fluvial Deposits
Br	Bedrock

Horizontal Scale in Feet
0 500 1000
0 200 400
Vertical Scale in Feet
Vertical Exaggeration x 2.5

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179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370
811 First Avenue #480
Seattle, WA 98104
(206)-328-7443

Geologic Cross Section E-E'

CADMAN Longview Mining Project
Gold Bar, Washington

DATE: 11/14/2003	PROJECT NO. 020050
DESIGNED BY: LJH/OGR	
DRAWN BY: JRS	FIGURE NO. 6A
REVISED BY: -	

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Appendix C

Ecology Internal Memorandum
(2010)

Department of Ecology Memorandum

Water Quality Program
Northwest Regional Office

DATE: Wednesday, June 16, 2010

TO: Jay Cook, NWR Water Resources Program

FROM: Gerald Shervey, PE , NWR Water Quality Program

RE: Cadman Gold Bar Sand & Gravel – Batch plants

CC: Raman Iyer

We discussed granting water rights to Cadman's Gold Bar Sand & Gravel mine. The water right will allow water use for rock washing and batch plants. I agree that granting the water right for these uses is appropriate as industrial uses at a sand & gravel mine.

You asked about rock washing impacting neighboring potable water supplies. The fact sheet for Ecology's Sand & Gravel General permit noted one case in Oregon where rock washing increased ground water turbidity down gradient, but said that incident was exceptional. (I copied that part of the fact sheet at the end of this memo.) I understand that Cadman will recycle wash water by using a lined pond. This practice will serve to protect ground water from turbidity increases while conserving water use.

Including asphalt and cement batch plants in the water right is consistent with general industry practice, but the permit for this facility covers only mining and rock washing now. Installing a batch plant will require a full SEPA review, NPDES permit modification, public notice about the change to the Sand & Gravel permit coverage, an engineering report to describe wastewater treatment and disposal, and any other information we need to evaluate impacts on ground water. Cadman can add batch plants to their sand & gravel NPDES permit coverage in the future, but will have to document how they will protect ground water.

The Sand & Gravel General permit has conditions to protect both ground and surface water. The permit requires practices to prevent fuel and chemical spills. Asphalt batch plants use no water. Cement batch plants do use water and they generate some waste water. The Sand & Gravel General Permit requires they treat the wastewater before discharging it to ground water. Typically, cement batch operations recycle as much waste water and gravel as possible. Depending on the design Cadman proposes for a cement batch plant, Ecology can require additional ground water monitoring or best management practices to protect ground water from impacts of batch plants

I think it is appropriate to include water use for batch operations, but the Water Quality Program would review any proposal for a batch plant prior to permitting it's installation and use. Rock washing is already covered by the permit.

Excerpt from Fact Sheet for Sand and Gravel General Permit (Ecology, 2005):

Turbidity *of water is related to the amount of suspended and colloidal matter contained in the water. It reduces the clarity and penetration of light. Turbidity is an indirect measure of total suspended solids. The data demonstrate that turbidity in discharges to surface water continues to pose a potential problem; approximately 7% of reported discharges exceeded the 50 NTU effluent limit. Because turbidity is a known and common pollutant in discharges associated with the industries covered under this general permit, it was selected as a parameter of concern. All surface water dischargers are required to monitor turbidity.*

Drinking water is a major beneficial use of ground water. In drinking water, turbidity is considered an aesthetic contaminant and indicates increased potential for other contaminants. Ground water standards do not allow significant degradation of background levels of contaminants in ground water nor can a discharge cause ground water to exceed maximum contamination levels (MCLs). The MCL for turbidity is 1 NTU. Mining operations often discharge highly turbid water to infiltration ponds. It is possible for this turbidity to be carried a significant distance through the aquifer but typically it will travel only a short distance. One site studied in Oregon had a turbidity plume that resulted in levels of 5 NTU or more in wells up to 6,000 feet from the site. The aquifer consisted of unconsolidated alluvial fan gravels of very high permeability and a background level of about 2 NTU.

Sand and gravel mining impacts on ground water turbidity were explored in a report, The Direct and Cumulative Effects of Gravel Mining on Ground Water Within Thurston County, Washington (Robert Mead, Thurston County Public Health and Social Services Department.) Although the report recognized the potential to impact ground water turbidity and expressed concern about disposal of highly turbid wash water into gravel pit ponds, the only example of significant contamination was the site in Oregon. While there is the potential for site specific concern, the typical sites covered by this permit do not appear to pose a threat to ground water turbidity and discharge limits or turbidity monitoring will not be included for discharges to ground water. The current permit under special condition S14.B., provided the basis for Ecology to require the installation of ground water monitoring wells if site specific conditions warrant it. In the proposed permit, this condition has been consolidated with General Condition, G13., which allows Ecology to establish additional monitoring requirements, including the installation of monitoring wells, by order or permit modification.