TETRA TECH

MEMORANDUM

TNC – Fisher Slough Final Design and Permitting
Subject: Well Review Memorandum

To: Betsy Stevenson and Allison Mohrs (Skagit County Planning and Development Services)
Jenny Baker, The Nature Conservancy

From: David Cline, P.E. (Tetra Tech)

Date: Dec. 18, 2009

Introduction

This technical memorandum addresses and documents the potential affects of the Fisher Slough tidal marsh restoration project, and the likely effects on neighboring groundwater wells. The memorandum was requested by Skagit County as part of their permitting process.

The contents of this memorandum address the following items:

- Map of local groundwater, drinking water supply wells within 300ft of the project boundary
- Overview of local geology, groundwater hydrology and well reports
- Assessment of potential affects on adjacent groundwater wells

Map and location of adjacent groundwater wells

A map was developed of the water wells in the region around Fisher Slough (**Figure 1**). Four wells were identified in the immediate project vicinity, with only the Hanson Well located within the 300ft buffer of interest. The wells is located 185ft east of the mid-line of the project boundary between Hill Ditch and Big Fisher Creek on Hanson's property. This is a domestic water supply well for the house and commercial dingy building business at this location.

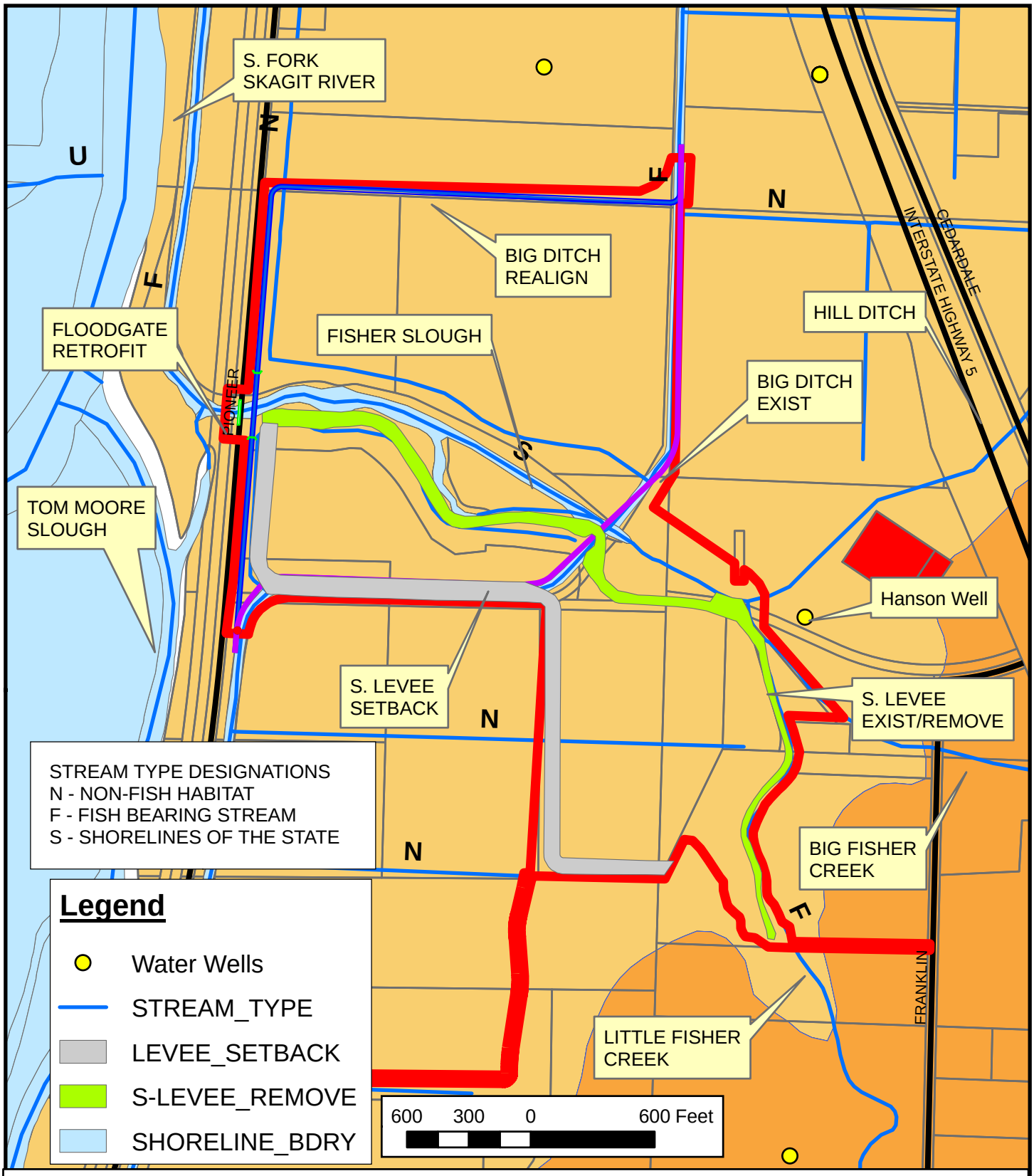

FIGURE 1. Fisher Slough
Project Location and Water Well Map
SKAGIT COUNTY, WASHINGTON

Overview of local geology, groundwater hydrology and well reports

The Fisher/Carpenter Creek landscape straddles the border of two physiographic regions, the North Cascade Mountains on the east and Puget Lowland to the west. Headwaters of the three watersheds that make up the Fisher Slough watershed (Little and Big Fisher Creeks and Carpenter Creek) originate in the terraces and foothills bordering the western edge of the Devil's and Cultus Mountains ranging between 800 and 1000 feet in elevation, that comprise the western slopes of the North Cascades. The area has been greatly influenced by glacial actions that created terrace and plateau features that trend north-northwest and range in elevations from 40 to 340 feet. The soils are moderately deep and moderately well drained and are formed in volcanic ash and glacial till. The creeks and their small tributaries cut through these terraces forming a rolling topography on the terraces. The creek channels form deeper ravines before entering the valley floodplain. The creeks converge to form Fisher Slough after entering the level to nearly level Skagit delta floodplain before terminating at the South Fork Skagit River. Underlying geology of the delta is comprised of glacial deposits and alluvium. Soils of the delta are very deep and naturally poorly drained. Big Fisher, Little Fisher and Carpenter Creeks all join together at the head of Fisher Slough.

Figure 2 shows geology of Big and Little Fisher Creeks. The downstream ends of Big and Little Fisher Creeks flow across nearshore deposits, which are primarily fine-grained estuary, tidal flat, and Skagit River overbank floodplain deposits. These fine-grained deposits are overlain in places by sand and gravel deposits from the creeks themselves. Slightly upstream, the creeks flow in valleys that are slightly incised into the Everson Glaciomarine Drift, which consists of silt and clay deposited on the floor of Puget Sound as the last glacier receded. Upstream, the ravines become deeper and narrower where they cut through Vashon Advance Outwash and Vashon Till. These two units provide most of the creeks' sediment supply and are located on Big Fisher Creek upstream from I-5, on the west fork of Little Fisher Creek upstream from Milltown Road, and on the east fork of Little Fisher Creek downstream of I-5 where the ravine parallels Milltown Road. Upstream from the ravines, the creeks emerge onto a relatively flat, glaciated upland and flow through Glaciomarine Outwash.

A number of well logs and boring test logs are available in the project vicinity. The Hanson well log was reviewed for soil profile lithology and composition (**Att. A**). The following is a summary of the soil profile:

- Surface soil (0ft to 1ft): Sand and gravel alluvial deposits
- 1ft to 23ft: Brown clay (likely an extension of the Everson Glaciomarine Drift)
- 23ft to 38ft: Blue clay
- 38ft to 85ft: Blue clay and gravel
- 85ft to 132ft: Blue clay
- 132 to 136ft: Water sand and gravel (water bearing layer for well)
- 136ft minus: Blue clay

The water well is approximately 136ft deep and located in a water bearing layer with significant clay (glacial till) deposits above and below the well. These tight layers of glacial till have very low permeability (typically on the order of $1e10^{-6}$ cm/s). This is an indicator that the groundwater supply to this layer is deep-seated, and not directly recharged through the 100+ feet of glacial till clays.

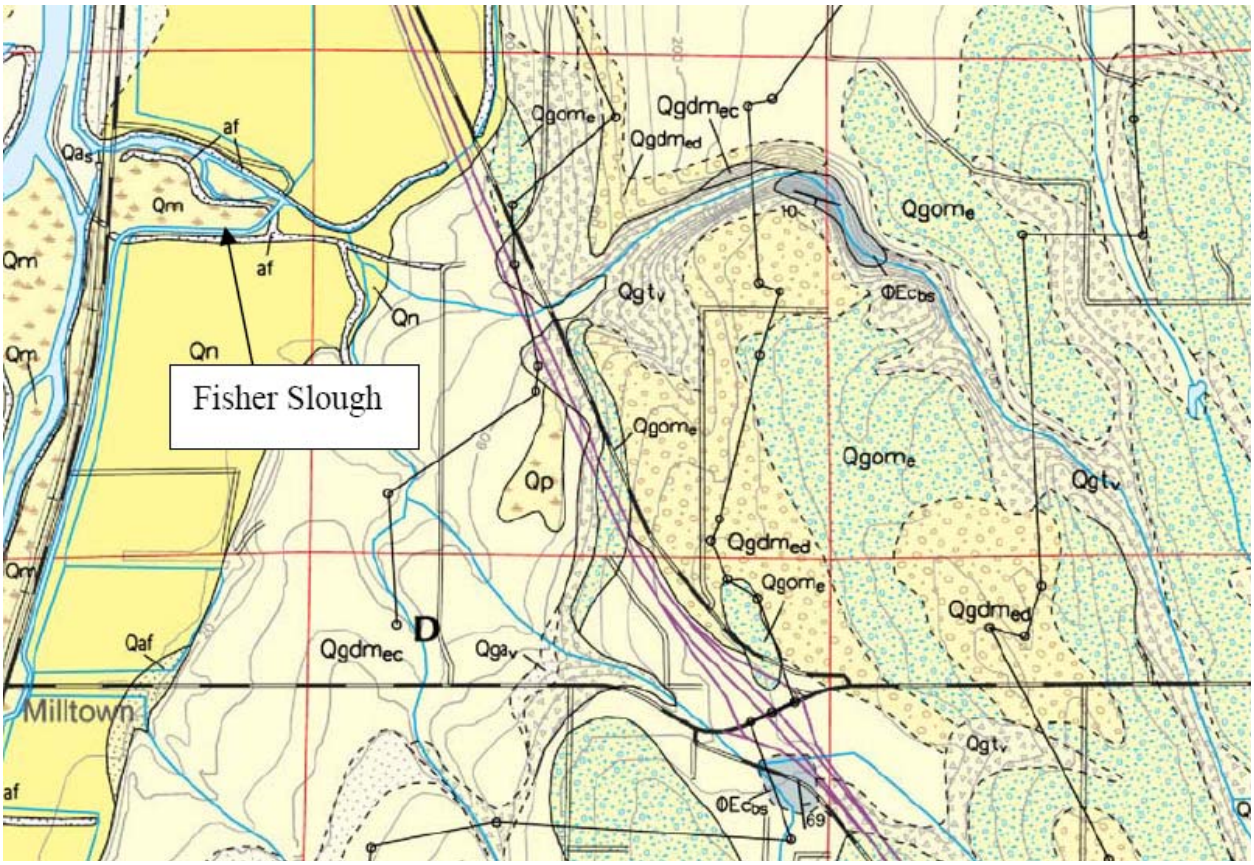

Figure 2. Local geology of Fisher Slough

Local groundwater hydrology has been characterized through a variety of studies. There are several sets of groundwater data and studies available for the Fisher Slough restoration site (**Figure 3**). These include the following data sets and reports:

- Fisher Slough original groundwater measurements inside and outside the existing levee made during the summer of 2006 (**Figure 4**).
- Fisher Slough recent groundwater monitoring measurements outside the levees made during 2009 (**Figure 5**).
- Fisher Slough surface water measurements of Big Ditch which is a corollary to Skagit Delta groundwater elevations.

- USGS groundwater studies on the Skagit Delta having general information regarding seasonal groundwater stages on the central delta.

On the whole, these data show that groundwater within the Slough and levees is closely associated with tidal and flood inflows, whereas groundwater outside of the levees is predominately linked to the underlying Skagit Delta aquifer. For the purposes of evaluating the effects on the project, the discussion will focus on groundwater effects inside the levees as the Hanson well is within the levee system, but on the alluvial fan hillside.

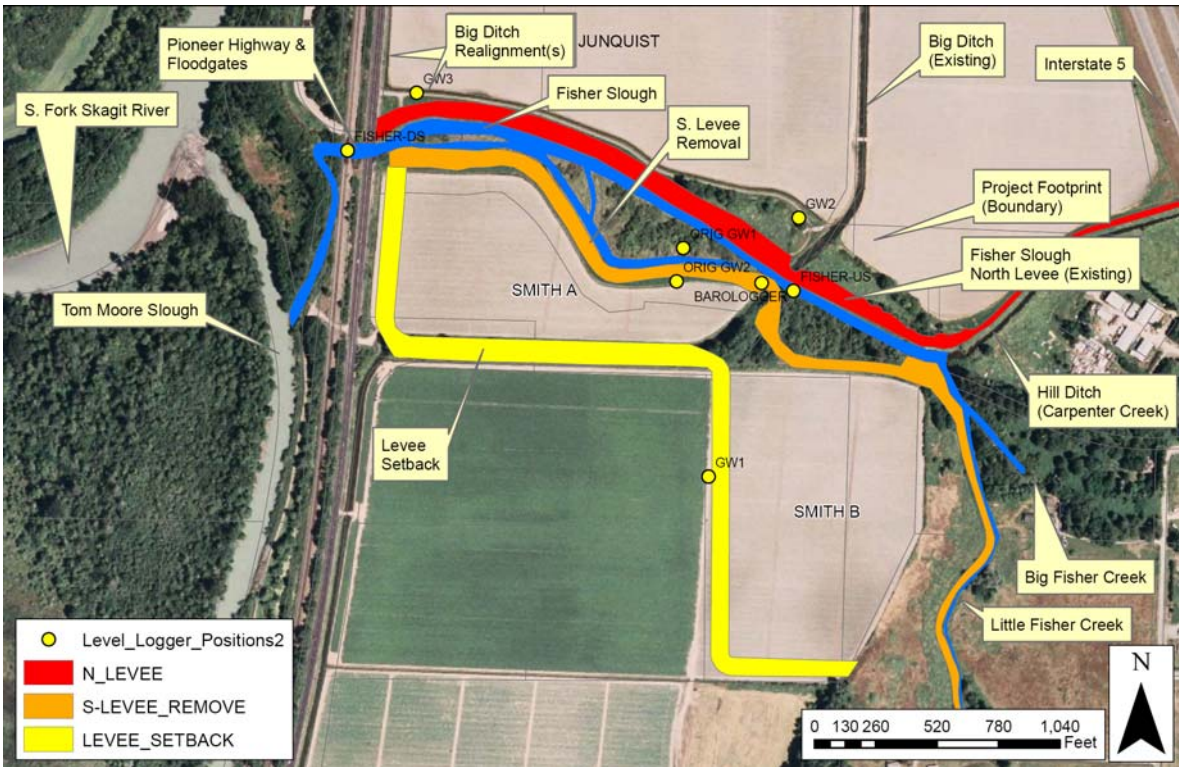

Figure 3. Surface Water Hydrology Measurements of Late Spring Flow Events at Fisher Slough

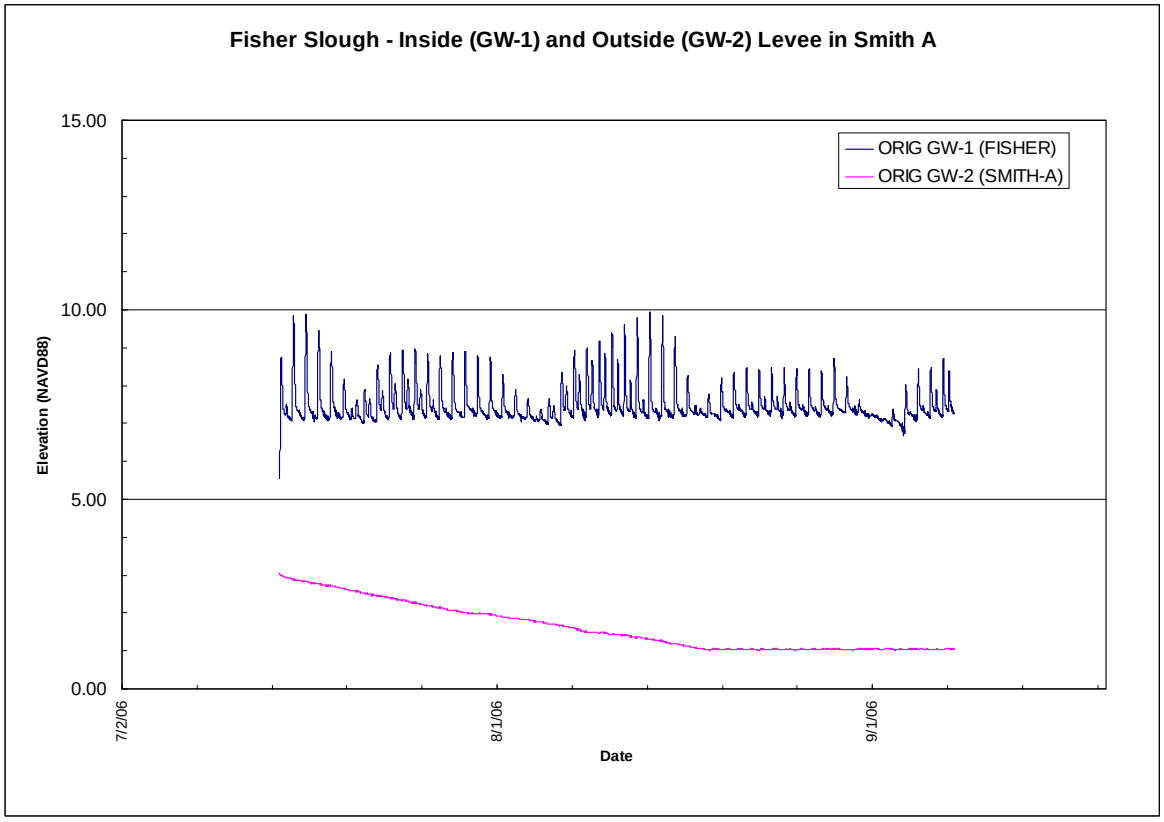

Figure 4. Groundwater measurements inside and outside the existing Fisher Slough levee

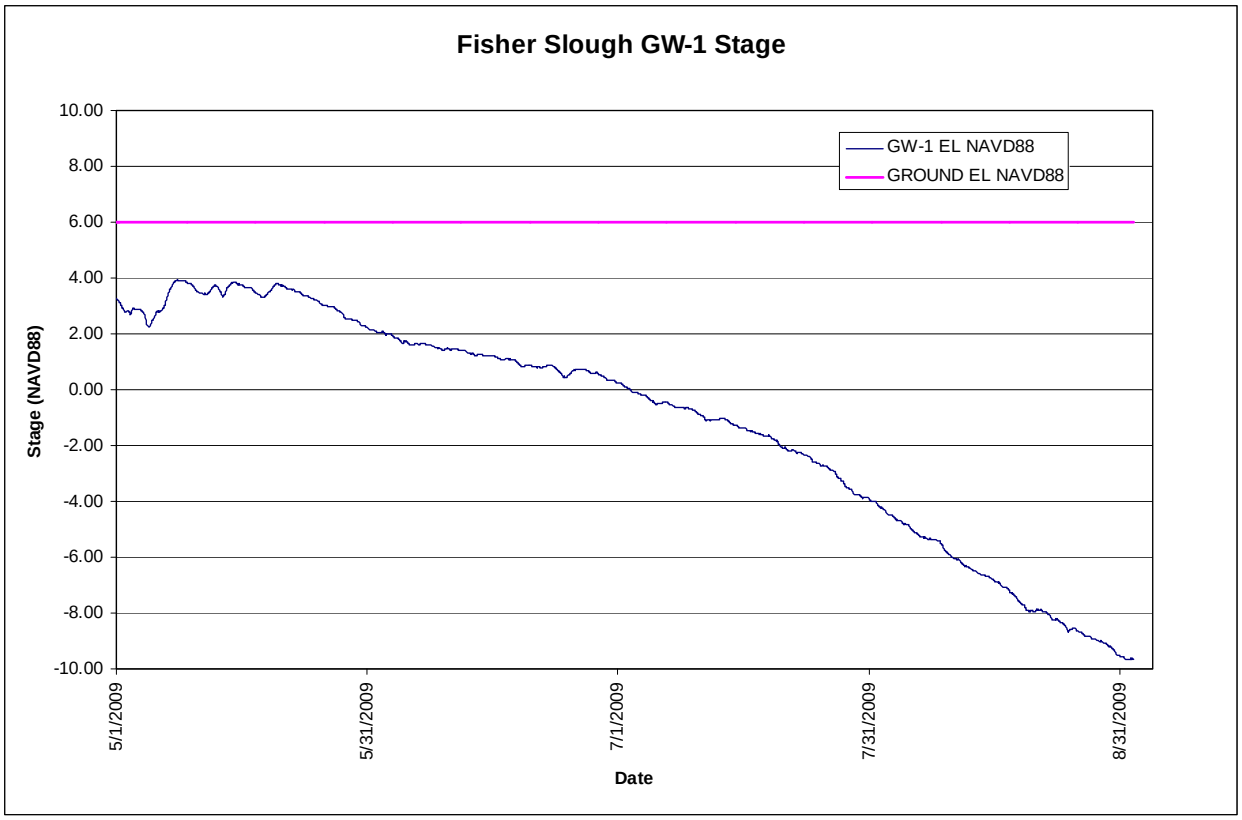

Figure 5. Groundwater measurements for existing conditions mid-way along Smith B, north-south levee section

Evaluation of potential effects of the project on the Hanson Well

The effects of the project within the levee are described in the following general terms:

- Setting back the levees and increased periods of opening the floodgates will provide significantly more tidal flushing and improve flood storage for the Hill Ditch, Big Fisher and Little Fisher tributaries. This will greatly enhance fish habitat while also providing improved flood conditions. The tidal exchange and gate operations are such that inflows to the site are within the normal tidal range that already occurs at the site, and well below the level of the Hanson well cap.
- The improvements in flood conditions are decreases in flood stages. For more frequent 5-10 year flood events, water surface elevations will decrease by nearly 2.8ft in elevation as a result of the improved flood storage. The highly constricted levee system overtops frequently and 5-year flood events have similar stages to 100-year flood events within the Slough. The project will not accommodate, nor likely impact the 100-year flood event stage for either the tributaries or the Skagit River.

The primary question of this memorandum is if the proposed project will have adverse effects. Typically, domestic water supply wells are very small and have low pumping capacity. Their capture zones are on the order of 50ft. It is likely that due to the clay till layers that the Hanson well is not connected to shallow groundwater. Daily tidal inundation and saturation of the uppermost soil layers and shallow groundwater layers are therefore not linked to the Hanson well intake.

The other concern that often arises when evaluating groundwater well systems is the potential for bacterial contamination and fouling that may occur, especially if inundated by flood waters, which typically have high bacterial content and poor water quality. The Fisher Slough project will actually decrease the probability of fouling by lowering the flood elevations for more frequent tributary flooding events (which are similar in stage to larger events due to low storage capacity), and is a benefit to the well owner. For larger flood events, these will still occur and the project has little to no benefit, and definitely no adverse affect to the well owner.

Attachment A – Hanson Well Log Report

RECEIVED
SEP 03 1993
DEPT. OF ECOLOGY

33/4E/29E

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. W 09684
Water Right Permit No.

(1) OWNER: Name HANSON, EARL Address 2241 E FRANKLIN ROAD MOUNT VERNON, WA 98273-

(2) LOCATION OF WELL: County SKAGIT - SW 1/4 NW 1/4 Sec 29 T 33 N., R 4 WM
(2a) STREET ADDRESS OF WELL (or nearest address) 2241 E FRANKLIN RD MT VRN

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 136 ft. Depth of completed well 136 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from 0 ft. to 131 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: YES
Manufacturer's Name
Type STAINLESS STEEL Model No. TELESCOPING
Diam. 6 slot size 12 from 131 ft. to 136 ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level ft. below top of well Date 07/29/93
Artesian Pressure lbs. per square inch Date
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data

Time	Water Level	Time	Water Level	Time	Water Level

Date of test / /
Bailer test 12+ gal/min. 45 ft. drawdown after 1 hrs.
Air test gal/min. w/ stem set at ft. for hrs.
Artesian flow .5 g.p.m. Date 07/29/93
Temperature of water Was a chemical analysis made?

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
TOPSOIL & GRAVEL	0	1
BROWN CLAY	1	23
BLUE CLAY	23	38
BLUE CLAY & GRAVEL	38	85
BLUE CLAY	85	132
WATER SAND & SOME GRAVEL	132	136
BLUE CLAY & GRAVEL	136	

Well Located According
Ordinance 12.48 Skagit County

Work started 07/28/93 Completed 07/29/93

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME DAHLMAN PUMP & WELL DRILL
(Person, firm, or corporation) (Type or print)

ADDRESS PO BOX 422,BURLINGTON, WA

[SIGNED] Ralph W. Dahlman License No. 2043

Contractor's
Registration No. DAHLMPW123LC Date 08/03/93