APPENDIX A

LEVEL I STUDY RESERVOIR EVALUATION MATRIX
### Environmental Issues

#### Dam Statistics

<table>
<thead>
<tr>
<th>Site #</th>
<th>Site Name</th>
<th>Dam Classification</th>
<th>Contributing Drainage Area - Indirect (square miles)</th>
<th>Contributing Drainage Area - Direct (square miles)</th>
<th>Contributing watershed</th>
<th>Dam embankment math</th>
<th>Potential for flood protection</th>
<th>Water Use Entitlement</th>
<th>Dam Improvement Information</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Allak Creek</td>
<td>B+</td>
<td>C - BBBB C - CB</td>
<td>B - C + BBB C + BB</td>
<td>Paintrock Cr is</td>
<td>D+</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>2</td>
<td>Big Trails</td>
<td>B</td>
<td>D</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>3</td>
<td>Bruner Gulch</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>4</td>
<td>Little Canyon Creek</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - BB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>5</td>
<td>Cottonwood Creek</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>6</td>
<td>County Line</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>7</td>
<td>Lower Brokenback</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>8</td>
<td>Lower Nowood</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
<tr>
<td>9</td>
<td>McDonald Draw</td>
<td>B</td>
<td>C</td>
<td>C - BBBB C - CB</td>
<td>Paintrock Cr is</td>
<td>B</td>
<td>Limited</td>
<td>Available</td>
<td>None / On Creek</td>
<td>None / On Creek</td>
</tr>
</tbody>
</table>

#### Dam Safety

| Site # | Site Name | Dam Classification | Potential for flood protection | Water Use Entitlement | Dam Improvement Information | Other comments |
|-------|-----------|--------------------|-------------------------------|-----------------------|----------------------------.|----------------|
| 1     | Allak Creek | B+                 | Limited                       | Available             | None / On Creek              | None / On Creek |
| 2     | Big Trails  | B                  | Limited                       | Available             | None / On Creek              | None / On Creek |
| 3     | Bruner Gulch| B                  | Limited                       | Available             | None / On Creek              | None / On Creek |
| 4     | Little Canyon Creek | B | Limited                       | Available             | None / On Creek              | None / On Creek |
| 5     | Cottonwood Creek | B | Limited                       | Available             | None / On Creek              | None / On Creek |
| 6     | County Line  | B                  | Limited                       | Available             | None / On Creek              | None / On Creek |
| 7     | Lower Brokenback | B | Limited                       | Available             | None / On Creek              | None / On Creek |
| 8     | Lower Nowood | B                  | Limited                       | Available             | None / On Creek              | None / On Creek |
| 9     | McDonald Draw | B                  | Limited                       | Available             | None / On Creek              | None / On Creek |
### Environmental Issues

#### Storage Availability

- **Game:** Elk
- **Sage Grouse Core Population Area:** None
- **Sage Grouse Leks within 2 miles:** None

#### Dam Statistics

- **Contributing watershed:** None
- **Reservoir pool area:** None
- **Dry Year (Indirect):** None
- **Indirect Supply Source:** None
- **Dry Year (ac ft) - Physically in the stream:** None
- **Normal Year (ac ft) - Physically in the stream:** None

#### Hydrology Method

- **Appurtenances:** None
- **Method of Reservoir Fill:** None
- **Total Dam Volume (cy):** None
- **Embankment Length (feet):** None
- **Proposed Type:** None
- **Maximum Water Depth (feet):** None
- **Surface Area (acres):** None
- **Capacity / Enlargement (acre-feet):** None
- **Mean annual precipitation:** None
- **Maximum basin relief in feet:** None
- **Basin perimeter in miles:** None
- **Maximum Elevation (feet MSL):** None
- **Contributing Drainage Area -Indirect (square miles):** None

#### Supply Mechanism

- **Indirect Supply Source:** None
- **Demand Potential (downstream shortages) (Dry/Normal):** None
- **Location Relative to Demand (Irrigated Acres downstream):** None

#### Impoundment

- **Embankment:** None
- **Total Project per ac-ft of storage:** None

#### Other

- **Residences:** None
- **Irrigated Acreage Inundated:** None
- **Fiber Optics (4300):** None
- **WDEQ Stream Classification:** None
- **Wetlands (acres impacted) From NWI data:** None

#### Estimated Construction Cost

- **Local:** $8,300,000
- **State:** $24,338,415
- **BLM:** $22,119,394
- **USFS:** $27,017,244
- **Total:** $9,890,556
- **Total Construction:** $11,100,000

#### Site Evaluation Summary Matrix

- **Site Name:** Meadowlark Lake
- **Site #:** 121
- **BLM Private, BLM, USFS Public (USFS)**
- **Longitude:** -107.232061
- **Latitude:** 44.165157
- **Mean annual precipitation:** 12.2
- **Maximum basin relief in feet:** 51.9
- **Basin perimeter in miles:** 690
- **Maximum Elevation (feet MSL):** 12.2
- **Contributing Drainage Area -Indirect (square miles):** None
- **Supply Mechanism:** Indirect Supply Source
- **Demand Potential (downstream shortages) (Dry/Normal):** None
- **Location Relative to Demand (Irrigated Acres downstream):** None

#### Geometry:

- **Site Evaluation Summary Matrix_REVISED.xlsx**
- **3/3/2010**
### Site & Description

#### Site Name
- **Site Name**: [Site Evaluation Summary Matrix_REVISED.xlsx](3/3/2010)
- **Latitude**: 44°13′23.30″
- **Longitude**: -107°30′16.00″

<table>
<thead>
<tr>
<th>Site</th>
<th>Upper Brokenback</th>
<th>Woods Gulch</th>
<th>Alkaid Creek South</th>
<th>South Fork Otter (lower)</th>
<th>South Fork Otter (Upper)</th>
<th>Canyon Creek</th>
<th>Lone Tree</th>
<th>North Brokenback</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Category A: Environmental Issues

- **On-Channel** / Off-Channel
- **Direct Supply Source**: Natural
- **Indirect Supply Source**: None
- **Hydrology Method**: None
- **Proposed Type**: None
- **Potential for flood protection**: Low
- **Mean annual precipitation**: 15.22
- **Demand Potential (downstream shortages)**: 15.22
- **Estimated Construction Cost**: $26,169

#### Category B: Dam Statistics

- **Total Project per ac-ft of storage**: $26,169
- **Total Dam Volume (cy)**: 1,970
- **Embankment Length (feet)**: 617
- **Dam Height (feet)**: 617
- **Proposed Type**: None
- **Maximum Water Depth (feet)**: 617

#### Category C: Reservoir Statistics

- **Mean annual precipitation**: 31.31
- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Dam Height (feet)**: 617
- **Potential for flood protection**: Low
- **Estimated Construction Cost**: $26,169

#### Category D: Economic Considerations

- **Spatial Location**: None
- **WDEQ Stream Classification**: 2AB
- **Fisheries**: No known fisheries concerns.
- **Impacted Acreage (irrigated)**: None
- **Fishery studies are needed**: None
- **Residences**: None
- **Transportation**: None

#### Category E: Geology

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category F: Hydrology

- **Mean annual precipitation**: 31.31
- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Dam Height (feet)**: 617
- **Potential for flood protection**: Low
- **Estimated Construction Cost**: $26,169

#### Category G: Infrastructure

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category H: Ownership

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category I: Other

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category J: Potential Benefits

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category K: Environmental Issues / Infrastructure

- **Critical Range**: Seasonal Range, Crucial Range
- **Outflow**: None
- **Channel**: None
- **Basin Plan Reach**: None
- **Tributary Dam**: None
- **Mainstem Dam**: None
- **Proposed Type**: None
- **Potential for flood protection**: Low
- **Estimated Construction Cost**: $26,169

#### Category L: Economic Considerations

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category M: Infrastructure

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category N: Ownership

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category O: Potential Benefits

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category P: Economic Considerations

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category Q: Infrastructure

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category R: Ownership

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category S: Potential Benefits

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category T: Economic Considerations

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category U: Infrastructure

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category V: Ownership

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category W: Potential Benefits

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

#### Category X: Economic Considerations

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category Y: Infrastructure

- **Total Dam Volume (cy)**: 617
- **Embankment Length (feet)**: 617
- **Method of Reservoir Fill**: None
- **Storage Efficiency (ac-ft/1000cy fill)**: None
- **Initial Reservoir Storage**: None
- **Reservoir pool area**: None
- **Reservoir capacity**: None
- **Reservoir characteristics**: None

#### Category Z: Ownership

- **Public (BLM)**: None
- **Private / BLM**: None
- **State**: None
- **Private**: None
- **BLM/State**: None
- **BLM/Private**: None

### Source

- **Source**: [Site Evaluation Summary Matrix_REVISED.xlsx](3/3/2010)
APPENDIX B

PUBLIC OUTREACH

B1. OUTREACH LISTINGS
B2. FACEBOOK TECHNICAL MEMORANDUM
B3. STAKEHOLDER PURPOSE AND NEED SURVEY FORM
B4. COMPLETED SURVEY FORMS
Community Organizations

Wyoming Association of Conservation Districts
http://www.conservewy.com/
Calendar of Events
Newsletter
65th Annual WACD Convention
   November 15-18, 2010
   Worland, WY

Farm Service Agency
Washakie County Farm Service Agency
   Darla Rhoddes (307) 347-2456 ext. 100
Big Horn County Farm Service Agency

Worland/Ten Sleep Chamber of Commerce
http://www.worlandchamber.com/ (calendar of events)
Newsletter

Washakie County Conservation District
http://www.conservewy.com/wccd.htm
Newsletter

Northern Wyoming Daily News
http://www.wyodaily.com/

City of Worland
http://www.cityofworland.org/

Washakie Development Association
http://www.washakiedevelopment.com/index.htm

Town of Hyattville
http://www.hyattville.org/ (Calendar of Events)

Wyoming Association of Municipalities
WAM news (monthly)
Heads Up (weekly)

Ten Sleep/Worland Website
http://www.tensleepworlandwyoming.net/

Wyoming Livestock Association
http://www.wylr.net/
Big Horn Mountain Coalition
http://www.bighornmountains.org/
Mission Statement: “Our Mission is to enhance the vitality of economic activities within the four county region and provide a high level of regional leadership, coordination, and cooperation between local, state and federal entities.”
Counties: Big Horn, Johnson, Sheridan, and Washakie
Big Horn Mountain Coalition, EDD
Trish Ullery, Executive Director
P.O. Box 250
214 Center Street, Suite 106
Kaycee, WY 82639
Office (307) 738-2225
Fax (307) 738-2471
trish.ullery@bighornmountains.org

Guardians of the Range
Guardians of the Range are a 501(c)3 organization dedicated to sound science and community partnership in public land management. The group addresses grazing issues on behalf of permittees on the Shoshone & Bighorn National Forests and the Cody / Worland / Lander BLM Resource Management areas.
http://www.guardiansoftherange.org/home.asp
Kathleen Jachowski, Executive Director
Phone (307) 587.3723
guardians@hughes.net
P.O. Box 472
Worland, WY 82401

Facebook Pages and Groups
Wyoming Association of Conservation Districts (78 Likes)
Wyoming Livestock Roundup (438 Likes)
Ten Sleep Rodeo Associations (481 Likes)
Ten Sleep (73 Fans)
Worland – Ten Sleep Chamber of Commerce (5 Likes)
Hyattville, Wyoming (0 Fans)
Nowood Watershed Study Level II (12 Likes)
Other Options

Google Alerts

YouTube

- Worland/Ten Sleep Chamber of Commerce
- See Washakie County
- Like No Place on Earth
- Hunting Fishing People

Recommended Events

August 2-7, Washakie County Fair at Washakie County Fairground, Worland
   Washakie County Conservation District has a booth that is unmanned. We could put a brochure or survey on the table.

August 14-21, Wyoming State Fair, Douglas
   Wyoming Association of Conservation has a booth that we could probably leave some handouts

September 25, Washakie County Conservation District Awards Banquet

October 14, Hunter Fest in Ten Sleep

Washakie Farmers Market
   Saturdays, July – September
   Let one non-profit have a booth for free at each event.
   Contact Chamber if interested.

February, West Ag Days*, Worland Community Center Complex

April, Annual Outdoor Show, Worland Community Center Complex

Worland - Ten Sleep Area Calendar of Events

2010

JULY 2010
3-4, Ten Sleep 4th of July Rodeo
3, Ten Sleep Independence Day Parade
10-11, Wyoming Horseshoe Tournament @ Washakie County Fairgrounds
12-15, 4-H Camp @ H Diamond W Youth Camp (18 miles northwest of Grass Creek)
17, Boltz Golf Tournament @ Green Hills Golf Club
17, 2010 Ten Sleep Youth Rodeo at Ten Sleep Rodeo Grounds
23-24, Crazy Daze & 2nd Annual Community Yard Sale
24, Washakie Farmers Market @ N 9th St. - Worland
24-25, API Scholarship Tournament @ Green Hills Golf Club
30, Big Horn Basin Junior Tournament @ Green Hills Golf Club
31, Washakie Farmers Market @ N 9th St. - Worland
AUGUST 2010
2-7, Washakie County Fair at Washakie County Fairground, Worland
7, Washakie County Fair Parade - Downtown Worland
7, Washakie Farmers Market - Worland
7-8, Wyoming State Jr. Golf Tournament @ Green Hills Golf Club
13-15, NOWOOD Stock Music Fest - Ten Sleep
14, Washakie Farmers Market - Worland
14, Worland Boy Scouts Triathlon @ Worland Pool
19-21, 6th Annual Pepsi Wyoming State BBQ Championship & Bluegrass Festival - Worland
21, Washakie Farmers Market - Worland
21-22, Eagles State Scramble @ Green Hills Golf Club, Worland
25, Customer Appreciation BBQ @ Worland Community Center Complex
28, Washakie Farmers Market - Worland
28-29, Worland City Open @ Green Hills Golf Club

SEPTEMBER 2010
2-3, High School Invitational @ Green Hills Golf Club
4, Washakie Farmers Market - Worland
4-5, Big Horn Basin Shootout @ Green Hills Golf Club
6, Labor Day Scramble @ Green Hills Golf Club
9-11, Wyoming Historical Society Convention in Worland
11, Washakie Farmers Market - Worland
18, Washakie Farmers Market - Worland
18-19, Big Horn Basin Gun Show - Worland Community Center Complex
25, Washakie Farmers Market - Worland
25, Washakie County Conservation District Awards Banquet
TBA, Harvest Fest Roping
TBA, Jim Bridger Days @ Worland Community Center Complex

OCTOBER 2010
1, High School Cross Country Invite @ Green Hills Golf Club
14, Hunter Fest in Ten Sleep
TBA, 2nd Annual Trail of the Sheep - Ten Sleep & Worland Celebrates the Sheep Industry
TBA, 3rd Annual Wine Tasting

NOVEMBER 2010
5, Chamber Annual Banquet
20, Soup & Cookie Fair @ Washakie Museum
TBA, Celebrate Freedom - Honoring the Military
TBA, Hobby Days
26, Christmas Opening & Parade of Lights

DECEMBER 2010
31, New Year’s Eve Ball @ Washakie Museum
TBA, 25th Annual Festival of Trees
TBA, Special Olympics Memory Tree
2011

JANUARY 2011
14, Museum Exhibit Opening – American through the CBS Eye@ 5:30 p.m. @ Washakie Museum

FEBRUARY 2011
TBA, West Ag Days – Worland Community Center Complex
11, Historical Reenactment

MARCH 2011
12-13, Big Horn Basin Gun Show - Worland Community Center Complex
TBA, Canal Heritage Days

APRIL 2011
TBA, Gorgeous Gals Gala - Worland
TBA, 4th Grade History Day @ Washakie Museum
TBA, Arbor Day - Tree City USA Celebration

MAY 2011
1-8, Clean Up Week
TBA, Cinco D'Mayo
TBA, High School Graduation

JUNE 2011
TBA, Car Show
TBA, Cloud Peak Freedom Run/Walk - Worland
TBA, CultureFest @ Pioneer Square
TBA, Demolition Derby

JULY 2011
TBA, Ten Sleep 4th of July Rodeo & Parade
TBA, Peterson’s Rumble in the Basin
TBA, Ten Sleep Youth Rodeo

AUGUST 2011
TBA, Washakie County Fair at Washakie County Fairground, Worland
TBA, All School Reunions
TBA, Corn Festival/Rail Road Days
TBA, Nowood Stock Festival in Ten Sleep
TBA, State Championship BBQ
TBA, Wyoming Sugar Days
APPENDIX B2

FACEBOOK TECHNICAL MEMORANDUM
Technical Memorandum

TO: Wyoming Water Development Office
FROM: Trihydro Corporation
DATE: August 4, 2010
REFERENCE: Nowood River Storage Level II Study
SUBJECT: Choosing Between Facebook Fan Pages and Groups

In order to create and implement an effective public communication and outreach effort for the Nowood River Storage Level II Study, Trihydro has been evaluating the use of social media websites to develop relationships and interact with project stakeholders, to generate project awareness, and to disseminate project information. Through the recommendation of a steering committee member, much of our focus has been centered on utilizing Facebook.

According to the “About Facebook” web page, Facebook was founded in 2004 as a social utility to help people “communicate more efficiently with their friends, family, and coworkers.” The idea behind Facebook is to transfer a person’s real world connections to the Internet to improve efficiency of sharing information through these networks. A couple of the ways Facebook allows users to develop and build these networks are through Fan Pages and Groups. The purpose of this technical memorandum is to provide a summary of the various features that Fan Pages and Groups have and how they differ from one another.

1. Groups
A Facebook Group can be created for just about anything. A group can be used as discussion forums, virtual petitions where membership indicates support for a cause, a space for sharing photos and videos, or a way of subscribing to get messages from an organization. The creator of a group has control over which features are enabled, and whether the feature is visible to all members of Facebook, or is closed and visible only to invited Facebook members. Facebook Groups are not visible to non-Facebook users.

Users of Facebook can join a group and then post messages on the wall or in the discussion forum (which allows for threaded discussions). Group Administrator(s) can send a message to all group members, which will appear in the member’s Facebook inbox. Group Administrator(s) can also invite group members to events created through the Facebook event system.

Group Pros
- Can send messages to group members which appear in member’s inbox
- Are marginally easier to set up and manage than pages
- Display Administrator names on the page
- Allow the Administrator to control the membership and content of a group
Group Cons
- Are only visible to Facebook members
- Cannot have extra applications added to them
- Have to visit a group regularly and to use the messaging feature to keep discussions flowing
- Directly connected to the people who administer them, meaning that activities could reflect on the administer personally

2. Fan Pages
Facebook Pages are created for entities such as a clubs, youth councils, organizations etc. Unlike groups which have members, and which are only visible to logged in Facebook users, most of a Facebook Page can be visible on the wider internet to those without a Facebook account, and have fans.

Page administrators can send updates to fans, but these will only be displayed on the side of a users homepage when they log-in, rather than appearing in their inbox. This means they are likely to get less attention than messages sent to group members.

Pages allow Administrators to add some applications, similar to the way applications are added to Facebook profiles. For example, an RSS application can be added that would pull in the headlines directly from a blog or from another discussion board to display on your Facebook page.

Page Pros
- Can be visible on the wider internet to non-Facebook members (although only Facebook members can interact with them)
- Can be customized with rich media and interactive applications to engage page visitors
- Presents visitor statistics
- Can only be created to represent a real or public figure, artist, brand or organization, and may only be created by an official representative of that entity

Cons
- Updates are lower key than messages from Groups
- Visitors need to be a member of Facebook if they want to join in discussions on your page message board
- No membership restrictions

A summary of the features that are available and not available in Facebook Pages and Groups is provided in Table 1.
Table 1. Fan Pages and Groups Features Summary

<table>
<thead>
<tr>
<th>Key Feature</th>
<th>Page</th>
<th>Group</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewable to unregistered Facebook users</td>
<td>Yes</td>
<td>No</td>
<td>Groups are not publically accessible via conventional search, and can only be accessed through Facebook itself. So, no matter how many members, no one outside of Facebook will be able to view the page.</td>
</tr>
<tr>
<td>Feed status updates</td>
<td>Yes</td>
<td>No</td>
<td>Whereas group members will only know if something has been updated by actually going to group page, fans will see new updates appearing in their feeds.</td>
</tr>
<tr>
<td>Personalized URL</td>
<td>Yes</td>
<td>No</td>
<td>Vanity URLs are available once you have 25 fans. (example: <a href="http://www.facebook.com/NowoodFans">http://www.facebook.com/NowoodFans</a>)</td>
</tr>
<tr>
<td>Mass messaging</td>
<td>No</td>
<td>Yes</td>
<td>With Fan Pages, you cannot send bulk messages using your friend list, inviting people to join. Fan page recruitment can be generated through more passive means, through external marketing (posting the URL on website) as well as through personal message invitations.</td>
</tr>
<tr>
<td>Discussion wall and discussion forum</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Hosts third-party applications</td>
<td>Yes</td>
<td>No</td>
<td>Widgets, badges, and boxes can be used to advertise your fan page on external website and blogs.</td>
</tr>
<tr>
<td>Messaging to all members</td>
<td>Yes</td>
<td>Yes</td>
<td>Messages sent to Group members will appear in their Facebook Inbox. Messages from pages appear in updates.</td>
</tr>
<tr>
<td>Targeted stream posts and updates</td>
<td>Yes</td>
<td>No</td>
<td>Pages have the ability to target stream posts based on location and language.</td>
</tr>
<tr>
<td>Visitor statistics</td>
<td>Yes</td>
<td>No</td>
<td>“Page Insights” allow you to view interactions over a two month period, including comments, likes and wall posts. There are also metrics around fan increases and drop offs, the actual demographics of your fans, and how many of them were active over the course of a week.</td>
</tr>
<tr>
<td>Video and photo public exchange</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Promotion with social ads</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>External search engine indexing (Google)</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Membership restrictions and privacy management</td>
<td>No</td>
<td>Yes</td>
<td>Groups can restrict visibility and choose to be a closed group.</td>
</tr>
<tr>
<td>Mobile accessible</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Visible administrator(s)</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Hierarchy of administrators</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Ultimately the purpose of the Project’s Facebook presence is to connect and regularly communicate with project stakeholders. After researching the differences between Pages and Groups, the Nowood River Storage Level II Study Project Team decided to use a Group because of the personalization features that are available. Facebook Groups are set up for more personal interaction than Pages, they provide the ability to message the members via mail, and the Administrators are prominently displayed on the Group’s main page. The advantages of these features seem to outweigh those of the Pages for this Project.
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
 Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
 Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
- Main stem of Nowood River downstream of Paint Rock Creek
- Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- Tensleep Creek watershed above Nowood River
- Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- Nowood River upstream of Mahogany Buttes
- Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- No operation / in-town residential
- Residential / non-farmed / non-ranched 2 to 20 acres
- Livestock / range use (less than 100 acres)
- Livestock / range use (greater than 100 acres)
- 10 to 100 acres irrigated
- 100 to 500 acres irrigated
- 500 or more acres irrigated
- Other:

3. Do you believe additional storage is needed within the Nowood watershed?
- More storage
- Sufficient storage
- Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
- Irrigation
- Flood protection
- Fisheries
- Water quality
- Other:
5. How many acres are you entitled to irrigate?  
______ acres

6. On average, how many acres do you actually irrigate?  
______ acres

7. On average, what dates do you start and stop irrigating?  
- Start before April 15  
- Start April 16 – April 30  
- Start May 1 – May 15  
- Start May 16 – May 31  
- Start June 1 – June 15  
- Start June 16 – June 30  
- Start after July 1  
- Stop before June 30  
- Stop July 1 – July 15  
- Stop July 16 – July 31  
- Stop August 1 – August 15  
- Stop August 15 – August 31  
- Stop September 1 – September 15  
- Stop September 16 – September 30  
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?  
- 0  
- 1-5 years  
- 5-10 years  
- 10-15 years  
- 15 or more years

9. What best describes the reason you've been unable to irrigate?  
- Does not apply to me  
- My water rights are junior / calls placed on the river  
- There was not water physically available  
- My diversion structure(s) could not divert at low flow  
- Other: __________

10. Which months during the irrigation season have you had problems irrigating?  
- May  
- June  
- July  
- August  
- September  
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa – yield ________/acre
- Grass hay – yield ________/acre
- Corn – yield ________/acre
- Oats – yield ________/acre
- Barley – yield ________/acre
- Other: _______ / yield ________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

- Yes – phone
- Yes – email
- No
- Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

- Yes – by mail
- Yes – by email
- No

### Optional Information:

- **Name:**
- **Address:**
- **Email:**
- **Phone Number(s):**

### Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
- Main stem of Nowood River downstream of Paint Rock Creek
- Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- Tensleep Creek watershed above Nowood River
- Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- Nowood River upstream of Mahogany Buttes
- Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- No operation / in-town residential
- Residential / non-farmed / non-ranched 2 to 20 acres
- Livestock / range use (less than 100 acres)
- Livestock / range use (greater than 100 acres)
- 10 to 100 acres irrigated
- 100 to 500 acres irrigated
- 500 or more acres irrigated
- Other:

3. Do you believe additional storage is needed within the Nowood watershed?
- More storage
- Sufficient storage
- Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
- Irrigation
- Flood protection
- Fisheries
- Water quality
- Other: Fishing and wildlife
5. How many acres are you entitled to irrigate?
   ____ acres

6. On average, how many acres do you actually irrigate?
   ____ acres

7. On average, what dates do you start and stop irrigating?
   - Start before April 15
   - Start April 16 – April 30
   - Start May 1 – May 15
   - Start May 16 – May 31
   - Start June 1 – June 15
   - Start June 16 – June 30
   - Start after July 1
   - Stop before June 30
   - Stop July 1 – July 15
   - Stop July 16 – July 31
   - Stop August 1 – August 15
   - Stop August 15 – August 31
   - Stop September 1 – September 15
   - Stop September 16 – September 30
   - Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?
   - 0
   - 1-5 years
   - 5-10 years
   - 10-15 years
   - 15 or more years

9. What best describes the reason you've been unable to irrigate?
   - Does not apply to me
   - My water rights are junior/calls placed on the river
   - There was not water physically available
   - My diversion structure(s) could not divert at low flow
   - Other: __________________________

10. Which months during the irrigation season have you had problems irrigating?
    - May
    - June
    - July
    - August
    - September
    - October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- Alfalfa – yield ___________/acre
- Grass hay – yield ___________/acre
- Corn – yield ___________/acre
- Oats – yield ___________/acre
- Barley – yield ___________/acre
- Other: ___________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?
- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More

more is better
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☐ Yes – email
☐ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☐ Yes – by mail
☐ Yes – by email
☐ No

Optional Information:

Name:
Address:
Email:
Phone Number(s):

Additional Comments/Input:

Weed more wildlife and places to go
For hunting and waterfowl for dock and ice fishing.
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
- Main stem of Nowood River downstream of Paint Rock Creek
- Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- Tensleep Creek watershed above Nowood River
- Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- Nowood River upstream of Mahogany Buttes
- Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- No operation / in-town residential
- Residential / non-farmed / non-ranched 2 to 20 acres
- Livestock / range use (less than 100 acres)
- Livestock / range use (greater than 100 acres)
- 10 to 100 acres irrigated
- 100 to 500 acres irrigated
- 500 or more acres irrigated
- Other:

3. Do you believe additional storage is needed within the Nowood watershed?
- More storage
- Sufficient storage
- Don't know

4. If you believe more storage is needed, for what purpose would the stored water be used?
- Irrigation
- Flood protection
- Fisheries
- Water quality
- Other:
5. How many acres are you entitled to irrigate?

- 30 acres

6. On average, how many acres do you actually irrigate?

- 30 acres

7. On average, what dates do you start and stop irrigating?

- Start before April 15
- Start April 16 – April 30
- Start May 1 – May 15
- Start May 16 – May 31
- Start June 1 – June 15
- Start June 16 – June 30
- Start after July 1
- Stop before June 30
- Stop July 1 – July 15
- Stop July 16 – July 31
- Stop August 1 – August 15
- Stop August 15 – August 31
- Stop September 1 – September 15
- Stop September 16 – September 30
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10-15 years
- 15 or more years

9. What best describes the reason you've been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other: [Other:]

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- Alfalfa – yield ________/acre
- Grass hay – yield ________/acre
- Corn – yield ________/acre
- Oats – yield ________/acre
- Barley – yield ________/acre
- Other: ________/yield ________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?
- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☐ Yes – email
☒ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☐ Yes – by mail
☐ Yes – by email
☒ No

Optional Information:

Name:

Address:

Email:

Phone Number(s):

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

### 1. Which portion of the watershed best defines your location?
- [ ] Main stem of Nowood River downstream of Paint Rock Creek
- [ ] Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- [ ] East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [ ] West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [ ] Tensleep Creek watershed above Nowood River
- [ ] Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- [ ] Nowood River upstream of Mahogany Buttes
- Other: ____________________________

### 2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- [ ] No operation / in-town residential
- [ ] Residential / non-farmed / non-ranchéd 2 to 20 acres
- [ ] Livestock / range use (less than 100 acres)
- [ ] Livestock / range use (greater than 100 acres)
- [ ] 10 to 100 acres irrigated
- [ ] 100 to 500 acres irrigated
- [ ] 500 or more acres irrigated
- [ ] Other: ____________________________

### 3. Do you believe additional storage is needed within the Nowood watershed?
- [x] More storage
- [ ] Sufficient storage
- [ ] Don't know

### 4. If you believe more storage is needed, for what purpose would the stored water be used?
- [x] Irrigation
- [x] Flood protection
- [x] Fisheries
- [ ] Water quality
- [ ] Other: ____________________________
5. How many acres are you entitled to irrigate?

40

6. On average, how many acres do you actually irrigate?

250

7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before April 15</td>
<td>Before June 30</td>
</tr>
<tr>
<td>April 16 - April 30</td>
<td>July 1 - July 15</td>
</tr>
<tr>
<td>May 1 - May 15</td>
<td>July 16 - July 31</td>
</tr>
<tr>
<td>May 16 - May 31</td>
<td>August 1 - August 15</td>
</tr>
<tr>
<td>June 1 - June 15</td>
<td>August 16 - August 31</td>
</tr>
<tr>
<td>June 16 - June 30</td>
<td>September 1 - September 15</td>
</tr>
<tr>
<td>after July 1</td>
<td>September 16 - September 30</td>
</tr>
<tr>
<td></td>
<td>Stop after October 1</td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10-15 years
- 15 or more years

9. What best describes the reason you've been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa - yield __________/acre
- Grass hay - yield __________/acre
- Corn - yield __________/acre
- Oats - yield __________/acre
- Barley - yield __________/acre
- Other: __________/yield __________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

- Yes - phone
- Yes - email
- No
- Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

- Yes - by mail
- Yes - by email
- No

Optional Information:

Name: [Redacted]
Address: [Redacted]
Email: [Redacted]
Phone Number(s): [Redacted]

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting [http://www.acewater.com/Nowood.htm](http://www.acewater.com/Nowood.htm) or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
- Main stem of Nowood River downstream of Paint Rock Creek
- Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- Tensleep Creek watershed above Nowood River
- Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- Nowood River upstream of Mahogany Buttes
- Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- No operation / in-town residential
- Residential / non-farmed / non-ranch 2 to 20 acres
- Livestock / range use (less than 100 acres)
- Livestock / range use (greater than 100 acres)
- 10 to 100 acres irrigated
- 100 to 500 acres irrigated
- 500 or more acres irrigated
- Other:

3. Do you believe additional storage is needed within the Nowood watershed?
- More storage
- Sufficient storage
- Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
- Irrigation
- Flood protection
- Fisheries
- Water quality
- Other:
5. How many acres are you entitled to irrigate?

_____ acres

6. On average, how many acres do you actually irrigate?

_____ acres

7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start before April 15</th>
<th>Stop before June 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start April 16 – April 30</td>
<td>Stop July 1 – July 15</td>
</tr>
<tr>
<td>Start May 1 – May 15</td>
<td>Stop July 16 – July 31</td>
</tr>
<tr>
<td>Start May 16 – May 31</td>
<td>Stop August 1 – August 15</td>
</tr>
<tr>
<td>Start June 1 – June 15</td>
<td>Stop August 15 – August 31</td>
</tr>
<tr>
<td>Start June 16 – June 30</td>
<td>Stop September 1 – September 15</td>
</tr>
<tr>
<td>Start after July 1</td>
<td>Stop September 16 – September 30</td>
</tr>
<tr>
<td>Stop after October 1</td>
<td>Stop after October 1</td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

<table>
<thead>
<tr>
<th>0</th>
<th>1-5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10 years</td>
<td>10 -15 years</td>
</tr>
<tr>
<td>15 or more years</td>
<td></td>
</tr>
</tbody>
</table>

9. What best describes the reason you've been unable to irrigate?

<table>
<thead>
<tr>
<th>Does not apply to me</th>
<th>My water rights are junior / calls placed on the river</th>
</tr>
</thead>
<tbody>
<tr>
<td>There was not water physically available</td>
<td>My diversion structure(s) could not divert at low flow</td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

10. Which months during the irrigation season have you had problems irrigating?

<table>
<thead>
<tr>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>August</td>
</tr>
<tr>
<td>September</td>
<td>October</td>
</tr>
</tbody>
</table>
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa – yield ________/acre
- Grass hay – yield ________/acre
- Corn – yield ________/acre
- Oats – yield ________/acre
- Barley – yield ________/acre
- Other: ________/yield ________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☐ Yes – email
☐ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☐ Yes – by mail
X ☐ Yes – by email
☐ No

Optional Information:
Name: ___________________________________________________________________________
Address: __________________________________________________________________________
Email: __________________________________________________________________________
Phone Number(s): _____________________________________________________________________

Additional Comments/Input:

T (HANKS)
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
   - Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
   - East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - Tensleep Creek watershed above Nowood River
   - Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
   - Nowood River upstream of Mahogany Buttes
   - Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
   - No operation / in-town residential
   - Residential / non-farmed / non-ranch 2 to 20 acres
   - Livestock / range use (less than 100 acres)
   - Livestock / range use (greater than 100 acres)
   - 10 to 100 acres irrigated
   - 100 to 500 acres irrigated
   - 500 or more acres irrigated
   - Other:

3. Do you believe additional storage is needed within the Nowood watershed?
   - More storage
   - Sufficient storage
   - Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
   - Irrigation
   - Flood protection
   - Fisheries
   - Water quality
   - Other:
5. How many acres are you entitled to irrigate?

<table>
<thead>
<tr>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
</tr>
</tbody>
</table>

6. On average, how many acres do you actually irrigate?

<table>
<thead>
<tr>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
</tr>
</tbody>
</table>

7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Stop Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start before April 15</td>
<td>Stop before June 30</td>
</tr>
<tr>
<td>Start April 16 – April 30</td>
<td>Stop July 1 – July 15</td>
</tr>
<tr>
<td>Start May 1 – May 15</td>
<td>Stop July 16 – July 31</td>
</tr>
<tr>
<td>Start May 16 – May 31</td>
<td>Stop August 1 – August 15</td>
</tr>
<tr>
<td>Start June 1 – June 15</td>
<td>Stop August 15 – August 31</td>
</tr>
<tr>
<td>Start June 16 – June 30</td>
<td>Stop September 1 – September 15</td>
</tr>
<tr>
<td>Start after July 1</td>
<td>Stop September 16 – September 30</td>
</tr>
<tr>
<td>Stop after October 1</td>
<td></td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

<table>
<thead>
<tr>
<th>Years</th>
<th>Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>3 Times</td>
</tr>
<tr>
<td>5-10 years</td>
<td></td>
</tr>
<tr>
<td>10-15 years</td>
<td></td>
</tr>
<tr>
<td>15 or more years</td>
<td></td>
</tr>
</tbody>
</table>

9. What best describes the reason you've been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

10. Which months during the irrigation season have you had problems irrigating?

<table>
<thead>
<tr>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
</tr>
<tr>
<td>June</td>
</tr>
<tr>
<td>July</td>
</tr>
<tr>
<td>August</td>
</tr>
<tr>
<td>September</td>
</tr>
<tr>
<td>October</td>
</tr>
</tbody>
</table>
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa - yield _______/acre
- Grass hay - yield _______/acre
- Corn - yield _______/acre
- Oats - yield _______/acre
- Barley - yield _______/acre
- Other: ___________________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other.

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More

I don't really know.
### 16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Yes – phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes – email</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Yes – by mail</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes – by email</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Optional Information:

- **Name:**
- **Address:**
- **Email:**
- **Phone Number(s):**

### Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:

- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
   - Main stem of Nowood River downstream of Paint Rock Creek
   - Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
   - East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - Tensleep Creek watershed above Nowood River
   - Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
   - Nowood River upstream of Mahogany Buttes
   - Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
   - No operation / in-town residential
   - Residential / non-farmed / non-ranched 2 to 20 acres
   - Livestock / range use (less than 100 acres)
   - Livestock / range use (greater than 100 acres)
   - 10 to 100 acres irrigated
   - 100 to 500 acres irrigated
   - 500 or more acres irrigated
   - Other:

3. Do you believe additional storage is needed within the Nowood watershed?
   - More storage
   - Sufficient storage
   - Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
   - Irrigation
   - Flood protection
   - Fisheries
   - Water quality
   - Other: Recreation
5. How many acres are you entitled to irrigate?

7 acres

6. On average, how many acres do you actually irrigate?

4.5 acres

7. On average, what dates do you start and stop irrigating?

- Start before April 15
- Start April 16 - April 30
- Start May 1 - May 15
- Start May 16 - May 31
- Start June 1 - June 15
- Start June 16 - June 30
- Start after July 1

- Stop before June 30
- Stop July 1 - July 15
- Stop July 16 - July 31
- Stop August 1 - August 15
- Stop August 15 - August 31
- Stop September 1 - September 15
- Stop September 16 - September 30
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10 -15 years
- 15 or more years

9. What best describes the reason you’ve been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- Alfalfa – yield ___/acre
- Grass hay – yield ___/acre
- Corn – yield ___/acre
- Oats – yield ___/acre
- Barley – yield ___/acre
- Other: __/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?
- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
### 16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

- [ ] Yes – phone
- [ ] Yes – email
- [ ] No
- [ ] Other:

### 17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

- [ ] Yes – by mail
- [ ] Yes – by email
- [ ] No

**Optional Information:**

- Name:
- Address:
- Email:
- Phone Number(s):

**Additional Comments/Input:**

Good Luck
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
   - Main stem of Nowood River downstream of Paint Rock Creek
   - Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
   - East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - Tensleep Creek watershed above Nowood River
   - Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
   - Nowood River upstream of Mahogany Buttes
   - Other: Nowood River Between

2. What type of operation or land use best describes your land use? [Please include consideration of leased lands in addition to deeded property]
   - No operation / in-town residential
   - Residential / non-farmed / non-ranched 2 to 20 acres
   - Livestock / range use (less than 100 acres)
   - Livestock / range use (greater than 100 acres)
   - 10 to 100 acres irrigated
   - 100 to 500 acres irrigated
   - 500 or more acres irrigated
   - Other:

3. Do you believe additional storage is needed within the Nowood watershed?
   - More storage
   - Sufficient storage
   - Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
   - Irrigation
   - Flood protection
   - Fisheries
   - Water quality
   - Other:
5. How many acres are you entitled to irrigate?  
40 acres

6. On average, how many acres do you actually irrigate?  

7. On average, what dates do you start and stop irrigating?  

<table>
<thead>
<tr>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start before April 15</td>
<td>Stop before June 30</td>
</tr>
<tr>
<td>Start April 16 – April 30</td>
<td>Stop July 1 – July 15</td>
</tr>
<tr>
<td>Start May 1 – May 15</td>
<td>Stop July 16 – July 31</td>
</tr>
<tr>
<td>Start May 16 – May 31</td>
<td>Stop August 1 – August 15</td>
</tr>
<tr>
<td>Start June 1 – June 15</td>
<td>Stop August 15 – August 31</td>
</tr>
<tr>
<td>Start June 16 – June 30</td>
<td>Stop September 1 – September 15</td>
</tr>
<tr>
<td>Start after July 1</td>
<td>Stop September 16 – September 30</td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?  

<table>
<thead>
<tr>
<th>Duration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td></td>
</tr>
<tr>
<td>5-10 years</td>
<td></td>
</tr>
<tr>
<td>10-15 years</td>
<td></td>
</tr>
<tr>
<td>15 or more years</td>
<td></td>
</tr>
</tbody>
</table>

9. What best describes the reason you've been unable to irrigate?  

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other: ____________________

10. Which months during the irrigation season have you had problems irrigating?  

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [ ] More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [ ] More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- [ ] Alfalfa - yield _2_/acre
- [ ] Grass hay - yield _2-3_/acre
- [ ] Corn - yield ________/acre
- [ ] Oats - yield ________/acre
- [ ] Barley - yield ________/acre
- [ ] Other: ________/yield ________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- [ ] Water conservation/saving supplies
- [ ] Water shortage
- [ ] Water quality
- [ ] More storage is needed
- [ ] Water for agriculture
- [ ] No need for dams
- [ ] Floods and flood-related damages
- [x] Streambank erosion and loss of riparian lands
- [ ] Habitat for fisheries
- [ ] Habitat for wildlife
- [ ] Maintaining agriculture
- [x] Too much water
- [x] Runoff occurring too early to use
- [ ] Other:

15. How much would you be willing to pay for additional water?

- [ ] Not willing to pay for additional water
- [ ] Less than $5/acre-ft
- [ ] $5 - $10/acre-ft
- [x] $10 - $15/acre-ft
- [ ] $15 - $20/acre-ft
- [ ] $20 - $25/acre-ft
- [ ] More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

- Yes - phone
- Yes - email
- No
- Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

- Yes - by mail
- Yes - by email
- No

Optional Information:
- Name:
- Address:
- Email:
- Phone Number(s):

Additional Comments/Input:
### STAKEHOLDER SURVEY: RESERVOIR STORAGE - PURPOSE AND NEED

**Instructions** — Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting [http://www.acewater.com/Nowood.htm](http://www.acewater.com/Nowood.htm) or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. **Which portion of the watershed best defines your location?**
   - Main stem of Nowood River downstream of Paint Rock Creek
   - Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
   - East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - Tensleep Creek watershed above Nowood River
   - Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
   - Nowood River upstream of Mahogany Buttes
   - Other:

2. **What type of operation or land use best describes your land use?** (Please include consideration of leased lands in addition to deeded property)
   - No operation / in-town residential
   - Residential / non-farmed / non-ranched 2 to 20 acres
   - Livestock / range use (less than 100 acres)
   - Livestock / range use (greater than 100 acres)
   - 10 to 100 acres irrigated
   - 100 to 500 acres irrigated
   - 500 or more acres irrigated
   - Other:

3. **Do you believe additional storage is needed within the Nowood watershed?**
   - More storage
   - Sufficient storage
   - Don’t know

4. **If you believe more storage is needed, for what purpose would the stored water be used?**
   - Irrigation
   - Flood protection
   - Fisheries
   - Water quality
   - Other:
5. How many acres are you entitled to irrigate?

- 520 acres Home
- 80 acres Rented

6. On average, how many acres do you actually irrigate?

- 300 acres

7. On average, what dates do you start and stop irrigating?

- Start before April 15
- Start April 16 – April 30
- Start May 1 – May 15
- Start May 16 – May 31
- Start June 1 – June 15
- Start June 16 – June 30
- Start after July 1

- Stop before June 30
- Stop July 1 – July 15
- Stop July 16 – July 31
- Stop August 1 – August 15
- Stop August 15 – August 31
- Stop September 1 – September 15
- Stop September 16 – September 30
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10 -15 years
- 15 or more years

9. What best describes the reason you've been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other: ________________________________

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [X] More than 2.0 feet per acre

100 acre feet

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [X] More than 2.0 feet per acre

100 acre feet

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- [ ] Alfalfa — yield ___________ ton/acre
- [ ] Grass hay — yield ___________ ton/acre
- [ ] Corn — yield ___________ ton/acre
- [ ] Oats — yield ___________ ton/acre
- [ ] Barley — yield ___________ ton/acre
- [ ] Other: ___________ yield ___________ ton/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- [X] Water conservation/saving supplies
- [X] Water shortage
- [X] Water quality
- [X] More storage is needed
- [X] Water for agriculture
- [ ] No need for dams
- [X] Floods and flood-related damages
- [X] Streambank erosion and loss of riparian lands
- [X] Habitat for fisheries
- [X] Habitat for wildlife
- [X] Maintaining agriculture
- [ ] Too much water
- [ ] Runoff occurring too early to use
- [ ] Other:

15. How much would you be willing to pay for additional water?

- [ ] Not willing to pay for additional water
- [ ] Less than $5/acre-ft
- [ ] $5 - $10/acre-ft
- [X] $10 - $15/acre-ft
- [ ] $15 - $20/acre-ft
- [ ] $20 - $25/acre-ft
- [ ] More

Our current charges per acre on water right.
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☒ Yes – email
☐ No
☒ Other: Snail Mail

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☒ Yes – by mail
☒ Yes – by email
☐ No

Optional Information:

Name: [Blank]
Address: [Blank]
Email: [Blank]
Phone Number(s): [Blank]

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.owewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?

☐ Main stem of Nowood River downstream of Paint Rock Creek
☐ Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
☐ East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
☐ West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
☐ Tensleep Creek watershed above Nowood River
☐ Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
☐ Nowood River upstream of Mahogany Buttes
☐ Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)

☐ No operation / in-town residential
☐ Residential / non-farmed / non-ranched 2 to 20 acres
☐ Livestock / range use (less than 100 acres)
☐ Livestock / range use (greater than 100 acres)
☐ 10 to 100 acres irrigated
☐ 100 to 500 acres irrigated
☐ 500 or more acres irrigated
☐ Other:

3. Do you believe additional storage is needed within the Nowood watershed?

☐ More storage
☐ Sufficient storage
☐ Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?

☐ Irrigation
☐ Flood protection
☐ Fisheries
☐ Water quality
☐ Other:
5. How many acres are you entitled to irrigate?
- 250 acres

6. On average, how many acres do you actually irrigate?
- 200 acres

7. On average, what dates do you start and stop irrigating?
- **Start before April 15**
- **Stop before June 30**
- **Start April 16 – April 30**
- **Stop July 1 – July 15**
- **Start May 1 – May 15**
- **Stop July 16 – July 31**
- **Start May 16 – May 31**
- **Stop August 1 – August 15**
- **Start June 1 – June 15**
- **Stop August 15 – August 31**
- **Start June 16 – June 30**
- **Stop September 1 – September 15**
- **Start after July 1**
- **Stop September 16 – September 30**
- **Stop after August 15**
- **Stop after October 1**

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?
- **0**
- 1-5 years
- 5-10 years
- 10 -15 years
- 15 or more years

9. What best describes the reason you’ve been unable to irrigate?
- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

10. Which months during the irrigation season have you had problems irrigating?
- **May**
- **June**
- **July**
- **August**
- **September**
- **October**
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- Alfalfa - yield 6 T/acre
- Grass hay - yield ____/acre
- Corn - yield 190 Bu./acre
- Oats - yield ____/acre
- Barley - yield 140 Bu./acre
- Beans - yield ____/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?
- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

<table>
<thead>
<tr>
<th></th>
<th>Yes – phone</th>
<th>Yes – email</th>
<th>No</th>
<th>Other:</th>
</tr>
</thead>
</table>

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

<table>
<thead>
<tr>
<th></th>
<th>Yes – by mail</th>
<th>Yes – by email</th>
<th>No</th>
</tr>
</thead>
</table>

Optional Information:

- Name: [Redacted]
- Address: [Redacted]
- Email: [Redacted]
- Phone Number(s): [Redacted]
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:

- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. **Which portion of the watershed best defines your location?**

- [x] Main stem of Nowood River downstream of Paint Rock Creek
- [ ] Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- [ ] East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [ ] West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [ ] Tensleep Creek watershed above Nowood River
- [ ] Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- [ ] Nowood River upstream of Mahogany Buttes
- [ ] Other:

2. **What type of operation or land use best describes your land use?** (Please include consideration of leased lands in addition to deeded property)

- [ ] No operation / in-town residential
- [ ] Residential / non-farmed / non-ranched 2 to 20 acres
- [ ] Livestock / range use (less than 100 acres)
- [ ] Livestock / range use (greater than 100 acres)
- [ ] 10 to 100 acres irrigated
- [x] 100 to 500 acres irrigated
- [ ] 500 or more acres irrigated
- [ ] Other:

3. **Do you believe additional storage is needed within the Nowood watershed?**

- [x] More storage
- [x] Sufficient storage
- [ ] Don’t know
- [x] No

4. **If you believe more storage is needed, for what purpose would the stored water be used?**

- [ ] Irrigation
- [ ] Flood protection
- [ ] Fisheries
- [ ] Water quality
- [ ] Other:
5. How many acres are you entitled to irrigate?
- 600 acres

6. On average, how many acres do you actually irrigate?
- 200 acres

7. On average, what dates do you start and stop irrigating?
- Start before April 15
- Start April 16 - April 30
- Start May 1 - May 15
- Start May 16 - May 31
- Start June 1 - June 15
- Start June 16 - June 30
- Start after July 1
- Stop before June 30
- Stop July 1 - July 15
- Stop July 16 - July 31
- Stop August 1 - August 15
- Stop August 15 - August 31
- Stop September 1 - September 15
- Stop September 16 - September 30
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?
- 0
- 1-5 years
- 5-10 years
- 10-15 years
- 15 or more years

9. What best describes the reason you've been unable to irrigate?
- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

10. Which months during the irrigation season have you had problems irrigating?
- May
- June
- July
- August
- September
- October
### 11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [ ] More than 2.0 feet per acre

### 12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- [ ] No additional water/not supply-limited
- [ ] 0 to 0.5 feet per acre
- [ ] 0.5 to 1.0 feet per acre
- [ ] 1.0 to 1.5 feet per acre
- [ ] 1.5 to 2.0 feet per acre
- [ ] More than 2.0 feet per acre

### 13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- [ ] Alfalfa — yield 2 ton/acre
- [ ] Grass hay — yield 2 ton/acre
- [ ] Corn — yield _______/acre
- [ ] Oats — yield _______/acre
- [ ] Barley — yield _______/acre
- [ ] Other: _______/acre

### 14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- [ ] Water conservation/saving supplies
- [ ] Water shortage
- [ ] Water quality
- [ ] More storage is needed
- [ ] Water for agriculture
- [ ] No need for dams
- [ ] Floods and flood-related damages
- [ ] Streambank erosion and loss of riparian lands
- [ ] Habitat for fisheries
- [ ] Habitat for wildlife
- [ ] Maintaining agriculture
- [ ] Too much water
- [ ] Runoff occurring too early to use
- [ ] Other:

### 15. How much would you be willing to pay for additional water?
- [ ] Not willing to pay for additional water
- [ ] Less than $5/acre-ft
- [ ] $5 - $10/acre-ft
- [ ] $10 - $15/acre-ft
- [ ] $15 - $20/acre-ft
- [ ] $20 - $25/acre-ft
- [ ] More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?
- Yes - phone
- Yes - email
- No
- Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?
- Yes - by mail
- Yes - by email
- No

Optional Information:

Name:
Address:
Email:
Phone Number(s):

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:
- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
- [ ] Main stem of Nowood River downstream of Paint Rock Creek
- [ ] Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- [ ] East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [X] West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- [ ] Tensleep Creek watershed above Nowood River
- [ ] Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- [ ] Nowood River upstream of Mahogany Buttes
- [ ] Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
- [ ] No operation / in-town residential
- [ ] Residential / non-farmed / non-ranched 2 to 20 acres
- [ ] Livestock / range use (less than 100 acres)
- [X] Livestock / range use (greater than 100 acres)
- [ ] 10 to 100 acres irrigated
- [ ] 100 to 500 acres irrigated
- [ ] 500 or more acres irrigated
- [ ] Other:

3. Do you believe additional storage is needed within the Nowood watershed?
- [X] More storage
- [ ] Sufficient storage
- [ ] Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
- [X] Irrigation
- [ ] Flood protection
- [ ] Fisheries
- [ ] Water quality
- [ ] Other:
5. How many acres are you entitled to irrigate?

____ acres

6. On average, how many acres do you actually irrigate?

____ acres

7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Channel</td>
</tr>
<tr>
<td>April 16 - April 30</td>
<td>July 1 - July 15</td>
</tr>
<tr>
<td>May 1 - May 15</td>
<td>July 16 - July 31</td>
</tr>
<tr>
<td>May 16 - May 31</td>
<td>August 1 - August 15</td>
</tr>
<tr>
<td>June 1 - June 15</td>
<td>August 15 - August 31</td>
</tr>
<tr>
<td>June 16 - June 30</td>
<td>September 1 - September 15</td>
</tr>
<tr>
<td>After July 1</td>
<td>After October 1</td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

<table>
<thead>
<tr>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1-5 years</td>
</tr>
<tr>
<td>5-10 years</td>
</tr>
<tr>
<td>10-15 years</td>
</tr>
<tr>
<td>15 or more years</td>
</tr>
</tbody>
</table>

9. What best describes the reason you’ve been unable to irrigate?

<table>
<thead>
<tr>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not apply to me</td>
</tr>
<tr>
<td>My water rights are junior / calls placed on the river</td>
</tr>
<tr>
<td>There was not water physically available</td>
</tr>
<tr>
<td>My diversion structure(s) could not divert at low flow</td>
</tr>
<tr>
<td>Other:</td>
</tr>
</tbody>
</table>

10. Which months during the irrigation season have you had problems irrigating?

<table>
<thead>
<tr>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
</tr>
<tr>
<td>June</td>
</tr>
<tr>
<td>July</td>
</tr>
<tr>
<td>August</td>
</tr>
<tr>
<td>September</td>
</tr>
<tr>
<td>October</td>
</tr>
</tbody>
</table>
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?
- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]
- Alfalfa - yield ________/acre
- Grass hay - yield ________/acre
- Corn - yield ________/acre
- Oats - yield ________/acre
- Barley - yield ________/acre
- Other: ________/yield ________/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]
- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?
- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☐ Yes – email
☐ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☐ Yes – by mail
☐ Yes – by email
☐ No

Optional Information:

Name:

Address:

Email:

Phone Number(s):

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:

- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trhydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?
   - Main stem of Nowood River downstream of Paint Rock Creek
   - Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
   - East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
   - Tensleep Creek watershed above Nowood River
   - Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
   - Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)
   - No operation / in-town residential
   - Residential / non-farmed / non-ranch 2 to 20 acres
   - Livestock / range use (less than 100 acres)
   - Livestock / range use (greater than 100 acres)
   - 10 to 100 acres irrigated
   - 100 to 500 acres irrigated
   - 500 or more acres irrigated
   - Other:

3. Do you believe additional storage is needed within the Nowood watershed?
   - More storage
   - Sufficient storage
   - Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?
   - Irrigation
   - Flood protection
   - Fisheries
   - Water quality
   - Other:
5. How many acres are you entitled to irrigate?
280 acres

6. On average, how many acres do you actually irrigate?
280 acres once 100 twice

7. On average, what dates do you start and stop irrigating?

- Start before April 15
- Start April 16 - April 30
- Start May 1 - May 15
- Start May 16 - May 31
- Start June 1 - June 15
- Start June 16 - June 30
- Start after July 1
- Stop before June 30
- Stop July 1 - July 15
- Stop July 16 - July 31
- Stop August 1 - August 15
- Stop August 15 - August 31
- Stop September 1 - September 15
- Stop September 16 - September 30
- Stop after October 1

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10 -15 years
- 15 or more years

9. What best describes the reason you’ve been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:
  - Dry years

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa – yield _______/acre
- Grass hay – yield _______/acre
- Corn – yield _______/acre
- Oats – yield _______/acre
- Barley – yield _______/acre
- Other: _______/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other:

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes – phone
☒ Yes – email
☐ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☐ Yes – by mail
☒ Yes – by email
☐ No

Optional Information:

Name: 
Address: 
Email: 
Phone Number(s):

Additional Comments/Input:
STAKEHOLDER SURVEY: RESERVOIR STORAGE – PURPOSE AND NEED

Instructions – Please answer as many or as few of the questions as you are comfortable with. For each question check each box that applies, in some cases more than one box may be checked. The more information that is provided to the project team, the more likely the results are to be representative of conditions experienced by users in the Nowood watershed. Any information or input you provide is greatly appreciated. You may choose to provide your name and contact information at the bottom of the survey.

You may obtain additional information on the Project by visiting http://www.acewater.com/Nowood.htm or by contacting:

- Jay Schug, Project Manager, Anderson Consulting Engineers, 970.226.0120
- Mark Donner, Assistant Project Manager, Trihydro Corporation, 307.745.7474

1. Which portion of the watershed best defines your location?

- Main stem of Nowood River downstream of Paint Rock Creek
- Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood
- East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek
- Tensleep Creek watershed above Nowood River
- Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte
- Nowood River upstream of Mahogany Buttes
- Other:

2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)

- No operation / in-town residential
- Residential / non-farmed / non-ranched 2 to 20 acres
- Livestock / range use (less than 100 acres)
- Livestock / range use (greater than 100 acres)
- 10 to 100 acres irrigated
- 100 to 500 acres irrigated
- 500 or more acres irrigated
- Other:

3. Do you believe additional storage is needed within the Nowood watershed?

- More storage
- Sufficient storage
- Don’t know

4. If you believe more storage is needed, for what purpose would the stored water be used?

- Irrigation
- Flood protection
- Fisheries
- Water quality
- Other:
5. How many acres are you entitled to irrigate?

\[
\text{\underline{200}} \text{ acres}
\]

6. On average, how many acres do you actually irrigate?

\[
\text{\underline{160}} \text{ acres}
\]

7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Stop Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start before April 15</td>
<td>Stop before June 30</td>
</tr>
<tr>
<td>Start April 16 - April 30</td>
<td>Stop July 1 - July 15</td>
</tr>
<tr>
<td>Start May 1 - May 15</td>
<td>Stop July 16 - July 31</td>
</tr>
<tr>
<td>Start May 16 - May 31</td>
<td>Stop August 1 - August 15</td>
</tr>
<tr>
<td>Start June 1 - June 15</td>
<td>Stop August 15 - August 31</td>
</tr>
<tr>
<td>Start June 16 - June 30</td>
<td>Stop September 1 - September 15</td>
</tr>
<tr>
<td>Start after July 1</td>
<td>Stop September 16 - September 30</td>
</tr>
<tr>
<td></td>
<td>Stop after October 1</td>
</tr>
</tbody>
</table>

8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

- 0
- 1-5 years
- 5-10 years
- 10-15 years
- 15 or more years

9. What best describes the reason you've been unable to irrigate?

- Does not apply to me
- My water rights are junior / calls placed on the river
- There was not water physically available
- My diversion structure(s) could not divert at low flow
- Other:

\[
\underline{\text{Other:}}
\]

10. Which months during the irrigation season have you had problems irrigating?

- May
- June
- July
- August
- September
- October
NOWOOD
River Storage - Level II Study

11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

- No additional water/not supply-limited
- 0 to 0.5 feet per acre
- 0.5 to 1.0 feet per acre
- 1.0 to 1.5 feet per acre
- 1.5 to 2.0 feet per acre
- More than 2.0 feet per acre

13. What crop(s) do you typically grow and on average, what are your yields per acre for each? [Multiple answers]

- Alfalfa - yield _____4.7_____/acre
- Grass hay - yield _____3.4_____/acre
- Corn - yield _____/acre
- Oats - yield _____/acre
- Barley - yield _____/acre
- Other: _______/yield _______/acre

14. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

- Water conservation/saving supplies
- Water shortage
- Water quality
- More storage is needed
- Water for agriculture
- No need for dams
- Floods and flood-related damages
- Streambank erosion and loss of riparian lands
- Habitat for fisheries
- Habitat for wildlife
- Maintaining agriculture
- Too much water
- Runoff occurring too early to use
- Other: _______ livestock water

15. How much would you be willing to pay for additional water?

- Not willing to pay for additional water
- Less than $5/acre-ft
- $5 - $10/acre-ft
- $10 - $15/acre-ft
- $15 - $20/acre-ft
- $20 - $25/acre-ft
- More
16. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

☐ Yes - phone
☐ Yes - email
☐ No
☐ Other:

17. Would you like to receive future information regarding the project (update flyers/meeting notices)?

☒ Yes - by mail
☐ Yes - by email
☐ No

Optional Information:
Name: [Redacted]
Address: [Redacted]
Email: [Redacted]
Phone Number(s): [Redacted]

Additional Comments/Input:
### 1. Which portion of the watershed best defines your location?

<table>
<thead>
<tr>
<th>Response Description</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main stem of Nowood River downstream of Paint Rock Creek</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Paint Rock Creek / Medicine Lodge Creek / Alkali Creek watershed (or other tributary) above confluence with Nowood</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>East of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>West of Nowood River upstream of Paint Rock Creek and downstream of Tensleep Creek</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Tensleep Creek watershed above Nowood River</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Nowood River upstream of Tensleep Creek and downstream of Mahogany Butte</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Nowood River upstream of Mahogany Buttes</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

**answered question:** 2

**skipped question:** 0

---

**Nowood - River Storage - Level II Study**

1 of 11
2. What type of operation or land use best describes your land use? (Please include consideration of leased lands in addition to deeded property)

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No operation / in-town residential</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Residential / non-farmed / non-ranched 2 to 20 acres</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Livestock / range use (less than 100 acres)</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Livestock / range use (greater than 100 acres)</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>10 to 100 acres irrigated</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>100 to 500 acres irrigated</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>500 or more acres irrigated</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

2 answered question, 0 skipped question

3. Do you believe additional storage is needed within the Nowood watershed?

<table>
<thead>
<tr>
<th>Storage Option</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>More storage</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Sufficient storage</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>50.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

2 answered question, 0 skipped question
4. If you believe more storage is needed, for what purpose would the stored water be used?

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Flood protection</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Fisheries</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Water quality</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0

5. How many acres are you entitled to irrigate?

Response Count
1

answered question 1
skipped question 1

6. On average, how many acres do you actually irrigate?

Response Count
1

answered question 1
skipped question 1
### 7. On average, what dates do you start and stop irrigating?

<table>
<thead>
<tr>
<th>Start Date</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before April 15</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>April 16 - April 30</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>May 1 - May 15</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>May 16 - May 31</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>June 1 - June 15</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>June 16 - June 30</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>After July 1</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Before June 30</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>July 1 - July 15</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>July 16 - July 31</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>August 1 - August 15</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>August 16 - August 31</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>September 1 - September 15</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>September 16 - September 30</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>After October 1</td>
<td>50.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

- **answered question**: 2
- **skipped question**: 0
8. How many years during the last 20 years have you been unable to irrigate the acres you typically irrigate, for a portion of the season?

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>1-5 years</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>5-10 years</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>10-15 years</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>15 or more</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0

9. What best describes the reason you’ve been unable to irrigate?

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not apply to me</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>My water rights are junior / calls placed on the river</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>There was not water physically available</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>My diversion structure(s) could not divert at low flow</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0
10. Which months during the irrigation season have you had problems irrigating?

<table>
<thead>
<tr>
<th>Month</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>September</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>October</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

 answered question 2
 skipped question 0

11. How much additional water would you need to overcome the shortages you have experienced on the acres you typically irrigate?

<table>
<thead>
<tr>
<th>Water Requirement</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional water/not supply-limited</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>0 to 0.5 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>0.5 to 1.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>1.0 to 1.5 feet per acre</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>1.5 to 2.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>More than 2.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

 answered question 2
 skipped question 0
12. How much additional water would you need to fully irrigate all the acres you are entitled to irrigate?

<table>
<thead>
<tr>
<th>Water Requirement</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional water/not supply-limited</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>0 to 0.5 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>0.5 to 1.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>1.0 to 1.5 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>1.5 to 2.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>More than 2.0 feet per acre</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0

13. What crop(s) do you typically grow?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Grass hay</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Corn</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Oats</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Barley</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0
14. On average, what are your yields per acre of each?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield/Acre</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td></td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Grass Hay</td>
<td></td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Corn</td>
<td></td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question: 2

skipped question: 0
15. What do you think are the most important water issues in the Nowood Watershed? [Multiple answers]

<table>
<thead>
<tr>
<th>Issue</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water conservation/saving supplies</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Water shortage</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Water quality</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>More storage is needed</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td><strong>Water for agriculture</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>No need for dams</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Floods and flood-related damages</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Streambank erosion and loss of riparian lands</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Habitat for fisheries</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Habitat for wildlife</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Maintaining agriculture</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Too much water</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Runoff occurring too early to use</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question: 2

skipped question: 0
16. How much would you be willing to pay for additional water?

<table>
<thead>
<tr>
<th>Not willing to pay for additional water</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $5/acre-ft</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>$5 - $10/acre-ft</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>$10 - $15/acre-ft</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>$15 - $20/acre-ft</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>$20 - $25/acre-ft</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>More</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0

17. Would you be willing to be contacted to provide input on the Nowood River Storage, Level II Study?

<table>
<thead>
<tr>
<th>Yes – phone</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes – email</td>
<td>50.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 0
18. Would you like to receive future information regarding the project (update flyers/meeting notices)?

<table>
<thead>
<tr>
<th></th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes – by mail</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Yes – by email</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td>100.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

19. Optional Information:

<table>
<thead>
<tr>
<th></th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>Address:</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Email:</td>
<td>50.0%</td>
<td>1</td>
</tr>
<tr>
<td>Phone Number(s):</td>
<td>50.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

20. Additional Comments/Input:

<table>
<thead>
<tr>
<th></th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>0</td>
</tr>
<tr>
<td>skipped question</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX C

STATEMOD MODEL TECHNICAL MEMORANDUMS

C1. AUGUST 2010 STAGE 1 TECHNICAL MEMORANDUM
C2. APRIL 2011 STAGE 2 TECHNICAL MEMORANDUM
C3. STATEMOD DEMANDS AND SHORTAGES SIMULATIONS
C4. FEBRUARY 2013 STAGE 3 TECHNICAL MEMORANDUM
APPENDIX C1

AUGUST 2010 STAGE 1 TECHNICAL MEMORANDUM
TECHNICAL MEMORANDUM

TO:        Joel Farber, Trihydro Corporation
FROM:      Rick Parsons
DATE:      August 10, 2010
RE:        Nowood Level II Study Task Order 1 – Initial Development of a Skeleton StateMod Model

Introduction
The general approach for the Wyoming StateMod modeling efforts is to use the spreadsheet models as a basis for the input file development and expanding the input time series to include monthly and annual variability over the model study period. The Nowood Model has the benefit of a Hydrologic Database (Database), including Microsoft Access calculation macros, that will be used as a basis for development of the StateMod input data set, rather than use of the Excel spreadsheet calculations common to other Basin Plan Models.

Although the model network from the previous modeling efforts will be used in the Level II Study, much of the historical data are missing. The StateMod model requires monthly input data that is complete (i.e., no missing data). This requires a significant amount of effort beyond the approach of the Wyoming Basin Plans that develop monthly averages of input data for three hydrologic years (wet, dry, and average). Therefore, the initial development of the StateMod model completed under Task Order 1 consisted of 1) Development of the model network using the standard StateMod approach, 2) Identifying the various input data necessary for the model and which of the data developed in the 2010 River Basin Plan Update (2010 Update, including the Draft Report) can be used for the StateMod model, and 3) Making specific recommendations to include more model nodes, gather more recorded data, and identify approaches to fill missing data and develop future demand data in order to develop the complete data set required by StateMod. The latter recommendations should be carried out under Task Order 2, after which the model will be ready to be run to estimate natural flows and simulate shortages to irrigation demands that might be reduced in the future through development of storage reservoirs and/or modifications to existing system operations.

Approach
The components of the StateMod model network data set are discussed below to provide the reviewer with a general understanding of the information necessary for use in model. The models developed and associated documentation from previous modeling efforts have been reviewed for this effort. Similarly, the Database has been reviewed. Although the available data and algorithms used in those studies are summarized herein, subsequent review of these sources is expected to produce additional information not gathered from initial review of these sources.

The information presented herein is intended to identify discussion points for WWDC and the Study consultants regarding additional data needs and modeling protocols to be used for the hydrologic analyses.

1. Model Network – The model network diagram represents physical connectivity of model nodes (upstream to downstream order). The network diagram is not used directly by
StateMod. The River Network File is a text file developed from the river network diagram that is input to the model.

The model network includes locations (i.e., nodes) where you have, or want to have, information. This includes gages, diversions, reservoirs, and instream flow points/reaches. A river network diagram was developed from the layout of the spreadsheet model using the GUI-based Data Management Interface software StateDMI that is integrated with development of StateMod input files. The surface water storage reservoirs identified in the Level I Study were included in the model network. Reservoirs identified in the Level II Study and other tributaries and model nodes will be included, excluded, and revised as model development progresses.

All data in the StateMod data sets center on the node identification (ID) number. A copy of the model network diagram and associated river network file are attached to the end of this memorandum. The following approach for node names, developed in other Wyoming basin StateMod models, is used here:

a. Gages – Based on USGS IDs. For example, ID 06270000 for Nowood River near Tensleep, Wyoming gage.

b. Diversions – Based on 2-digit Water District followed by 5-digit ID (additional zeros are included to make the ID 7 digits long). For example, Basin Plan Model node 9.0150 is set to ID 0900150.

c. Reservoirs – Developed using alphabetic name. For example, ID CarothersLk for Carothers Lake.

d. Instream Flow Points/Reaches – To be developed using alphabetic name if instream flows added later during model development.

2. Gages – Gages are represented in the model based on the location on the river. Input data for gages include the historical time series of flows recorded at the gages, which are used to estimate natural flows in the model area. Complete time series are required in the model input data sets. The 2010 Update used a 1973 through 2008 study period, which is appropriate for use with the StateMod model. Therefore, complete 1973 through 2008 monthly data sets are required for all time series.

Linear regressions for main stem gages and “regional equations” for tributary inflow gages were used in the spreadsheet model. Questions have been raised regarding previous estimates of tributary inflows to the southern reaches of the Nowood River basin. These estimates and those for all gages will be reviewed, and other gage data and data filling algorithms analyzed to develop the complete time series of stream flow data and inflow data required for the model. Gage data from nearby tributaries, including data collected pursuant to the Level I Study, and seasonal streamflow data collected by the Wyoming SEO will be reviewed to determine the applicability of using these data in development of gages flows throughout the basin.
Seven (7) stream gages are included in the spreadsheet model. None of these gages is active. The top of each modeled tributary is modeled as an inflow gage. The model network, as currently set up, includes 25 tributary inflow points. Time series of inflows are necessary for these nodes in the model data set.

An approach to estimating ungaged tributary basin inflows frequently used in StateMod modeling efforts is called the “neighboring gage” approach. In this approach, GIS analysis is used to calculate tributary drainage areas and average annual precipitation amounts over the drainage areas. These values are used to estimate upper basin inflows based on the ratio of the drainage area times the average precipitation at the ungaged location: drainage area times precipitation at the gaged location. This approach results in the same shape of runoff hydrograph at both the gaged and ungaged location. If this is not considered appropriate, the approach can be revised to estimate annual runoff volumes via the neighboring gage approach and to then distribute those volumes over the year based on a different pattern than the gage with the original recorded data.

All gage filling will be conducted using the TSTool DMI (Time Series Tool) that supports the development of input files of time series (e.g., gage flows, diversions, and storage contents) for use with the StateMod model.

Other than gages, all nodes have Structure files, summarizing physical characteristics; Rights files, summarizing priority dates and amounts; and a Demands file, summarizing monthly time series of demands to be met with legally available flows during model simulation.

3. Diversion Nodes – A total of fifty-six (56) diversion nodes in the spreadsheet model are used to represent the 311 irrigated acreage polygons included in the Database. The spreadsheet model nodes represent an individual diversion (15 explicit nodes) or a combination of diversions that are aggregated based on the close physical proximity of multiple smaller users (41 aggregate nodes). The 2010 Update indicates explicit nodes represent diversions greater than 10 cfs or are used for reaches with only a single diversion structure.

   a. Structure file information for diversion nodes include ID; Location of diversion headgate; Ditch name; Ditch capacity; Irrigated acreage and crop type; Monthly efficiencies; and Return flow locations and timing. The ideal situation is to have a one-to-one-to-one correspondence between Ditch headgate location, Amount/type of irrigated acreage, and Water right. This correlation provides the model with the best input to estimate divertible flow in priority, system efficiencies, and return flow locations that impact natural flows in the system.

   i. IDs are input as discussed in Step 1b.

   ii. Diversion Headgates – Currently set up based on the relative order of nodes in the spreadsheet model network.

      1. Explicit Nodes - Based on review of the ditch layouts from topographical quadrangles, it appears the river diversion locations for some of the explicit nodes should be modified. A first step for this would be to do a brief review of the GIS coverages from the 2003
Basin Plan and 2010 Update. If warranted, further GIS review should be conducted.
   a. Municipal demands can be represented explicitly, with a presumed full water supply, if it is desirable to have these consumptive uses represented separately in the model.

2. Aggregate Nodes – The StateMod approach for aggregate nodes is to identify a common diversion location for the multiple structures included in the aggregate above or below other model nodes (e.g., ditches, reservoirs, and gages). This approach allows representation of the operations and consumptive uses for smaller ditches without including the detail used in the model for the explicit nodes. A brief review of the GIS coverages may result in recommendations to revise the current set up of aggregate structures in the model.

   iii. Ditch Names are pulled from the Database.

   iv. Ditch Capacity - All ditches assigned 999 cfs capacity in order to not limit simulated diversions. Variations on this approach can be incorporated for situations where ditch layout, topography, geology, operational issues, etc. limit water delivery to irrigated fields.

   v. Irrigated Acreage – A total of 21,876 acres is represented with individual nodes ranging from 6.7 acres to 2,567.2 acres. A small amount of acreage assigned to some of the explicit nodes and larger acreage amounts assigned to some of the individual ditches in the aggregate nodes further supports re-assessment of the node locations / assignments.

   1. Crop types used in the 2010 Update are based on the location of the irrigated parcel and associated County Agricultural Statistics. These assignments result in crops unlikely to be irrigated in certain locations within the Nowood River basin (e.g., row crops and vegetable crops). Crop types assigned to irrigated areas should be reviewed based on information learned during the Level I Study or information from local irrigators.

   2. Although the Database includes agricultural statistics from 1926 through 2008, the crop types used in the 2010 Update represent averages over the 2004 through 2006 period. Acreage and crop types can vary by structure by year in the StateMod model. The acreage and crop type(s) assigned to the diversion nodes can be repeated for each year of the study period if more detailed data are not available for input to the model.

   3. Sub-irrigated acreage in Big Horn and Washakie Counties is identified in the 2010 Update (Table 14, page 54). Sub-irrigated acreage is not typically represented explicitly in the StateMod model data sets unless that acreage is actively irrigated with water diverted pursuant to a water right. Sub-irrigated acreage can be implicitly represented by increasing maximum farm efficiency inputs to the model to illustrate a “second” use of direct flow water to sub-irrigated lands.
vi. Monthly Efficiencies – Monthly efficiencies developed in the 2003 Basin Plan, which were based on previous studies, were used in the 2010 Update. Ideally, efficiencies would be calculated based on historical irrigation water requirements for model nodes and complete records of historical diversions for those nodes. Without these data for making those estimates, and similar to past Wyoming StateMod model efforts, representative efficiencies will be developed for groups of structures based on common acreages, seniority of water rights, locations near or far from the river, etc. Any recommended changes to the approach used in the spreadsheet model will be highlighted and discussed with WWDC.

vii. Return flow locations and timing will be taken directly from the 2010 Update.

b. Direct Flow Rights will be developed from the database originally developed by Forrest Sentinella. The database includes priority dates and amounts associated with various ditches. These rights will be summarized by ditch and by diversion node in the model. A summary of the rights and any issues identified in review of the database will be provided to WWDC for review and comment.

i. Lands with Water Awards (i.e., a 1968 priority) are identified in the 2010 Update (Table 14, page 54). It is not clear what these awards are, but they can be included as separate water rights associated with diversion nodes if the awards are present in the Nowood River basin.

ii. Tribal rights are noted in the 2010 Update (Table 8, page 27). It is not clear if any of these rights affect Nowood River basin operations, but these rights can be incorporated into the StateMod model if associated with a specific demand.

c. Diversion Demands represent river headgate demands and will be calculated based on monthly crop irrigation requirement (CIR) for irrigated crops divided by average monthly system efficiencies.

d. Historical Diversions are required on a monthly basis and used to calculate natural flows in the model area. The Database includes continuous data and spot data over variable periods for some of the ditches modeled in the Wind / Bighorn basins. The 2010 Update apparently included data available from the 2002 through 2008 Hydrographers records. Diversion data for structures in the Nowood River basin in the Database appear to include only spot data measurements for the Anita Ditch. If possible, local irrigators should be contacted to determine if additional data might be available beyond that included in the Database. Thereafter, the approach used for filling missing diversion data in the StateMod model development for other Wyoming river basins is recommended:

i. Missing diversion data can be filled based on a) Historical CIR divided by monthly system efficiencies (Step 3. a. vi.) to estimate historical river demands, and b) Representative days per month of supply from other studies or information from local irrigators to represent water-supply limited historical diversions. For example, if structures in the basin or on a tributary divert water an average of 18 days during July, historical monthly July diversions would be set equal to calculated CIR times 60 percent, based on 18 days divided by 31 days during the month.
4. Reservoir Nodes – Meadowlark Lake and Carothers Lake are included in the spreadsheet model. The seven Priority 1 reservoirs identified in the Level I Study were included in the model network as placeholders for future scenario runs. Other existing reservoirs (e.g., Renner Lake) and projected reservoirs can be easily added to the model network.
   a. Structure file information for reservoir nodes include ID; Storage capacity (dead and active); Account ownership; Area-Capacity-Seepage tables; and Net evaporation data.
      i. IDs are input as discussed in Step 1c.
      ii. Storage capacity input and Area-Capacity-Seepage tables – These data will be developed for existing reservoirs from reservoir operators; and for future reservoirs based on topographic review. All future reservoirs will be assumed to have no dead storage, unless otherwise directed by reservoir operators.
      iii. Account Ownership - All reservoirs will be assigned one account holder, unless otherwise directed by reservoir operators.
      iv. Net evaporation data will be taken directly from the 2010 Update.
   b. Storage Rights (priorities and amounts) will be developed based on information learned during the Level I Study or information from local irrigators. Storage rights for potential reservoirs will be assigned 2010 priority dates to ensure the storage rights are junior to all other modeled rights. Potential reservoir storage rights will be assigned an amount equal to planned storage capacity. Reservoir storage will be operated based on Wyoming Water Law, including a one-fill limit over the October through September period with October 1 storage contents counted against the one-fill storage volume.
   c. Reservoir Demands are set to monthly storage target contents. The monthly targets will be set to capacity for all reservoirs in the model.

5. Instream Flow Points / Reaches – Instream flows can be modeled at a single location or over a reach of the river that might encompass other uses (e.g., from tributary headwaters to confluence with main stem). Instream flow points are also used to represent reservoir bypass flows.
   a. Structure file information for instream flow nodes includes ID and Location on the river or upstream and downstream termini of reaches.
      i. IDs are input as discussed in Step 1d.
      ii. Locations will be identified if instream flows are added later during model development. Specific instream flows noted in the 2010 Update include the following:
         • Permitted right on Tensleep Creek (22 cfs)
         • Permitted right on Tensleep Creek at Wigwam Hatchery (4.7 cfs)
         • Pending right Medicine Lodge Creek (9 cfs to 20 cfs)
         • Other potential rights, including Federal Reserve rights to maintain instream flows within National Forest boundaries; whitewater rafting reaches, etc.
b. Instream Flow Rights are set to permitted values at rates equal to the highest monthly rates used for modeling instream flow demands (see below).

c. Instream Flow Demands are set to monthly rates based on permits or other associated filing information related to the instream flow points / reaches.

6. Operating rules – the Basin Plan model does not operate storage reservoirs to meet downstream demands. Operating rules will be added for new storage reservoirs and to mimic reservoir operations with the existing reservoirs (Meadowlark Lake and Carothers Lake) using the StateMod operating rules input file. Other generic rules are available for use in the StateMod model, including carrier diversion to storage, reservoir release to instream flow; release to diversion structures and other reservoirs, either directly or by exchange.

Operating rules are assigned priorities by the user so that the model can simulate the operations in the context of other input water right priorities for direct flow, storage, and instream flow uses. Priorities assigned to carrier diversions to storage are typically set equal to the priority of the storage right. Priorities assigned to reservoir release rules are typically assigned just junior to the primary right (direct flow or instream flow) used to satisfy the recipient demand. This is appropriate since reservoir releases are generally supplemental water supplies used to satisfy the destination demand.

Different references to the Yellowstone River Compact are made in the 2010 Update. Although it is not clear if or how the Compact impacts model runs in the Nowood River basin, StateMod includes different operating rules that can be used to represent a total or partial limitation on diversions due to Compact obligations.

Model Scenarios
StateMod model scenarios will be run to a) Estimate natural flows, 2) Simulate historical conditions (i.e., gage flows) based on estimated natural flows and historical structure demands (river diversions and end-of-month contents), limited by administrative constraints (direct flow and storage water rights and operating rules), and 3) Simulate future conditions based on estimated natural flows and future structure demands (river headgate demands to meet full CIR, storage capacity targets, instream flow amounts), limited by administrative constraints (direct flow and storage water rights and operating rules).

Scenario 2 is the step where model calibration would typically be executed. Successful model calibration is generally defined by the ability of the model to adequately represent historical gage flows, diversions, and storage end-of-month contents based on input natural flows. Although recent stream gage installation and recording is helpful, the extent of historical gage and diversion data in the basin is insufficient to support model calibration.

Instead, Scenario 2 will be simulated to determine the ability of model inputs to mimic actual historical monthly gage data records. This approach is similar to the Calibration run in the 2010 Update that is used to estimate gains and losses for use in subsequent model runs. Modifications
to estimated input diversions, return flow locations and timing in the StateMod model will be made to better mimic historical gage flows in Scenario 2.

Comments
From the hydrological modeling standpoint, one recommendation coming out of the Level II Study will be to increase the amount and frequency of record keeping of water uses in the basin. This is especially true for river headgate diversions since those records are necessary to better understand system efficiencies, and amount and timing of return flows. More diversion records and gage records will be necessary to improve to model representation of natural flow hydrology and estimates of legally available flow.

Another recommendation, as discussed in Section 3. a., is for better mapping and correlation of Ditch headgate locations, Amounts of irrigated acreage, and Water rights serving those lands. This correlation will improve the model’s ability to estimate natural flows and to simulate legally divertible flows to meet various demands.
SEE <NowoodNetworkDiagram.jng> ATTACHED TO EMAIL FOR GRAPHIC OF NETWORK DIAGRAM

RIVER NETWORK FILE (nowood.rin) – Note IDs limited to 12 characters and Names limited to 20 characters in *.rin file printout

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>0902760</td>
<td>Alkali Ck Inflow</td>
</tr>
<tr>
<td>0902765</td>
<td>Alkavale Ditch</td>
</tr>
<tr>
<td>0902701</td>
<td>Medicine Lodge Ck In</td>
</tr>
<tr>
<td>0902710</td>
<td>Loretta Ditch</td>
</tr>
<tr>
<td>06273000</td>
<td>MedicineLodgeCkNrHyatvi</td>
</tr>
<tr>
<td>0902717</td>
<td>MedicineLodgeCkDivns</td>
</tr>
<tr>
<td>0902720</td>
<td>Enl. Highland Ditch</td>
</tr>
<tr>
<td>0902725</td>
<td>Anita Ditch</td>
</tr>
<tr>
<td>0902728</td>
<td>Bayne-George Ditch</td>
</tr>
<tr>
<td>06272500</td>
<td>PaintRockCkNrHyattvi</td>
</tr>
<tr>
<td>0902738</td>
<td>Big Bear Ditch</td>
</tr>
<tr>
<td>0902740</td>
<td>Elk Ditch</td>
</tr>
<tr>
<td>0902742</td>
<td>Go-Ahead Ditch</td>
</tr>
<tr>
<td>0902744</td>
<td>Military Ditch</td>
</tr>
<tr>
<td>0902746</td>
<td>Anita Supplemental D</td>
</tr>
<tr>
<td>0902748</td>
<td>PaintRockCDivAbMedLo</td>
</tr>
<tr>
<td>0902755</td>
<td>PaintRockCDivBlMedLo</td>
</tr>
<tr>
<td>0902775</td>
<td>Bernstein No. 2 Ditch</td>
</tr>
<tr>
<td>0902785</td>
<td>Weintz Ditch</td>
</tr>
<tr>
<td>0902790</td>
<td>Bernstein No. 1 Ditch</td>
</tr>
<tr>
<td>0902792</td>
<td>PaintRockCDivAbMouth</td>
</tr>
<tr>
<td>06273500</td>
<td>Paint Rock Ck nr Mou</td>
</tr>
<tr>
<td>0902795</td>
<td>PaintRockCDivBlMouth</td>
</tr>
<tr>
<td>0902510</td>
<td>Gomer No. 1 Well Inf</td>
</tr>
<tr>
<td>09092550</td>
<td>Gomer No. 1 Well</td>
</tr>
<tr>
<td>0902320</td>
<td>Gomer No. 2 Well Inf</td>
</tr>
<tr>
<td>0902340</td>
<td>Gomer No. 2 Well</td>
</tr>
<tr>
<td>0902310</td>
<td>Buffalo Flat Ck Infl</td>
</tr>
<tr>
<td>0902330</td>
<td>Buffal Flat Ck Divns</td>
</tr>
<tr>
<td>0902130</td>
<td>Green Beret No. 2 We</td>
</tr>
<tr>
<td>0902140</td>
<td>Green Beret No. 2 We</td>
</tr>
<tr>
<td>0902110</td>
<td>Broken Back Creek In</td>
</tr>
<tr>
<td>CarothersLk</td>
<td>Carothers Lake</td>
</tr>
<tr>
<td>0902120</td>
<td>Broken Back Creek Di</td>
</tr>
<tr>
<td>0902010</td>
<td>Unnamed Creek Inflow</td>
</tr>
<tr>
<td>0902050</td>
<td>Enl. Mallard Ditch</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>0901930</td>
<td>Beth Wells Inflow</td>
</tr>
<tr>
<td>0901940</td>
<td>Beth Wells</td>
</tr>
<tr>
<td>0901840</td>
<td>Canyon Ck Blw Cooks</td>
</tr>
<tr>
<td>0901845</td>
<td>Big Canyon Creek Div</td>
</tr>
<tr>
<td>06270500</td>
<td>Canyon Creek nr Tens</td>
</tr>
<tr>
<td>0901817</td>
<td>W Fk Tensleep Creek</td>
</tr>
<tr>
<td>0901810</td>
<td>E Fk Tensleep Creek</td>
</tr>
<tr>
<td>MdwlarkRes</td>
<td>Meadowlark Reservoir</td>
</tr>
<tr>
<td>0901820</td>
<td>Wigwam No. 2 Ditch</td>
</tr>
<tr>
<td>06271000</td>
<td>Tensleep Ck nr Tensl</td>
</tr>
<tr>
<td>0901880</td>
<td>Lower Tensleep Ck Di</td>
</tr>
<tr>
<td>0901430</td>
<td>Taylor No. 2 Well In</td>
</tr>
<tr>
<td>0901435</td>
<td>Taylor No. 2 Well</td>
</tr>
<tr>
<td>0901440</td>
<td>N Fk Spring Ck Inflo</td>
</tr>
<tr>
<td>0901450</td>
<td>N Fk Spring Ck Divns</td>
</tr>
<tr>
<td>0901410</td>
<td>Spring Ck Inflow</td>
</tr>
<tr>
<td>0901420</td>
<td>Upper Spring Ck Divn</td>
</tr>
<tr>
<td>0901490</td>
<td>Lower Spring Ck Divn</td>
</tr>
<tr>
<td>0901230</td>
<td>S Fk Otter Ck Inflow</td>
</tr>
<tr>
<td>0901240</td>
<td>S Fk Otter Ck Divns</td>
</tr>
<tr>
<td>0901210</td>
<td>Otter Ck Inflow</td>
</tr>
<tr>
<td>0901220</td>
<td>Upper Otter Ck Divns</td>
</tr>
<tr>
<td>0901290</td>
<td>Lower Otter Ck Divns</td>
</tr>
<tr>
<td>0900920</td>
<td>S Fk Little Canyon C</td>
</tr>
<tr>
<td>0900930</td>
<td>S Fk Little Canyon C</td>
</tr>
<tr>
<td>0900910</td>
<td>Little Canyon Ck Inf</td>
</tr>
<tr>
<td>0900990</td>
<td>Little Canyon Ck Div</td>
</tr>
<tr>
<td>0900730</td>
<td>Redbank Creek Inflow</td>
</tr>
<tr>
<td>0900740</td>
<td>Redbank Creek Divns</td>
</tr>
<tr>
<td>0900710</td>
<td>Box Elder Creek Infl</td>
</tr>
<tr>
<td>0900720</td>
<td>Upper Box Elder Ck D</td>
</tr>
<tr>
<td>0900790</td>
<td>Lower Box Elder Ck D</td>
</tr>
<tr>
<td>0900510</td>
<td>Deep Creek Inflow</td>
</tr>
<tr>
<td>DeepCkRes</td>
<td>Deep Creek Reservoir</td>
</tr>
<tr>
<td>0900550</td>
<td>Deep Creek Diversion</td>
</tr>
<tr>
<td>0900310</td>
<td>Bear Creek Inflow</td>
</tr>
<tr>
<td>0900350</td>
<td>Mead No. 2 Ditch</td>
</tr>
<tr>
<td>0900110</td>
<td>Lone Tree Creek Infl</td>
</tr>
<tr>
<td>0900150</td>
<td>Crowley Ditch</td>
</tr>
<tr>
<td>0900001</td>
<td>Nowood River Inflow</td>
</tr>
<tr>
<td>NwdCrwrdRes</td>
<td>Nowood-Crawford Reservoir</td>
</tr>
<tr>
<td>0900200</td>
<td>NowoodDivnsBlwLoneTr</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>0900400</td>
<td>Divn Placeholder</td>
</tr>
<tr>
<td>0900600</td>
<td>NowoodDivnsBlowDeepC</td>
</tr>
<tr>
<td>UpprNwdRes</td>
<td>Upper Nowood Reservoir</td>
</tr>
<tr>
<td>BigTrailsRes</td>
<td>Big Trails Reservoir</td>
</tr>
<tr>
<td>0900800</td>
<td>NowoodDivnsBlwBoxEld</td>
</tr>
<tr>
<td>0901100</td>
<td>NowoodDivnsBlwLitCan</td>
</tr>
<tr>
<td>BrunerGulRes</td>
<td>Bruner Gulch Reservoir</td>
</tr>
<tr>
<td>TaylorDrwRes</td>
<td>Taylor Draw Reservoir</td>
</tr>
<tr>
<td>0901300</td>
<td>NowoodDivnsBlwOtterC</td>
</tr>
<tr>
<td>0901500</td>
<td>FarmersCanalAndFarmer</td>
</tr>
<tr>
<td>0901550</td>
<td>Cheeney Ditch</td>
</tr>
<tr>
<td>06270000</td>
<td>Nowood R nr Tensleep</td>
</tr>
<tr>
<td>0901700</td>
<td>NowoodDivnsAbvTensle</td>
</tr>
<tr>
<td>0901900</td>
<td>JumboAndWinsorDitches</td>
</tr>
<tr>
<td>0902150</td>
<td>Melley Ditch</td>
</tr>
<tr>
<td>0902200</td>
<td>Western Ditch</td>
</tr>
<tr>
<td>0902250</td>
<td>NowoodDivBlwBrokenBa</td>
</tr>
<tr>
<td>0902400</td>
<td>Ilg Ditch</td>
</tr>
<tr>
<td>0902600</td>
<td>NowoodDivAbvPaintRoc</td>
</tr>
<tr>
<td>06274000</td>
<td>Nowood River at Bona</td>
</tr>
<tr>
<td>0902900</td>
<td>NowoodDivBlwPaintRoc</td>
</tr>
<tr>
<td>0902950</td>
<td>Van Alstine-Walker Ditch</td>
</tr>
<tr>
<td>0903000</td>
<td>Shafer Ditch</td>
</tr>
<tr>
<td>0903100</td>
<td>Harmony Ditch</td>
</tr>
</tbody>
</table>
TECHNICAL MEMORANDUM

TO: Joel Farber, Trihydro Corporation
FROM: Rick Parsons, ParsonsWater Consulting LLC
DATE: April 13, 2011
RE: Nowood Level II Study Stage 2 – Hydrologic Analysis Using Nowood River StateMod Model

Introduction

ParsonsWater Consulting LLC (PWC) is providing technical professional consulting to Trihydro for the Nowood River Storage Level II Study for the Wyoming Water Development Commission (WWDC). Work being performed fulfills the hydrologic modeling elements appurtenant to the following tasks in the Scope of Services to Trihydro’s contract with the WWDC:

   Task 2. Literature and Model Review
   Task 4. Hydrologic Analysis
   Task 8. Alternative Analysis
   Task 17. Reports

PWC’s work is being undertaken in three stages, as outlined below.

1. Initial Development of a Skeleton StateMod Model.
2. StateMod Model Refinement.
3. Analyses of Project Alternatives.

Stage 1 of the Nowood Level II Study included the Initial Development of a StateMod model based on the architecture and approach used in the 2010 River Basin Plan Update (2010 Update). This effort included development of the Nowood model network and identification of the various input data that needed to be gathered or estimated, beyond the work completed in the 2010 Update.

Missing data identified during Stage 1 were filled in during Stage 2, resulting in a complete Nowood Model Baseline data set representing the monthly variability of water supply and demands over an historical period (1973 through 2008) representative of wet, dry, and average hydrologic conditions in the Nowood River basin. The Baseline scenario results provide reasonable estimates of irrigation demands and shortages associated with permitted acreage in the basin. In addition, the model results provide estimates of flows legally available for diversion under a junior water right for the initial list of 22 identified reservoir sites. The legally available flows and estimates of Baseline irrigation shortages provide some of the metrics used to develop a short list of alternative reservoir sites to be explored further in subsequent Tasks of the Nowood Level II Study effort.

The Baseline scenario input, output, and StateMod protocol used for development of the Baseline data set is summarized below. Variations to the spreadsheet model approach were identified through review of the various input data necessary for the Nowood model. The changes and comparisons of the various input and output data between the spreadsheet model...
and Baseline data set is included below. The discussion follows on the information summarized in the Stage I memorandum. Comments at the end of the Stage 2 memorandum are provided for consideration in future data collection and Stage 3 modeling efforts for the Nowod River basin.

**Baseline Data Set**

1. **Model Network and River Network File** – Includes locations (i.e., nodes) where you have, or want to have, information. This includes gages, diversions, reservoirs, and instream flow points/reaches. Figure 1 includes the model network that forms the basis of the Nowood Level II Study StateMod model (the “Nowood Model”). Changes made to the spreadsheet model include the following:

   a. **General** – The Model Network defines the various input nodes used in the Nowood model based on 2-digit Water District followed by 5-digit ID (additional zeros were included to make the ID 7 digits long). For example, Basin Plan Model node (Bnode) 9.0150 was set to ID 0900150.

      Various input data are developed unique to each model input node. Tributary inflow nodes are represented separately from diversion nodes in the Basin Plan network. StateMod provides for all diversion and reservoir model nodes to double as tributary inflow or intermediate natural flow nodes. The separate inflow nodes were removed from the model network to minimize the number of model nodes necessary in subsequent Nowood model input files.

      The Basin Plan highlights stream confluences as distinct nodes. These nodes are part of the physical model network with StateMod but have no associated data in the other StateMod input files. Therefore, no identification of stream confluences are highlighted in the StateMod input files.

   b. **Diversions** – The general layout of diversion nodes in the Basin Plan were used to input diversion nodes locations in the Nowood model network. Trihydro developed preliminary associations of water right permits with points of diversion (PODs) on the river and associations of the PODs and permits with the Level I Study irrigated acreage GIS coverage. The PODs, permits, and irrigated acreage were associated with the model diversion nodes in established during Stage 2.

      i. Some diversion nodes were moved to different tributaries or locations on the same tributary or on to the main stem if the PODs associated with the acreage are located on different tributaries or the main stem in comparison to their original location.

      ii. Some nodes were added to the model network if PODs and acreage were identified, including ID 0902080 – Nowood Diversion above Brokenback Creek and ID 0902850 – Ilg Enlargement.

      iii. The associations resulted in some model nodes with no assigned acreage. Some of the model nodes removed from the model includes Bnode 9.0400 – Nowood River diversions below Bear Creek and above Deep Creek; Bnode 9.1820 – Wigwam No. 2...
Ditch; Bnode 9.2250 – Nowood River diversions below Brokenback Creek and above Buffalo Flat Creek.

iv. Gomer Well No. 2 (Bnode 9.2340) and Gomer Well No. 1 (Bnode 9.2550) were aggregated into a single node (ID 0902550).

v. Alkavale Ditch (Bnode 9.2765) was the only Basin Plan node located on Alkali Creek. The Alkavale Ditch was aggregated with other PODs that have water rights on Alkali Creek (ID 0902765 – Alkali Creek Diversions).

vi. Bnode 9.1290 – Otter Creek diversions was split into two nodes above (ID 0901280) and below (ID 0901290) the proposed Otter Creek Reservoir to represent diversions and return flows above and below the reservoir.

c. Stream Gages – Two stream gages were added to the model network.

i. ID 06270450 – Canyon Creek below Cooks Canyon was added to the top of Big Canyon Creek at the location of this historical stream gage. This location is above the Canyon Creek Reservoir site.

ii. ID 9999999 – Nowood River at Mouth was added to the bottom of the model network to represent basin outflows to the Bighorn River and gains and losses below Paint Rock Creek.

d. Instream Flow Points/Reaches – Two instream flow points (permitted right on Tensleep Creek for 22 cfs and pending right Medicine Lodge Creek for 9 cfs to 20 cfs) and one instream flow point (permitted right on Tensleep Creek at Wigwam Hatchery for 4.7 cfs) were included in the model network. The monthly demands were set equal to the respective instream flow rights. There is no consumptive use associated with the instream flows but they were included to represent potential impacts on future reservoir operations.

2. Natural Flow Hydrology – Represents physical streamflows available for diversion absent man’s impact. Natural flows are generally calculated first at stream gage locations based on historical gage record + upstream diversions – upstream return flows +/- changes in upstream storage. Natural flows calculated at stream gage locations are then distributed to upstream, ungaged locations.

a. Stream Gages - Seven (7) stream gages were included in the spreadsheet model. None of these gages is active. Linear regressions for main stem gages and “regional equations” for tributary inflow gages were used in the spreadsheet model. The linear regressions used to develop wet, dry, and average year streamflows were based on annual correlations.

Monthly linear regressions were investigated during the Stage 2 work effort to represent monthly variability at the Nowood River stream gages based on correlations with active stream gages located outside the Nowood River basin.

i. The Nowood River near Tensleep gage (ID 0627000) is the only basin stream gage with historical record within the 1973 through 2008 study period (gage data available...
through 1992) and was therefore the primary gage for which data needs to be estimated.

Extensive analyses between active gages located throughout and near Wyoming and the Nowood River near Tensleep gage with overlapping periods of record resulted in fair to poor correlations with the independent gages (see Table 1). Monthly r-squared correlation factors were typically in the 0.30 to 0.60 range and many winter months with r-squared correlation factors less than 0.20.

The approach used in the 2010 Update (annual correlation with Black Mountain station precipitation data) was repeated for the Nowood model. Annual flows filled for the Nowood River near Tensleep stream gage were distributed monthly based on the historical pattern recorded at the Nowood River near Tensleep stream gage. The r-squared correlation coefficient for the 17 years of overlapping data was 0.48.

Attempts at annual correlations between the near Tensleep gage and other climate station data in the basin were analyzed (Big Horn basin average precipitation, Basin station precipitation, Burgess station precipitation, Greybull station precipitation, Powder River Pass SNOTEL precipitation, Shell station precipitation, and Tensleep 16SSE station precipitation). These correlations were not as good as that developed with the Black Mountain station.

The remaining stream gages were filled using monthly regressions and various approaches, based on analyses conducted as part of the 2010 Update or independent analyses carried out in Stage 2. Details regarding the gage data filling approaches are listed in Table 2.

Representation of Nowood River outflows to the Bighorn River was included in the model with a Nowood River at mouth stream gage added to the bottom of the model network. This gage was used to represent the natural flows at the bottom of the river network. A portion of the stream gains calculated between the Bonanza gage and the mouth gage would be available for diversion at the McDermott Draw Reservoir site.

ii. Diversions – Historical diversions are needed to represent man’s impact on the stream system, as reflected in the streamflow records. Spot data available from the Hydrographer’s Records were included in the Hydrologic Database for 12 ditches located in the Paint Rock Creek basin and lower Nowood River (Anita Ditch, Anita Supplemental Ditch, Bernstein No. 1 Ditch, Big Bear Ditch Enlargement, Elk Ditch, George and Bayne Ditch, Go Ahead Ditch, Harmony Ditch, Highland Ditch, Shafer Ditch, Van Alstine Ditch, and Western Ditch).

The spot data were collected and extended to monthly values based on linear interpolation between data points, with missing values extended from mid-April through mid-October. Monthly data missing for entire years were filled based on wet-dry-average yearly averages for months with spot data. The hydrologic
characterizations developed in the 2010 Update (Table 52 – 2010 Update May 2010 Report) were used to fill the missing data. Any remaining data missing for these 12 ditches were filled with historical monthly averages.

Historical diversions were developed for the other 50 diversion nodes in the model to represent these inputs to the natural flow calculations. Diversions were added because, in the natural flow calculations, the StateMod program accounts for the historical consumptive use and the timing, location, and amounts of diversions and associated return flows.

The missing diversion data were estimated based on the measured irrigated acreage, calculated crop irrigation requirement (CIR), system efficiencies to calculate river headgate demand associated with the crop demand, and then application of "representative" monthly shortage to estimate water supply-limited historical diversions. The average monthly efficiencies from the 2010 Update, summarized below, were used in the model for all the ditches in the Nowood model. One exception was the Anita Ditch, which was assigned a pattern of higher efficiencies in the spreadsheet model due to its improved irrigation delivery system.

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>20%</td>
<td>20%</td>
<td>28%</td>
<td>44%</td>
<td>42%</td>
<td>26%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Monthly shortages were estimated using the StateCU model by comparing the monthly CIR for the 12 ditches with diversion records over the 1973 through 2008 period. Water-supply limited historical diversions were input for the natural flow calculations since the historical natural flows are based on man’s impact, which is best represented by water-short deliveries than full supply deliveries to irrigated lands.

The irrigation demands under the majority of the 12 ditches were satisfied based on the estimated historical diversions and amounts of irrigated acreage assigned to the different systems. The water-supply limited analysis for the Big Bear Ditch resulted in the following average monthly shortages, which were assigned to the 50 diversion nodes without historical data to estimate historical diversions under those ditch systems.

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortage</td>
<td>32%</td>
<td>3%</td>
<td>5%</td>
<td>17%</td>
<td>22%</td>
<td>7%</td>
<td>28%</td>
</tr>
</tbody>
</table>

iii. Return flows – Return flow locations, amounts, and timing are additional input to the natural flow calculations. The amount of return flows are estimated in the StateMod program based on monthly diversion times (1 – monthly efficiency). The resulting amount of return flows was then routed to different locations. The same return flow timing was assigned to all nodes in the spreadsheet model. The following monthly return flow timing values were assigned to all ditches in the Nowood model:
Return flow locations were developed from three main sources, listed below in order of increasing importance:

- Basin adjudication maps
- Spreadsheet model assignments
- Visual review of GIS coverages of irrigated acreage assigned to PODs in context of nearby PODs that would have physical access to return flows at their respective river headgate locations

iv. Reservoir Storage Contents – The change in storage was added or subtracted from the downstream gage record to represent the natural flows at the stream gage absent construction of the reservoir. Two existing reservoirs from the spreadsheet model were included in the Nowood model – Meadowlark Lake and Carothers Lake. Changes in monthly contents and monthly releases from these reservoirs were used as calibration variables in the spreadsheet model. Anecdotal information supports these reservoirs are generally kept full although irrigation releases are made from Carothers Lake during dry years. No actual storage records were identified. The historical reservoir storage contents are not considered to significantly affect natural flow calculations. Therefore, the historical storage contents were set to full every month over the study period, which results in evaporative losses being the only impact on the stream system from the reservoirs. The monthly evaporation rates from the spreadsheet model were input to the Nowood model.

v. Tributary Inflows – Represented at 18 inflow nodes, 4 well locations, and 12 reservoirs either located at the top of tributaries or located off-channel that may be able to store some amount of native inflows (e.g., Cornell Gulch, McDermott Draw, and Weintz Draw). The inflows to ungaged tributaries were estimated using the “gain” approach, in which natural flows estimated at stream gage locations were distributed upstream based on prorated inflow volumes. In this approach, GIS was used to calculate inflow volumes based on tributary drainage areas and average annual precipitation amounts over the drainage areas. These values were used to estimate upper basin inflows based on the ratio of the drainage area times the average precipitation (“area-precip”) at an ungaged location : area-precip at a gaged location.

For example, natural flows at the Nowood River near Tensleep gage (ID 06270000) were distributed upstream to Cornell Gulch, upper Nowood River, Lone Tree Creek, Bear Creek, Deep Creek, Boxelder Creek, Redbank Creek, Little Canyon Creek, South Fork Little Canyon Creek, Crooked Creek, Otter Creek, South Fork Otter Creek, Spring Creek, North Fork Spring Creek, and Alkali Creek South.
The Level I and Level II gage data recorded during 2009 and 2010 were compared to the estimated natural flows, which led to some revisions in modeling approach. A brief summary of the comparisons is included below:

- Recorded gage flows on Upper Nowood River (Nowood-Crawford Reservoir site), Upper Deep Creek, Otter Creek, Brokenback Creek, and Alkali Creek substantiate the magnitude of estimated flows on the respective tributaries.
- Recorded gage flows on Cottonwood Creek in 2009 (approximately 500 acre-feet) are significantly less than the annual natural flows prorated to that tributary (approximately 9,500 acre-feet). Natural flows on both Big and Little Cottonwood Creeks were set to zero outside of the spring runoff season based on the recent gage data records and anecdotal reports.
- The area-precip inflow volumes at the inflow points tributary to the Nowood River near Tensleep stream gage total approximately 47 percent of the area-precip inflow value at the gage. Therefore, 47 percent of the natural flow calculated at the Nowood River near Tensleep was distributed upstream to the (mostly) ungaged locations.

For comparison, the tributary inflows above the Nowood River near Tensleep gage input to the spreadsheet model total approximately 117,500 acre-feet per year, on average (Table 27 of 2010 Update May 2010 Task 4A – Surface Water Hydrology memorandum). This is about 29,200 acre-feet per year greater than the Nowood River near Tensleep gage flows (~88,300 acre-feet per year, which implies approximately 29,200 acre-feet of water was consumed (~9,000 acre-feet per year) or lost (~20,000 acre-feet per year) in the upper reaches of the basin. The tributary inflows assigned in the spreadsheet model seem somewhat excessive. Less than 5,000 irrigated acres were identified above the gage during the Level I study, corresponding to about 9,000 acre-feet per year of irrigation consumptive use based on a unit CIR of 1.82 feet per year (see Section 4.c. below).

The default approach in the StateMod program is to assign the remaining approximately 53 percent of calculated gain as accruing at the stream gage location. Recent gage data recorded on Lower Deep Creek support more of the remaining gain accruing higher up in the river basin. Therefore, Big Trails Reservoir was input as an intermediate natural flow node. It is intermediate in the sense it is not a tributary inflow node and not a stream gage node. Intermediate natural flow nodes are used to distribute gains between inflow nodes and stream gages. A portion of the remaining gain at the Nowood River near Tensleep gage (16 percent – or 30 percent of the remaining 53 percent) was distributed to the Big Trails Reservoir location, which resulted in natural flows at that location substantiated with the various Level I and Level II tributary inflow gage data and the Lower Deep Creek gage data records.
Wells at four locations were included in the model network. The Nowood model is not intended to explicitly represent aquifer volume, withdrawals, and recharge. The representation of the wells was meant to primarily account for the return flows from well use. Therefore, inflows to wells were set equal to the associated crop demand, accounting for a 75 percent sprinkler efficiency associated with well use. In this manner, the irrigated lands under the wells were fully satisfied and the calculated runoff was routed back to the river system, thereby providing physical flows for diversion by other model demand nodes.

3. Water Rights – Water permits assigned to PODs represent the relative priority of legal supply to water available to meet the associated demands in the Nowood model. Water rights were not represented in the spreadsheet model.

As noted above, Trihydro developed associations of water right permits with PODs on the river and preliminary associations of the PODs and permits with the Level I Study irrigated acreage GIS coverage. The PODs and permits were associated with the diversion nodes included in the model, and were adjusted based on visual inspection of the locations of lands and river drainages in various GIS coverages in relation to the PODs.

A total of 389.8 cfs of direct flow rights was included in the model (see Table 3). The senior input direct flow water right was an April 1, 1884 priority for 0.57 cfs under the Two Bar Ditch (Terr. Permit 2924). This POD was aggregated with other ditches located on Lower Boxelder Creek in diversion node ID 0900790.

A total of 333 direct flow rights were input to the model with priority dates prior to March 1, 1945. Second cfs water rights were assigned to these PODs with priority dates relative to one another. Therefore, the Two Bar Ditch right above has a second cfs right assigned senior to all other second cfs rights.

Thirty-nine direct flow rights with post-1945 priority dates were input to the model. Second cfs water rights were assigned to these PODs with priority dates relative to one another.

The analysis resulted in six model nodes with no associated water rights. Three of these nodes also did not have any measured acreage assigned to them. Three of the nodes did have acreage assigned. The three nodes with no water rights or acreage were kept in the model as placeholders since two of them define a tributary stream and one was an explicit structure included in the spreadsheet model (ID 0900150 – Crowley Ditch, ID 0901220, ID 0901220 – Upper Otter Creek Diversions; and ID 0902710 – Loretta Ditch). The three model nodes with measured acreage associated to them were assigned junior, essentially free river, water rights of 10 cfs so they would have a legal right to divert water to their respective demands in the model simulation. These exceptions should perhaps be checked, as the POD-permit-acreage associations are refined in the future.

An exception to the approach for direct flow rights was used for the four well nodes included in the model. As noted above, representation of the wells in the model was not intended to
illustrate the impact of well withdrawals on ground water supplies but rather the consumptive use and return flows associated with lands irrigated by wells. “Tributary” inflows to the well nodes were set equal to their respective crop demand to ensure sufficient physical supply was available to the model node. The wells were assigned direct flow rights senior to all other modeled rights to ensure the well diversions would occur in the model without being called out by senior downstream rights.

4. Baseline Demands – The StateMod program is demand-driven. Demands are assigned to diversion nodes to represent the demand on the natural flows at the location on the river associated with certain acreage and water rights. A portion of the demand was satisfied in the model by natural flows and water rights to meet those demands. The remainder of the demand, that was not satisfied, represents the irrigation shortages. The irrigation shortages in the Baseline scenario, the Baseline Shortages, help define the purpose and need for supplementary storage.

Irrigation demands are based on the amount of acreage, the crop types under irrigation, climate data, and system efficiencies associated with delivering water from the river to the irrigated lands.

a. Acreage – The Nowood Level I Study identified approximately 21,103 acres of lands currently under irrigation. The POD-permit-acreage analysis described above, with additional visual inspection of the GIS coverages, resulted in association of the measured irrigated acreage with the model diversion nodes (see Table 3). The 2010 Update included 22,506 acres of existing irrigated lands in the Nowood River basin (Table 10 of 2010 Update May 2010 Task 3A – Agricultural Water Use memorandum). The amount of permitted acreage associated with water rights in the basin was estimated to total 27,761 acres based on the water rights assigned to the various diversion nodes and a duty of water of 1 cfs to 70 acres. The permitted acreage represents an approximately 24 percent increase over the amount of measured acreage.

The amount of permitted acreage represented in the model is summarized in Table 3. Certain exceptions were made to the 1 cfs to 70 acres duty of water, in which the amount of measured acreage was used for the permitted acreage scenario. The exceptions occurred if a) Measured acreage was greater than 70 acres per cfs (15 model nodes); b) Measured acreage was much less (generally than 5 acres per cfs – 2 model nodes); and c) Acreage assigned to wells (4 model nodes). These exceptions should perhaps be checked, as the POD-permit-acreage associations are refined in the future.

b. Crop Types – The crop types used in the 2010 Update were based on the location of the irrigated parcel and associated County Agricultural Statistics. These assignments result in some crops (e.g., row crops and vegetable crops) unlikely to be irrigated in certain locations within the Nowood River basin. The approach used in the Nowood model was to assign irrigated pasture to all lands located upstream of the Nowood River – Paint Rock Creek confluence. A crop mix of 60 percent grass pasture, 20 percent spring grain,
and 20 percent corn grain were assigned to the irrigated lands lower in the Nowood River basin between Paint Rock Creek and the Bighorn River.

c. Climate Data –CIR was estimated using the StateCU program based on irrigated acreage, crop types, and the modified Blaney-Criddle method with Big Horn basin average monthly temperature and precipitation data available from the Western Regional Climate Center (http://www.wrcc.dri.edu/summary/Climsmwy.html).

Other climate station data were reviewed but were not used, including the Basin Station (ID 480540), Tensleep 4NE Station (ID 488852), Tensleep 16SSE Station (ID 488858), Worland Station (ID 489770), and the Worland Airport Station (ID 489785). The basin average data were chosen since it constituted the only complete set of available input data over the 1973 through 2008 study period.

The annual CIR for pasture grass calculated using StateCU over the 1973 through 2008 period ranged from 1.38 feet to 2.20 feet with an average of 1.77 feet. For comparison, the 2010 Update had an average annual CIR of 1.82 feet associated with the crop mixes in the County Agricultural Statistics (Table 7 and Table 10 of 2010 Update May 2010 Task 3A – Agricultural Water Use memorandum).

d. System Efficiencies –Monthly system efficiencies developed in the 2003 Basin Plan, which were based on previous studies, were used in the 2010 Update (Table 12 of 2010 Update May 2010 Task 3A – Agricultural Water Use memorandum). The monthly system efficiencies, ranging from 20 percent to 44 percent, were used to estimate river headgate demands based on monthly CIR divided by average monthly system efficiency.

The Baseline demands for the entire basin total approximately 142,043 acre-feet per year, on average (see Table 4). This corresponds to an annual river headgate demand of approximately 5.11 feet for the 27,761 permitted acres included in the Baseline scenario. Dry year demands of 142,827 acre-feet per year were estimated for the dry years identified in the 2010 Update (1980, 1981, 1982, 1985, 1989, 1992, 2001, and 2002 – see Table 52 of 2010 Update May 2010 Report). The average value over these eight dry years was only one-half of one percent higher than the average year values. The maximum annual demand during 2001 over the 36-year study period was 178,644 acre-feet, which was approximately 26 percent higher than the annual average.

5. StateMod Program Default Operations – The StateMod program simulates input water rights to meet demands based on natural flows in priority. Irrigation demands assigned to river headgates associated with water rights represent a standard operation in the program. Storage of water under a storage right in an on-channel reservoir is another standard operation. Water uses that vary from these standard operations require user-input operating rules, as discussed in Section 6.

The StateMod program provides input variables to allow the model to simulate diversions to meet CIR based on a “variable efficiency” approach. The variable efficiency approach
addresses irrigation operations during times of water shortage. The Baseline demands were based on CIR and average monthly system efficiencies. When these demands were not satisfied by input water rights in priority during model simulation, the StateMod program allows water deliveries at user-defined maximum system efficiencies. The maximum values input to the Nowood model were 54 percent for flood-irrigated lands and 75 percent for sprinkler-irrigated lands. The sprinkler-irrigated lands were determined from crop circles evident on the GIS coverage of measured acreage and the percentage of sprinkler-irrigated lands was translated to the permitted acreage amounts. Including the acreage under the four well nodes, sprinklers were assigned to approximately 9.2 percent (2,550 acres) of the 27,761 acres.

The StateMod program allows separate inputs for ditch loss and farm loss. The values used in the Nowood model were 10 percent and 0 percent for ditch loss and 60 percent and 75 percent for maximum farm efficiency (1 minus farm loss) for flood-irrigated and sprinkler-irrigated lands, respectively. The combined losses for flood-irrigated lands (1 minus 0.10) times (1 minus 0.60) result in an overall system efficiency of 54 percent.

6. User-Input Operating Rules – The StateMod program includes approximately 49 generic operating rules that can be input to the model to represent operations different from some of the default operations described above. These other operations include carrying water from the river to a separate demand (e.g., Carrier ditch to off-channel reservoir, carrier ditch to separate demand; reservoir release to meet demand, etc.).

The two existing reservoirs in the model (Meadowlark Lake and Carothers Lake) are not actively operated and therefore did not require any operating rules in the Nowood model. The only operating rules needed to model existing conditions were rules to divert the Anita Supplemental Ditch water rights from Paint Rock Creek and carry the water to meet the demand associated with the Anita Ditch, located on Medicine Lodge Creek. Thirty-four operating rules were input to carry water to the Anita Ditch associated with the 34 water rights assigned to the Anita Supplemental Ditch. These operating rules were operated using the priorities of the individual water rights.

Generic reservoir operating rules will be input as part of Stage 3 work to perform Task 8 Alternatives Analyses to convey water to off-channel reservoirs and release supplemental water supplies from reservoirs to various diversion nodes to meet the Baseline Shortages.

**Baseline Scenario Output**

Nowood model scenarios were run to a) Estimate natural flows over the historical study period (1973 through 2008) and 2) Simulate direct flow rights to meet irrigation demands associated with permitted acreage using calculated natural flows over the same period.

The Baseline Shortages are summarized in Table 4. The total basin annual shortage was estimated at approximately 13 percent (18,015 acre-feet) and 14 percent (20,240 acre-feet) in average and dry years, respectively. A maximum shortage of approximately 21 percent (36,632 acre-feet)
acre-feet) was simulated in 2001. The distribution of shortages varies throughout the basin, with the highest percent shortages located in the upper basin above Tensleep Creek. Shortages in Paint Rock Creek were similar to the basin shortage values, with more of the model demand satisfied in other parts of the basin.

An advantage of the StateMod program is the large volume of output generated from model simulations. Water balance calculations of river inflows, return flows, diversions from various sources (river, storage, via carrier), total returns, and river outflows are reported for every node in the model network for each month of the model simulation. The model output can be used to quantify the physical flow and available flow at every location for each time step. The available flow is that portion of the physical flow that was not being called by, or delivered to, downstream model nodes.

The available flow represents the water at a certain location that is available for diversion to a water right after all other model input water rights were simulated. Available flow at different locations is interdependent since the water shepherded to downstream nodes affects the amount of flow available for diversion at all upstream nodes. Therefore, available flow in a certain time step at different nodes is not additive.

The available flow at the various reservoir sites and associated feeder ditches identified in the first cut of the Level II Study is summarized in Table 5. As expected, dry-year available flows were less than average-year available flows - generally on the order of about 15 percent to 50 percent less than average. Note the flow available during dry years was close to, or greater than, the flow available in average years on Paint Rock Creek. This was possibly due to the seniority of direct flow rights on Paint Rock Creek with respect to the rest of the basin. During low-flow periods, the model simulates Paint Rock Creek diversions associated with these senior rights at the expense of more junior rights in other portions of the basin. More diversions results in more return flows that, along with the Paint Rock basin’s location relatively low in the basin, increases the water available for diversion by junior rights.

The model simulation shows dry-year available flows much higher than average-year available flows for reservoirs located between Tensleep Creek and Paint Rock Creek (Big Cottonwood Reservoir, Little Cottonwood Reservoir, Lower Brokenback Reservoir, and North Brokenback Reservoir). This was a consequence of the various regressions used (see Table 2) to estimate flows at the stream gages within this reach (Nowood River near Tensleep – ID 06270000, Tensleep Creek near Tensleep – ID 06271000, Paint Rock Creek near mouth – ID 06273500, and Nowood River near Bonanza – ID 06274000). As discussed above, the streamflow data were converted into natural flow data based on upstream diversions and return flows. The streamflow regressions ultimately used resulted in gage flows that were not entirely consistent, and which result in natural flows that represent no stream gains during most summer and fall months during the study period between Tensleep Creek and Paint Rock Creek. The eastern tributaries in this reach (Brokenback Creek and Buffalo Flat Creek) typically run year-round. The Level I gage data collected on Cottonwood Creek were used, in part, to shift summertime stream gains from the west side to the east side of this reach of the Nowood River. It is possible the natural flows in
this reach do illustrate a losing reach after accounting for (positive) inflows from the east side tributaries and removing late-season irrigation return flows if no irrigation took place (i.e., absent man’s impact). This model output, particularly in this reach of the basin, illustrates the need for additional gathering of streamflow and diversion data in the area to improve the estimates of streamflows upon which natural flows are developed.

Comments

From the hydrological modeling standpoint, one recommendation coming out of the Stage 2 model development is to increase the amount and frequency of record keeping of water uses in the basin. This is especially true for river headgate diversions since those records improve estimates of system efficiencies, and amount and timing of return flows. More gage records and diversion records generally improve model representation of natural flow hydrology and estimates of legally available flow.

Another recommendation is for continued review and association of ditch headgate locations, irrigated acreage, and water rights serving those lands. Enhancing the correlation between these model parameters should improve the WWDO’s capability to estimate natural flows and to simulate legally divertible flows to meet various demands.
FIGURE 1
Nowood River
Level II Study
StateMod Model Network
### Table 1

#### SUMMARY OF MONTHLY CORRELATION ANALYSIS TO FILL missing DATA USING active USGS Gages THAT have overlapping DATA (PRE-1992)

| Independent Gage | USGS ID | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Note | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Name USGS | ID Gage | Note |
|------------------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|---------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|---------|
|                  |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |       |           |         |           |         |           |         |           |         |       |           |         |
|                  |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |       |           |         |           |         |           |         |       |           |         |       |           |         |       |
|                  |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |           |         |       |           |         |           |         |           |         |       |           |         |       |           |         |       |

**Note:**
- USGS website (http://waterdata.usgs.gov/nwis); summarized in <Nowood_USGS_GageData.stm>
- Correlation coefficient greater than 0.70 highlighted in **bold**; coefficients greater than 0.50 highlighted in *bold*
- Total months with data for dependent gage is 24 over Oct through Dec and 25 over Jan through Sept
### Table 2

#### Summary of Filling Methods for Model Network Stream Gages

<table>
<thead>
<tr>
<th>Dependent Gage</th>
<th>Independent Gage</th>
<th>Source</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>USGS 06270000 NOWOOD RIVER NR TEN Sleep</td>
<td>BLACK MOUNTAIN CLIMATE STATION PRECIPITATION DATA</td>
<td>2010 Basin Plan Update</td>
<td>Annual r-squared value 0.48</td>
</tr>
<tr>
<td>USGS 06271000 TEN Sleep CREEK NR TEN Sleep</td>
<td>USGS 0627800 SHELL CREEK ABY SHELL RESERVOIR</td>
<td>2010 Basin Plan Update</td>
<td>Winter values (Dec - Mar) filled with previously-filled Nowood R nr Ten sleep data - these r-squared values are not that good but they are better than the Shell Creek r-squared values.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06270450 CANYON CREEK BELOW COOKS CANYON, NEAR TEN Sleep, WY</td>
<td>USGS 06271000 TEN Sleep CREEK NR TEN Sleep, WY</td>
<td>Not Included in 2010 Basin Plan Update</td>
<td>Only 30-month record for dependent gage (4/1969-9/1971). These data overlap the Tensleep gage near Tensleep data but not the lower Canyon Creek gage (USGS 06270500).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06270500 CANYON CREEK NR TEN Sleep, WY</td>
<td>USGS 06270000 NOWOOD RIVER NEAR TEN Sleep, WY</td>
<td>2010 Basin Plan Update</td>
<td>Only 4 years 3 months of raw data overlap (6/1939-9/1943) and the correlation &gt; 0.48 in Feb - Apr, Jun, Jul and not good in other months.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06273000 MEDICINE LODGE CREEK NR HYATTVILLE</td>
<td>USGS 0627800 SHELL CREEK ABY SHELL RESERVOIR</td>
<td>2010 Basin Plan Update</td>
<td>Apr - Nov r-squared &gt; 0.5 but Dec - Mar values not good. The winter values filled with previously-filled Nowood R nr Tensleep data - these r-squared values are not that good but they are better than the Shell Creek r-squared values.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06272500 PAINT ROCK CREEK NR HYATTVILLE</td>
<td>USGS 0627000 SHELL CREEK NR SHELL</td>
<td>2010 Basin Plan Update</td>
<td>This independent gage does not have any winter records (Oct - Mar) after 1972 so other fill method needed for monthly correlations. Correlation during winter months better with filled Medicine Lodge Creek data above than with filled Nowood R nr Tensleep data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06274500 PAINT ROCK CREEK NEAR MOUTH BELOW HYATTVILLE WY</td>
<td>USGS 06271000 TEN Sleep CREEK NR TEN Sleep, WY</td>
<td>Not filled in 2010 Basin Plan Update</td>
<td>This gage has not been active since 1923. Correlation with upstream Paint Rock and Medicine Lodge Creek gages not good. Apr, Jan, Dec r-squared &gt; 0.3 to 0.4 correlated with Bonanza gage, with May and May r-squared values close to zero. Correlation with Tensleep Creek nr Ten sleep gage very good Apr - Jan with r-squared &gt; 0.57 and usually &gt; 0.80.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USGS 06274000 NOWOOD RIVER AT BONANZA</td>
<td>USGS ID 0627000, USGS ID 0627100, USGS ID 06273000</td>
<td>2010 Basin Plan Update</td>
<td>This gage has not been active since 1927. Correlations with two nearby upstream gages - Paint Rock at mouth and Tensleep Creek nr Ten sleep - over their common periods of record are pretty good in the summer and fall (Jun - Dec) with r-squared &gt; 0.72 and 5 of 7 months with &gt; 0.9. Not so good in other months. After numerous approaches to filling data, the best correlation was with the Tensleep Creek nr Ten sleep gage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOWOOD RIVER AT MOUTH (StateMod Gage ID 9999999)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: USGS Data)
TABLE 3

NOWOOD RIVER MODEL
WATER RIGHTS AND ACREAGE SUMMARY

<table>
<thead>
<tr>
<th>NODE ID</th>
<th>NAME</th>
<th>WATER RIGHTS (cfs)</th>
<th>IRRIGATED ACRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>0900150</td>
<td>Crowley Ditch</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>0900200</td>
<td>NowoodDivnsBlwLoneTr</td>
<td>2.28</td>
<td>51.1</td>
</tr>
<tr>
<td>0900350</td>
<td>Mead No. 2 Ditch</td>
<td>2.1</td>
<td>58.9</td>
</tr>
<tr>
<td>0900550</td>
<td>Deep Creek Diversion</td>
<td>7.62</td>
<td>12.3</td>
</tr>
<tr>
<td>0900600</td>
<td>NowoodDivnsBelowDeep</td>
<td>6.59</td>
<td>337.1</td>
</tr>
<tr>
<td>0900720</td>
<td>Upper Box Elder Ck D</td>
<td>1.87</td>
<td>8.9</td>
</tr>
<tr>
<td>0900740</td>
<td>Redbank Creek Dvns</td>
<td>2.45</td>
<td>132.3</td>
</tr>
<tr>
<td>0900790</td>
<td>Lower Box Elder Ck D</td>
<td>1.29</td>
<td>68.1</td>
</tr>
<tr>
<td>0900800</td>
<td>NowoodDivnsBlwBoxEld</td>
<td>2.76</td>
<td>73.8</td>
</tr>
<tr>
<td>0900910</td>
<td>Red Bank Ditch</td>
<td>4.8</td>
<td>238.1</td>
</tr>
<tr>
<td>0900920</td>
<td>Red Bank Enlargement</td>
<td>3.3</td>
<td>189.6</td>
</tr>
<tr>
<td>0900990</td>
<td>Little Canyon Ck Div</td>
<td>8.745</td>
<td>345.7</td>
</tr>
<tr>
<td>0901050</td>
<td>Crooked Ck Divns</td>
<td>2.36</td>
<td>300.7</td>
</tr>
<tr>
<td>0901100</td>
<td>NowoodDivnsAbvOtterC</td>
<td>9.19</td>
<td>456.4</td>
</tr>
<tr>
<td>0901220</td>
<td>Upper Otter Ck Div</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>0901240</td>
<td>S Fk Otter Ck Divns</td>
<td>10</td>
<td>19.2</td>
</tr>
<tr>
<td>0901280</td>
<td>Middle Otter Ck Divn</td>
<td>2.5</td>
<td>100.6</td>
</tr>
<tr>
<td>0901290</td>
<td>Lower Otter Ck Divns</td>
<td>8.23</td>
<td>442.5</td>
</tr>
<tr>
<td>0901300</td>
<td>NowoodDivnsBlwOtterC</td>
<td>11.62</td>
<td>605.8</td>
</tr>
<tr>
<td>0901420</td>
<td>Upper Spring Ck Divn</td>
<td>5.98</td>
<td>266.1</td>
</tr>
<tr>
<td>0901435</td>
<td>Taylor No. 2 Well</td>
<td>1</td>
<td>81.6</td>
</tr>
<tr>
<td>0901450</td>
<td>N Fk Spring Ck Divn</td>
<td>10</td>
<td>173.8</td>
</tr>
<tr>
<td>0901490</td>
<td>Lower Spring Ck Divn</td>
<td>7.67</td>
<td>347.8</td>
</tr>
<tr>
<td>0901500</td>
<td>FarmersCanalAndFarme</td>
<td>5.27</td>
<td>96.7</td>
</tr>
<tr>
<td>0901550</td>
<td>Cheeney Ditch</td>
<td>0.36</td>
<td>43.3</td>
</tr>
<tr>
<td>0901700</td>
<td>NowoodDivnsAbvTensile</td>
<td>0.14</td>
<td>0.0</td>
</tr>
<tr>
<td>0901845</td>
<td>Big Canyon Creek Div</td>
<td>10.29</td>
<td>644.3</td>
</tr>
<tr>
<td>0901880</td>
<td>Lower Tensleep Ck Di</td>
<td>36.19</td>
<td>1882.4</td>
</tr>
<tr>
<td>0901900</td>
<td>JumboAndWinsorDitch</td>
<td>7.78</td>
<td>406.2</td>
</tr>
<tr>
<td>0901940</td>
<td>Beth Wells</td>
<td>1.5</td>
<td>134.4</td>
</tr>
<tr>
<td>0902050</td>
<td>Enl. Mallard Ditch</td>
<td>3.25</td>
<td>365.4</td>
</tr>
<tr>
<td>0902080</td>
<td>NowoodDivnsAbvBrknbk</td>
<td>0.5</td>
<td>306.1</td>
</tr>
<tr>
<td>0902120</td>
<td>Brokenback Creek Div</td>
<td>3.01</td>
<td>439.3</td>
</tr>
<tr>
<td>0902140</td>
<td>Green Beret No. 2 We</td>
<td>1.5</td>
<td>28.4</td>
</tr>
<tr>
<td>0902150</td>
<td>Melley Ditch</td>
<td>8.84</td>
<td>341.5</td>
</tr>
<tr>
<td>0902200</td>
<td>Western Ditch</td>
<td>9.82</td>
<td>516.9</td>
</tr>
<tr>
<td>0902330</td>
<td>Buffalo Flat Ck Divns</td>
<td>10</td>
<td>183.2</td>
</tr>
<tr>
<td>0902400</td>
<td>Ilg Ditch</td>
<td>3.29</td>
<td>389.0</td>
</tr>
<tr>
<td>0902550</td>
<td>Gomez No. 1 and 2 We</td>
<td>5.1</td>
<td>916.8</td>
</tr>
<tr>
<td>0902600</td>
<td>NowoodDivnsAbvPaintRoc</td>
<td>10.58</td>
<td>375.4</td>
</tr>
<tr>
<td>0902710</td>
<td>Loretta Ditch</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0902717</td>
<td>MedicineLodgeCkDivs</td>
<td>9.52</td>
<td>659.3</td>
</tr>
<tr>
<td>0902720</td>
<td>Enl. Highland Ditch</td>
<td>12.94</td>
<td>778.1</td>
</tr>
<tr>
<td>0902725</td>
<td>Anita Ditch</td>
<td>19.8</td>
<td>1311.1</td>
</tr>
<tr>
<td>0902728</td>
<td>Bayne-George Ditch</td>
<td>8.67</td>
<td>475.7</td>
</tr>
<tr>
<td>0902738</td>
<td>Big Bear Ditch</td>
<td>6.77</td>
<td>580.9</td>
</tr>
<tr>
<td>0902740</td>
<td>Elk Ditch</td>
<td>6.93</td>
<td>487.7</td>
</tr>
<tr>
<td>0902742</td>
<td>Go Ahead Ditch</td>
<td>7.61</td>
<td>395.9</td>
</tr>
<tr>
<td>0902744</td>
<td>Military Ditch</td>
<td>2.04</td>
<td>304.2</td>
</tr>
<tr>
<td>0902746</td>
<td>Anita Supplemental D</td>
<td>19.0</td>
<td>396.4</td>
</tr>
<tr>
<td>0902748</td>
<td>PaintRockDivsAbMedLo</td>
<td>8.337</td>
<td>153.9</td>
</tr>
<tr>
<td>0902755</td>
<td>PaintRockCDivBlMedLo</td>
<td>8.41</td>
<td>416.2</td>
</tr>
<tr>
<td>0902765</td>
<td>AlkaliCkDivs</td>
<td>3.92</td>
<td>394.1</td>
</tr>
<tr>
<td>0902785</td>
<td>Weintz Ditch</td>
<td>2.01</td>
<td>139.7</td>
</tr>
<tr>
<td>0902790</td>
<td>Bernstein No. 1 Ditch</td>
<td>5.86</td>
<td>218.2</td>
</tr>
<tr>
<td>0902792</td>
<td>PaintRockDivsAbMouth</td>
<td>7.76</td>
<td>315.0</td>
</tr>
<tr>
<td>0902795</td>
<td>Bernstein No. 2 Ditch</td>
<td>1.04</td>
<td>113.3</td>
</tr>
<tr>
<td>0902850</td>
<td>Ilg Enlargement</td>
<td>3.62</td>
<td>422.8</td>
</tr>
<tr>
<td>0902900</td>
<td>NowoodDivsBlwPaintRoc</td>
<td>10.02</td>
<td>486.1</td>
</tr>
<tr>
<td>0902950</td>
<td>Van Alstine-Walker D</td>
<td>23.04</td>
<td>1085.7</td>
</tr>
<tr>
<td>0903000</td>
<td>Shafer Ditch</td>
<td>11.949</td>
<td>633.4</td>
</tr>
<tr>
<td>0903100</td>
<td>Harmony Ditch</td>
<td>10.74</td>
<td>351.8</td>
</tr>
</tbody>
</table>

TOTALS 389.8 21,103 27,761

Notes:
- Permitted acreage equal to measured acreage if a) measured > 70 cfs, b) measured < 70 cfs, c) well structure.
- * No water rights assigned to acreage. Dummy junior right of 10 cfs used in model. 10 cfs right not included in Total.
<table>
<thead>
<tr>
<th></th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire Basin Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>7,138</td>
<td>21,932</td>
<td>31,575</td>
<td>30,198</td>
<td>26,542</td>
<td>19,609</td>
<td>5,050</td>
<td>142,043</td>
</tr>
<tr>
<td>DRY</td>
<td>10,229</td>
<td>23,019</td>
<td>29,998</td>
<td>25,802</td>
<td>25,981</td>
<td>19,462</td>
<td>4,338</td>
<td>142,827</td>
</tr>
<tr>
<td><strong>Entire Basin Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>230</td>
<td>977</td>
<td>3,137</td>
<td>4,802</td>
<td>5,499</td>
<td>3,083</td>
<td>288</td>
<td>18,015</td>
</tr>
<tr>
<td>DRY</td>
<td>470</td>
<td>1,220</td>
<td>3,314</td>
<td>5,551</td>
<td>6,176</td>
<td>3,239</td>
<td>21</td>
<td>20,240</td>
</tr>
<tr>
<td><strong>Entire Basin Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>3%</td>
<td>4%</td>
<td>10%</td>
<td>16%</td>
<td>21%</td>
<td>16%</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>DRY</td>
<td>5%</td>
<td>5%</td>
<td>11%</td>
<td>19%</td>
<td>24%</td>
<td>17%</td>
<td>6%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>1,896</td>
<td>5,711</td>
<td>7,938</td>
<td>7,480</td>
<td>6,708</td>
<td>5,080</td>
<td>1,355</td>
<td>36,168</td>
</tr>
<tr>
<td>DRY</td>
<td>2,706</td>
<td>5,979</td>
<td>7,529</td>
<td>7,393</td>
<td>6,588</td>
<td>5,043</td>
<td>1,163</td>
<td>36,400</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>43</td>
<td>142</td>
<td>1,198</td>
<td>2,381</td>
<td>2,434</td>
<td>1,374</td>
<td>58</td>
<td>7,629</td>
</tr>
<tr>
<td>DRY</td>
<td>136</td>
<td>522</td>
<td>1,716</td>
<td>2,759</td>
<td>2,698</td>
<td>1,595</td>
<td>83</td>
<td>9,508</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>2%</td>
<td>2%</td>
<td>15%</td>
<td>32%</td>
<td>36%</td>
<td>27%</td>
<td>4%</td>
<td>21%</td>
</tr>
<tr>
<td>DRY</td>
<td>5%</td>
<td>9%</td>
<td>23%</td>
<td>41%</td>
<td>32%</td>
<td>27%</td>
<td>7%</td>
<td>26%</td>
</tr>
<tr>
<td><strong>Tensleep Creek Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>944</td>
<td>2,842</td>
<td>3,955</td>
<td>3,729</td>
<td>3,344</td>
<td>2,530</td>
<td>675</td>
<td>18,019</td>
</tr>
<tr>
<td>DRY</td>
<td>1,348</td>
<td>2,975</td>
<td>3,751</td>
<td>3,685</td>
<td>3,284</td>
<td>2,512</td>
<td>579</td>
<td>18,134</td>
</tr>
<tr>
<td><strong>Tensleep Creek Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>0</td>
<td>0</td>
<td>49</td>
<td>344</td>
<td>292</td>
<td>95</td>
<td>7</td>
<td>787</td>
</tr>
<tr>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>45</td>
<td>479</td>
<td>319</td>
<td>117</td>
<td>9</td>
<td>968</td>
</tr>
<tr>
<td><strong>Tensleep Creek Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>9%</td>
<td>9%</td>
<td>4%</td>
<td>1%</td>
<td>4%</td>
</tr>
<tr>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>13%</td>
<td>10%</td>
<td>5%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>1,232</td>
<td>3,706</td>
<td>5,166</td>
<td>4,874</td>
<td>4,372</td>
<td>3,304</td>
<td>880</td>
<td>23,533</td>
</tr>
<tr>
<td>DRY</td>
<td>1,761</td>
<td>3,878</td>
<td>4,898</td>
<td>4,817</td>
<td>4,293</td>
<td>3,279</td>
<td>756</td>
<td>23,682</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>54</td>
<td>491</td>
<td>988</td>
<td>730</td>
<td>875</td>
<td>615</td>
<td>140</td>
<td>3,893</td>
</tr>
<tr>
<td>DRY</td>
<td>74</td>
<td>366</td>
<td>795</td>
<td>669</td>
<td>835</td>
<td>535</td>
<td>109</td>
<td>3,383</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>4%</td>
<td>13%</td>
<td>19%</td>
<td>15%</td>
<td>20%</td>
<td>19%</td>
<td>16%</td>
<td>17%</td>
</tr>
<tr>
<td>DRY</td>
<td>4%</td>
<td>9%</td>
<td>16%</td>
<td>14%</td>
<td>16%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>2,262</td>
<td>6,807</td>
<td>9,467</td>
<td>8,933</td>
<td>8,032</td>
<td>6,055</td>
<td>1,614</td>
<td>43,169</td>
</tr>
<tr>
<td>DRY</td>
<td>3,231</td>
<td>7,124</td>
<td>8,976</td>
<td>8,828</td>
<td>7,888</td>
<td>6,011</td>
<td>1,386</td>
<td>43,444</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>133</td>
<td>339</td>
<td>766</td>
<td>1,271</td>
<td>1,794</td>
<td>999</td>
<td>83</td>
<td>5,385</td>
</tr>
<tr>
<td>DRY</td>
<td>260</td>
<td>324</td>
<td>685</td>
<td>1,572</td>
<td>2,158</td>
<td>992</td>
<td>70</td>
<td>6,061</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>6%</td>
<td>5%</td>
<td>8%</td>
<td>14%</td>
<td>22%</td>
<td>16%</td>
<td>5%</td>
<td>12%</td>
</tr>
<tr>
<td>DRY</td>
<td>8%</td>
<td>5%</td>
<td>8%</td>
<td>18%</td>
<td>27%</td>
<td>17%</td>
<td>5%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Below Paint Rock Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>804</td>
<td>2,866</td>
<td>5,049</td>
<td>5,183</td>
<td>4,086</td>
<td>2,640</td>
<td>527</td>
<td>21,155</td>
</tr>
<tr>
<td>DRY</td>
<td>1,182</td>
<td>3,063</td>
<td>4,845</td>
<td>5,080</td>
<td>3,927</td>
<td>2,617</td>
<td>453</td>
<td>21,167</td>
</tr>
<tr>
<td><strong>Below Paint Rock Shortage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>0</td>
<td>5</td>
<td>136</td>
<td>76</td>
<td>103</td>
<td>0</td>
<td>0</td>
<td>321</td>
</tr>
<tr>
<td>DRY</td>
<td>0</td>
<td>8</td>
<td>74</td>
<td>72</td>
<td>167</td>
<td>0</td>
<td>0</td>
<td>320</td>
</tr>
<tr>
<td><strong>Below Paint Rock Percent Short</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>1%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Notes:**

Values exclude approximately 2718 acre-feet per year average well demand.
**TABLE 5**

NOWOOD RIVER STATEMODEL

SIMULATED AVAILABLE FLOWS (acre-feet)

BASELINE SCENARIO WITH PERMITTED ACREAGE

Average values for 1973 through 2008 period


<table>
<thead>
<tr>
<th>Workbook:</th>
<th>NowoodModel_BaselineScenariosOutput.xlsx</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATEMOD</td>
<td>BASELINE SCENARIO</td>
</tr>
<tr>
<td>based WITH ACREAGE</td>
<td>PERMITTED</td>
</tr>
</tbody>
</table>
### TABLE S

**NOWOOD RIVER STATEMODEL**

**SIMULATED AVAILABLE FLOWS (acre-feet)**

**BASELINE SCENARIO WITH PERMITTED ACREAGE**

Average values for 1973 through 2008 period


<table>
<thead>
<tr>
<th>Workbook:</th>
<th>NowoodRiver_BaselinePermitWater.xls</th>
<th>Workbook:</th>
<th>NowoodRiver_BaselinePermitWater.xls</th>
<th>Workbook:</th>
<th>NowoodRiver_BaselinePermitWater.xls</th>
</tr>
</thead>
</table>

#### FEEDER CANALS / DITCHES TO OFF-CHANNEL RESERVOIRS

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Nowood Physical Flow</td>
<td>AVG</td>
<td>209</td>
<td>245</td>
<td>406</td>
<td>629</td>
<td>1,637</td>
<td>787</td>
<td>291</td>
<td>214</td>
<td>247</td>
<td>235</td>
<td>225</td>
</tr>
<tr>
<td>DRY</td>
<td>161</td>
<td>203</td>
<td>296</td>
<td>430</td>
<td>672</td>
<td>425</td>
<td>255</td>
<td>180</td>
<td>199</td>
<td>187</td>
<td>173</td>
<td>173</td>
</tr>
<tr>
<td>Upper Nowood Available Flow</td>
<td>AVG</td>
<td>209</td>
<td>245</td>
<td>406</td>
<td>582</td>
<td>1,494</td>
<td>590</td>
<td>93</td>
<td>41</td>
<td>119</td>
<td>201</td>
<td>225</td>
</tr>
<tr>
<td>DRY</td>
<td>161</td>
<td>203</td>
<td>296</td>
<td>362</td>
<td>522</td>
<td>237</td>
<td>65</td>
<td>15</td>
<td>73</td>
<td>161</td>
<td>178</td>
<td>173</td>
</tr>
<tr>
<td>Ladd Tunnel Physical Flow</td>
<td>AVG</td>
<td>213</td>
<td>186</td>
<td>202</td>
<td>342</td>
<td>4,366</td>
<td>6,527</td>
<td>2,947</td>
<td>1,037</td>
<td>780</td>
<td>484</td>
<td>308</td>
</tr>
<tr>
<td>DRY</td>
<td>219</td>
<td>183</td>
<td>204</td>
<td>388</td>
<td>3,597</td>
<td>4,980</td>
<td>2,425</td>
<td>876</td>
<td>637</td>
<td>477</td>
<td>303</td>
<td>257</td>
</tr>
<tr>
<td>Ladd Tunnel Available Flow</td>
<td>AVG</td>
<td>211</td>
<td>186</td>
<td>202</td>
<td>313</td>
<td>2,825</td>
<td>5,677</td>
<td>1,632</td>
<td>195</td>
<td>125</td>
<td>439</td>
<td>308</td>
</tr>
<tr>
<td>DRY</td>
<td>219</td>
<td>183</td>
<td>204</td>
<td>214</td>
<td>2,926</td>
<td>4,222</td>
<td>1,192</td>
<td>40</td>
<td>330</td>
<td>441</td>
<td>303</td>
<td>257</td>
</tr>
<tr>
<td>Anita Ditch Physical Flow</td>
<td>AVG</td>
<td>700</td>
<td>631</td>
<td>637</td>
<td>362</td>
<td>2,728</td>
<td>5,722</td>
<td>1,130</td>
<td>85</td>
<td>138</td>
<td>808</td>
<td>1,007</td>
</tr>
<tr>
<td>DRY</td>
<td>760</td>
<td>613</td>
<td>662</td>
<td>293</td>
<td>2,774</td>
<td>6,671</td>
<td>677</td>
<td>69</td>
<td>160</td>
<td>853</td>
<td>984</td>
<td>845</td>
</tr>
<tr>
<td>Anita Ditch Available Flow</td>
<td>AVG</td>
<td>700</td>
<td>631</td>
<td>637</td>
<td>245</td>
<td>2,432</td>
<td>5,379</td>
<td>912</td>
<td>0</td>
<td>63</td>
<td>806</td>
<td>1,007</td>
</tr>
<tr>
<td>DRY</td>
<td>760</td>
<td>613</td>
<td>662</td>
<td>125</td>
<td>2,473</td>
<td>3,359</td>
<td>517</td>
<td>0</td>
<td>89</td>
<td>853</td>
<td>984</td>
<td>845</td>
</tr>
<tr>
<td>Middle Nowood Physical Flow</td>
<td>AVG</td>
<td>7,080</td>
<td>7,211</td>
<td>9,993</td>
<td>13,158</td>
<td>42,505</td>
<td>36,928</td>
<td>13,140</td>
<td>5,134</td>
<td>6,615</td>
<td>9,284</td>
<td>9,166</td>
</tr>
<tr>
<td>DRY</td>
<td>6,423</td>
<td>6,432</td>
<td>8,207</td>
<td>9,265</td>
<td>26,402</td>
<td>23,145</td>
<td>10,462</td>
<td>4,270</td>
<td>5,739</td>
<td>8,540</td>
<td>8,153</td>
<td>7,106</td>
</tr>
<tr>
<td>Middle Nowood Available Flow</td>
<td>AVG</td>
<td>6,988</td>
<td>7,200</td>
<td>9,993</td>
<td>13,007</td>
<td>30,212</td>
<td>35,870</td>
<td>11,920</td>
<td>2,054</td>
<td>5,460</td>
<td>8,957</td>
<td>9,123</td>
</tr>
<tr>
<td>DRY</td>
<td>6,423</td>
<td>6,432</td>
<td>8,207</td>
<td>9,186</td>
<td>26,299</td>
<td>22,471</td>
<td>9,493</td>
<td>883</td>
<td>5,136</td>
<td>8,540</td>
<td>8,153</td>
<td>7,106</td>
</tr>
<tr>
<td>Lower Nowood Physical Flow</td>
<td>AVG</td>
<td>7,697</td>
<td>7,705</td>
<td>15,901</td>
<td>16,769</td>
<td>44,847</td>
<td>36,570</td>
<td>12,272</td>
<td>2,455</td>
<td>6,185</td>
<td>9,686</td>
<td>9,732</td>
</tr>
<tr>
<td>DRY</td>
<td>7,325</td>
<td>7,134</td>
<td>14,249</td>
<td>14,410</td>
<td>34,378</td>
<td>22,954</td>
<td>9,825</td>
<td>3,493</td>
<td>5,353</td>
<td>9,015</td>
<td>8,750</td>
<td>7,638</td>
</tr>
<tr>
<td>Lower Nowood Available Flow</td>
<td>AVG</td>
<td>7,595</td>
<td>7,661</td>
<td>15,901</td>
<td>16,762</td>
<td>42,067</td>
<td>36,313</td>
<td>11,920</td>
<td>2,054</td>
<td>5,476</td>
<td>9,292</td>
<td>9,675</td>
</tr>
<tr>
<td>DRY</td>
<td>7,325</td>
<td>7,134</td>
<td>14,410</td>
<td>14,410</td>
<td>34,378</td>
<td>22,834</td>
<td>9,933</td>
<td>883</td>
<td>5,367</td>
<td>8,987</td>
<td>8,750</td>
<td>7,638</td>
</tr>
<tr>
<td>Lower Paint Rock Physical Flow</td>
<td>AVG</td>
<td>2,228</td>
<td>1,845</td>
<td>1,873</td>
<td>2,296</td>
<td>21,035</td>
<td>23,688</td>
<td>15,248</td>
<td>4,417</td>
<td>3,880</td>
<td>4,407</td>
<td>3,810</td>
</tr>
<tr>
<td>DRY</td>
<td>2,342</td>
<td>1,820</td>
<td>1,926</td>
<td>1,835</td>
<td>20,819</td>
<td>28,518</td>
<td>12,030</td>
<td>3,749</td>
<td>3,101</td>
<td>4,451</td>
<td>3,702</td>
<td>2,888</td>
</tr>
<tr>
<td>Lower Paint Rock Available Flow</td>
<td>AVG</td>
<td>1,760</td>
<td>1,706</td>
<td>1,873</td>
<td>2,027</td>
<td>15,871</td>
<td>31,874</td>
<td>8,695</td>
<td>1,038</td>
<td>1,842</td>
<td>3,276</td>
<td>3,476</td>
</tr>
<tr>
<td>DRY</td>
<td>2,056</td>
<td>1,663</td>
<td>1,926</td>
<td>1,469</td>
<td>16,402</td>
<td>22,598</td>
<td>6,352</td>
<td>214</td>
<td>1,992</td>
<td>3,446</td>
<td>3,385</td>
<td>2,573</td>
</tr>
</tbody>
</table>

(1) Representative of Cornell Gulch Reservoir feeder ditch from Nowood River
(2) Based on prorata area-precip factor of 18.8% of flow at Paint Rock Creek near Hyattville gage.
(3) Representative of Alkali Creek Reservoir and Weintz Draw Reservoir feeder ditch from Medicine Lodge Creek
(4) Representative of Alkali Creek Reservoir and Weintz Draw Reservoir feeder ditch from Upper Paint Rock Creek
(5) Representative of Little Cottonwood Reservoir feeder ditch from Nowood River
(6) Representative of Big Cottonwood Reservoir feeder ditch from Nowood River
(7) Representative of McDermott Draw Reservoir feeder ditch from Lower Paint Rock Creek

(continued...)

*Table continued on next page...*
APPENDIX C3

STATEMOD DEMANDS AND SHORTAGES SIMULATIONS
APPENDIX C3-1. DEMANDS AND SHORTAGES BETWEEN LONE TREE RESERVOIR AND BIG TRAILS RESERVOIR
NOWOOD RIVER STORAGE, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands (acre-feet)</th>
<th>Shortages (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>240</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>724</td>
<td>0</td>
</tr>
<tr>
<td>Jun</td>
<td>1,004</td>
<td>2</td>
</tr>
<tr>
<td>Jul</td>
<td>946</td>
<td>50</td>
</tr>
<tr>
<td>Aug</td>
<td>848</td>
<td>43</td>
</tr>
<tr>
<td>Sep</td>
<td>643</td>
<td>2</td>
</tr>
<tr>
<td>Oct</td>
<td>172</td>
<td>0</td>
</tr>
</tbody>
</table>

StateMOD Simulated Flow (acre-feet)
APPENDIX C3-2. BEAR CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

Legend:
- Demands
- Shortages

<table>
<thead>
<tr>
<th>Month</th>
<th>StateMOD Simulated Flow (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>44</td>
</tr>
<tr>
<td>May</td>
<td>131</td>
</tr>
<tr>
<td>Jun</td>
<td>182</td>
</tr>
<tr>
<td>Jul</td>
<td>171</td>
</tr>
<tr>
<td>Aug</td>
<td>153</td>
</tr>
<tr>
<td>Sep</td>
<td>116</td>
</tr>
<tr>
<td>Oct</td>
<td>31</td>
</tr>
</tbody>
</table>

Note: '0' indicates no demand or shortage for the respective month.
APPENDIX C3-3. DEEP CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

StateMOD Simulated Flow (acre-feet)

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands</th>
<th>Shortages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Jun</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Jul</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Aug</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Sep</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Oct</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Month

StateMOD Simulated Flow (acre-feet)
APPENDIX C3-4. REDBANK CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

![Graph showing StateMOD Simulated Flow and Demands vs. Shortages for each month from April to October.](image-url)
APPENDIX C3-5. LITTLE CANYON CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands</th>
<th>Shortages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>291</td>
<td>3</td>
</tr>
<tr>
<td>May</td>
<td>1,070</td>
<td>4</td>
</tr>
<tr>
<td>Jun</td>
<td>1,544</td>
<td>332</td>
</tr>
<tr>
<td>Jul</td>
<td>1,438</td>
<td>773</td>
</tr>
<tr>
<td>Aug</td>
<td>1,247</td>
<td>764</td>
</tr>
<tr>
<td>Sep</td>
<td>925</td>
<td>471</td>
</tr>
<tr>
<td>Oct</td>
<td>212</td>
<td>9</td>
</tr>
</tbody>
</table>

StateMOD Simulated Flow (acre-feet)
APPENDIX C3-7. OTTER CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

![Graph showing StateMOD Simulated Flow (acre-feet) and demands and shortages by month.]

- **Month**: April, May, June, July, August, September, October
- **Values**:
  - April: Demands - 172, Shortages - 0
  - May: Demands - 0, Shortages - 0
  - June: Demands - 1,019, Shortages - 14
  - July: Demands - 945, Shortages - 110
  - August: Demands - 809, Shortages - 145
  - September: Demands - 594, Shortages - 21
  - October: Demands - 127, Shortages - 1
APPENDIX C3-8. SPRING CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

StateMOD Simulated Flow (acre-feet)

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands</th>
<th>Shortages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>253</td>
<td>4</td>
</tr>
<tr>
<td>May</td>
<td>1,019</td>
<td>62</td>
</tr>
<tr>
<td>Jun</td>
<td>1,496</td>
<td>478</td>
</tr>
<tr>
<td>Jul</td>
<td>1,388</td>
<td>796</td>
</tr>
<tr>
<td>Aug</td>
<td>1,188</td>
<td>744</td>
</tr>
<tr>
<td>Sep</td>
<td>872</td>
<td>476</td>
</tr>
<tr>
<td>Oct</td>
<td>187</td>
<td>12</td>
</tr>
</tbody>
</table>
APPENDIX C3-9. DEMANDS AND SHORTAGES BETWEEN BIG TRAILS RESERVOIR AND TENSLEEP CREEK
NOWOOD RIVER STORAGE, LEVEL II STUDY

![Bar graph showing StateMOD Simulated Flow (acre-feet) for demands and shortages by month.]

- April: 409
- May: 1,648
- June: 2,422
- July: 2,248
- August: 1,925
- September: 1,412
- October: 302

Month: Apr, May, Jun, Jul, Aug, Sep, Oct
StateMOD Simulated Flow (acre-feet): 0, 0, 0, 2,422, 0, 0, 0, 0, 0, 0, 0, 0
Demands: 0, 0, 0, 2,248, 0, 0, 0, 0, 0, 0, 0, 0
Shortages: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
APPENDIX C3-10. TENSLEEP CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands</th>
<th>Shortages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>545</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>2,980</td>
<td>0</td>
</tr>
<tr>
<td>Jun</td>
<td>4,581</td>
<td>0</td>
</tr>
<tr>
<td>Jul</td>
<td>4,205</td>
<td>191</td>
</tr>
<tr>
<td>Aug</td>
<td>3,452</td>
<td>167</td>
</tr>
<tr>
<td>Sep</td>
<td>2,459</td>
<td>50</td>
</tr>
<tr>
<td>Oct</td>
<td>419</td>
<td>2</td>
</tr>
</tbody>
</table>

StateMOD Simulated Flow (acre-feet)
APPENDIX C3.11. BROKENBACK CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

[Bar chart showing StateMOD simulated flow (acre-feet) for each month from April to October. The months are April, May, June, July, August, September, and October. The demands and shortages for each month are indicated by blue and orange bars, respectively.]

- April: Demands 73, Shortages 3
- May: Demands 401, Shortages 141
- June: Demands 617, Shortages 377
- July: Demands 566, Shortages 213
- August: Demands 465, Shortages 399
- September: Demands 331, Shortages 270
- October: Demands 56, Shortages 55

Month: April, May, June, July, August, September, October

StateMOD Simulated Flow (acre-feet)
APPENDIX C3-12. BUFFALO FLAT CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

![Chart showing StateMOD Simulated Flow (acre-feet) for various months with demands and shortages indicated.]

- April: 31 demands, 1 shortage
- May: 168 demands, 55 shortage
- June: 258 demands, 136 shortage
- July: 237 demands, 92 shortage
- August: 195 demands, 191 shortage
- September: 139 demands, 121 shortage
- October: 24 demands, 23 shortage

Legend:
- Blue bars: Demands
- Orange bars: Shortages
APPENDIX C3-13. DEMANDS AND SHORTAGES BETWEEN TENSLEEP CREEK AND PAINT ROCK CREEK
NOWOOD RIVER STORAGE, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Month</th>
<th>StateMOD Simulated Flow (acre-feet)</th>
<th>Demands</th>
<th>Shortages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>600</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>3,279</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jun</td>
<td>5,049</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jul</td>
<td>4,638</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Aug</td>
<td>3,807</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sep</td>
<td>2,709</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oct</td>
<td>461</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
APPENDIX C-14. PAINT ROCK CREEK ABOVE MEDICINE LODGE CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

StateMOD Simulated Flow (acre-feet)

Month

Apr  0
May  0
Jun  3,152
Jul  3,124
Aug  2,735
Sep  1,945
Oct  320

Demands
Shortages
APPENDIX C3-15. MEDICINE LODGE CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

<table>
<thead>
<tr>
<th>Month</th>
<th>Demands (acre-feet)</th>
<th>Shortages (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr</td>
<td>527</td>
<td>11</td>
</tr>
<tr>
<td>May</td>
<td>2,496</td>
<td>0</td>
</tr>
<tr>
<td>Jun</td>
<td>3,914</td>
<td>158</td>
</tr>
<tr>
<td>Jul</td>
<td>3,888</td>
<td>1,024</td>
</tr>
<tr>
<td>Aug</td>
<td>3,426</td>
<td>1,459</td>
</tr>
<tr>
<td>Sep</td>
<td>2,414</td>
<td>788</td>
</tr>
<tr>
<td>Oct</td>
<td>0</td>
<td>397</td>
</tr>
</tbody>
</table>

StateMOD Simulated Flow (acre-feet)
APPENDIX C3-17. BELOW PAINT ROCK CREEK DEMANDS AND SHORTAGES
NOWOOD RIVER STORAGE, LEVEL II STUDY

![Graph showing StateMOD Simulated Flow (acre-feet) for months April to October.
- April: 625
- May: 3,607
- June: 6,183
- July: 5,760
- August: 4,265
- September: 2,802
- October: 469

Differences:
- June: 34
- August: 484

Legend:
- Blue: Demands
- Orange: Shortages]
APPENDIX C4

FEBRUARY 2013 STAGE 3 TECHNICAL MEMORANDUM
Introduction

ParsonsWater Consulting LLC (PWC) is providing technical professional consulting to Trihydro for the Nowood River Storage Level II Study for the Wyoming Water Development Commission (WWDC). Work being performed fulfills the hydrologic modeling elements appurtenant to the following tasks in the Scope of Services to Trihydro’s contract with the WWDC:

- Task 2. Literature and Model Review
- Task 4. Hydrologic Analysis
- Task 8. Alternative Analysis
- Task 17. Reports

PWC’s work is being undertaken in three stages, as outlined below.

1. Initial Development of a Skeleton StateMod Model.
2. StateMod Model Refinement and Support/Participation in Cooper Consulting, LLC Peer Review.
3. Analyses of Project Alternatives.

Stage 1 of the Nowood Level II Study included the Initial Development of a StateMod model based on the architecture and approach used in the 2010 River Basin Plan Update (2010 Update). This effort included development of the Nowood model network and identification of the various input data that needed to be gathered or estimated, beyond the work completed in the 2010 Update.

Missing data identified during Stage 1 were filled in Stage 2, resulting in a complete Nowood Model Baseline data set representing the monthly variability of water supply and demands over an historical period (1973 through 2008) representative of wet, dry, and average hydrologic conditions in the Nowod River basin. The Baseline scenario results provide reasonable estimates of irrigation demands and shortages associated with permitted acreage in the basin. In addition, the model results provide estimates of flows legally available for diversion under a junior water right for the initial list of 22 identified reservoir sites. The legally available flows and estimates of Baseline irrigation shortages provide some of the metrics used to develop a short list of alternative reservoir sites to be explored further in subsequent Tasks of the Nowood Level II Study effort.
Stage 3 of the Nowood Level II Study identified five preferred reservoir alternative sites located throughout the basin to compare the potential reductions to the Baseline irrigation shortages associated with operation of each of the reservoirs. However, discussions with project participants and additional review of geologic, environmental, and land access issues affected the total number of reservoir alternatives analyzed. The preferred reservoir sites analyzed were reduced to the following:

1. Alkali Creek Reservoir
2. Meadowlark Lake Enlargement

Independent review of the model developed in Stage 2 resulted in recommendations to improve model input in the Stage 3 model (see June 17, 2011 Cooper Consulting, LLC Memorandum re: Nowood River StateMod). Changes were made to the Baseline Data Set pursuant to these recommendations, which resulted in changes to the Stage 3 Baseline irrigation shortages (see Table 1) and estimates of physically available and legally available flow at the initial list of 22 identified reservoir sites (see Table 2). The changes to the Baseline data set did not affect the choice of reservoir alternatives analyzed in Stage 3 of the Nowood Level II Study.

Changes to the Baseline Data Set input and output are summarized below, followed by a discussion of the representation of the reservoir alternatives within the model input and comparison of the model simulation outputs that include operation of the reservoirs to reduce Baseline irrigation shortages.

**Baseline Data Set**

As noted above, changes were made to the Baseline Data Set in this task. The changes are summarized below. Detailed information regarding the original development of the Baseline Data Set can be found in the *Nowood Level II Study Stage 2 – Hydrologic Analysis Using Nowood River StateMod Model* memorandum, dated April 13, 2011.

1. Model Network and River Network File – Changes made to the Stage 2 model include the following:
   a. General – Nineteen (19) irrigation nodes were added to the bottom of tributaries (14) and along sections of the main stem (5) to refine representation of the Wyoming Surplus Water Law in the model (see Paragraphs 1b and 3).
   b. Diversions – Surplus water rights on each modeled tributary were aggregated at a Surplus Water Right node located at the bottom of the tributary. Four Surplus Water Right nodes were included on the Paint Rock tributary due its geographic extent. Additional Surplus Water Right nodes were aggregated along the Nowood River main stem between tributary confluences and or locations of reservoir alternative sites.
The nodes added to the model network are highlighted in Figure 1 and listed below, in upstream to downstream order.

<table>
<thead>
<tr>
<th>Model Node ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoneTreeSurp</td>
<td>Lone Tree Creek</td>
</tr>
<tr>
<td>BearCkSurp</td>
<td>Bear Creek</td>
</tr>
<tr>
<td>DeepCkSurp</td>
<td>Deep Creek</td>
</tr>
<tr>
<td>RedbankSurp</td>
<td>Redbank Creek</td>
</tr>
<tr>
<td>AbvBigTrSurp</td>
<td>Nowood River main stem above Big Trails Reservoir site</td>
</tr>
<tr>
<td>LitCanySurp</td>
<td>Little Canyon Creek</td>
</tr>
<tr>
<td>CrookedSurp</td>
<td>Crooked Creek</td>
</tr>
<tr>
<td>OttCkSurp</td>
<td>Otter Creek</td>
</tr>
<tr>
<td>SprCkSurp</td>
<td>Spring Creek</td>
</tr>
<tr>
<td>AbvTensSurp</td>
<td>Nowood River main stem between Big Trails Reservoir site and Tensleep Creek confluence</td>
</tr>
<tr>
<td>TensSurp</td>
<td>Tensleep Creek</td>
</tr>
<tr>
<td>BrknbkSurp</td>
<td>Bokenback Creek</td>
</tr>
<tr>
<td>BuffaloSurp</td>
<td>Buffalo Creek</td>
</tr>
<tr>
<td>AbvPtRSurp</td>
<td>Nowood River main stem between Tensleep Creek confluence and Paint Rock confluence</td>
</tr>
<tr>
<td>MedLgSurp</td>
<td>Medicine Lodge Creek</td>
</tr>
<tr>
<td>AlkCkSurp</td>
<td>Alkali Creek</td>
</tr>
<tr>
<td>UpPtRSurp</td>
<td>Upper Paint Rock Creek</td>
</tr>
<tr>
<td>LowPtRSurp</td>
<td>Lower Paint Rock Creek</td>
</tr>
<tr>
<td>MandSurp</td>
<td>Nowood River main stem below Paint Rock confluence</td>
</tr>
</tbody>
</table>

c. Stream Gages – No changes made to the Stage 2 model. Stream gage information summarized in the Stage 2 memorandum is included herein for reference.

d. Instream Flow Points/Reaches – One instream flow point was added on Otter Creek below a feeder ditch that was analyzed to fill an off-channel Taylor Draw Reservoir. The instream flow was added to represent a bypass flow that would need to be met prior to making any diversions to Taylor Draw Reservoir. This instream flow is Off in all scenarios but is maintained in the model network as a placeholder for future model scenarios.

2. Natural Flow Hydrology – No changes made to the Stage 2 model.

The natural flow hydrology is based, in part, on historical diversions. Absent records of historical operations, the approach originally used to estimate historical diversions was based on crop irrigation water requirements (CIR), system efficiencies, and representative monthly diversion shortages. The estimates of historical diversions would change based on the new crop mixes assigned to the irrigation nodes in the Stage 3 model (see Paragraph 4b). Efforts
to incorporate those changes to the model input and subsequent calculation of natural flows based on historical stream flows, historical diversions, system efficiencies, and return flow locations and amounts is considered beyond the scope of work for revision to the Stage 2 model.

In addition, changes to the natural flow hydrology are not anticipated to change significantly from the Stage 2 model since the changes to CIR from the new crop mixes are not significant in comparison to the Stage 2 model (see Paragraph 4c and Figure 2).

3. Water Rights –

A total of 381.8 cfs of direct flow rights was input to the Stage 2 model, which included a total of 355.9 cfs with priority dates senior to March 1, 1945. The total rights were increased in the Stage 3 model to 383.1 cfs (1.3 cfs increase) based on the following recommendations made by Craig Cooper:

- Include 0.37 cfs for Crowley Ditch (Node ID 0900150) and associated acreage at standard duty of water (25.9 acres equal to 0.37 cfs times 70 acres per cfs)
- Revise Big Bear Ditch (Node ID 0902738) total right of 6.77 cfs to 7.69 cfs

These changes increased the pre-1945 priority water rights a similar amount, to a total of 357.2 cfs.

(Note the values originally listed in the Stage 2 memorandum are different than those listed above due to some errors in spreadsheet calculations that have since been corrected.)

The Wyoming Surplus Water Law allocates water in excess of senior rights on a proportionate share basis to all pre-1945 water rights, dependent on acreage with water rights. The second cfs water rights were assigned to irrigation nodes with priority dates relative to one another in the Stage 2 model. The 19 Surplus Water Right nodes were included in the Stage 3 model to better reflect river administration.

The 19 nodes individually represent an aggregate of the irrigation nodes located on a tributary or within a particular stretch of the Nowood River main stem. The acreage assigned to the various model nodes, as modified in Stage 3 (see Paragraph 4a and Table 3), were summed for each Surplus Water Right node. The total 357.2 cfs of pre-1945 water rights were assigned to the Surplus Water Rights based on the pro-rata acreage assigned to each of the nodes.

These cfs amounts were input as water rights for each of the Surplus Water Right nodes, as tabulated below. Although administration of the Surplus Water Right Law anticipates access to surplus water as equivalent for all users, the StateMod program operates all input rights distinct from one another (i.e., two equal input priorities are operated one senior to the other dependent on which right is read first from the input files by the StateMod program). The
Surplus Water Rights were therefore assigned priorities relative to one another based on upstream to downstream location within the basin.

This approach will allow excess physical supplies at upstream nodes to be used at the upstream nodes rather than these excess flows being shepherded downstream to other users. This approach is considered reasonable considering actual operations understood to occur in the basin.

<table>
<thead>
<tr>
<th>Surplus Water Right Node</th>
<th>Acres*</th>
<th>cfs</th>
<th>Acreage %</th>
<th>cfs %</th>
<th>Surplus Water Right Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoneTreeSurp</td>
<td>26</td>
<td>0.4</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.4 1945.01</td>
</tr>
<tr>
<td>BearCkSurp</td>
<td>147</td>
<td>2.1</td>
<td>1%</td>
<td>1%</td>
<td>2.2 1945.02</td>
</tr>
<tr>
<td>DeepCkSurp</td>
<td>12</td>
<td>7.6</td>
<td>0%</td>
<td>2%</td>
<td>0.2 1945.03</td>
</tr>
<tr>
<td>RedbankSurp</td>
<td>225</td>
<td>5.0</td>
<td>1%</td>
<td>1%</td>
<td>3.3 1945.04</td>
</tr>
<tr>
<td>AbvBigTrSurp</td>
<td>814</td>
<td>11.6</td>
<td>3%</td>
<td>3%</td>
<td>12.0 1945.05</td>
</tr>
<tr>
<td>LitCanySurp</td>
<td>1,180</td>
<td>16.9</td>
<td>5%</td>
<td>5%</td>
<td>17.4 1945.06</td>
</tr>
<tr>
<td>CrookedSurp</td>
<td>292</td>
<td>2.3</td>
<td>1%</td>
<td>1%</td>
<td>4.3 1945.07</td>
</tr>
<tr>
<td>OttCkSurp</td>
<td>734</td>
<td>10.5</td>
<td>3%</td>
<td>3%</td>
<td>10.8 1945.08</td>
</tr>
<tr>
<td>SprCkSurp</td>
<td>956</td>
<td>13.7</td>
<td>4%</td>
<td>4%</td>
<td>14.1 1945.09</td>
</tr>
<tr>
<td>AbvTensSurp</td>
<td>1,624</td>
<td>23.2</td>
<td>7%</td>
<td>6%</td>
<td>23.9 1945.10</td>
</tr>
<tr>
<td>TensSurp</td>
<td>3,194</td>
<td>45.6</td>
<td>13%</td>
<td>13%</td>
<td>47.1 1945.11</td>
</tr>
<tr>
<td>BrknbkSurp</td>
<td>439</td>
<td>2.9</td>
<td>2%</td>
<td>1%</td>
<td>6.5 1945.12</td>
</tr>
<tr>
<td>BuffaloSurp</td>
<td>0</td>
<td>0.0</td>
<td>0%</td>
<td>0%</td>
<td>0.0 1945.13</td>
</tr>
<tr>
<td>AbvPtRSurp</td>
<td>3,237</td>
<td>38.8</td>
<td>13%</td>
<td>11%</td>
<td>47.7 1945.14</td>
</tr>
<tr>
<td>MedLgSurp</td>
<td>2,417</td>
<td>51.2</td>
<td>10%</td>
<td>14%</td>
<td>35.6 1945.15</td>
</tr>
<tr>
<td>AlkCkSurp</td>
<td>3,549</td>
<td>50.7</td>
<td>15%</td>
<td>14%</td>
<td>52.3 1945.16</td>
</tr>
<tr>
<td>UpPtRSurp</td>
<td>394</td>
<td>3.9</td>
<td>2%</td>
<td>1%</td>
<td>5.8 1945.17</td>
</tr>
<tr>
<td>LowPtRSurp</td>
<td>1,796</td>
<td>25.1</td>
<td>7%</td>
<td>7%</td>
<td>26.5 1945.18</td>
</tr>
<tr>
<td>MandSurp</td>
<td>3,212</td>
<td>45.9</td>
<td>13%</td>
<td>13%</td>
<td>47.3 1945.19</td>
</tr>
<tr>
<td>TOTAL</td>
<td>24,248</td>
<td>357.2</td>
<td>100%</td>
<td>100%</td>
<td>357.2</td>
</tr>
</tbody>
</table>

* Acreage excludes 1,161 acres assigned to four well structures in the model and 2,412 acres assigned to post-1945 water rights.

An additional change to the model input occurred subsequent to further review of water rights assigned to irrigated lands in comparison to the associated model demands. During model simulation, the irrigation demands are met by its input water rights to the extent physical flow is available at a ditch headgate, in priority. Calculated demands may be in excess of the total input water rights. For example, a 10 cfs water right represents a potential legal supply of 595 ac-ft in June, since 10 cfs times 1.9835 ac-ft per cfs times 30 days in June equals 595 ac-ft. A structure with only a 10 cfs right, for instance, would be unable to fully
satisfy a June demand of 620 ac-ft due to insufficient legal supply. To address the few months in the study period when this imbalance might occur (e.g., during a hot, dry summer month), free river water rights were assigned to certain model nodes to ensure they are not limited during simulation based on the input legal rights. Free river rights of 999 cfs were assigned with priorities junior to all other input rights so that operation of the free river rights would not negatively impact decreed, senior rights.

4. Baseline Demands – Irrigation demands are based on the amount of acreage, the crop types under irrigation, climate data, and system efficiencies associated with delivering water from the river to the irrigated lands.

a. Acreage – As noted above, approximately 26 acres of additional acreage was included in the Stage 3 model. Other minor changes to the water rights input resulted in an increase of about 34 acres, or a total increase of 60 acres. These changes resulted in a total of 27,821 acres in the Stage 3 model (versus 27,761 acres in the Stage 2 model).

b. Crop Types – The Stage 2 model included one hundred percent pasture grass above the Nowood River – Paint Rock Creek confluence. A crop mix of 60 percent grass pasture, 20 percent spring grain, and 20 percent corn grain was originally assigned to the irrigated lands lower in the Nowood River basin below Paint Rock Creek.

Crop mixes were changed in the Stage 3 model pursuant to recommendations by Craig Cooper, as follows:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>Alfalfa</th>
<th>Pasture</th>
<th>Corn</th>
<th>Grains</th>
<th>Beets</th>
<th>Total</th>
<th>CROP-WEIGHTED AVERAGE CIR (ft/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Big Trails Reservoir</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.77</td>
</tr>
<tr>
<td>Big Trails Reservoir to Tensleep Creek confluence</td>
<td>25%</td>
<td>70%</td>
<td>5%</td>
<td></td>
<td></td>
<td>100%</td>
<td>1.83</td>
</tr>
<tr>
<td>Tensleep Creek confluence to Paint Rock Creek confluence</td>
<td>45%</td>
<td>45%</td>
<td>10%</td>
<td></td>
<td></td>
<td>100%</td>
<td>1.88</td>
</tr>
<tr>
<td>Paint Rock Creek basin</td>
<td>30%</td>
<td>50%</td>
<td>15%</td>
<td>5%</td>
<td></td>
<td>100%</td>
<td>1.80</td>
</tr>
<tr>
<td>Nowood River below Paint Rock Creek</td>
<td>35%</td>
<td>35%</td>
<td>25%</td>
<td>5%</td>
<td></td>
<td>100%</td>
<td>1.78</td>
</tr>
<tr>
<td>AVERAGE CIR (feet/acre)</td>
<td>2.08</td>
<td>1.77</td>
<td>1.47</td>
<td>1.47</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c. Climate – No changes made to the Stage 2 model.

d. System Efficiencies – No changes made to the Stage 2 model.
Changes to the crop mix resulted in a 2.6% increase (3,709 ac-ft/yr) in basin-wide demands (Stage 2 – 142,043 ac-ft/yr; Stage 3 – 145,752 ac-ft/yr). As shown in Figure 2, the main difference in input demands resulting from the change in crops is the lower demands during the shoulder months (April and October) and higher demands during the middle of summer (June through August). These changes will tend to impact the availability of water to junior water rights but, due to the relatively minor increase in demands, the change in crop mix is not anticipated to significantly change the simulation output.

e. Demand Representation in Relation to First cfs and Second cfs Water Rights

The StateMod program is demand-driven. The 145,752 ac-ft/yr demand calculated for all irrigation nodes is based on monthly CIR divided by average monthly system efficiencies. Inclusion of the 19 Surplus Water Right nodes in the model network requires demands for those nodes in order for the surplus rights assigned to those nodes to trigger during model simulation. The demand the Surplus Water Right will try to meet is that portion of the irrigation node demands in the area that is beyond the first cfs of legal supply. Therefore, the following approach was used to develop the Surplus Water Right demands in a manner that does not change the total demand or seasonality of demand represented in the model:

$$Surplus\ Area\ Water\ Right\ Demand = \sum_{i=1}^{n} \sum_{x=April\ to\ October} \left( Irrigation\ Demand\ Node\ (i)_{month\ x} - Senior\ Water\ Rights\ (i)\right) > 0$$

This approach will limit the demand on the Surplus Water Right to the irrigation demand that would be met with if it were represented at the irrigation nodes within the Surplus Area. This approach to calculating the demand also maintains the shape on the demand curve (low in shoulder season, high in spring, etc.).

5. StateMod Program Default Operations – No changes made to the Stage 2 model. Other than the 60 additional acres in model, no changes were made to the amount of land represented as irrigated by sprinklers.

6. User-Input Operating Rules – No changes made to the Stage 2 model.

Baseline Scenario Output

The Baseline Shortages are summarized in Table 1. The total basin annual shortage was estimated at approximately 10 percent (15,151 acre-feet) and 11 percent (16,990 acre-feet) in average and dry years, respectively. A maximum shortage of approximately 16 percent (31,985
acre-feet) was simulated in 2001. The distribution of shortages varies throughout the basin, with the highest percent shortages located in the upper basin above Tensleep Creek and in the Paint Rock Creek basin.

The basin shortage was reduced in the Stage 3 model by approximately 2,864 ac-ft/yr, on average from the Stage 2 model basin shortage of 18,015 ac-ft/yr. This occurs despite an increase in Baseline Demand of about 3,700 ac-ft/yr. The change in the Stage 3 model is due predominantly to the aggregation of Surplus Water Rights at the bottom of the tributaries and reaches of the Nowood River main stem, which provide greater physical supply to these surplus water rights than would be available at each of the irrigation nodes, individually, as the rights were represented in Stage 2 model.

Despite the reduction in shortages to the demands in the Stage 3 model, the available flow at the various reservoir sites and associated feeder ditches is not significantly different from that estimated in the Stage 2 model (see Table 2).

Although the differences between the Stage 2 model and the Stage 3 model output are not significant, the refinements to the model in Stage 3 are considered to better represent basin conditions.

**Reservoir Alternatives**

Five reservoirs from the initial list of 22 reservoir sites were identified as preferred sites. Subsequent analysis reduced the list to two sites. The two reservoirs were included in the Stage 3 model network at the storage capacities listed below.

- Alkali Creek Reservoir Southern Alignment – 7,402 acre-feet, with 25 percent of capacity set aside as a conservation pool
- Meadowlark Lake Enlargement – Increased from 3,316 acre-feet to 4,678 acre-feet, with 25 percent of capacity set aside as a conservation pool

The Alkali Creek Reservoir was assigned a one-fill right equal to the storage capacity with a 2012 priority date. Meadowlark Lake is typically kept full. Therefore, both the senior storage right (3,509 acre-feet; March 1, 1938 priority date) and enlargement storage right (1,362 acre-feet; 2012 priority date) were assigned fill and refill rights, which allow the reservoir to refill storage volume lost to evaporation and irrigation releases throughout the year.

One additional change made in the Stage 3 model was a revision to the net evaporation rates used to calculate surface water losses from the reservoirs. The monthly rates for the Stage 2 model were pulled directly from the spreadsheet model used in the 2010 Basin Plan Update. The documentation for the 2010 Basin Plan Update noted the rates were developed based on an annual gross evaporation rate of 45 inches and average monthly precipitation totaling 21 inches per year. The spreadsheet values totaled 45 inches rather than the net evaporation rate of 24 inches per year. That oversight was corrected in the Stage 3 model.
To ensure maximum utilization of the storage alternatives, releases were modeled as supplemental supply to all model nodes. The order of priority assigned to the releases was determined based on the general proximity of the irrigation nodes to the reservoirs (e.g., nodes close to the reservoir receive water prior to nodes located farther away).

One scenario was run for each reservoir alternative:

1. **Strict application of prior appropriation doctrine**
   - Reservoir stores water, when available, in priority.
   - Operating rule(s) added to release water from reservoir to meet the Baseline Irrigation Shortages.
     - The Baseline data set output includes 1) water supply pursuant to the first cfs used to meet demands at the individual irrigation nodes, and 2) water supply pursuant to the second cfs used to meet the Surplus Water Right demand. The total supply to meet the irrigation demand is that simulated to meet the demands for both the irrigation node and the Surplus Water Right node.
     - The Baseline Irrigation Shortage is calculated as the total irrigation demand minus the total supply to meet the irrigation demand. To avoid simulation of a “double” supply (i.e., same demand supplied by direct flow rights and reservoir releases), the Baseline Irrigation Shortages were assigned to a separate Aggregate Reservoir Demand node. The Aggregate Reservoir Demand node is supplied exclusively with reservoir releases.

**Reservoir Scenarios Input and Output**

**Alkali Creek Reservoir Southern Alignment**

The proposed reservoir embankment dam is located approximately one quarter mile downstream from where the Anita Ditch and Alkali Creek intersect. Nonetheless, land is not irrigated by the Anita Ditch up slope of the reservoir location. Irrigation return flows from diversions in the Anita Ditch are represented in the model accruing to Medicine Lodge Creek and Paint Rock Creek and are therefore not available for storage in Alkali Creek Reservoir.

The storage right was operated in the model to allow storage from on-channel inflows and water under the 2012 storage right diverted from Medicine Lodge Creek through the Anita Ditch and from upper Paint Rock Creek through and Anita Supplemental Ditch.
Baseline Data Set Demand and Shortages

<table>
<thead>
<tr>
<th>Location</th>
<th>Annual Average Demand</th>
<th>Annual Average Shortage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Paint Rock Ck</td>
<td>13,706 ac-ft</td>
<td>141 ac-ft</td>
</tr>
<tr>
<td>Medicine Lodge Ck</td>
<td>17,061 ac-ft</td>
<td>3,440 ac-ft</td>
</tr>
<tr>
<td>Alkali Ck</td>
<td>2,150 ac-ft</td>
<td>1,894 ac-ft</td>
</tr>
<tr>
<td>Lower Paint Rock Ck</td>
<td>9,692 ac-ft</td>
<td>171 ac-ft</td>
</tr>
<tr>
<td>Total Paint Rock Basin</td>
<td>42,609 ac-ft</td>
<td>5,646 ac-ft</td>
</tr>
<tr>
<td>Tensleep Creek Basin</td>
<td>18,640 ac-ft</td>
<td>410 ac-ft</td>
</tr>
<tr>
<td>Nowood River Basin</td>
<td>145,752 ac-ft</td>
<td>15,151 ac-ft</td>
</tr>
</tbody>
</table>

Basin-wide shortages for this reservoir alternative scenario are summarized in Table 4. Reservoir operations nearly eliminated the shortages on Alkali Creek, as illustrated in the table below. The shortages on Medicine Lodge Creek did not benefit from reservoir operations diversions to meet the shortages would occur by exchange with releases from storage. The Baseline irrigation shortages on Medicine Lodge Creek occur predominantly during low-flow summer months when Medicine Lodge Creek was simulated to dry up above its confluence with Paint Rock Creek (typically due to diversions into the Anita Ditch). The exchange potential up to the demand is limited, or non-existent, when the river is flowing very low or if it dries up. Therefore, during the same months that the Medicine Lodge Creek demands were shorted, there was typically no exchange potential and the upstream demands could not benefit from reservoir releases.

The total basin shortage was reduced by approximately 21 percent (3,149 acre-feet per year, on average). In addition to the approximately 2,200 acre-feet per year reduction in shortages in the Paint Rock Creek basin, the irrigation demands on Tensleep Creek basin and the Nowood River below Paint Rock Creek were the major beneficiaries from Alkali Creek Reservoir operations.

Alkali Creek Reservoir Southern Alignment Alternative Demands and Shortages

<table>
<thead>
<tr>
<th>Location</th>
<th>Annual Average Demand</th>
<th>Annual Average Shortage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Paint Rock Ck</td>
<td>13,706 ac-ft</td>
<td>0 ac-ft</td>
</tr>
<tr>
<td>Medicine Lodge Ck</td>
<td>17,061 ac-ft</td>
<td>3,436 ac-ft</td>
</tr>
<tr>
<td>Alkali Ck</td>
<td>2,150 ac-ft</td>
<td>10 ac-ft</td>
</tr>
<tr>
<td>Lower Paint Rock Ck</td>
<td>9,692 ac-ft</td>
<td>0 ac-ft</td>
</tr>
<tr>
<td>Total Paint Rock Basin</td>
<td>42,609 ac-ft</td>
<td>3,446 ac-ft</td>
</tr>
<tr>
<td>Tensleep Creek Basin</td>
<td>18,640 ac-ft</td>
<td>15 ac-ft</td>
</tr>
<tr>
<td>Nowood River Basin</td>
<td>145,752 ac-ft</td>
<td>12,002 ac-ft</td>
</tr>
</tbody>
</table>

The simulated end-of-month contents in Alkali Creek Reservoir over the 36-year study period are shown in Figure 3. Almost all of the diversions to storage came from Alkali Creek inflows, which were provided mostly from tail water out of the Anita Ditch. The operating rules used to carry the storage right through the Anita Ditch and Anita Supplemental Ditch never triggered since they would only be in priority during the high flow melt period and, during that period, outflows from irrigation water run in the Anita Ditch system were stored from Alkali Creek under the Alkali Creek Reservoir storage rights.
The capacity of the reservoir is in a good range to meet demands and store available supply, as shown in Figure 3. Although the reservoir does not fill every year, it fills in the 3,000 ac-ft to 4,091 ac-ft range during wet years. The demands on the reservoir do not typically pull the reservoir down too much. Although after the simulated fill in 1996 and 1997, the ensuing drought period nearly drained the reservoir into 2002. Therefore, the input reservoir capacity is appropriate to meet shortages over multiple drought years.

Meadowlark Lake Enlargement

The enlargement to Meadlark Lake would increase the existing storage capacity by approximately 1,362 acre-feet. Twenty-five percent of the enlarged reservoir is modeled as a conservation pool that is not available for release.

Basin-wide shortages for this reservoir alternative scenario are summarized in Table 5. Reservoir operations eliminated the shortages on Tensleep Creek and, similar, to the Alkali Creek Reservoir alternative, nearly eliminated the shortages on the Nowood River below Paint Rock Creek (see table below). This scenario, though, provided little benefit to irrigation demands in the Paint Rock Creek basin (due to tributary basin dry up points) or in the Nowood River basin upstream of Tensleep Creek (due to limited natural flows and corresponding exchange potential).

The total basin shortage was reduced by approximately 7 percent (1,048 acre-feet per year, on average). It is worth noting the Alkali Creek Reservoir scenario reduced shortages on Tensleep Creek at close to the same level as the Meadlark Lake scenario. This is due to a combination of relatively high natural flows on Tensleep Creek and not too many calls placed on the Nowood River between Tensleep Creek and Paint Rock Creek. This results in sufficient exchange potential from Alkali Creek up to Tensleep Creek. In addition, the Baseline shortages on Tensleep Creek are not that high so the amount of water necessary to eliminate shortages is not significant.

### Meadlark Lake Enlargement Alternative Demands and Shortages

<table>
<thead>
<tr>
<th>Location</th>
<th>Annual Average Demand</th>
<th>Annual Average Shortage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Paint Rock Ck</td>
<td>13,706 ac-ft</td>
<td>140 ac-ft</td>
</tr>
<tr>
<td>Medicine Lodge Ck</td>
<td>17,061 ac-ft</td>
<td>3,440 ac-ft</td>
</tr>
<tr>
<td>Alkali Ck</td>
<td>2,150 ac-ft</td>
<td>1,894 ac-ft</td>
</tr>
<tr>
<td>Lower Paint Rock Ck</td>
<td>9,692 ac-ft</td>
<td>155 ac-ft</td>
</tr>
<tr>
<td>Total Paint Rock Basin</td>
<td>42,609 ac-ft</td>
<td>5,630 ac-ft</td>
</tr>
<tr>
<td>Tensleep Creek Basin</td>
<td>18,640 ac-ft</td>
<td>10 ac-ft</td>
</tr>
<tr>
<td>Nowood River Basin</td>
<td>145,752 ac-ft</td>
<td>14,103 ac-ft</td>
</tr>
</tbody>
</table>

The simulated end-of-month contents in Meadlark Lake over the 36-year study period are shown in Figure 4. The simulated end-of-month contents of Meadlark Lake from the Baseline data set are included in the figure for comparison. Similar to the Baseline scenario, the lake fills every year. The demands on the reservoir do not typically pull the reservoir down too much. Releases of more than 500 acre-feet are simulated for 21 years during the study period but the storage contents are reduced below the Baseline scenario only six times during the study period.
FIGURE 1
Nowood River
Level II Study
StateMod Stage 3 Model
River Network
FIGURE 2 - NOWOOD RIVER BASIN AVERAGE MONTHLY DEMANDS

STAGE 2 MODEL - 142,043 ac-ft/yr  STAGE 3 MODEL - 145,752 ac-ft/yr
FIGURE 3
ALKALI CREEK RESERVOIR SOUTHERN ALIGNMENT EOM CONTENTS (ac-ft)

ALKALI CREEK SOUTH RESERVOIR MODELED WITH 1,851 AC-FT FISH POOL NOT AVAILABLE FOR RELEASES

AlkaliCkResSOUTH, AlkCkRes.StateMod.Sim_EOM.Month (1973-01 to 2008-12)
FIGURE 4
MEADOWLARK LAKE EOM CONTENTS (ac-ft)

0.0 400.0 800.0 1200.0 1600.0 2000.0 2400.0 2800.0 3200.0 3600.0 4000.0 4400.0 4800.0

- Meadowlark Lake Enl, MdwllarkLk.StateMod.Sim_EOM.Month (1973-01 to 2008-12)
- Meadowlark Lake, MdwllarkLk.StateMod.Sim_EOM.Month (1973-01 to 2008-12)
TABLE 1

NOWOOD RIVER STATEMOD MODEL - Stage 3
SIMULATED DEMANDS AND SHORTAGES (acre-feet)   BASELINE SCENARIO WITH PERMITTED ACREAGE

<table>
<thead>
<tr>
<th></th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Basin Demand</td>
<td>AVG</td>
<td>4,758</td>
<td>22,497</td>
<td>34,921</td>
<td>32,981</td>
<td>27,517</td>
<td>19,513</td>
<td>3,566</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>6,884</td>
<td>23,930</td>
<td>33,368</td>
<td>32,481</td>
<td>26,777</td>
<td>19,251</td>
<td>2,930</td>
</tr>
<tr>
<td>Entire Basin Shortage</td>
<td>AVG</td>
<td>39</td>
<td>532</td>
<td>2,160</td>
<td>4,069</td>
<td>5,521</td>
<td>2,666</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>104</td>
<td>619</td>
<td>2,448</td>
<td>4,747</td>
<td>6,197</td>
<td>2,723</td>
<td>153</td>
</tr>
<tr>
<td>Entire Basin Percent Short</td>
<td>AVG</td>
<td>1%</td>
<td>2%</td>
<td>6%</td>
<td>12%</td>
<td>20%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2%</td>
<td>3%</td>
<td>7%</td>
<td>15%</td>
<td>23%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td>Alv nr Tensleep Gage Demand</td>
<td>AVG</td>
<td>1,567</td>
<td>5,828</td>
<td>8,442</td>
<td>7,862</td>
<td>6,806</td>
<td>5,036</td>
<td>1,145</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2,245</td>
<td>6,147</td>
<td>8,037</td>
<td>7,759</td>
<td>7,660</td>
<td>4,982</td>
<td>963</td>
</tr>
<tr>
<td>Alv nr Tensleep Gage Shortage</td>
<td>AVG</td>
<td>14</td>
<td>92</td>
<td>1,068</td>
<td>2,069</td>
<td>2,057</td>
<td>1,197</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>34</td>
<td>373</td>
<td>1,495</td>
<td>2,407</td>
<td>2,279</td>
<td>1,364</td>
<td>57</td>
</tr>
<tr>
<td>Alv nr Tensleep Gage Percent Short</td>
<td>AVG</td>
<td>1%</td>
<td>2%</td>
<td>12%</td>
<td>26%</td>
<td>30%</td>
<td>24%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2%</td>
<td>6%</td>
<td>19%</td>
<td>31%</td>
<td>34%</td>
<td>27%</td>
<td>6%</td>
</tr>
<tr>
<td>Tensleep Creek Demand</td>
<td>AVG</td>
<td>545</td>
<td>2,980</td>
<td>4,581</td>
<td>4,205</td>
<td>3,452</td>
<td>2,459</td>
<td>419</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>790</td>
<td>3,177</td>
<td>4,382</td>
<td>4,140</td>
<td>3,357</td>
<td>2,420</td>
<td>336</td>
</tr>
<tr>
<td>Tensleep Creek Shortage</td>
<td>AVG</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>191</td>
<td>167</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>292</td>
<td>177</td>
<td>67</td>
<td>1</td>
</tr>
<tr>
<td>Tensleep Creek Percent Short</td>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>5%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>5%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Btwn Tensleep and Paint Rock Demand</td>
<td>AVG</td>
<td>705</td>
<td>3,848</td>
<td>5,924</td>
<td>5,441</td>
<td>4,666</td>
<td>3,178</td>
<td>541</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,022</td>
<td>4,101</td>
<td>5,666</td>
<td>5,357</td>
<td>4,345</td>
<td>3,128</td>
<td>434</td>
</tr>
<tr>
<td>Btwn Tensleep and Paint Rock Shortage</td>
<td>AVG</td>
<td>5</td>
<td>196</td>
<td>514</td>
<td>305</td>
<td>619</td>
<td>391</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>20</td>
<td>356</td>
<td>218</td>
<td>628</td>
<td>296</td>
<td>54</td>
</tr>
<tr>
<td>Btwn Tensleep and Paint Rock Percent Short</td>
<td>AVG</td>
<td>1%</td>
<td>5%</td>
<td>9%</td>
<td>6%</td>
<td>14%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>4%</td>
<td>14%</td>
<td>9%</td>
<td>13%</td>
</tr>
<tr>
<td>Paint Rock Creek Demand</td>
<td>AVG</td>
<td>1,316</td>
<td>6,223</td>
<td>9,791</td>
<td>9,713</td>
<td>8,528</td>
<td>6,038</td>
<td>992</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,893</td>
<td>6,625</td>
<td>9,333</td>
<td>9,594</td>
<td>8,333</td>
<td>5,967</td>
<td>814</td>
</tr>
<tr>
<td>Paint Rock Creek Shortage</td>
<td>AVG</td>
<td>21</td>
<td>244</td>
<td>605</td>
<td>1,504</td>
<td>2,194</td>
<td>1,028</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>70</td>
<td>226</td>
<td>597</td>
<td>1,829</td>
<td>2,666</td>
<td>996</td>
<td>41</td>
</tr>
<tr>
<td>Paint Rock Creek Percent Short</td>
<td>AVG</td>
<td>2%</td>
<td>4%</td>
<td>6%</td>
<td>15%</td>
<td>26%</td>
<td>17%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>4%</td>
<td>3%</td>
<td>6%</td>
<td>19%</td>
<td>32%</td>
<td>17%</td>
<td>5%</td>
</tr>
<tr>
<td>Below Paint Rock Demand</td>
<td>AVG</td>
<td>625</td>
<td>3,607</td>
<td>6,183</td>
<td>5,760</td>
<td>4,265</td>
<td>2,802</td>
<td>469</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>934</td>
<td>3,880</td>
<td>5,952</td>
<td>5,632</td>
<td>4,082</td>
<td>2,754</td>
<td>383</td>
</tr>
<tr>
<td>Below Paint Rock Shortage</td>
<td>AVG</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>484</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>446</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Below Paint Rock Percent Short</td>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>11%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>11%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Notes:
Values include change to representation of Surplus Water Law - second cfs rights turned off for irrigation nodes and assigned to 19 Surplus Water Right nodes located at the bottom of tributaries (Lone Tree Ck, Bear Ck, Deep Ck, Redbank Ck, Little Canyon Ck, Otter Ck, Soring Ck, Tensleep Ck, Brokenback Ck, Buffalo Flat Ck, Medicine Lodge Ck, Upper Paint Rock Ck, Akalii Ck, lower Paint Rock Ck) and sections of Nowood River main stem (above Big Trails Res, alb Tensleep Ck confluence, alb Paint Rock Ck confluence, big Paint Rock Ck confluence).

Demands placed on Surplus Water Right nodes equal to the portion of the calculated demand beyond the first cfs for each of the tributary nodes (e.g., 0900720, 0900740, 0900790 on Redbank Ck)

Shortages calculated based on sum of demand for each tributary node minus (sum of total supply for each tributary node plus total supply to Surplus Water Right node).

Values exclude approximately 2718 acre-feet per year average well demand.
### TABLE 2

**HOWCUM RIVER STATEWOM MODEL - Stage 2**  
**BASELINE SCENARIO WITH PERMITTED ACREAGE**

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artificial Flow</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Artificial Flow Available</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Base Flow</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Base Flow Available</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Effluent Flow</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Effluent Flow Available</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Groundwater Flow</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Groundwater Flow Available</strong></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Note: Data provided for illustrative purposes only.*
TABLE 2

NORWOOD RIVER STATEMENT MODEL - Stage 2

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Avgr</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Stdv</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

FEEDER CANALS / DITCHES TO OFF-CHANNEL RESERVOIRS

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Avgr</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Stdv</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Notes:
1. Representative of Cornell Gulch Reservoir feeder ditch from Norwood River.
2. Little Tunnel diversion added to model network in Stage 3. Therefore, Available Flow NOT equal to Stage 2 estimate of 18.2% of Norwood River Available Flow but equal to Stage 3 model annual output.
3. Representative of Alkali Creek Reservoir and Winter Creek Reservoir feeder ditch from Medicine Lodge Creek.
4. Representative of Alkali Creek Reservoir and Winter Creek Reservoir feeder ditch from Upper Paint Rock Creek.
5. Representative of Little Cottonwood Reservoir feeder ditch from Norwood River.
6. Representative of Big Cottonwood Reservoir Reservoir feeder ditch from Norwood River.
7. Representative of McDermott Draw Reservoir feeder ditch from Lower Paint Rock Creek.

* Antics ditch return flows moved DOWSTREAM of Alkali Creek Reservoir.
Technical Memorandum to Derrick Thompson and Joel Farber
March 11, 2013
Page 19

ParsonsWater Consulting LLC

4729 W32nd Ave, Denver, CO 80212

303.667.5067


**TABLE 4**

NOWOOD RIVER STATEMOD MODEL - Stage 3 => BASELINE SCENARIO WITH ALKALI CREEK SOUTHERN ALIGNMENT OPERATING
SIMULATED DEMANDS AND SHORTAGES (acre-feet) => BASELINE SCENARIO WITH PERMITTED ACREAGE


<table>
<thead>
<tr>
<th></th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire Basin Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,758</td>
<td>22,497</td>
<td>34,921</td>
<td>32,981</td>
<td>27,517</td>
<td>19,513</td>
<td>3,566</td>
<td>145,752</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>6,884</td>
<td>23,930</td>
<td>33,368</td>
<td>32,481</td>
<td>26,777</td>
<td>19,251</td>
<td>2,930</td>
</tr>
<tr>
<td><strong>Entire Basin Shortage</strong></td>
<td>AVG</td>
<td>30</td>
<td>276</td>
<td>1,655</td>
<td>3,376</td>
<td>4,164</td>
<td>2,390</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>85</td>
<td>373</td>
<td>1,965</td>
<td>3,959</td>
<td>4,563</td>
<td>2,518</td>
<td>111</td>
</tr>
<tr>
<td><strong>Entire Basin Percent Short</strong></td>
<td>AVG</td>
<td>1%</td>
<td>1%</td>
<td>5%</td>
<td>10%</td>
<td>13%</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1%</td>
<td>2%</td>
<td>6%</td>
<td>12%</td>
<td>17%</td>
<td>13%</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Abovr Tensleep Gage Demand</strong></td>
<td>AVG</td>
<td>1,567</td>
<td>5,828</td>
<td>8,442</td>
<td>7,862</td>
<td>6,806</td>
<td>5,086</td>
<td>1,145</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2,245</td>
<td>6,147</td>
<td>8,037</td>
<td>7,759</td>
<td>6,660</td>
<td>4,982</td>
<td>963</td>
</tr>
<tr>
<td><strong>Abovr Tensleep Gage Shortage</strong></td>
<td>AVG</td>
<td>14</td>
<td>90</td>
<td>979</td>
<td>2,069</td>
<td>2,055</td>
<td>1,197</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>34</td>
<td>373</td>
<td>1,482</td>
<td>2,407</td>
<td>2,279</td>
<td>1,364</td>
<td>57</td>
</tr>
<tr>
<td><strong>Abovr Tensleep Gage Percent Short</strong></td>
<td>AVG</td>
<td>1%</td>
<td>2%</td>
<td>12%</td>
<td>26%</td>
<td>30%</td>
<td>24%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2%</td>
<td>6%</td>
<td>19%</td>
<td>31%</td>
<td>34%</td>
<td>27%</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Tensleep Creek Demand</strong></td>
<td>AVG</td>
<td>545</td>
<td>2,980</td>
<td>4,581</td>
<td>4,205</td>
<td>3,452</td>
<td>2,459</td>
<td>419</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>790</td>
<td>3,177</td>
<td>4,382</td>
<td>4,140</td>
<td>3,357</td>
<td>2,420</td>
<td>336</td>
</tr>
<tr>
<td><strong>Tensleep Creek Shortage</strong></td>
<td>AVG</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td><strong>Tensleep Creek Percent Short</strong></td>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Demand</strong></td>
<td>AVG</td>
<td>705</td>
<td>3,848</td>
<td>5,924</td>
<td>5,441</td>
<td>4,466</td>
<td>3,179</td>
<td>541</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,022</td>
<td>4,101</td>
<td>5,666</td>
<td>5,357</td>
<td>4,345</td>
<td>3,128</td>
<td>434</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Shortage</strong></td>
<td>AVG</td>
<td>5</td>
<td>186</td>
<td>467</td>
<td>283</td>
<td>604</td>
<td>391</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>327</td>
<td>194</td>
<td>609</td>
<td>256</td>
<td>54</td>
<td>1,481</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Percent Short</strong></td>
<td>AVG</td>
<td>1%</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
<td>14%</td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Demand</strong></td>
<td>AVG</td>
<td>1,316</td>
<td>6,233</td>
<td>9,791</td>
<td>9,713</td>
<td>8,528</td>
<td>6,038</td>
<td>992</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,893</td>
<td>6,625</td>
<td>9,333</td>
<td>9,594</td>
<td>8,333</td>
<td>5,967</td>
<td>814</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Shortage</strong></td>
<td>AVG</td>
<td>11</td>
<td>0</td>
<td>158</td>
<td>1,024</td>
<td>1,454</td>
<td>798</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>51</td>
<td>0</td>
<td>146</td>
<td>1,358</td>
<td>1,469</td>
<td>840</td>
<td>0</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Percent Short</strong></td>
<td>AVG</td>
<td>1%</td>
<td>0%</td>
<td>2%</td>
<td>13%</td>
<td>17%</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>3%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Below Paint Rock Demand</strong></td>
<td>AVG</td>
<td>625</td>
<td>3,607</td>
<td>6,183</td>
<td>5,760</td>
<td>4,265</td>
<td>2,802</td>
<td>469</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>934</td>
<td>3,880</td>
<td>5,952</td>
<td>5,632</td>
<td>4,082</td>
<td>2,754</td>
<td>383</td>
</tr>
<tr>
<td><strong>Below Paint Rock Shortage</strong></td>
<td>AVG</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Below Paint Rock Percent Short</strong></td>
<td>AVG</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Notes:
Values include change to representation of Surplus Water Law - second cfs rights turned off for irrigation nodes and assigned to 19 Surplus Water Right nodes located at the bottom of tributaries (Lone Tree Ck, Bear Ck, Deep Ck, Redbank Ck, Little Canyon Ck, Otter Ck, Spring Ck, Tensleep Ck, Brokenback Ck, Buffalo Flat Ck, Medicine Lodge Ck, Upper Paint Rock Ck, Alkali Ck, lower Paint Rock Ck) and sections of Nowood River main stem (above Big Trails Res, abv Tensleep Ck confluence, abv Paint Rock Ck confluence, bw Paint Rock Ck confluence).
Demand placed on Surplus Water Right nodes equal to the portion of the calculated demand beyond the first cfs for each of the tributary nodes (e.g., 0900720, 0900740, 0900790 on Redbank Ck)
Shortages calculated based on sum of demand for each tributary node minus (sum of total supply for each tributary node plus total supply to Surplus Water Right node).
Values exclude approximately 2718 acre-feet per year average well demand.
### TABLE 5

**NOWOOD RIVER STATEMOD MODEL - Stage 3 => BASELINE SCENARIO WITH MEADOWLARK LAKE ENLARGEMENT OPERATING SIMULATED DEMANDS AND SHORTAGES (acre-feet) BASELINE SCENARIO WITH PERMITTED ACREAGE**

Average values for 1973 through 2008 period

<table>
<thead>
<tr>
<th></th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entire Basin Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4,758</td>
<td>22,497</td>
<td>34,921</td>
<td>32,981</td>
<td>27,517</td>
<td>19,513</td>
<td>3,566</td>
<td>145,752</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>6,884</td>
<td>23,390</td>
<td>33,368</td>
<td>32,481</td>
<td>24,777</td>
<td>19,251</td>
<td>2,930</td>
</tr>
<tr>
<td><strong>Entire Basin Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>520</td>
<td>2,101</td>
<td>3,856</td>
<td>4,809</td>
<td>2,616</td>
<td>162</td>
<td>14,103</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>104</td>
<td>599</td>
<td>2,416</td>
<td>4,431</td>
<td>5,430</td>
<td>2,656</td>
<td>152</td>
</tr>
<tr>
<td><strong>Entire Basin Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>2%</td>
<td>6%</td>
<td>12%</td>
<td>17%</td>
<td>13%</td>
<td>5%</td>
<td>9.7%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2%</td>
<td>3%</td>
<td>7%</td>
<td>14%</td>
<td>20%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,567</td>
<td>5,828</td>
<td>8,442</td>
<td>7,862</td>
<td>6,806</td>
<td>5,036</td>
<td>1,145</td>
<td>36,687</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2,245</td>
<td>6,147</td>
<td>8,017</td>
<td>7,759</td>
<td>6,660</td>
<td>4,982</td>
<td>963</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>90</td>
<td>996</td>
<td>2,069</td>
<td>2,055</td>
<td>1,197</td>
<td>34</td>
<td>6,454</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>34</td>
<td>373</td>
<td>1,492</td>
<td>2,407</td>
<td>2,279</td>
<td>1,364</td>
<td>57</td>
</tr>
<tr>
<td><strong>Abv nr Tensleep Gage Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>2%</td>
<td>12%</td>
<td>26%</td>
<td>30%</td>
<td>24%</td>
<td>3%</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>2%</td>
<td>6%</td>
<td>19%</td>
<td>31%</td>
<td>34%</td>
<td>27%</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Tensleep Creek Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>545</td>
<td>2,980</td>
<td>4,581</td>
<td>4,205</td>
<td>3,452</td>
<td>2,459</td>
<td>419</td>
<td>18,460</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>790</td>
<td>3,177</td>
<td>4,382</td>
<td>4,140</td>
<td>3,357</td>
<td>2,420</td>
<td>336</td>
</tr>
<tr>
<td><strong>Tensleep Creek Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Tensleep Creek Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>709</td>
<td>3,848</td>
<td>5,924</td>
<td>5,441</td>
<td>4,466</td>
<td>3,178</td>
<td>541</td>
<td>24,103</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,022</td>
<td>4,101</td>
<td>5,666</td>
<td>5,357</td>
<td>4,345</td>
<td>3,128</td>
<td>434</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>186</td>
<td>467</td>
<td>283</td>
<td>576</td>
<td>391</td>
<td>78</td>
<td>1,985</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>327</td>
<td>104</td>
<td>485</td>
<td>296</td>
<td>54</td>
</tr>
<tr>
<td><strong>Btwn Tensleep and Paint Rock Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
<td>13%</td>
<td>12%</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,316</td>
<td>6,233</td>
<td>9,791</td>
<td>9,713</td>
<td>8,528</td>
<td>6,038</td>
<td>992</td>
<td>42,609</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>1,883</td>
<td>6,625</td>
<td>9,333</td>
<td>9,594</td>
<td>8,333</td>
<td>5,967</td>
<td>814</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>244</td>
<td>605</td>
<td>1,504</td>
<td>2,177</td>
<td>1,028</td>
<td>50</td>
<td>5,630</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>70</td>
<td>226</td>
<td>597</td>
<td>1,829</td>
<td>2,666</td>
<td>996</td>
<td>41</td>
</tr>
<tr>
<td><strong>Paint Rock Creek Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>4%</td>
<td>6%</td>
<td>15%</td>
<td>26%</td>
<td>17%</td>
<td>5%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>4%</td>
<td>3%</td>
<td>6%</td>
<td>19%</td>
<td>32%</td>
<td>17%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Below Paint Rock Demand</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>623</td>
<td>3,607</td>
<td>6,183</td>
<td>5,760</td>
<td>4,265</td>
<td>2,802</td>
<td>469</td>
<td>23,712</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>934</td>
<td>3,880</td>
<td>5,952</td>
<td>5,632</td>
<td>4,082</td>
<td>2,754</td>
<td>383</td>
</tr>
<tr>
<td><strong>Below Paint Rock Shortage</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Below Paint Rock Percent Short</strong></td>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>DRY</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Notes:**
- Values include change to representation of Surplus Water Law - second cfs rights turned off for irrigation nodes and assigned to 19 Surplus Water Right nodes located at the bottom of tributaries (Lone Tree Creek, Bear Creek, Deep Creek, Redbank Creek, Little Canyon Creek, Otter Creek, Spring Creek, Tensleep Creek, Brokenback Creek, Buffalo Flat Creek, Medicine Lodge Creek, Upper Paint Rock Creek, Alkali Creek, lower Paint Rock Creek) and sections of Nowood River main stem (above Big Trails Reservoir, Tensleep Creek confluence, Paint Rock Creek confluence, below Paint Rock Creek confluence).
- Demands placed on Surplus Water Rights nodes equal to the portion of the calculated demand beyond the first cfs for each of the tributary nodes (e.g., 0900720, 0900740, 0900790 on Redbank Creek).
- Shortages calculated based on sum of demand for each tributary node minus (sum of total supply for each tributary node plus total supply to Surplus Water Right node).
- Values exclude approximately 2718 acre-feet per year average well demand.
APPENDIX D

(PLEASE SEE ATTACHED CD)

TEMPORARY STREAM GAGE DATA SETS
APPENDIX E

GEOTECHNICAL INVESTIGATIONS

E1. NOVEMBER 2010 PRELIMINARY GEOTECHNICAL ENGINEERING INVESTIGATIONS REPORT

E2. OCTOBER 2009 GEOLOGICAL ASSESSMENT OF POTENTIAL RESERVOIR SITES
Date: November 24, 2010

Subject: Results of Preliminary Geotechnical Engineering Investigations of Seven Potential Irrigation Water Storage Sites for the Nowood River Storage Project, Level II Study, Washakie and Big Horn Counties, Wyoming

Job No.: 10-149

Mr. J. Joel Farber, PG & PE
Trihydro Corporation
1252 Commerce Drive
Laramie, Wyoming 82070

Dear Mr. Farber:

As requested, Hollingsworth Associates, Inc. conducted a review of available geologic, geotechnical, and soils data pertinent to the watershed and a field reconnaissance of seven potential water storage sites with you on September 29 and 30, 2010. The geotechnical engineering services were provided for Task II of the Nowood River Storage Project Level II Study. The project location is the watershed of the Nowood River in Washakie and Big Horn Counties, Wyoming.

The purpose of this letter is to report the results of the field reconnaissance studies of each of the seven sites. The following is a brief description of each of the sites and an initial evaluation of the type(s) of dams appropriate for the sites. Included are photographs of each site prepared by Trihydro as Figures 1 through 7.

Lower Lumen Creek Site: The Lower Lumen Creek Site, shown in Figure 1, is located in a fairly well defined V-shaped valley with Lumen Creek flowing through a meandering channel. The left abutment is significantly steeper than right abutment. The bedrock is sandstone of the Tensleep sandstone and Amsden Formation. The right abutment was mantled with fine grained silty sand which appeared to be at least 10 feet thick. Fine grained silty sand was exposed in the stream cut in the valley bottom for a depth in excess of 10 feet. The left abutment had a similar mantle of fine grained silty sands to just above the valley bottom and then exposed well cemented, fairly coarse
grained brown sandstone. The site has a good grass cover with scattered shrubs and small trees, especially in the valley bottom.

The site appears to be suitable for a homogeneous earthfill dam if the silty sands have sufficient fines. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 15 feet on the right abutment, 20 feet to 30 feet in the valley bottom, and essentially nil on the left abutment. The foundation bedrock may require grouting to control under seepage depending on the permeability. The maximum possible height of dam will be governed by the elevation of the right abutment which would be the logical location for a spillway.

**Upper Lumen Creek Site:** The Upper Lumen Creek Site, shown in Figure 2, is located in a fairly broad U-shaped valley with Lumen Creek flowing through a meandering channel. The left abutment is significantly steeper than the right abutment. The bedrock is sandstone of the Tensleep sandstone and Amsden Formation. There were rock outcrops on both abutments. Both abutments were mantled with fine grained silty sand and scattered boulders. Fine grained silty sand with minor lenses of gravel was exposed in the stream cut in the valley bottom for a depth in excess of 10 feet. The site has a good cover of grass and scattered trees.

The site appears to be suitable for a homogeneous earthfill dam if the silty sands have sufficient fines. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 20 feet to 30 feet in the valley bottom. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The right abutment would be the logical location for a spillway because the slope is less steep than the left abutment.

**Paint Rock Creek Site:** The Paint Rock Creek Site, shown in Figure 3, is located in a broad U-shaped valley with Paint Rock Creek running through on the left side of the valley at a fairly steep
gradient. The bedrock is limestone and dolomite of the Madison limestone and shale and siltstone of the Darby Formation. The right abutment is an essentially vertical outcrop starting at the valley floor. The left abutment is slightly less steep with bedrock outcrops at the stream level and a minor soil mantle on the slope up to the vertical face. The valley bottom has sandy clay soils and the stream channel has sand and gravel with numerous cobble and boulders. It is very difficult to estimate the depth of soil in the valley bottom. Because the site is fairly high up on the stream and the stream has a fairly steep gradient, a fairly shallow depth of soil would be expected. However, the wide valley leads to an estimate of a significant depth of soil in the valley. Depth to bedrock is probably 30 feet or greater in the valley bottom, nil on the right abutment and 5 feet to 15 feet on the left abutment. The dam site is a maintained meadow.

The site appears to be suitable for an earthfill dam, either homogeneous or zoned, or a roller compacted concrete dam. Foundation preparation may not require excavation of the soils from beneath the entire footprint of the dam down to the bedrock for the earthfill dam, depending on the permeability and consolidation characteristics of the dam foundation soils when wetted. Foundation preparation for the roller compacted concrete dam will require excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 10 feet to 15 feet on the left abutment, 30 feet in the valley bottom and nil on the right abutment. The foundation bedrock may not require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The left abutment would be the logical location for a spillway for an earthfill dam because the slope is less steep than the right abutment.

Alkali Creek Site: The Alkali Creek Site, shown in Figure 4, is located in a very wide, U-shaped valley with Alkali Creek running on the right side of the valley in a channel approximately 15 feet deep. It appeared that Alkali Creek has been channelized through the site to provide room for the irrigated meadow which occupies the dam site. The bedrock is sandstone of the Cloverly and Morrison Formations. There were rock outcrops on both abutments with the right abutment steeper than the left abutment. The Anita Ditch flows into the valley upstream of the dam site and drops approximately 10 feet over a sandstone ledge into a sandstone stilling basin in the valley floor. The soils in the valley bottom are sandy clays at least 15 feet in depth. There is a large
exposure of claystone in the Alkali Creek drainage well upstream of the dam site which is most likely the source of the sandy clays at the dam site.

The site appears to be suitable for a homogeneous earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam for a depth sufficient to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 30 feet in the valley bottom and essentially nil on the abutments. The bedrock in the abutment may require a sandy clay blanket to control seepage through the abutments depending on the permeability. The maximum possible height of dam will be governed by the elevation of the right abutment which would be the logical location for a spillway.

**Big Trails Site:** The Big Trails Site, shown in Figure 5, is located in a somewhat wide V-shaped valley with the Nowood River running through a meandering channel. The bedrock is sandstone and shale of the Sundance Formation and interbeded shale, dolomite and gypsum of the Gypsum Springs Formation. The left abutment was a relatively steep soil slope with scattered bedrock outcrops. The valley bottom was essentially flat with at least 15 feet of soil exposed in a cut bank on the left side. The soils exposed in the cut bank were mainly sandy silt with sand and gravel layers. The right abutment was a very steep bedrock outcrop. The site has a good cover of grass and scattered trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the left abutment, 30 feet in the valley bottom and nil on the right abutment. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The left abutment would be the logical location for a spillway because the slope is less steep than the right abutment.

**Cornell Gulch Site:** The Cornell Gulch Site, shown in Figure 6, is located in a very wide V-
shaped valley with Cornell Gulch cutting through. Cornell Gulch was dry at the time of the field reconnaissance. The bedrock on the left abutment is the Nugget sandstone and siltstone of the Chugwater Formation. The bedrock is sandstone and shale of the Sundance Formation on the right abutment. Starting at Cornell Gulch, the left abutment is a soil mantled approximately 4H:1V slope rising to a near vertical sandstone outcrop. Starting at Cornell Gulch, the right abutment is a soil mantled approximately 6H:1V slope rising to a much steeper slope. There were no rock outcrops on the dam centerline on the right abutment but sandstone was exposed in an erosion gully just upstream of the dam centerline. The surface soils in the reservoir area were red sandy silt. Approximately 10 feet of grey sandy clay were exposed in Cornell Gulch which appeared to have originated from a grey claystone outcrop upstream of the reservoir area. There was a rather thin sand and gravel deposit in the left side of the reservoir upstream of the dam site that has been worked. The site has a good grass cover and scattered trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 30 feet in the valley bottom. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The right abutment would be the logical location for a spillway because the slope is less steep than the left abutment.

Lower Brokenback Site: The Lower Brokenback Site, shown in Figure 7, is located in a fairly broad U-shaped valley with Brokenback Creek flowing through a meandering channel and several small (approximately 30 feet diameter) marshy areas. The bedrock is sandstone and shale of the Sundance Formation and interbeded shale, dolomite and gypsum of the Gypsum Springs Formation. There were minor rock outcrops on both abutments. Both abutments were mantled with silty sand and gravel that appeared to be terrace deposits. Downstream of the dam centerline on the right side of the valley, a granular terrace deposit is currently being commercially mined. Sandy clay was exposed in the stream cut in the valley bottom upstream of the dam centerline for a depth of approximately 10 feet. The site has a good cover of grass on the abutments and in the
reservoir area above the stream channel. The stream channel has extensive wetlands vegetation and numerous trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 30 feet in the valley bottom. The foundation bedrock may require grouting or a clay blanket to control under seepage depending on the permeability. The site topography will limit the maximum possible height of dam. The spillway may be located on either abutment.

If we can provide further information at this time, please call.

Sincerely,

HOLLINGSWORTH ASSOCIATES, INC.

Harold Hollingsworth, P.E.

Reviewed By: TRH

Figures 1 through 7
NOTE: PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 1
LOWER LUMEN CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC  Checked By: JF  Scale: NONE  Date: 10/5/10  File: 09NLUMENCRK261010
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

UPPER LUMEN CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC  Checked By: JF  Suite: NONE  Date: 10/6/16  File: 06NULUMENCREEK201010
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION:
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 3
PAINT ROCK CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC   Checked By: JF   Scale: NONE   Date: 10/5/10   File: 06N_PAINTROCKCREED20103
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 4
ALKALI CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY
NOTE: EXPLANATION
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010
LOCATION WHERE PHOTOGRAPH WAS SHOT

A VIEW OF LEFT ABUTMENT

B VIEW OF RIGHT ABUTMENT

FIGURE 5
BIG TRAILS (REVISED) SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC  Checked By: JF  Scale: NONE  Date: 10/5/10  File: 06N_BIGTRAILS201010
NOTE: EXPLANATION
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010
A LOCATION WHERE PHOTOGRAPH WAS SHOT

A VIEW OF LEFT ABUTMENT

B VIEW OF RIGHT ABUTMENT

FIGURE 6
LOWER BROKENBACK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC Checked By: JF Scale: NONE Date: 10/1/10 File: 06NLBROKENBACK10/10
NOTE: PHOTOS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 7
CORNELL GULCH SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY
APPENDIX E2

OCTOBER 2009 GEOLOGIC ASSESSMENT OF POTENTIAL RESERVOIR SITES
Introduction

This memorandum summarizes the findings from a reconnaissance-level study and field evaluation of the geotechnical feasibility of potential reservoir sites completed by Trihydro Corporation in the Nowood watershed in north-central Wyoming. Investigation activities were performed from May through August of 2009. The scope of the investigation encompassed review of 35 potential reservoir storage sites identified by Anderson Consulting Engineers (ACE). Additionally, ACE requested Trihydro provide an overview of the geologic characteristics of the watershed as part of this technical memorandum.

The first phase of the project involved a reconnaissance-level assessment of the 35 sites ACE provided. The assessment was based on statewide geologic mapping of bedrock, structures, surficial geology, and geologic hazards. Each reservoir site was evaluated in terms of the expected geologic conditions along the dam embankment, within the reservoir pool area, and within the contributing drainage area. Trihydro assigned a letter grade (A-F) to each of these three focus areas for each of the sites. A grade of “A” indicated most favorable conditions and a grade of “F” indicated the site had a fatal flaw. None of the sites were determined to have a fatal flaw (received an F) during the first phase of the investigation.

The results of the reconnaissance-level assessment are presented in Table 1. Bedrock geology had the greatest influence on the grading process because of the regional risks for karstic formations and formations comprised primarily of erodible gypsum. The formations determined at highest risk for karst features are as follows: Gypsum Springs, Madison, Goose Egg, and Ten Sleep.
General Geology

The following sections provide an overview of the geology of the Nowood watershed. The watershed lies mostly within Big Horn and Washakie Counties in north central Wyoming. Small portions of the watershed however, overlap into Johnson, Natrona, Fremont and Hot Springs Counties. This overview includes information about the surficial geology, bedrock geology, geological structure and geological hazards of the watershed.

Surficial Geology

The surficial deposits found within the Nowood watershed are presented on Figure 1. The figure shows the wide distribution of alluvium, glacial deposits, residuum, slope wash and colluvium within the watershed. These sediment types constitute the dominant exposed geology within the watershed. The remaining exposed geology is composed of bedrock, grus, landslide, and terrace deposits. A discussion of bedrock and landslides are presented in the bedrock geology and hazards sections below.

Alluvium is found adjacent to surface drainages and is of fluvial origin (produced by the action of a stream or river). The extent of the alluvial deposits varies with the size of the respective fluvial system. Headwater deposits are typically narrower and shallower compared to downstream areas in the watershed. Alluvium ranges from 10-50 feet in thickness and is composed of sand, gravel, and loam (Cooley and Head 1979). These deposits are actively growing with the fluvial action of existing surface drainages. Fluvial action includes flooding (vertical deposition) and point-bar migration (lateral deposition).

Glacial till exists in the northwestern portion of the watershed and is associated with lateral and terminal moraines. The lateral moraines typically begin at an elevation about 10,000 feet and can be traced to approximately 8,000 feet, where they meet the terminal moraines (Darton, 1906). Drift composition is dominantly igneous and metamorphic rock from upland areas. Some Paleozoic sedimentary rocks also exist within the till located at lower elevations. These deposits consist of unconsolidated, poorly sorted, angular rock fragments. Some areas may display greater levels of sorting due to esker formation.

Residuum is an in-situ deposit formed from the weathering of bedrock. Soluble components of the bedrock were transported from the area by fluvial, fluvio-glacial, and groundwater processes. The insoluble portions of the rock experienced some mechanical weathering from freeze-thaw and rain-drop impact with little to no transport of the remaining materials. The residuum deposits within the Nowood watershed are primarily derived from late Paleozoic to Mesozoic rocks. The deposits are relatively young and are therefore thin compared to other quaternary deposits.

Colluvium exists throughout the watershed and has a genetic origin related to mass wasting mechanisms. These sediments were derived from the movement of material down slope under the influence of gravity. The colluvial deposits are composed of material derived from bedrock at higher elevations. Grain sizes range from silt to gravel, and grain shape is predominantly angular to subangular. These deposits have a maximum thickness of 15 feet (Cooley and Head 1979) but thin as they near the source material at higher elevations.
Bedrock Geology

The bedrock geology exposed and directly underlying the Nowood watershed contains rock formations with ages ranging from the Cambrian Period to present. The bedrock geology outcropping at or near the surface is presented on Figure 2. The dominant formations in the Nowood watershed (from youngest to oldest, top to bottom, then left to right) include the:

- Fort Union Formation
- Mesaverde Formation
- Cody Shale
- Frontier Formation*
- Mowry Shale*
- Thermopolis Shale*
- Cloverly shale*
- Morrison Formation*
- Sundance Formation*
- Gypsum Spring Formation*
- Chugwater Formation*
- Goose Egg Formation
- Tensleep sandstone
- Amsden Formation
- Madison limestone*
- Bighorn dolomite
- Gallatin Formation
- Gros Ventre Formation

Other formations are mapped within the Nowood watershed, but the above units have the greatest influence on the watershed’s geology. The starred units were encountered at the various reservoir sites and are described in greater detail herein below.

The general pattern of outcrop of the units is of younger formations on the western side of the watershed and older units on the eastern side (Susong et al. 1993). An exception to the pattern is the quaternary, surficial deposits discussed in the previous section. The youngest Tertiary-age rocks that crop out in the watershed are of the Fort Union Formation and are approximately 2-68 million years old (ma). This formation consists of interbedded layers of sandstone and shale. Coal seams exist within the formation but are smaller and less frequent than those found in the Fort Union of southeastern Montana. In the area of the Nowood River, the Fort Union Formation is 1,000 to 1,500 feet thick (Cooley and Head 1979).

The next youngest rocks are of Cretaceous age (68-142 ma) and include units of the Mesaverde, Cody Frontier, Mowry, Thermopolis, and Cloverly Formations. Within the Nowood watershed, these formations comprise the bedrock (other than the Tertiary formations) found west of the Nowood River and the areas northwest of Hyattville, WY. They are comprised of thick shale layers with thinner beds of sandstone. Coal is present within these rocks as well (Darton 1906). The thickness of the entire sequence is from 6,600 to 7,500 feet (Cooley and Head 1979; Fischer 1906).

The Frontier Formation is Upper Cretaceous and is composed of fine to medium lenticular sandstone with gray and black marine shale. Thin bentonite and tuff beds are present as well. The Mowry Formation is Lower Cretaceous and composed of black and gray thin-bedded resistant shale interbedded with thin sandstone and bentonite. The Thermopolis Shale is a soft, black shale of the Lower Cretaceous. The Cloverly Formation is Lower Cretaceous and composed of light gray channel sandstones and pebble conglomerates interbedded with variegated bentonite mudstone (Weitz and Love 1952).

To the east of the cretaceous rocks are Jurassic to Pennsylvanian age (142-320 ma) rocks, which include the Morrison, Sundance, Gypsum Spring, Chugwater, Goose Egg, Tensleep, and Amsden Formations.
These formations range from reddish-brown shale to silty sandstone to sandstone. Thin beds of limestone also exist. The Tensleep Formation consists entirely of lightly cross-stratified sandstone. Gypsum exists in the Gypsum Spring and Goose Egg Formations, the solution of which has produced karst topography. The total thickness of these formations ranges from 2,000 to 2,400 feet (Susong et al. 1993; Cooley and Head 1979).

The Morrison Formation is Upper Jurassic and composed of calcareous gray silty sandstone and sandy claystone with lenticular limestone. The Sundance Formation is Middle Jurassic and is a greenish-gray glauconitic calcareous sandstone and shale. The Gypsum Springs Formation is Middle Jurassic and an interbedded red claystone, shale, siltstone and limestone with massive gypsum beds. The Chugwater Formation is Triassic and composed of massive, cross-bedded very fine grained red sandstone, siltstone and shale.

Mississippian to Ordovician age rocks (320-505 ma) crop out further to the east and southeast. These rocks are composed of the Madison limestone and Bighorn dolomite. Both formations contain light-gray massive limestone with the Bighorn Formation also containing dolomite. Dissolution of these formations has also produced karst topography and cave systems in the Nowood watershed. The extensive cave systems associated with these formations suggests a high volume of water is exchanged during surface water-groundwater interactions. The Madison limestone has a thickness of 500 to 700 feet, while the Bighorn dolomite is 300 feet thick (Susong et al. 1993; Cooley and Head 1979).

The oldest Phanerozoic rocks in the watershed were deposited during the Cambrian Period (505-560 ma) and are the Gallatin and Gros Ventre Formations. Both formations are a greenish to gray shale. The formations are in the western portion of the watershed, adjacent to the Oldest Gneiss Formation and other plutonic rocks. These igneous and metamorphic rocks are the basement, Precambrian rocks found in the center of the broad anticlinal structure of the Bighorn Mountains (Susong et al. 1993; Darton 1906; Fischer 1906).

**Structure**

The Nowood watershed is located in the southeastern portion of the Bighorn Basin. The basin was formed from folding and faulting during the Laramide orogeny, which occurred approximately 40-70 ma. The Laramide also produced the mountains that border the basin (Susong et al. 1993). To the east the basin is bordered by the Bighorn Mountains and to the south by the Owl Creek Mountains (Fischer 1906). Bounded by these mountain ranges, the Nowood watershed drains the southeastern-most portion of the Bighorn basin.

The general structure of the Bighorn Mountains is an anticline, and a portion of the Nowood watershed drains the southwestern limb. The axial plane of the anticline strikes northwest to southeast, causing the west-east age pattern in the Phanerozoic rocks. The attitude of Phanerozoic rocks is similar to the anticline, with strikes ranging from north to south to northwest to southeast. However, smaller scale anticlines and synclines are present within the watershed, and these local structures create variations in bed orientation.

The smaller scale anticlines and synclines are genetically related to the larger Bighorn anticline and therefore have similar orientations. The beds within them strike to the northwest and generally dip 5-12° to the southwest. Beds with an opposite dip direction (to the northeast) are present but less prevalent. This bed reversal typically indicates the presence of a local syncline (Hosterman et al. 1989;
Cooley and Head 1979). Synclines can often be found associated with an anticline of similar size and extent. One anticline-syncline pair in the Nowood watershed can be found along the western side of the Nowood River with the axial plane running from Manderson, WY, to Crooked Creek (Cooley and Head 1979). Similar but less extensive structures are also found in the northeastern portion of the watershed, near Hyattville and Ten Sleep, as well as in the southern part of the watershed in the vicinity of Mahogany Butte and Orchard.

Faulting is evident within the eastern portions of the Nowood watershed (Figure 3). These faults are characterized as high-angle (60-90°) normal faults with the downthrown side located to the west of the fault line (Hosterman et al., 1989; Darton, 1906). Faults of this type are associated with extensional tectonics. One distinctive fault that displays these characteristics is located adjacent to Big Canyon Creek and Ten Sleep. The fault displays a vertical displacement of 700 feet near Big Canyon Creek. This displacement decreases towards the west, and the fault eventually merges into a monocline approximately 4 miles west of Ten Sleep (Hosterman et al. 1989; Cooley and Head 1979; Darton 1906). Also, a large prominent fault, called the Big Trails Fault System, trends generally north-south along the eastern perimeter of the watershed in the southern Bighorn Mountains (Verploeg 1992).

Hazards
Karst, landslide, and seismic geological hazards exist within the Nowood watershed. Karst creates sinkhole hazards and occurs from the dissolution of chemical rocks (limestone, gypsum, dolomite, etc.). Landslides occur when sediment moves down slope under the influence of gravity, potentially damaging structures and altering the hydrogeology of the watershed. Seismic events create a hazard to structures and tend to occur along fault lines, but earthquakes have occurred in areas with no known respective structural feature. The potential areas at risk for these hazards are presented on Figure 3.

Karst topography within the Nowood watershed is predominantly located to the east of the Nowood River. Closed depressions and solution collapse features are found on the surface and have been associated with the Goose Egg and Gypsum Spring Formations (Cooley and Head, 1979). These features were developed from the dissolution of gypsum and limestone underlying surficial deposits. The surficial deposits then reflected the karst topography below them. The limestone and dolomite of the Madison, Bighorn, and Gallatin Formations have also developed a karst topography. Some of this topography is concealed by the Amsden Formation, which unconformably overlies paleokarst features of the Madison (Hosterman et al., 1989). However, extensive, recently developed caves exist in the northeastern portion of the Nowood watershed, near Medicine Lodge Creek (Susong et al., 1993).

Collapse risk due to sinkholes can be difficult to determine due to their subsurface nature. Certain features can be indicative of karst: closed depressions, sinking streams, blind valleys, and others. However, subsurface investigations (including geophysical, tracer dye, and field surveys) need to be conducted to provide an adequate assessment.

Landslide hazards exist in areas where the resisting forces (friction and cohesion/adhesion between sediment particles) have the potential to be exceeded by the driving forces (gravity). This condition can be found throughout the upland areas of the Nowood watershed. Paleolandslides (“li” unit in Figure 3) are indicators of future landslide activity. Slopes experiencing undercutting due to lateral erosion of streams are also at high risk. Severe erosion problems have been noted on the Nowood River, with less severe erosion on the Paint Rock, Ten Sleep, Otter, and Canyon Creeks (USDA 1971). The lateral erosion by streams undercuts the toe of slopes and removes their underlying support. Other factors for
potential landslide areas include grain size and shape, lateral and underlying support, slope angle, sediment composition, and water content.

The Nowood watershed is an area with minor historical seismicity. According to Stover et al. (1984), epicenters of 11 earthquakes were recorded to have been in or near the watershed. The largest magnitude earthquake, with a magnitude of 4.9, occurred in 1970. The epicenter was located approximately 8 miles southwest of Ten Sleep. The smallest magnitude earthquakes of 3.0 occurred in 1998 and 2000 (USGS 2009; Case et al. 2002). Two earthquakes recorded in 1925 and 1966, occurred before magnitude measurements were regularly recorded. The earthquakes were rated using the Modified Mercalli Intensity Scale. Intensity was not noted for the 1966 earthquake, and an intensity V level was applied to the 1925 event. The 1925 event was felt in Ten Sleep, Sheridan, Fort McKenzie, and Dome Lake Resort, but damage was not reported (Case et al. 2002).

Two fault systems are located adjacent to each other in the southern portion of Nowood watershed: the Cedar Ridge and Dry Fork fault systems. Evidence suggests that the fault systems are inactive. However, one confirmed case of Pleistocene-aged movement, in the form of a fault scarp, was documented in northeastern Fremont County (Case et al. 2002). If either the Cedar Ridge or Dry Fork fault systems were to become active, they could potentially generate 6.7 and 7.1 magnitude earthquakes, respectively. A 6.7 magnitude earthquake at the Cedar Ridge System could produce a peak horizontal ground acceleration of 2.9%g at Ten Sleep and 2.0%g at Big Trails. A 7.1 magnitude earthquake at the Dry Fork System would produce a peak ground acceleration of 3.8%g at Ten Sleep and 7.4%g at Big Trails. In either case, minor damage could result from these earthquakes at Big Trails, Wyoming (Case et al. 2002).

Although active fault systems are not currently identified near the Nowood watershed, large earthquakes can still occur in areas without a known source structure. These earthquakes are known as “floating earthquakes.” Federal and state regulations require a floating earthquake analysis for certain structures (mill tailing sites, landfills, etc.). If a structure within the Nowood watershed required such analysis, a 6.25 magnitude earthquake with an epicenter 15 miles from the structure could be used as a conservative estimate for design ground accelerations. An earthquake of this magnitude and distance could produce ground accelerations of 15%g (Case et al. 2002). A more detailed, site specific, design analysis of seismological hazards is performed in association with the development of significant structures, such as large dams.

Another type of seismic hazard analysis, completed by the USGS, estimates the probability of exceeding the peak horizontal ground acceleration that could occur from an earthquake in the next 50 years. This analysis was most recently updated in 2008 and can be found at http://gldims.cr.usgs.gov/nshmp2008/viewer.htm. For the Nowood watershed, the peak horizontal ground acceleration that has a 10% chance of being exceeded from 2008 to 2058, is from 4-5%g. The peak ground acceleration that has a 2% chance of being exceeded from 2008 to 2058 is from 15-17%g. This methodology uses the frequency and magnitude of past earthquakes to estimate the frequency and magnitude of future earthquakes. A weakness to this method is that it can inaccurately predict earthquake risk in areas with a low frequency of earthquakes, like the Nowood watershed. However, few other alternatives for estimating the risk exist.
Field Investigations of Potential Reservoir Sites

Upon completion of the reconnaissance-level assessment, ACE provided Trihydro with a list of nine sites advanced in the project for field investigation: Little Canyon, Nowood-Crawford, Cottonwood Creek, Meadowlark Lake (enlargement of existing reservoir), Taylor Draw, Deep Creek, Bruner Gulch, Upper Nowood, and Big Trails. Trihydro’s field investigations of these sites included verifying and describing the bedrock conditions along the embankment alignment, collecting selected samples of foundation and potential embankment fill materials, identifying possible spillway locations, and compiling photograph documentation of each site. The remainder of this memorandum provides summary findings from field investigations of the nine reservoir sites performed during the week of July 27-31, 2009.

Little Canyon
The project was discussed in detail with the landowner, but access to the reservoir site was not granted. Based on direction from ACE, Trihydro excluded this site from further consideration for investigation.

Nowood-Crawford
The proposed dam location for the Nowood-Crawford site is on the Nowood River, approximately 800 feet downstream of the Crawford Creek confluence. The embankment location is within the Jurassic part of the section, with sandstones of the Sundance Formation outcropping at the left abutment (Figure 4A) and siltstones of the Gypsum Springs Formations outcropping near the right abutment (Figure 4B). Sandstones of the Chugwater Formation were observed to the south of the right abutment. The beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the north at 15° (degrees) along a strike of 98°. Near the right abutment, the beds dip to the north at 20° along a strike of 101°.

Three samples were collected from this site. The first sample was collected from an outcrop to the south of the right abutment and consists of yellow, fine-grained sandstone with well-sorted, subrounded quartz grains and a very minor lithic fragment component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid. The second sample was taken from the alluvium near the right bank of the Nowood River and consists of red silty clay with sand and gravel. The fine fraction of the alluvium holds a weak thread when wet. The third sample was collected from an outcrop near the base of the left abutment and consists of greenish-gray, hard, glauconitic, very fine-grained sandstone or siltstone, with minor lithic fragment and gypsum components.

The proposed embankment alignment is near the contact between the Gypsum Springs and Sundance Formations and was observed in an outcrop on the left side of the drainage approximately 400 feet upstream of the left abutment. The Gypsum Springs Formation was also observed outcropping in the bottom of the drainage near the embankment location (Figure 4C) and is likely overlain by the alluvium and colluvium in the valley bottom and right abutment. Although this formation was flagged as a high risk in the reconnaissance-level assessment, an existing dam and reservoir is located in a similar geologic setting approximately 1 mile downstream of the identified site. (Figure 4D). The existing dam embankment appeared to be stable; however, observation of the sediment accumulated within the upstream portion of the existing reservoir indicates this portion of the watershed has a high siltation potential.
A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. Depending on the embankment height, a possible spillway location was identified near the right abutment (Figure 4B). Construction of a reservoir at this site would likely dictate portions of the Nowood River Road and the Bates Creek Road to be rerouted.

**Cottonwood Creek**

The proposed dam location for the Cottonwood Creek site is on Cottonwood Creek approximately 4,400 feet upstream of its confluence with the Nowood River. The alignment evaluated in the field is located approximately 850 feet upstream of the alignment identified by ACE. The embankment location is within the lower Cretaceous part of the section, with sandstones of the Cloverly Formation outcropping at the left and right abutments (Figures 5A and 5B). The sandstone bedding planes in the area of the abutments dip to the south at 11° along a strike of 264°.

A small cave has eroded in the sandstone near the base of the left abutment (Figure 6B). Foundation conditions need to be evaluated during a subsequent subsurface investigation. Foundation conditions, similar to the cave documented in Figure 6B do not appear to be widespread, and this feature may be an isolated occurrence.

Three samples were collected at this site. The first sample was collected near the right abutment and consists of dark red, hard, glauconitic silt shale. The second sample was taken from the alluvium in the bottom of the Cottonwood Creek valley and consists of light tan silty clay that holds a weak thread when wet. The third sample was collected near the base of the left abutment and consists of yellow-tan, fine-grained sandstone with well-sorted, frosted, subrounded quartz grains and a very minor mafic component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid.

A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. A possible spillway location was identified near the right abutment, which would utilize an existing drainage immediately downstream of the abutment (Figure 6A).

**Meadowlark Lake Enlargement**

Meadowlark Lake is an existing reservoir on Tensleep Creek near the confluence with East Tensleep Creek. The reservoir was constructed in the late 1930s as a work project for the Civilian Conservation Corps (CCC). An enlargement project may require consideration of the historical value of the site.

The existing dam consists of a 30-foot tall embankment with a primary outlet channel near the right-center of the embankment, an emergency spillway near the left side of the embankment, and what appears to be a fish ladder adjacent to the spillway (Figure 7). The primary outlet and spillway channels are in need of repair. The internal condition of the primary outlet could not be assessed. Based on the surface area of the reservoir from the SEO filing, raising the water level could yield approximately 300 acre-feet of additional storage per foot of water surface elevation.
Taylor Draw
The proposed dam location for the Taylor Draw site is near the mouth of Taylor draw approximately 2,100 feet upstream of the confluence with the Nowood River. The embankment location is within the lower Cretaceous part of the section, with Thermopolis Shale outcropping near the left and right abutments (Figures 8A and 8B). The shale at the ground surface is easily erodible, but the material becomes more competent with depth. The shale in outcrops on both sides of the drainage consistently dips to the west.

Two samples were collected at this site. The first sample was taken from the right abutment and consists of moderately hard, but easily friable, black clay shale. The second sample was collected from the channel bottom and consists of brownish-tan silty clay that holds a fine-diameter thread when wet.

The channel morphology of Taylor Draw suggests that the drainage basin may not receive enough runoff to directly support a reservoir (Figure 8C). However, the site may be feasible for an off-channel reservoir storing water from the Nowood River. Adequate borrow material for use as embankment fill could likely be found in the valley bottom. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. A potential spillway location was identified near the left abutment.

Deep Creek
The proposed dam location for the Deep Creek site is just downstream of the Cherry Creek road crossing. The location is within the lower Mississippian part of the section, with limestone of the Madison Formation outcropping at the left and right abutments (Figure 9). The limestone in the area of the embankment appeared to be resistant, but karstic erosional features were observed in downstream outcrops (Figure 10A). Compared to the downstream outcrops, the outcrop near the left abutment appeared relatively resistant, with minor dissolution along fracture planes. A geode was observed in the outcrop, illustrating the potential for dissolution (Figure 10B).

Two samples were collected at this site. The first sample was collected from an outcrop at the left abutment near the bottom of the drainage and consists of massive gray limestone/mudstone with little to no allochems (allochems are carbonate aggregates, which form the framework of mechanically deposited limestones). The second sample was collected on the north side of the access road approximately 600 feet upstream of the provided dam location. This sample consists of a greenish-gray, hard siltstone or shale with quartz veins interbedded with a green conglomerate with subangular to subrounded, flat pebble clasts. The second sample is of the Gallatin Limestone, which indicates the dam site is located near the contact between the Madison and Gallatin formations.

This site may be feasible for an embankment, but a significant subsurface investigation would be required to determine the competency of the underlying bedrock for holding water in the reservoir and serving as a foundation for the embankment. Borrow material for an earthen embankment may be difficult to locate in proximity to this dam site. Given the potential foundation conditions and the borrow material limitations, a concrete or rock fill dam structure may be alternative embankment designs for this location. The dam would likely need to be designed with a spillway running down the downstream face, because a good spillway location was not identified at this site.
Bruner Gulch
The proposed dam location for the Bruner Gulch site is on Buffalo Creek immediately upstream of Bruner Draw. The embankment location is within the upper Cretaceous part of the section, with sandstone of the Frontier Formation outcropping at the left abutment and sandstone and shale of the Frontier Formation outcropping at the right abutment (Figures 11A and 11B). The sandstone beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the west at 17° along a strike of 353°. Near the right abutment, the beds dip to the west at 17° along a strike of 350°. Shale materials derived from either the Frontier Formation or the Mowry Shale was observed downstream of the left and right abutments. Downstream of the left abutment, this shale dips to the west at 21° along a strike of 344°.

Four samples were collected at this site. One sample was taken from the left abutment and consists of gray, fine- to medium-grained lithic arenite with poorly sorted, subrounded quartz grains and lithic fragments. The sandstone is well-cemented but friable. A second sample was collected from the channel bottom near the left abutment and consists of gray silty clay that holds a fine diameter thread when wet. The third sample was collected from a shale outcrop near the right abutment and consists of gray, easily friable, silt shale with faint, thin laminations. The fourth sample was collected from a shale outcrop downstream of the Bruner Draw confluence near the right abutment and consists of gray, moderately soft to hard, friable, silt shale.

A sufficient volume of borrow material for construction of an embankment is likely available in the valley bottom. The engineering properties of this material for use as embankment fill should be confirmed with additional investigation. The second sample described for this site was collected to represent locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed at the site, and this material would likely need to be imported. A possible spillway location was identified near the left abutment, which would utilize an existing drainage immediately downstream of the abutment.

Upper Nowood
The proposed dam location for the Upper Nowood site is on the Nowood River approximately 3 miles upstream of the Little Canyon Creek confluence. Two potential embankment locations were evaluated at this site: one at the location provided by ACE (Figure 12) and one approximately 500 yards upstream of the provided location (Figure 13). This site is located in the upper Jurassic part of the section, with sandstones of the Sundance Formation outcropping near each abutment. The sandstones higher on the slope comprising the left abutment may be of the Morrison Formation. The sandstone beds near each abutment are similarly oriented. Near the right abutment of the upstream location, the beds dip to the west at 2° along a strike of 32°. Near the left abutment of the downstream location, the beds dip to the west at 7° along a strike of 36°. Along with sandstone outcrops, the hill slope comprising the left abutment at the upstream location consists of thick beds of soft, erodible siltstone or claystone (Figure 14A).

Three samples were collected from this site. The first sample was collected from the right abutment of the upstream location and consists of tan, well-cemented, very fine-grained quartz sandstone with calcareous cement. The second sample was collected in the floodplain on the left side of the river and consists of red silty clay. The clay holds a fine diameter thread when wet, but is less dense than the silty clays at the other sites. The third sample was taken from left abutment of the original location and consists of the same sandstone as the first sample.
The site topography would allow construction of high embankment damming a large reservoir. A sufficient volume of borrow material could likely be found in the valley bottom for construction of an earthen embankment. Additional investigations will need to be performed to determine the engineering properties of the available borrow material for use as embankment fill. The second sample described for this site was collected to represent this locally available borrow material. Gravel and cobble lenses were observed in the bank of the Nowood, representing former channel deposits (Figure 14B). The coarse material from the former channel deposits could likely be used for embankment drainage. A source of coarse material for riprap was not observed at the site, and this material would likely need to be imported. Depending on the height of the embankment, two small drainages east of the right abutment could be used in the construction of spillways (Figures 12C and 13C).

**Big Trails**

The proposed dam location for the Big Trails site is on the Nowood River, approximately 5 miles upstream of the Little Canyon Creek confluence. The embankment location is within the Jurassic part of the section, with both abutments primarily within the Gypsum Springs Formation (Figure 15A). Sandstones of the Sundance Formation were observed cropping out as capstone above both abutments, but the abutments themselves would be located within very soft, erodible gypsum (Figure 15B). Because of these foundation conditions, this site is not recommended for further consideration as a potential reservoir location.

Two samples were collected at this site. The first sample was taken near the base of the left abutment and consists of gypsum. The second sample was collected from the capstone outcropping at the top of the left abutment and consists of greenish-gray, glauconitic, hard, very fine-grained sandstone.

**Summary Findings**

The geologic conditions for each embankment location were evaluated by mapping outcrops at the surface and by inferring subsurface conditions based on observed structure and published regional stratigraphy. The findings presented in this memorandum regarding each site should be verified by subsurface investigations, including investigative borings.

Based on this surface investigation, Cottonwood Creek, Meadowlark Lake, Taylor Draw, Bruner Gulch, and Upper Nowood would warrant additional subsurface study to evaluate the competency of the foundation materials. Outstanding geologic risk was not found at these sites.

If other driving factors favor development of the Nowood-Crawford and Deep Creek sites, these sites would also warrant additional subsurface investigation. The geology at these two sites was not as favorable as the aforementioned. A high potential for karstic features exists in the foundation of Deep Creek, and there is a high risk of gypsum being one of the primary foundation materials for Nowood-Crawford.

The only site not recommended for further investigation is Big Trails because of the amount of gypsum outcropping at the embankment location. This material is erodible and does not appear to provide a suitable foundation for construction of a dam embankment.
References


<table>
<thead>
<tr>
<th>No.</th>
<th>Dam and Reservoir Site Name</th>
<th>Description of site geology</th>
<th>Dam embankment foundation</th>
<th>Reservoir pool area</th>
<th>Contributing watershed</th>
<th>Rating</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alkali Creek</td>
<td>Quaternary alluvium in footprint of dam embankment; Cloverly - Morrison Formations within reservoir pool area</td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>2</td>
<td>Big Trails</td>
<td>Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Ten Sleep in basin; faulting in basin</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td></td>
<td>Embankment within mapped Gypsum area</td>
</tr>
<tr>
<td>3</td>
<td>Bruner Gulch</td>
<td>Embankment on alluvium/colluvium over Frontier; Cody in pool; Mesaverde, Fort Union, Lance, Mowry/Thermopolis in basin</td>
<td>B-</td>
<td>B</td>
<td>B</td>
<td></td>
<td>Field verify alluvium and potential for seepage through Frontier</td>
</tr>
<tr>
<td>4</td>
<td>Canyon Creek</td>
<td>Tensleep/Amsden at embankment and pool; Goose Egg in pool; some Madison near faulting in basin; some Gneiss and Gallatin in headwaters</td>
<td>C+</td>
<td>C+</td>
<td>B</td>
<td></td>
<td>Edge of mapped gypsum area, field verify Tensleep condition</td>
</tr>
<tr>
<td>5</td>
<td>Cottonwood Creek</td>
<td>Quaternary alluvium/colluvium underlying embankment footprint, potential for Cloverly and Morrison; Mowry and Thermopolis, Cody within pool and contributing watershed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>6</td>
<td>County Line</td>
<td>Quaternary terrace and fan deposits, Mowry and Thermopolis shales ; Cloverly and Morrison Formations within contributing watershed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>7</td>
<td>Lower Brokenback</td>
<td>Alluvium/sandstone/Gypsum springs at embankment; Chugwater/Goose Egg in pool and basin; Tensleep/Amsden, Madison in basin;</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td></td>
<td>Embankment within mapped Gypsum area, field verify Gypsum Springs condition</td>
</tr>
<tr>
<td>8</td>
<td>Lower Nowood</td>
<td>Quaternary alluvium in footprint of dam embankment; Mowry and Thermopolis shales with pool area, mixed bag with contributing watershed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>9</td>
<td>McDermott Draw</td>
<td>Frontier Formation at embankment; Mowry and Thermopolis Shales</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td></td>
<td>Field verify potential for foundation seepage</td>
</tr>
<tr>
<td>10</td>
<td>Meadowlark Lake</td>
<td>Glacial and landslide deposits near Madison at embankment; Gallatin, Bighorn, gneiss in pool and basin</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td></td>
<td>Existing lake, south end of embankment on mapped landslide hazard, karst risk from ACE layer</td>
</tr>
<tr>
<td>11</td>
<td>Medicine Lodge</td>
<td>Glacial deposits</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td></td>
<td>Need to field verify nature of glacial deposits</td>
</tr>
<tr>
<td>12</td>
<td>Otter Creek</td>
<td>Alluvium/colluvium, Cloverly/Morrison, Sundance/Gypsum Springs at embankment; Chugwater/Goose Egg in pool; Tensleep/Amsden in basin; some Madison, Gneiss, Bighorn, Gallatin near faulting high in basin;</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td></td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping</td>
</tr>
<tr>
<td>13</td>
<td>Paint Rock Creek</td>
<td>Contact between Madison and Tensleep near the embankment; Madison with area projected to be inundated by the reservoir;</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td></td>
<td>Karst risk from ACE layer</td>
</tr>
<tr>
<td>14</td>
<td>Lower Trout Creek</td>
<td>Glacial deposits, Precambrian</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td></td>
<td>Need to field verify nature of glacial deposits</td>
</tr>
<tr>
<td>15</td>
<td>Pete</td>
<td>Cody shale and Frontier formation</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>16</td>
<td>Solitude</td>
<td>Precambrian (oldest gneiss complex)</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>Existing lake, mapped fault, field verify foundation competency</td>
</tr>
<tr>
<td>17</td>
<td>Summit</td>
<td>Precambrian (oldest gneiss complex)</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>Field verify foundation competency</td>
</tr>
<tr>
<td>18</td>
<td>Taylor Draw</td>
<td>Mowry/Thermopolis at the embankment and pool; Cloverly/Morrison, Sundance/Gypsum Springs, Chugwater/Goose Egg in basin;</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td></td>
<td>No outstanding geologic risk evident at the embankment</td>
</tr>
<tr>
<td>19</td>
<td>Upper Nowood</td>
<td>Cloverly/Morrison, Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Tensleep in basin; faulting in basin;</td>
<td>C-</td>
<td>C-</td>
<td>C-</td>
<td></td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping</td>
</tr>
<tr>
<td>20</td>
<td>West Fork Willow Creek</td>
<td>Frontier Formation at embankment; Cody shale in pool</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>Field verify potential for foundation seepage</td>
</tr>
<tr>
<td>21</td>
<td>West Tensleep Lake</td>
<td>Embankment on glacial deposits; embankment and pool on Precambrian gneiss complex</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td></td>
<td>Embankment near mapped landslide, field verify nature of glacial deposits, existing lake</td>
</tr>
<tr>
<td>22</td>
<td>Little Cottonwood Creek</td>
<td>Cloverly/Morrison at the embankment and pool; Mowry/Thermopolis pool basin; Frontier, Cody, Mesaverde, Lance, Fort Union, igneous in basin</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>No outstanding geologic risk evident</td>
</tr>
<tr>
<td>23</td>
<td>Nowood Mahogany Butte 1</td>
<td>Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td>Karst risk from ACE layer, gypsum mapping surrounding embankment</td>
</tr>
<tr>
<td>24</td>
<td>Nowood Mahogany Butte 2</td>
<td>Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td>Karst risk from ACE layer, gypsum mapping surrounding embankment</td>
</tr>
<tr>
<td>25</td>
<td>Deep Creek</td>
<td>Madison at the embankment; Gallatin in pool, embankment, basin; gneiss in basin</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td></td>
<td>Karst risk from ACE layer</td>
</tr>
<tr>
<td>Dam and Reservoir Site Name</td>
<td>Description of site geology</td>
<td>Dam embankment foundation</td>
<td>Reservoir pool area</td>
<td>Contributing watershed</td>
<td>Rating</td>
<td>Note</td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>-------------------</td>
<td>----------------------</td>
<td>--------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>28 Nowood - Crawford</td>
<td>Sundance and Gypsum Springs at the embankment; Madison, Ten Sleep, Wagon Bed, Gallatin in basin</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>Embankment on mapped gypsum area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Weintz Draw</td>
<td>Frontier Formation underlying embankment; Course colluvium</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>Field verify potential for foundation seepage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Upper Brokenback</td>
<td>Chugwater/Goose Egg at the embankment; Tensleep/Amsden, Madison in basin</td>
<td>D</td>
<td>C</td>
<td>C</td>
<td>Embankment on mapped gypsum area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Woods Gulch</td>
<td>Mowry and Thermopolis shales at embankment and in pool area; Cloverly/Morrison, Sundance/Gypsum Springs, and Chugwater/Goose Egg in basin</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident at the embankment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Alkali Creek South</td>
<td>Cloverly/Morrison at embankment and in pool area; Sundance/Gypsum Springs and Chugwater/Goose Egg in basin</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident at the embankment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 South Fork Otter (Lower)</td>
<td>Tensleep/Amsden at embankment and in pool; Chugwater/Goose Egg in pool; Tensleep/Amsden, Chugwater/Goose Egg, Madison limestone, basement Gneiss in basin; mapped landslide in pool</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Tensleep/Amsden mapping, field verify condition of Tensleep, field verify mapped landslide in pool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 South Fork Otter (Upper)</td>
<td>Tensleep/Amsden at embankment; Madison limestone in pool; Gneiss in basin; faulting near embankment and in basin; mapped landslide in pool and near embankment</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, verify structure near embankment, field verify mapped landslides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 Canyon Creek</td>
<td>Madison limestone, Chugwater/Goose Egg, Tensleep/Amsden at embankment and in pool; Tensleep/Amsden and Madison in basin; fault at the embankment; mapped landslide deposits near embankment</td>
<td>D+</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, verify structure and landslides near embankment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 Lone Tree</td>
<td>Tensleep/Amsden, Goose Egg, and Gypsum Springs near embankment, pool and basin; Madison and Gallatin in basin; faulting near pool</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Embankment within mapped Gypsum area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 North Brokenback</td>
<td>Tensleep/Amsden at embankment and in pool; Madison/Darby in basin</td>
<td>C+</td>
<td>C+</td>
<td>D</td>
<td>Field verify Tensleep condition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTES:
1. PHOTOS TAKEN ON JULY 27, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.

Figure 8
TAYLOR DRAW SITE PHOTOS
NOWOOD RIVER
WATERSHED STUDY

A) VIEW OF LEFT ABUTMENT

B) VIEW OF RIGHT ABUTMENT

C) DRAINAGE BOTTOM UPSTREAM OF EMBANKMENT LOCATION
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.

Figure 14
UPPER NOWOOD SITE PHOTOS
NOWOOD RIVER
WATERSHED STUDY

A. BASE OF LEFT ABUTMENT
   UPPER LOCATION

B. SOIL HORIZONS AND FORMER CHANNEL BED
   RIGHT BANK OF NOWOOD RIVER
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
Memorandum

To: Jason Mead, P.E.
    Wyoming Water Development Office

From: Joel Farber, P.G., P.E. & Mark Donner, P.E.

Date: February 8, 2011

Re: Further Evaluation of Proposed Storage Sites
    Nowood River Storage Level II Study

The purpose of this memorandum is to provide the Wyoming Water Development Office (WWDO) with a summary of the updated Reservoir Evaluation Matrix (Matrix) as part of the Nowood River Storage Level II Study. The Matrix is attached as Table 1. The original Matrix, which was developed as part of the Level I Study (ACE 2010), included a wide array of relevant information regarding potential storage sites compiled from the watershed inventory results. The Level I Study Matrix also included environmental, hydrologic, geology, and geotechnical information, as well as potential benefits, costs, and ownership issues. Thirty-five potential surface water storage sites were initially compiled in the Level I Study. The current Matrix includes sites previously identified, as well as additional sites recommended by the Steering Committee and knowledgeable stakeholders, the WWDO, and sites identified during a topographic review of the watershed.

The Level II Study, Task 6, includes the identification of potential water storage alternatives. The primary objective of the Level II Study is to further narrow the scope (i.e., number of potential sites) and identify viable alternatives for beneficial surface water development. This technical memorandum presents summaries of site prioritization, evaluation of additional sites, field reconnaissance, potential sage grouse issues, recommended reprioritization of potential sites, recommendations, and future activities.

SITE PRIORITIZATION
In the Level I Study Matrix was used to assign relative priorities to the sites (ACE 2010). The priority descriptions, as stated in the Level I Study, are as follows:

**Priority 1 Sites:** represent the most potentially feasible of the sites evaluated and provide the most benefit at the least cost or environmental impact. These sites would be recommended for further evaluation in future investigations.

**Priority 2 Sites:** while potentially feasible, have attributes making them less desirable for further study than Priority 1 Sites. For example, some sites have potential benefits commensurate with Priority 1 Sites, but their overall costs were estimated to be higher. Designation as a Priority 2 Site does not preclude the site from being included in future Level II, Phase 1 studies.
Priority 3 Sites: have either ‘fatal flaws’ that eliminated them from recommendation for further study (e.g., location within the wilderness area), or other attributes causing them to be highly unlikely to be implemented.

The project team has further evaluated site suitability relative to geology and engineering at each of the proposed sites (Table 1).

EVALUATION OF ADDITIONAL SITES
Several areas within the Nowood River watershed were evaluated to determine the potential for reservoir development based on feedback received from the sponsor and the WWDO subsequent to the completion of the Level I Study. These areas included: the Paint Rock Creek drainage; areas adjacent to the Nowood River, upstream from Big Trails, which may be suitable for development of off-channel storage; and the Little Canyon Creek and Box Elder/Redbank Creek drainages. These areas were targeted to develop a range of alternatives for developing reservoir storage potentially capable of serving demands throughout the Nowood River watershed.

The evaluation considered the following site characteristics:

1. Consideration of the topography insofar as feasibility for constructing a reservoir.
2. Feasibility of diverting water and conveying it to the reservoir.
4. Site geology.
5. Landownership in the vicinity of the reservoir site, including the embankment and areas inundated by the reservoir pool, and appurtenant facilities such as the diversion and conveyance.

The following sections document the contributing drainages that were considered and evaluated at a desktop level. Potentially feasible sites are identified with a recommendation for additional preliminary investigations that may be performed at the direction of the WWDO. Sites deemed not to be feasible are listed within this memo, along with brief documentation of the reason(s) the site is not recommended for further study.

Paint Rock Creek Drainage
Several alternative sites were identified within the Paint Rock Creek drainage during the Level I Study. However, a number of the more ideally located sites, in terms of the potential to provide a secondary supply to irrigated lands, were discounted in priority because of possible geotechnical concerns. Each of the sites indentified during the Level I Study were reviewed and, based on discussions with the WWDO,
the Alkali Creek and Paint Rock Creek sites were selected for further evaluation during a reconnaissance-level geotechnical field evaluation.

Additionally, the Paint Rock Creek drainage was evaluated to determine if other potential reservoir sites might be identified. The evaluation established two new potentially feasible sites located on Luman Creek. Luman Creek is a small tributary to Paint Rock Creek. The creek flows northwesterly with a contributing drainage area that encompasses a relatively low-elevation drainage of the watershed, which is not expected to yield significant water annually. However, two potential reservoir sites were identified on this drainage because its confluence with Paint Rock Creek is located upstream of most of the irrigated acreage along Paint Rock Creek and diversion and conveyance facilities may feasibly be constructed to supply the sites from higher elevation areas of the South Fork of Paint Rock Creek. During our desktop study, the sites also appeared to have more favorable geotechnical conditions.

Landowners potentially affected by development of storage in the Luman Creek drainage include the State of Wyoming and John Alm. The diversion and conveyance facilities to supply these sites may also be located marginally near United States Forest Service (USFS) land.

**Off-Channel and Upstream from Big Trails along Nowood River**

A desktop review was performed to identify potential off-channel storage sites along the Nowood River upstream from Big Trails. The evaluation was focused on drainages adjacent to the floodplain of the Nowood River, whereby a diversion might be made from the river to a storage reservoir constructed near the outfall of the tributary drainage.

The following list of potential alternatives is presented from south to north (upstream to downstream with respect to the Nowood River).

*Cornell Gulch (Section 20, T42N, R88W)* – This is a site that was identified by the WWDO. Cornell Gulch appears potentially viable and is recommended to be carried forward during the Level II Study. The following items document the evaluation relative to the five criteria considered:

1. Site topography appears feasible for development of a reservoir.
2. Diversion would entail an approximately 3-mile-long channel conveyance from the river based on the 5,560-foot elevation contour. The diversion would likely be located slightly downstream of the Lone Tree site.
3. There may be a possibility of constructing an emergency spillway in a topographic “notch” located off of the right abutment area. However, this spillway location would conflict with the supply conveyance from the river.
4. Bedrock mapping shows the embankment is located on the Gypsum Springs formation. This formation has a potential concern for karst features. A reconnaissance geotechnical review and field investigation is recommended before the site is advanced for further consideration.

5. The embankment is located near the boundary between State land and Orchard Ranch lands. The supply conveyance also appears to affect these two land owners, and possibly Bureau of Land Management (BLM) near the river diversion.

**Homestead Gulch (Section 4, T42N, R88W)** – This site does not appear feasible and we recommend the site be discounted from further consideration. The topography does not appear to allow for reasonable storage capacity.

1. Site is located above Orchard’s airport runway. An embankment may be constructed to an elevation of approximately 5,300 feet; however, the storage capacity appears somewhat limited.

2. Diversion will likely require an approximately 3-mile channel from the river based on the 5,320-foot elevation contour.

3. An emergency spillway may be sited in an un-named draw to the south. Similar to Cornell Gulch, this location would spill “upstream” and across the supply conveyance.

4. Bedrock mapping indicates the embankment would be located on the Gypsum Springs formation. Diversion would be located on the Goose Egg Formation.

5. The embankment would be located on Orchard Ranch property. The inundated area would include BLM lands. Supply conveyance and diversion would be located largely on State lands.

**Telephone Draw (Section 34, T43N, R88W)** – This site does not appear feasible and we recommend the site be discounted from further consideration. The topography does not appear to allow for reasonable storage capacity.

**Un-named Draw north of Mahogany Butte (Section 26, T43N, R88W)** – This site does not appear feasible and we recommend the site be discounted from further consideration. The topography does not appear to allow for reasonable storage capacity, nor a viable opportunity to divert water from the river.

**SV Draw (Section 25, T43N, R88W)** – This site does not appear viable. The topography is somewhat more attractive than the Un-named Draw north of Mahogany Butte, but the site does not appear topographically feasible, particularly with regard to developing a conveyance from the Nowood River. The following items document the evaluation relative to the five criteria considered:
1. The site is located in a small narrow drainage. An embankment may be sited near the mouth of the drainage. The embankment may be constructed to an elevation of approximately 5,200 feet to maximize storage potential.

2. The diversion of water by gravity to supply this site would be difficult, particularly if the site was developed to maximize storage potential. The site is located downstream of Mahogany Butte, whereby a canal would need to be constructed through the length of the “canyon” formed by the river where it cuts across the butte.

3. An embankment would need to be constructed to an elevation of 5,200 feet in order to take advantage of the site topography to locate a spillway. Of course, a spillway may be designed within the embankment section, which may be feasible given the small contributing drainage area for SV Draw.

Un-named Draw (near north section line, Section 6, T43N, R87W) – This site does not appear feasible and we recommend the site be discounted from further consideration. The topography does not appear to allow for reasonable storage capacity.

Willow Creek (confluence located in Section 1, T44N, R88W) – Willow Creek is a relatively significant tributary to the Nowood River located on the west side of the river. A potential reservoir site was identified on the west fork of Willow Creek during the Level I Study. The potential for constructing a storage reservoir near the outfall of this tributary, whereby a supply may be established by a diversion from the Nowood River, does not appear feasible. Therefore, the feasibility for establishing storage within this drainage would largely depend on the potential yield of water from the Willow Creek drainage. Review of available GIS data shows several small storage reservoirs already exist within the Willow Creek drainage. Based on the evaluation of the West Fork Willow Creek site, this alternative is recommended to be discounted from further study.

Horton Draw (Section 11, T45N, R88W) – Horton Draw is a small tributary drainage located on the west side of the watershed and a short distance upstream from the confluence of Otter Creek and the Nowood River. The topography of this draw does not appear prospective for establishing a storage reservoir. We recommend this site be discounted from further consideration.

Mud Gulch (Section 2, T45N, R88W) – Although this drainage appears to provide a viable site to construct an off-channel reservoir, construction of a supply conveyance from the river at an elevation needed to develop the site would be tenuous and costly. We recommend that this site be discounted from further consideration.

Bud Kimball Creek (Section 23, T46N, R88W) – Reservoir storage may potentially be established at this site, but the length of a supply conveyance, number of landowners likely affected, and the potential for sedimentation derived from the tributary drainage are negatives. The following items document the evaluation relative to the five criteria considered:
1. The site is located in a larger tributary drainage contributing to the Nowood River downstream of Taylor Draw (located on the east side of river) and upstream of the confluence with Spring Creek. An embankment may be sited near the mouth of the drainage on BLM land in the vicinity of the Section corner between Sections 22, 23, 26 and 27, T46N, R88W. The top elevation of the embankment may be established at/below an elevation of 4,600 feet.

2. The diversion structure would be constructed along the 4,600-foot elevation contour line and would divert flow from the Nowood River. This would result in an approximately 6-mile-long channel, with a diversion structure located in Section 19, T45N, R87W.

3. An emergency spillway may best be sited from the right (south) abutment. However, locating a spillway here would potentially create a conflict between discharge from the spillway and a supply canal from the river.

4. Review of bedrock mapping shows the embankment would be located on the Cretaceous-age shale (Mowry and Thermopolis Formations). A geotechnical field reconnaissance is recommended to be completed before this site is considered for further study or potential advancement. Diversion would traverse Cretaceous shale, Frontier Formation, and Quaternary alluvium deposits.

5. The embankment would be located on BLM. The conveyance to supply this site would traverse significant private land holdings, including Lyman Ranch, Alex Johnstone, Breeden Trust, Ney Beckley, Lazy Bighorn Ranch, Christopherson Trust.

**Little Canyon and Box Elder/Redbank Creek Drainages**

**Little Canyon Creek (Section 24, T44N, R87W)**

A potential reservoir site was located on this drainage during the Level I Study. This was the reservoir site located on lands owned by Mr. Lewton, which Trihydro was scheduled to perform a geotechnical field reconnaissance at this site during 2009; however, Mr. Lewton indicated he did not have any interest in developing a reservoir on his property, and prohibited site access.

Nonetheless, the project mapping was reviewed to determine if there may be an alternative site along this drainage. In general, Little Canyon Creek flows in a deeply-incised canyon formed in Paleozoic strata. The stream channel has a relatively steep gradient, averaging approximately 105 feet per mile (~2%). There is a possible site located at the confluence of the north and south forks of the creek (NE1/4 of Section 2, T43N, R87W). This site is unusual in that a fair storage volume may be developed on the south fork but the north fork of the creek remains steep and narrow. However, the lands that would be inundated on the south fork appear to be irrigated. Moreover, a house and structures owned by Mr. Lewton may also be inundated by developing storage at this location.

Additional prospective sites are not evident in the remainder of the drainage. A dam embankment may be constructed across a number of locations in this drainage basin given the constricted canyon through most
of the length of this creek, but the available storage capacity would be restricted by the canyon
topography and the gradient of the creek.

In summary, a reservoir site(s) in this drainage with significant potential for additional study was not identified.

*Redbank Drainage*

The watershed area that contributes to Redbank Creek is very limited. The total length of the Redbank Creek watershed is only about 3.5 miles upstream from its confluence with Box Elder Creek. The watershed is attractive as a potential site for additional storage inasmuch as its headwater abuts the South Fork of Little Canyon Creek, which has a more significant drainage area that encompasses areas of higher elevation likely capable of yielding a more substantial water supply. A diversion of water from the Canyon Creek watershed to Redbank Creek appears feasible.

However, an ideal site for development of significant reservoir storage on Redbank Creek is not evident. The Redbank Creek watershed is broad, with a relatively gentle gradient and the Upper Nowood Road alignment is parallel and adjacent to Redbank Creek throughout its length, whereby the road alignment would need to be reestablished if a reservoir of significant size is considered. Also, two small reservoirs on Redbank Creek already exist at the upstream end of the watershed. These reservoirs are presumably capable of storing surplus water yielded from the watershed, whereby the existing water supply would need to be augmented by diversion from Little Canyon Creek.

*Box Elder Drainage*

Similar to Little Canyon Creek, Box Elder Creek flows with a relatively steep gradient in a deeply incised canyon formed in Paleozoic strata. Prospective reservoir sites were not evident based on our review. Although there does appear to be some potential to develop storage high in the watershed at the “mouth” of the canyons that source the creek (Sections 2, 11 & 14, T43N, R87W). However, based on the character of the stream channels in this portion of the watershed, the hydrology at these sites does not appear capable of supporting significant storage. These locations may be better suited for development of smaller stock water reservoirs since the land appears to be primarily owned by the Hampton Sheep Company.

*Cherry Creek Drainage (Sections 32 and 33, T43N, R87W)*

Cherry Creek does appear to provide some potential for development of storage, and a potential site was added to the project GIS for further study. The site is located on lands owned by the Crowfoot Ranch and Tolman Sheep Company. Some BLM land (Sec. 33) may also be inundated.

Although the site is located on Cherry Creek, a diversion of the flow from Box Elder Creek appears feasible, whereby a significant source of supply for the reservoir may be secured. However, the storage volume of the reservoir may not be substantial enough to warrant development of conveyance from Box
Elder Creek. The bedrock geology in the area of the reservoir consists of Triassic and Jurassic age rocks. Additional evaluation of this site is recommended.

In 2009, Trihydro conducted a reconnaissance-level geologic assessment of potential reservoir sites during the Level I study. A copy of the technical memorandum is included as Attachment A.

FIELD RECONNAISSANCE (2010)
Seven sites (Upper Luman Creek, Lower Luman Creek, Paint Rock Creek, Alkali Creek, Big Trails, Cornell Gulch, and Lower Brokenback) were evaluated during the fall 2010. Trihydro and Hollingsworth & Associates, Inc. (HAI) conducted a field reconnaissance these additional sites on September 29 and 30, 2010. A technical memorandum summarizing the field reconnaissance was provided to Trihydro by HAI. A copy of this technical memorandum is included as Attachment B.

POTENTIAL SAGE GROUSE ISSUES
Sites identified with potential sage grouse issues will be additionally evaluated by the BLM on a case-by-case basis. BLM will consider and evaluate sage grouse habitat conservation measures related to timing, distance, and density for proposed projects both within and outside of Core Areas (USDOI/BLM 2009). The mapping of sage grouse lek perimeters is underway in cooperation with the Wyoming Fish and Game Department (WFGD). BLM field offices are encouraged to coordinate with the WFGD to complete lek perimeter mapping. For reference, the Wyoming BLM Greater Sage Grouse Project Authorization Screen flow charts (Figures 1 and 2) are included as Attachment C. Sites identified with potential sage grouse issues may be considered for further development; however, sites that impose on identified sage grouse leks inside core areas (0.6-mile radius perimeter) will likely have an extensive and difficult permitting process.

REPRIORITIZATION OF IDENTIFIED SITES
Under Task 6 of the Level II Study we have reviewed potential reservoir sites and updated/refined the Matrix originally developed as part of the Level I Study. The Matrix was updated based on additional due diligence for the various categories. We are recommending that the potential sites be reprioritized as shown in Table 1. The recommended reprioritization uses the criteria presented in the Level I Study. Based on the updated evaluation, the sites were reorganized into recommended Priority 1, 2, and 3 sites (presented in reverse order below):

Priority 3 Sites
Trihydro recommends the following sites be excluded from further consideration due to the identified attributes:
- Bruner Gulch (temporary stream gauge located upstream of proposed dam site)
  - Reservoir footprint (partial pool within sage grouse buffer zone [0.6-mile radius])
  - Five sage grouse leks within 2 miles
  - Nine sage grouse leks within 4 miles
  - Additional cost for infrastructure
  - Potential landowner concerns (Greet)
- Cherry Creek
  - Reservoir footprint (partial pool within sage grouse buffer zone [0.6-mile radius])
  - Five sage grouse leks within 2 miles
  - Eight sage grouse leks within 4 miles
- County Line
  - Additional cost of infrastructure (i.e., pumping)
- Little Canyon Creek
  - Landowner concerns (Lewton Operating Company)
- Lower Nowood
  - Landowner concerns (Brewster Ranch Limited Partnership)
  - Estimated 540 acres of irrigated land inundated
  - Estimated 240 acres of wetlands impacted
- Lower Trout Creek
  - Location within watershed (i.e., redundancy, USFS land)
- Nowood – Mahogany Butte 1
  - Landowner concerns (Orchard Ranch Ltd.)
- Nowood – Mahogany Butte 2
  - Landowner concerns (Orchard Ranch Ltd.)
- Otter (South Fork - Upper)
  - Landowner concerns (Double H Ranch)
- Otter (South Fork - Lower)
  - Landowner concerns (Double H Ranch)
- Pete
  - Location within watershed (i.e., redundancy)
- Solitude
  - Location within watershed (i.e., Cloud Peak Wilderness area)
- Summit
  - Location within watershed (i.e., Cloud Peak Wilderness area)
- Taylor Draw
  - Reservoir footprint (partial pool within sage grouse buffer zone [0.6-mile radius])
  - Two sage grouse leks within 2 miles
  - Four sage grouse leks within 4 miles
- Upper Brokenback
  - Cost/benefit (i.e., ~$26K per acre-foot of storage)
- Upper Nowood
  - Reservoir footprint (partial pool within sage grouse buffer zone [0.6-mile radius])
  - Five sage grouse leks within 2 miles
  - Eight sage grouse leks within 4 miles
  - Upstream fishery
- West Fork Willow Creek
  - Reservoir footprint (partial pool within sage grouse buffer zone [0.6-mile radius])
  - Five sage grouse leks within 2 miles
  - Nine sage grouse leks within 4 miles

As stated earlier, sites identified with potential sage grouse issues may be considered for further development; however, sites that impose on identified sage grouse leks inside core areas (0.6-mile radius perimeter) will likely have an extensive and difficult permitting process.
Priority 2 Sites
Trihydro recommends the following sites be ranked as a Priority 2 and be further evaluated utilizing StateMod:

- Big Trails
  - Four sage grouse leks within 2 miles
  - Ten sage grouse leks within 4 miles
  - Estimated 265 acres of irrigated land inundated
  - Estimated 7 acres of wetlands impacted

- Canyon Creek
  - Estimated 47 acres of wetlands impacts
  - Estimated 378 acres of irrigated land impacts
  - Additional cost of infrastructure

- Cottonwood Creek
  - Location within watershed (i.e., lower end of watershed)
  - Hydrologic analysis results

- Little Cottonwood Creek
  - Relatively expensive alternative (~$21.2MM)
  - Additional cost of infrastructure

- Lone Tree
  - Potential geology issues
  - One sage grouse lek within 4 miles
  - Environmental issues
    - Elk (seasonal range and migration route)
    - Mule Deer (seasonal and crucial range)

- Lower Brokenback (temporary stream gauge located upstream of proposed dam site)
  - Estimated 14 acres of wetlands impacts
  - One sage grouse lek within 4 miles
• Luman Creek (Lower)
  ▫ Additional cost of infrastructure

• Luman Creek (Upper)
  ▫ Additional cost of infrastructure

• McDermott Draw
  ▫ Location within watershed (i.e., lower end of watershed)

• Medicine Lodge
  ▫ Estimated 52 acres of wetlands impacted
  ▫ Fishery concerns
  ▫ Relatively expensive alternative (~$24.3MM)
  ▫ Location within watershed (i.e., USFS)

• North Brokenback
  ▫ Cost/benefit (i.e., ~$20K per acre-foot of storage)

• Otter Creek (temporary stream gauge located upstream of proposed dam site)
  ▫ Two sage grouse leks within 2 miles
  ▫ Seven sage grouse leks within 4 miles
  ▫ Estimated 130 acres of irrigated acres inundated
  ▫ Landowner concerns (Double H Ranch)

• Weintz Draw
  ▫ Relatively small reservoir capacity (1,120 acre feet)
  ▫ Additional cost of infrastructure

• West Tensleep Lake
  ▫ Cost/benefit (i.e., ~$48K per acre-feet of storage)
  ▫ Location within watershed (i.e., USFS)

• Woods Gulch
  ▫ Cost/benefit (i.e., ~$18K per acre-foot of storage)
**Priority 1 Sites**
Trihydro recommends the following sites for further analysis:

- Alkali Creek (landowner is promoting development; temporary stream gauge location; temporary stream gage location)
- Alkali Creek South
- Cornell Gulch
- Deep Creek (temporary stream gauge location)
- Meadowlark Lake Enlargement
- Nowood – Crawford (temporary stream gauge location)
- Paint Rock Creek

A map of the Priority 1 and 2 site locations is depicted on Figure 1. Trihydro recommends noting that the preliminary raw data collected from the stream gauges at Deep Creek and Nowood – Crawford indicates lower than anticipated runoff volumes. The hydrology will be further evaluated during the StateMod analysis.

**COST ESTIMATES**
As part of the Level I Study, conceptual-level cost estimates were developed for each of the prioritized sites. As discussed earlier, three sites (Cornell Gulch, Lower Luman, and Upper Luman) were added to the matrix table and evaluated accordingly. Cornell Gulch was categorized as a Priority 1 site, and the Upper and Lower Luman Creeks were categorized as Priority 2 sites. As part of the evaluation process, conceptual-level cost estimates for these three sites were generated based on the logic presented in the Level I Study. These estimates are based on 2010 economics.

**RECOMMENDATIONS**
Trihydro recommends the Priority 1 and 2 sites indentified above be further analyzed using StateMod. We anticipate that the results from the StateMod analysis will allow the project team to further narrow the number of viable sites considered for the Level II Study. Trihydro proposes to meet with the WWDO following preliminary evaluation of the Priority 1 and 2 sites with StateMod to discuss storage alternatives to be presented to the Steering Committee for further evaluation during the Level II Study.
REFERENCES


06N-002-001
<table>
<thead>
<tr>
<th>Site #</th>
<th>Name</th>
<th>Category of Relevance</th>
<th>Description</th>
<th>Water Source</th>
<th>Seasonal Range</th>
<th>Storage #</th>
<th>Improvement</th>
<th>Description</th>
<th>Name</th>
<th>Class (Small, Medium, Large)</th>
<th>Other</th>
<th>Transportation</th>
<th>Irrigated Acreage Inundated</th>
<th>Total Dam Volume (cy)</th>
<th>Maximum Water Depth (feet)</th>
<th>Mean annual precipitation (inches)</th>
<th>Maximum basin relief (feet)</th>
<th>Contributing Drainage Area - Direct (square miles)</th>
<th>Impact</th>
<th>Fish and Wildlife Impacts</th>
<th>Hydrology</th>
<th>11/24/10</th>
<th>11/24/10</th>
<th>11/24/10</th>
<th>11/24/10</th>
<th>11/24/10</th>
<th>11/24/10</th>
<th>11/24/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Name</td>
<td>Category &amp; Watershed Description</td>
<td>Hydrology Method</td>
<td>Storage Availability</td>
<td>Direct Supply Source</td>
<td>Indirect Supply Source</td>
<td>Water Quality</td>
<td>Aquatic Fauna</td>
<td>Habitat &amp; Vegetation Features</td>
<td>Potential for Flood Protection</td>
<td>Landowner Interest</td>
<td>Land Use</td>
<td>Transportation</td>
<td>Hydrologic Method</td>
<td>Recharge Methodology</td>
<td>Infrastructure</td>
<td>Fisheries</td>
<td>Irrigated Acreage Transformed</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td>Water Quality Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------</td>
<td>------------------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>---------------</td>
<td>-------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>-----------------------</td>
<td>---------</td>
<td>----------------</td>
<td>------------------</td>
<td>-------------------</td>
<td>---------------</td>
<td>---------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Otter Creek</td>
<td>Low Low Low None Low Moderate Low Low Low Low</td>
<td>Basin Plan Reach 741 Channel</td>
<td>None (0.0 ft)</td>
<td>NA</td>
<td>NA</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>Bank protection</td>
<td>Dam</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
</tr>
<tr>
<td>Canyon Creek</td>
<td>Low Low Low None Low Moderate Low Low Low Low</td>
<td>Basin Plan Reach 741 Channel</td>
<td>None (0.0 ft)</td>
<td>NA</td>
<td>NA</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>Bank protection</td>
<td>Dam</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
</tr>
<tr>
<td>Medicine Lodge</td>
<td>Low Low Low None Low Moderate Low Low Low Low</td>
<td>Basin Plan Reach 741 Channel</td>
<td>None (0.0 ft)</td>
<td>NA</td>
<td>NA</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>Bank protection</td>
<td>Dam</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
</tr>
<tr>
<td>West Tensleep Lake</td>
<td>Low Low Low None Low Moderate Low Low Low Low</td>
<td>Basin Plan Reach 741 Channel</td>
<td>None (0.0 ft)</td>
<td>NA</td>
<td>NA</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>Bank protection</td>
<td>Dam</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
</tr>
<tr>
<td>Medicine Lodge</td>
<td>Low Low Low None Low Moderate Low Low Low Low</td>
<td>Basin Plan Reach 741 Channel</td>
<td>None (0.0 ft)</td>
<td>NA</td>
<td>NA</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>Bank protection</td>
<td>Dam</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
<td>None / 0</td>
</tr>
</tbody>
</table>

**Notes:**
- **Storage Availability:** None (0.0 ft)
- **Direct Supply Source:** NA
- **Indirect Supply Source:** NA
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Rangeland Priority</th>
<th>Category A: Resource Management</th>
<th>Category B: Water Management</th>
<th>Category C: Reservoir Statistics</th>
<th>Category D: Dam Description</th>
<th>Category E: Indirect Supply Source</th>
<th>Category F: Appurtenances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Trout</td>
<td>3</td>
<td>Natural Water</td>
<td>6.1 5.7 1.3 2.1 3.1</td>
<td>NA 75 75 75 155 95</td>
<td>NA 40 75 55 25</td>
<td>NA 355.8 655.2</td>
<td>None None None None</td>
</tr>
<tr>
<td>Blue Creek</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Taylor Draw</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Upper Newcomb</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Lower Treat Creek</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Little Cogans Creek</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>County Line</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Lower Newcomb</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Pete</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Solitude</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Summit</td>
<td>3</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Buffalo Creek</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Taylor Draw</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Newcomb River</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Other Creek</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>County Line</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Lower Newcomb</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Pete</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Solitude</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Summit</td>
<td>4</td>
<td>Natural Water</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

**Category A: Resource Management**
- **Storage Availability**
  - Normal Year (ac ft) - Physically in the stream
- **Appurtenances**
  - Total Dam Volume (cy)
  - Proposed Type
  - Maximum Water Depth (feet)
  - Mean annual precipitation (inches)
  - Maximum basin relief (feet)
- **Indirect Supply Source**
  - Residences
  - Irrigated Acreage Inundated
  - Sage Grouse Leks Inside Core Areas: Site within 4 miles
  - Sage Grouse Leks Inside Core Areas: Site within 0.6 miles
  - Sage Grouse Leks within 2 miles
  - Game: Moose
  - Game: Antelope
  - Game: Black Bear
  - Game: White Tailed Deer
- **Category B: Water Management**
  - Seasonal Range
  - Crucial Range
  - Partial pool in buffered area
  - Pool entirely within buffered area
  - None of pool in buffered area
  - None of pool in critical area
  - Pool entirely within critical area
  - None of pool in catastrophic area
- **Category C: Reservoir Statistics**
  - Total Project per cubic yard of fill
  - Category H: Economic Considerations
  - Category J: Potential Benefits
  - Category K: Water Quality
  - Category L: Wildlife
  - Category M: Fishery
  - Category N: Stream Classification
  - Fishery: Lunker Largemouth Bass
  - Fishery: White Bass
  - Fishery: Smallmouth Bass
  - Fishery: Sunfish
  - Fishery: Catfish
  - Fishery: Salmon
  - Fishery: Sturgeon
  - Fishery: Eel
  - Fishery: Pike
  - Fishery: Perch
  - Fishery: Walleye
  - Fishery: Bluegill
  - Fishery: Crappie
  - Fishery: Bass
  - Fishery: Trout
  - Fishery: Other

**Category D: Dam Description**
- **Proposed Type**
  -生活的灿烂，未来更精彩！
<table>
<thead>
<tr>
<th>Site</th>
<th>Name</th>
<th>Ranked Priority</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>West Fork</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Willow Creek</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Nowood -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Montana River</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Upper Breaksback</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>South Fork</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Oceanview</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>South Fork</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Location</td>
<td>Other</td>
</tr>
</tbody>
</table>

### Environmental Issues

- **Contribution to Watershed**:
  - BLM Private
  - BLM
  - State

### Infrastructure

- **Storage Efficiency (ac-ft/1000 cy fill)**
  - NA
- **Total Dam Volume (cy)**
  - NA
- **Proposed Type**
  - Earthen
  - Concrete Arch
  - Concrete Arch
  - Earthen
  - Earthen
  - Earthen
- **Mean annual precipitation (inches)**
  - 17.6
  - 45.4
  - 12.2
  - 31.7
  - 12.8
- **Basin perimeter (miles)**
  - NA

### Hydrometry

- **Mean elevation (feet MSL)**
  - NA

### Fishery

- **Fisheries**
  - None
  - None

### Cultural

- **Transportation**
  - Dirt Rd

### Site Information

- **Location Relative to Demand (Irrigated Acres downstream)**
  - 5,753

### Potential Benefits

- **Total Project per ac-ft of storage**
  - $1,328
- **Total Project per cubic yard of fill**
  - $1,491
- **Surface Area (acres)**
  - 0
- **Capacity / Enlargement (acre-feet)**
  - 97
- **Minimum Elevation (feet)**
  - NA
- **Contribution Drainage Area - Indirect (square miles)**
  - 577
- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd

### Method of Reservoir Fill

- **On Channel**
- **Off Channel**

### Stressor

- **Indirect Supply Source**
  - None
  - None
  - None
  - None
  - None

### Potential Benefits

- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd
- **Fisheries**
  - Cutthroat
  - Trout

### Habitat

- **Location Relative to Demand (Irrigated Acres downstream)**
  - 5,753

### Recreation

- **Location Relative to Demand (Irrigated Acres downstream)**
  - 5,753

### Dam Description

- **Surface Area (acres)**
  - NA
- **Capacity / Enlargement (acre-feet)**
  - NA
- **Mean annual precipitation (inches)**
  - 17.6
- **Basin perimeter (miles)**
  - NA
- **Minimum Elevation (feet MSL)**
  - NA
- **Contribution Drainage Area - Indirect (square miles)**
  - 577
- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd
- **Fisheries**
  - Cutthroat
  - Trout

### Geology

- **Mean elevation (feet MSL)**
  - NA
- **Contribution Drainage Area - Indirect (square miles)**
  - 577
- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd
- **Fisheries**
  - Cutthroat
  - Trout

### Water

- **Mean elevation (feet MSL)**
  - NA
- **Contribution Drainage Area - Indirect (square miles)**
  - 577
- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd
- **Fisheries**
  - Cutthroat
  - Trout

### Recreation

- **Location Relative to Demand (Irrigated Acres downstream)**
  - 5,753

### Dam Description

- **Surface Area (acres)**
  - NA
- **Capacity / Enlargement (acre-feet)**
  - NA
- **Mean annual precipitation (inches)**
  - 17.6
- **Basin perimeter (miles)**
  - NA
- **Minimum Elevation (feet MSL)**
  - NA
- **Contribution Drainage Area - Indirect (square miles)**
  - 577
- **Estimated Construction Cost (budgetary-level)**
  - $1,328
- **Transportation**
  - 1.17 miles dirt rd
- **Fisheries**
  - Cutthroat
  - Trout
FIGURE
NOWOOD RIVER WATERSHED
PROPOSED STORAGE SITE PRIORITIES

NOWOOD RIVER STORAGE LEVEL II STUDY

FIGURE 1

EXPLANATION

- Green: Priority 1
- Orange: Priority 2

Drawn By: DW
Checked By: DW
Scale: 1" = 40,000'
Date: 01/20/11
File: Nowood_Level_II_Priorities.mxd
Technical memorandum

Nowood River Storage/Watershed Level I Study
Geologic Assessment of Potential Reservoir Sites

October 2009

Introduction

This memorandum summarizes the findings from a reconnaissance-level study and field evaluation of the geotechnical feasibility of potential reservoir sites completed by Trihydro Corporation in the Nowood watershed in north-central Wyoming. Investigation activities were performed from May through August of 2009. The scope of the investigation encompassed review of 35 potential reservoir storage sites identified by Anderson Consulting Engineers (ACE). Additionally ACE requested Trihydro provide an overview of the geologic characteristics of the watershed as part of this technical memorandum.

The first phase of the project involved a reconnaissance-level assessment of the 35 sites ACE provided. The assessment was based on statewide geologic mapping of bedrock, structures, surficial geology, and geologic hazards. Each reservoir site was evaluated in terms of the expected geologic conditions along the dam embankment, within the reservoir pool area, and within the contributing drainage area. Trihydro assigned a letter grade (A-F) to each of these three focus areas for each of the sites. A grade of “A” indicated most favorable conditions and a grade of “F” indicated the site had a fatal flaw. None of the sites were determined to have a fatal flaw (received an F) during the first phase of the investigation.

The results of the reconnaissance-level assessment are presented in Table 1. Bedrock geology had the greatest influence on the grading process because of the regional risks for karstic formations and formations comprised primarily of erodible gypsum. The formations determined at highest risk for karst features are as follows: Gypsum Springs, Madison, Goose Egg, and Ten Sleep.
General Geology

The following sections provide an overview of the geology of the Nowood watershed. The watershed lies mostly within Big Horn and Washakie Counties in north central Wyoming. Small portions of the watershed however, overlap into Johnson, Natrona, Fremont and Hot Springs Counties. This overview includes information about the surficial geology, bedrock geology, geological structure and geological hazards of the watershed.

Surficial Geology

The surficial deposits found within the Nowood watershed are presented on Figure 1. The figure shows the wide distribution of alluvium, glacial deposits, residuum, slope wash and colluvium within the watershed. These sediment types constitute the dominant exposed geology within the watershed. The remaining exposed geology is composed of bedrock, grus, landslide, and terrace deposits. A discussion of bedrock and landslides are presented in the bedrock geology and hazards sections below.

Alluvium is found adjacent to surface drainages and is of fluvial origin (produced by the action of a stream or river). The extent of the alluvial deposits varies with the size of the respective fluvial system. Headwater deposits are typically narrower and shallower compared to downstream areas in the watershed. Alluvium ranges from 10-50 feet in thickness and is composed of sand, gravel, and loam (Cooley and Head 1979). These deposits are actively growing with the fluvial action of existing surface drainages. Fluvial action includes flooding (vertical deposition) and point-bar migration (lateral deposition).

Glacial till exists in the northwestern portion of the watershed and is associated with lateral and terminal moraines. The lateral moraines typically begin at an elevation about 10,000 feet and can be traced to approximately 8,000 feet, where they meet the terminal moraines (Darton, 1906). Drift composition is dominantly igneous and metamorphic rock from upland areas. Some Paleozoic sedimentary rocks also exist within the till located at lower elevations. These deposits consist of unconsolidated, poorly sorted, angular rock fragments. Some areas may display greater levels of sorting due to esker formation.

Residuum is an in-situ deposit formed from the weathering of bedrock. Soluble components of the bedrock were transported from the area by fluvial, fluvioglacial, and groundwater processes. The insoluble portions of the rock experienced some mechanical weathering from freeze-thaw and rain-drop impact with little to no transport of the remaining materials. The residuum deposits within the Nowood watershed are primarily derived from late Paleozoic to Mesozoic rocks. The deposits are relatively young and are therefore thin compared to other quaternary deposits.

Colluvium exists throughout the watershed and has a genetic origin related to mass wasting mechanisms. These sediments were derived from the movement of material down slope under the influence of gravity. The colluvial deposits are composed of material derived from bedrock at higher elevations. Grain sizes range from silt to gravel, and grain shape is predominantly angular to subangular. These deposits have a maximum thickness of 15 feet (Cooley and Head 1979) but thin as they near the source material at higher elevations.
**Bedrock Geology**

The bedrock geology exposed and directly underlying the Nowood watershed contains rock formations with ages ranging from the Cambrian Period to present. The bedrock geology outcropping at or near the surface is presented on Figure 2. The dominant formations in the Nowood watershed (from youngest to oldest, top to bottom, then left to right) include the:

- Fort Union Formation
- Mesaverde Formation
- Cody Shale
- Frontier Formation*
- Mowry Shale*
- Thermopolis Shale*
- Cloverly Shale*
- Morrison Formation*
- Sundance Formation*

- Gypsum Spring Formation*
- Chugwater Formation*
- Goose Egg Formation
- Tensleep sandstone
- Amsden Formation
- Madison Limestone*
- Bighorn dolomite
- Gallatin Formation
- Gros Ventre Formation

Other formations are mapped within the Nowood watershed, but the above units have the greatest influence on the watershed’s geology. The starred units were encountered at the various reservoir sites and are described in greater detail herein below.

The general pattern of outcrop of the units is of younger formations on the western side of the watershed and older units on the eastern side (Susong et al. 1993). An exception to the pattern is the quaternary surficial deposits discussed in the previous section. The youngest Tertiary-age rocks that crop out in the watershed are of the Fort Union Formation and are approximately 2-68 million years old (Ma). This formation consists of interbedded layers of sandstone and shale. Coal seams exist within the formation but are smaller and less frequent than those found in the Fort Union of southeastern Montana. In the area of the Nowood River, the Fort Union Formation is 1,000 to 1,500 feet thick (Cooley and Head 1979).

The next youngest rocks are of Cretaceous age (68-142 ma) and include units of the Mesaverde, Cody Frontier, Mowry, Thermopolis, and Cloverly Formations. Within the Nowood watershed, these formations comprise the bedrock (other than the Tertiary formations) found west of the Nowood River and the areas northwest of Hyattville, WY. They are comprised of thick shale layers with thinner beds of sandstone. Coal is present within these rocks as well (Darton 1906). The thickness of the entire sequence is from 6,600 to 7,500 feet (Cooley and Head 1979; Fischer 1906).

The Frontier Formation is Upper Cretaceous and is composed of fine to medium lenticular sandstone with gray and black marine shale. Thin bentonite and tuff beds are present as well. The Mowry Formation is Lower Cretaceous and composed of black and gray thin-bedded resistant shale interbedded with thin sandstone and bentonite. The Thermopolis Shale is a soft, black shale of the Lower Cretaceous. The Cloverly Formation is Lower Cretaceous and composed of light gray channel sandstones and pebble conglomerates interbedded with variegated bentonite mudstone (Weitz and Love 1952).

To the east of the cretaceous rocks are Jurassic to Pennsylvanian age (142-320 ma) rocks, which include the Morrison, Sundance, Gypsum Spring, Chugwater, Goose Egg, Tensleep, and Amsden Formations.
These formations range from reddish-brown shale to silty sandstone to sandstone. Thin beds of limestone also exist. The Tensleep Formation consists entirely of lightly cross-stratified sandstone. Gypsum exists in the Gypsum Spring and Goose Egg Formations, the solution of which has produced karst topography. The total thickness of these formations ranges from 2,000 to 2,400 feet (Susong et al. 1993; Cooley and Head 1979).

The Morrison Formation is Upper Jurassic and composed of calcareous gray silty sandstone and sandy claystone with lenticular limestone. The Sundance Formation is Middle Jurassic and is a greenish-gray glauconitic calcareous sandstone and shale. The Gypsum Springs Formation is Middle Jurassic and an interbedded red claystone, shale, siltstone and limestone with massive gypsum beds. The Chugwater Formation is Triassic and composed of massive, cross-bedded very fine grained red sandstone, siltstone and shale.

Mississippian to Ordovician age rocks (320-505 ma) crop out further to the east and southeast. These rocks are composed of the Madison limestone and Bighorn dolomite. Both formations contain light-gray massive limestone with the Bighorn Formation also containing dolomite. Dissolution of these formations has also produced karst topography and cave systems in the Nowood watershed. The extensive cave systems associated with these formations suggests a high volume of water is exchanged during surface water-groundwater interactions. The Madison limestone has a thickness of 500 to 700 feet, while the Bighorn dolomite is 300 feet thick (Susong et al. 1993; Cooley and Head 1979).

The oldest Phanerozoic rocks in the watershed were deposited during the Cambrian Period (505-560 ma) and are the Gallatin and Gros Ventre Formations. Both formations are a greenish to gray shale. The formations are in the western portion of the watershed, adjacent to the Oldest Gneiss Formation and other plutonic rocks. These igneous and metamorphic rocks are the basement, Precambrian rocks found in the center of the broad anticlinal structure of the Bighorn Mountains (Susong et al. 1993; Darton 1906; Fischer 1906).

Structure
The Nowood watershed is located in the southeastern portion of the Bighorn Basin. The basin was formed from folding and faulting during the Laramide orogeny, which occurred approximately 40-70 ma. The Laramide also produced the mountains that border the basin (Susong et al. 1993). To the east the basin is bordered by the Bighorn Mountains and to the south by the Owl Creek Mountains (Fischer 1906). Bounded by these mountain ranges, the Nowood watershed drains the southeastern-most portion of the Bighorn basin.

The general structure of the Bighorn Mountains is an anticline, and a portion of the Nowood watershed drains the southwestern limb. The axial plane of the anticline strikes northwest to southeast, causing the west-east age pattern in the Phanerozoic rocks. The attitude of Phanerozoic rocks is similar to the anticline, with strikes ranging from north to south to northwest to southeast. However, smaller scale anticlines and synclines are present within the watershed, and these local structures create variations in bed orientation.

The smaller scale anticlines and synclines are genetically related to the larger Bighorn anticline and therefore have similar orientations. The beds within them strike to the northwest and generally dip 5-12° to the southwest. Beds with an opposite dip direction (to the northeast) are present but less prevalent. This bed reversal typically indicates the presence of a local syncline (Hosterman et al. 1989;
Synclines can often be found associated with an anticline of similar size and extent. One anticline-syncline pair in the Nowood watershed can be found along the western side of the Nowood River with the axial plane running from Manderson, WY, to Crooked Creek (Cooley and Head 1979). Similar but less extensive structures are also found in the northeastern portion of the watershed, near Hyattville and Ten Sleep, as well as in the southern part of the watershed in the vicinity of Mahogany Butte and Orchard.

Faulting is evident within the eastern portions of the Nowood watershed (Figure 3). These faults are characterized as high-angle (60-90°) normal faults with the downthrown side located to the west of the fault line (Hosterman et al., 1989; Darton, 1906). Faults of this type are associated with extensional tectonics. One distinctive fault that displays these characteristics is located adjacent to Big Canyon Creek and Ten Sleep. The fault displays a vertical displacement of 700 feet near Big Canyon Creek. This displacement decreases towards the west, and the fault eventually merges into a monocline approximately 4 miles west of Ten Sleep (Hosterman et al. 1989; Cooley and Head 1979; Darton 1906). Also, a large prominent fault, called the Big Trails Fault System, trends generally north-south along the eastern perimeter of the watershed in the southern Bighorn Mountains (Verploeg 1992).

Hazards
Karst, landslide, and seismic geological hazards exist within the Nowood watershed. Karst creates sinkhole hazards and occurs from the dissolution of chemical rocks (limestone, gypsum, dolomite, etc.). Landslides occur when sediment moves down slope under the influence of gravity, potentially damaging structures and altering the hydrogeology of the watershed. Seismic events create a hazard to structures and tend to occur along fault lines, but earthquakes have occurred in areas with no known respective structural feature. The potential areas at risk for these hazards are presented on Figure 3.

Karst topography within the Nowood watershed is predominantly located to the east of the Nowood River. Closed depressions and solution collapse features are found on the surface and have been associated with the Goose Egg and Gypsum Spring Formations (Cooley and Head, 1979). These features were developed from the dissolution of gypsum and limestone underlying surficial deposits. The surficial deposits then reflected the karst topography below them. The limestone and dolomite of the Madison, Bighorn, and Gallatin Formations have also developed a karst topography. Some of this topography is concealed by the Amsden Formation, which unconformably overlies paleokarst features of the Madison (Hosterman et al., 1989). However, extensive, recently developed caves exist in the northeastern portion of the Nowood watershed, near Medicine Lodge Creek (Susong et al., 1993).

Collapse risk due to sinkholes can be difficult to determine due to their subsurface nature. Certain features can be indicative of karst: closed depressions, sinking streams, blind valleys, and others. However, subsurface investigations (including geophysical, tracer dye, and field surveys) need to be conducted to provide an adequate assessment.

Landslide hazards exist in areas where the resisting forces (friction and cohesion/adhesion between sediment particles) have the potential to be exceeded by the driving forces (gravity). This condition can be found throughout the upland areas of the Nowood watershed. Paleolandslides (“li” unit in Figure 3) are indicators of future landslide activity. Slopes experiencing undercutting due to lateral erosion of streams are also at high risk. Severe erosion problems have been noted on the Nowood River, with less severe erosion on the Paint Rock, Ten Sleep, Otter, and Canyon Creeks (USDA 1971). The lateral erosion by streams undercuts the toe of slopes and removes their underlying support. Other factors for
potential landslide areas include grain size and shape, lateral and underlying support, slope angle, sediment composition, and water content.

The Nowood watershed is an area with minor historical seismicity. According to Stover et al. (1984), epicenters of 11 earthquakes were recorded to have been in or near the watershed. The largest magnitude earthquake, with a magnitude of 4.9, occurred in 1970. The epicenter was located approximately 8 miles southwest of Ten Sleep. The smallest magnitude earthquakes of 3.0 occurred in 1998 and 2000 (USGS 2009; Case et al. 2002). Two earthquakes recorded in 1925 and 1966, occurred before magnitude measurements were regularly recorded. The earthquakes were rated using the Modified Mercalli Intensity Scale. Intensity was not noted for the 1966 earthquake, and an intensity V level was applied to the 1925 event. The 1925 event was felt in Ten Sleep, Sheridan, Fort McKenzie, and Dome Lake Resort, but damage was not reported (Case et al. 2002).

Two fault systems are located adjacent to each other in the southern portion of Nowood watershed: the Cedar Ridge and Dry Fork fault systems. Evidence suggests that the fault systems are inactive. However, one confirmed case of Pleistocene-aged movement, in the form of a fault scarp, was documented in northeastern Fremont County (Case et al. 2002). If either the Cedar Ridge or Dry Fork fault systems were to become active, they could potentially generate 6.7 and 7.1 magnitude earthquakes, respectively. A 6.7 magnitude earthquake at the Cedar Ridge System could produce a peak horizontal ground acceleration of 2.9%g at Ten Sleep and 2.0%g at Big Trails. A 7.1 magnitude earthquake at the Dry Fork System would produce a peak ground acceleration of 3.8%g at Ten Sleep and 7.4%g at Big Trails. In either case, minor damage could result from these earthquakes at Big Trails, Wyoming (Case et al. 2002).

Although active fault systems are not currently identified near the Nowood watershed, large earthquakes can still occur in areas without a known source structure. These earthquakes are known as “floating earthquakes.” Federal and state regulations require a floating earthquake analysis for certain structures (mill tailing sites, landfills, etc.). If a structure within the Nowood watershed required such analysis, a 6.25 magnitude earthquake with an epicenter 15 miles from the structure could be used as a conservative estimate for design ground accelerations. An earthquake of this magnitude and distance could produce ground accelerations of 15%g (Case et al. 2002). A more detailed, site specific, design analysis of seismological hazards is performed in association with the development of significant structures, such as large dams.

Another type of seismic hazard analysis, completed by the USGS, estimates the probability of exceeding the peak horizontal ground acceleration that could occur from an earthquake in the next 50 years. This analysis was most recently updated in 2008 and can be found at http://gldims.cr.usgs.gov/nshmp2008/viewer.htm. For the Nowood watershed, the peak horizontal ground acceleration that a has 10% chance of being exceeded from 2008 to 2058, is from 4-5%g. The peak ground acceleration that has a 2% chance of being exceeded from 2008 to 2058 is from 15-17%g. This methodology uses the frequency and magnitude of past earthquakes to estimate the frequency and magnitude of future earthquakes. A weakness to this method is that it can inaccurately predict earthquake risk in areas with a low frequency of earthquakes, like the Nowood watershed. However, few other alternatives for estimating the risk exist.
Field Investigations of Potential Reservoir Sites

Upon completion of the reconnaissance-level assessment, ACE provided Trihydro with a list of nine sites advanced in the project for field investigation: Little Canyon, Nowood-Crawford, Cottonwood Creek, Meadowlark Lake (enlargement of existing reservoir), Taylor Draw, Deep Creek, Bruner Gulch, Upper Nowood, and Big Trails. Trihydro’s field investigations of these sites included verifying and describing the bedrock conditions along the embankment alignment, collecting selected samples of foundation and potential embankment fill materials, identifying possible spillway locations, and compiling photograph documentation of each site. The remainder of this memorandum provides summary findings from field investigations of the nine reservoir sites performed during the week of July 27-31, 2009.

Little Canyon
The project was discussed in detail with the landowner, but access to the reservoir site was not granted. Based on direction from ACE, Trihydro excluded this site from further consideration for investigation.

Nowood-Crawford
The proposed dam location for the Nowood-Crawford site is on the Nowood River, approximately 800 feet downstream of the Crawford Creek confluence. The embankment location is within the Jurassic part of the section, with sandstones of the Sundance Formation outcropping at the left abutment (Figure 4A) and siltstones of the Gypsum Springs Formations outcropping near the right abutment (Figure 4B). Sandstones of the Chugwater Formation were observed to the south of the right abutment. The beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the north at 15° (degrees) along a strike of 98°. Near the right abutment, the beds dip to the north at 20° along a strike of 101°.

Three samples were collected from this site. The first sample was collected from an outcrop to the south of the right abutment and consists of yellow, fine-grained sandstone with well-sorted, subrounded quartz grains and a very minor lithic fragment component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid. The second sample was taken from the alluvium near the right bank of the Nowood River and consists of red silty clay with sand and gravel. The fine fraction of the alluvium holds a weak thread when wet. The third sample was collected from an outcrop near the base of the left abutment and consists of greenish-gray, hard, glauconitic, very fine-grained sandstone or siltstone, with minor lithic fragment and gypsum components.

The proposed embankment alignment is near the contact between the Gypsum Springs and Sundance Formations and was observed in an outcrop on the left side of the drainage approximately 400 feet upstream of the left abutment. The Gypsum Springs Formation was also observed outcropping in the bottom of the drainage near the embankment location (Figure 4C) and is likely overlain by the alluvium and colluvium in the valley bottom and right abutment. Although this formation was flagged as a high risk in the reconnaissance-level assessment, an existing dam and reservoir is located in a similar geologic setting approximately 1 mile downstream of the identified site. (Figure 4D). The existing dam embankment appeared to be stable; however, observation of the sediment accumulated within the upstream portion of the existing reservoir indicates this portion of the watershed has a high siltation potential.
A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. Depending on the embankment height, a possible spillway location was identified near the right abutment (Figure 4B). Construction of a reservoir at this site would likely dictate portions of the Nowood River Road and the Bates Creek Road to be rerouted.

**Cottonwood Creek**

The proposed dam location for the Cottonwood Creek site is on Cottonwood Creek approximately 4,400 feet upstream of its confluence with the Nowood River. The alignment evaluated in the field is located approximately 850 feet upstream of the alignment identified by ACE. The embankment location is within the lower Cretaceous part of the section, with sandstones of the Cloverly Formation outcropping at the left and right abutments (Figures 5A and 5B). The sandstone bedding planes in the area of the abutments dip to the south at 11° along a strike of 264°.

A small cave has eroded in the sandstone near the base of the left abutment (Figure 6B). Foundation conditions need to be evaluated during a subsequent subsurface investigation. Foundation conditions, similar to the cave documented in Figure 6B do not appear to be widespread, and this feature may be an isolated occurrence.

Three samples were collected at this site. The first sample was collected near the right abutment and consists of dark red, hard, glauconitic silt shale. The second sample was taken from the alluvium in the bottom of the Cottonwood Creek valley and consists of light tan silty clay that holds a weak thread when wet. The third sample was collected near the base of the left abutment and consists of yellow-tan, fine-grained sandstone with well-sorted, frosted, subrounded quartz grains and a very minor mafic component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid.

A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed at the site, and this material would likely need to be imported. A possible spillway location was identified near the right abutment, which would utilize an existing drainage immediately downstream of the abutment (Figure 6A).

**Meadowlark Lake Enlargement**

Meadowlark Lake is an existing reservoir on Tensleep Creek near the confluence with East Tensleep Creek. The reservoir was constructed in the late 1930s as a work project for the Civilian Conservation Corps (CCC). An enlargement project may require consideration of the historical value of the site.

The existing dam consists of a 30-foot tall embankment with a primary outlet channel near the right-center of the embankment, an emergency spillway near the left side of the embankment, and what appears to be a fish ladder adjacent to the spillway (Figure 7). The primary outlet and spillway channels are in need of repair. The internal condition of the primary outlet could not be assessed. Based on the surface area of the reservoir from the SEO filing, raising the water level could yield approximately 300 acre-feet of additional storage per foot of water surface elevation.
Taylor Draw
The proposed dam location for the Taylor Draw site is near the mouth of Taylor draw approximately 2,100 feet upstream of the confluence with the Nowood River. The embankment location is within the lower Cretaceous part of the section, with Thermopolis Shale outcropping near the left and right abutments (Figures 8A and 8B). The shale at the ground surface is easily erodible, but the material becomes more competent with depth. The shale in outcrops on both sides of the drainage consistently dips to the west.

Two samples were collected at this site. The first sample was taken from the right abutment and consists of moderately hard, but easily friable, black clay shale. The second sample was collected from the channel bottom and consists of brownish-tan silty clay that holds a fine-diameter thread when wet.

The channel morphology of Taylor Draw suggests that the drainage basin may not receive enough runoff to directly support a reservoir (Figure 8C). However, the site may be feasible for an off-channel reservoir storing water from the Nowood River. Adequate borrow material for use as embankment fill could likely be found in the valley bottom. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. A potential spillway location was identified near the left abutment.

Deep Creek
The proposed dam location for the Deep Creek site is just downstream of the Cherry Creek road crossing. The location is within the lower Mississippian part of the section, with limestone of the Madison Formation outcropping at the left and right abutments (Figure 9). The limestone in the area of the embankment appeared to be resistant, but karstic erosional features were observed in downstream outcrops (Figure 10A). Compared to the downstream outcrops, the outcrop near the left abutment appeared relatively resistant, with minor dissolution along fracture planes. A geode was observed in the outcrop, illustrating the potential for dissolution (Figure 10B).

Two samples were collected at this site. The first sample was collected from an outcrop at the left abutment near the bottom of the drainage and consists of massive gray limestone/mudstone with little to no allochems (allochems are carbonate aggregates, which form the framework of mechanically deposited limestones). The second sample was collected on the north side of the access road approximately 600 feet upstream of the provided dam location. This sample consists of a greenish-gray, hard siltstone or shale with quartz veins interbedded with a green conglomerate with subangular to subrounded, flat pebble clasts. The second sample is of the Gallatin Limestone, which indicates the dam site is located near the contact between the Madison and Gallatin formations.

This site may be feasible for an embankment, but a significant subsurface investigation would be required to determine the competency of the underlying bedrock for holding water in the reservoir and serving as a foundation for the embankment. Borrow material for an earthen embankment may be difficult to locate in proximity to this dam site. Given the potential foundation conditions and the borrow material limitations, a concrete or rock fill dam structure may be alternative embankment designs for this location. The dam would likely need to be designed with a spillway running down the downstream face, because a good spillway location was not identified at this site.
Bruner Gulch
The proposed dam location for the Bruner Gulch site is on Buffalo Creek immediately upstream of Bruner Draw. The embankment location is within the upper Cretaceous part of the section, with sandstone of the Frontier Formation outcropping at the left abutment and sandstone and shale of the Frontier Formation outcropping at the right abutment (Figures 11A and 11B). The sandstone beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the west at 17° along a strike of 353°. Near the right abutment, the beds dip to the west at 17° along a strike of 350°. Shale materials derived from either the Frontier Formation or the Mowry Shale was observed downstream of the left and right abutments. Downstream of the left abutment, this shale dips to the west at 21° along a strike of 344°.

Four samples were collected at this site. One sample was taken from the left abutment and consists of gray, fine- to medium-grained lithic arenite with poorly sorted, subrounded quartz grains and lithic fragments. The sandstone is well-cemented but friable. A second sample was collected from the channel bottom near the left abutment and consists of gray silty clay that holds a fine diameter thread when wet. The third sample was collected from a shale outcrop near the right abutment and consists of gray, easily friable, silt shale with faint, thin laminations. The fourth sample was collected from a shale outcrop downstream of the Bruner Draw confluence near the right abutment and consists of gray, moderately soft to hard, friable, silt shale.

A sufficient volume of borrow material for construction of an embankment is likely available in the valley bottom. The engineering properties of this material for use as embankment fill should be confirmed with additional investigation. The second sample described for this site was collected to represent locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed at the site, and this material would likely need to be imported. A possible spillway location was identified near the left abutment, which would utilize an existing drainage immediately downstream of the abutment.

Upper Nowood
The proposed dam location for the Upper Nowood site is on the Nowood River approximately 3 miles upstream of the Little Canyon Creek confluence. Two potential embankment locations were evaluated at this site: one at the location provided by ACE (Figure 12) and one approximately 500 yards upstream of the provided location (Figure 13). This site is located in the upper Jurassic part of the section, with sandstones of the Sundance Formation outcropping near each abutment. The sandstones higher on the slope comprising the left abutment may be of the Morrison Formation. The sandstone beds near each abutment are similarly oriented. Near the right abutment of the upstream location, the beds dip to the west at 2° along a strike of 32°. Near the left abutment of the downstream location, the beds dip to the west at 7° along a strike of 36°. Along with sandstone outcrops, the hill slope comprising the left abutment at the upstream location consists of thick beds of soft, erodible siltstone or claystone (Figure 14A).

Three samples were collected from this site. The first sample was collected from the right abutment of the upstream location and consists of tan, well-cemented, very fine-grained quartz sandstone with calcareous cement. The second sample was collected in the floodplain on the left side of the river and consists of red silty clay. The clay holds a fine diameter thread when wet, but is less dense than the silty clays at the other sites. The third sample was taken from left abutment of the original location and consists of the same sandstone as the first sample.
The site topography would allow construction of high embankment damming a large reservoir. A sufficient volume of borrow material could likely be found in the valley bottom for construction of an earthen embankment. Additional investigations will need to be performed to determine the engineering properties of the available borrow material for use as embankment fill. The second sample described for this site was collected to represent this locally available borrow material. Gravel and cobble lenses were observed in the bank of the Nowood, representing former channel deposits (Figure 14B). The coarse material from the former channel deposits could likely be used for embankment drainage. A source of coarse material for riprap was not observed at the site, and this material would likely need to be imported. Depending on the height of the embankment, two small drainages east of the right abutment could be used in the construction of spillways (Figures 12C and 13C).

**Big Trails**

The proposed dam location for the Big Trails site is on the Nowood River, approximately 5 miles upstream of the Little Canyon Creek confluence. The embankment location is within the Jurassic part of the section, with both abutments primarily within the Gypsum Springs Formation (Figure 15A). Sandstones of the Sundance Formation were observed cropping out as capstone above both abutments, but the abutments themselves would be located within very soft, erodible gypsum (Figure 15B). Because of these foundation conditions, this site is not recommended for further consideration as a potential reservoir location.

Two samples were collected at this site. The first sample was taken near the base of the left abutment and consists of gypsum. The second sample was collected from the capstone outcropping at the top of the left abutment and consists of greenish-gray, glauconitic, hard, very fine-grained sandstone.

**Summary Findings**

The geologic conditions for each embankment location were evaluated by mapping outcrops at the surface and by inferring subsurface conditions based on observed structure and published regional stratigraphy. The findings presented in this memorandum regarding each site should be verified by subsurface investigations, including investigative borings.

Based on this surface investigation, Cottonwood Creek, Meadowlark Lake, Taylor Draw, Bruner Gulch, and Upper Nowood would warrant additional subsurface study to evaluate the competency of the foundation materials. Outstanding geologic risk was not found at these sites.

If other driving factors favor development of the Nowood-Crawford and Deep Creek sites, these sites would also warrant additional subsurface investigation. The geology at these two sites was not as favorable as the aforementioned. A high potential for karstic features exists in the foundation of Deep Creek, and there is a high risk of gypsum being one of the primary foundation materials for Nowood-Crawford.

The only site not recommended for further investigation is Big Trails because of the amount of gypsum outcropping at the embankment location. This material is erodible and does not appear to provide a suitable foundation for construction of a dam embankment.
References


<table>
<thead>
<tr>
<th>Dam and Reservoir Site Name</th>
<th>Description of site geology</th>
<th>Dam embankment foundation</th>
<th>Reservoir pool area</th>
<th>Contributing watershed</th>
<th>Rating</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali Creek</td>
<td>Quaternary alluvium in footprint of dam embankment; Cloverly - Morrison Formations within reservoir pool area</td>
<td>B+</td>
<td>B</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big Trails</td>
<td>Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Ten Sleep in basin; faulting in basin</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bruner Gulch</td>
<td>Embankment on alluvium/colluvium over Frontier; Cody in pool; Mesaverde, Fort Union, Lance, Mowry/Thermopolis in basin</td>
<td>B-</td>
<td>B</td>
<td>B</td>
<td>Field verify alluvium and potential for seepage through Frontier</td>
<td></td>
</tr>
<tr>
<td>Canyon Creek</td>
<td>Tensleep/Amsden at embankment and pool; Goose Egg in pool; some Madison near faulting in basin; some Gneiss and Gallatin in headwaters</td>
<td>C+</td>
<td>C+</td>
<td>B</td>
<td>Edge of mapped gypsum area, field verify Tensleep condition</td>
<td></td>
</tr>
<tr>
<td>Cottonwood Creek</td>
<td>Quaternary alluvium/colluvium underlying embankment footprint, potential for Cloverly and Morrison; Mowry and Thermopolis, Cody within pool and contributing watershed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>No outstanding geologic risk evident</td>
<td></td>
</tr>
<tr>
<td>County Line</td>
<td>Quaternary terrace and fan deposits, Mowry and Thermopolis shales ; Cloverly and Morrison Formations within contributing watershed</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>No outstanding geologic risk evident</td>
<td></td>
</tr>
<tr>
<td>Lower Brokenback</td>
<td>Alluvium/sandstone, Sundance/Gypsum springs at embankment; Chugwater/Goose Egg in pool and basin; Tensleep/Amsden, Madison in basin;</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td>Embankment within mapped Gypsum area, field verify Gypsum Springs condition</td>
<td></td>
</tr>
<tr>
<td>Lower Nowood</td>
<td>Quaternary alluvium in footprint of dam embankment; Mowry and Thermopolis shales with pool area; mixed bag with contributing watershed</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident</td>
<td></td>
</tr>
<tr>
<td>McDermott Draw</td>
<td>Frontier Formation at embankment; Mowry and Thermopolis Shales</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>Field verify potential for foundation seepage</td>
<td></td>
</tr>
<tr>
<td>Meadowlark Lake</td>
<td>Glacial and landslide deposits near Madison at embankment; Gallatin, Bighorn, gneiss in pool and basin</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>Existing lake, south end of embankment on mapped landslide hazard, karst risk from ACE layer</td>
<td></td>
</tr>
<tr>
<td>Medicine Lodge</td>
<td>Glacial deposits</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>Need to field verify nature of glacial deposits</td>
<td></td>
</tr>
<tr>
<td>Otter Creek</td>
<td>Alluvium/colluvium, Cloverly/Morrison, Sundance/Gypsum Springs at embankment; Chugwater/Goose Egg in pool; Tensleep/Amsden in basin; some Madison, Gneiss, Bighorn, Gallatin near faulting high in basin</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping</td>
<td></td>
</tr>
<tr>
<td>Paint Rock Creek</td>
<td>Contact between Madison and Tensleep near the embankment; Madison with area projected to be inundated by the reservoir;</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>Karst risk from ACE layer</td>
<td></td>
</tr>
<tr>
<td>Lower Trout Creek</td>
<td>Glacial deposits, PreCambrian</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>Need to field verify nature of glacial deposits</td>
<td></td>
</tr>
<tr>
<td>Pete</td>
<td>Cody shale and Frontier formation</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>No outstanding geologic risk evident</td>
<td></td>
</tr>
<tr>
<td>Solitude</td>
<td>PreCambrian (oldest gneiss complex)</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>Existing lake, mapped fault, field verify foundation competency</td>
<td></td>
</tr>
<tr>
<td>Summit</td>
<td>PreCambrian (oldest gneiss complex)</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>Field verify foundation competency</td>
<td></td>
</tr>
<tr>
<td>Taylor Draw</td>
<td>Mowry/Thermopolis at the embankment and pool; Cloverly/Morrison, Sundance/Gypsum Springs, Chugwater/Goose Egg in basin</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident at the embankment</td>
<td></td>
</tr>
<tr>
<td>Upper Nowood</td>
<td>Cloverly/Morrison, Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Tensleep in basin; faulting in basin</td>
<td>C-</td>
<td>C-</td>
<td>C-</td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping</td>
<td></td>
</tr>
<tr>
<td>West Fork Willow Creek</td>
<td>Frontier Formation at embankment; Cody shale in pool</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>Field verify potential for foundation seepage</td>
<td></td>
</tr>
<tr>
<td>West Tensleep Lake</td>
<td>Embankment on glacial deposits; embankment and pool on Precambrian gneiss complex</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>Embankment near mapped landslide, field verify nature of glacial deposits, existing lake</td>
<td></td>
</tr>
<tr>
<td>Little Cottonwood Creek</td>
<td>Cloverly/Morrison at the embankment and pool; Mowry/Thermopolis pool basin; Frontier, Cody, Mesaverde, Lance, Fort Union, igneous in basin</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>No outstanding geologic risk evident</td>
<td></td>
</tr>
<tr>
<td>Nowood Mahogany Butte 1</td>
<td>Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, gypsum mapping surrounding embankment</td>
<td></td>
</tr>
<tr>
<td>Nowood Mahogany Butte 2</td>
<td>Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, gypsum mapping surrounding embankment</td>
<td></td>
</tr>
<tr>
<td>Deep Creek</td>
<td>Madison at the embankment; Gallatin in pool, embankment, basin; gneiss in basin</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>Karst risk from ACE layer</td>
<td></td>
</tr>
<tr>
<td>Dam and Reservoir Site Name</td>
<td>Description of site geology</td>
<td>Dam embankment foundation</td>
<td>Reservoir pool area</td>
<td>Contributing watershed</td>
<td>Rating</td>
<td>Note</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------------------------</td>
<td>---------------------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>28 Nowood - Crawford</td>
<td>Sundance and Gypsum Springs at the embankment; Madison, Ten Sleep, Wagon Bed, Gallatin in basin</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Weintz Draw</td>
<td>Frontier Formation underlying embankment; Course colluvium</td>
<td>C</td>
<td>B</td>
<td>B</td>
<td>Field verify potential for foundation seepage</td>
<td></td>
</tr>
<tr>
<td>30 Upper Brokenback</td>
<td>Chugwater/Goose Egg at the embankment; Ten Sleep/Amesden, Madison in basin</td>
<td>D</td>
<td>C-</td>
<td>C-</td>
<td>Embankment on mapped gypsum area</td>
<td></td>
</tr>
<tr>
<td>29 Woods Gulch</td>
<td>Mowry and Thermopolis shales at embankment and in pool area; Cloverly/Morrison, Sundance/Gypsum Springs, and Chugwater/Goose Egg in basin</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident at the embankment</td>
<td></td>
</tr>
<tr>
<td>30 Alkali Creek South</td>
<td>Cloverly/Morrison at embankment and in pool area; Sundance/Gypsum Springs and Chugwater/Goose Egg in basin</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>No outstanding geologic risk evident at the embankment</td>
<td></td>
</tr>
<tr>
<td>31 South Fork Otter (Lower)</td>
<td>Tensleep/Amesden at embankment and in pool; Chugwater/Goose Egg in pool; Tensleep/Amesden, Chugwater/Goose Egg, Madison limestone, basement Gneiss in basin; mapped landslide in pool</td>
<td>C</td>
<td>C-</td>
<td>C-</td>
<td>Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Tensleep/Amesden mapping, field verify condition of Tensleep, field verify mapped landslide in pool</td>
<td></td>
</tr>
<tr>
<td>32 South Fork Otter (Upper)</td>
<td>Tensleep/Amesden at embankment; Madison limestone in pool; Gneiss in basin; faulting near embankment and in basin; mapped landslide in pool and near embankment</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, verify structure near embankment, field verify mapped landslides</td>
<td></td>
</tr>
<tr>
<td>33 Canyon Creek</td>
<td>Madison limestone, Chugwater/Goose Egg, Tensleep/Amesden at embankment and in pool; Tensleep/Amesden and Madison in basin; fault at the embankment; mapped landslide deposits near embankment</td>
<td>D-</td>
<td>D</td>
<td>D</td>
<td>Karst risk from ACE layer, verify structure and landslides near embankment</td>
<td></td>
</tr>
<tr>
<td>34 Lone Tree</td>
<td>Tensleep/Amesden, Goose Egg, and Gypsum Springs near embankment, pool and basin; Madison and Gallatin in basin; faulting near pool</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>Embankment within mapped Gypsum area</td>
<td></td>
</tr>
<tr>
<td>35 North Brokenback</td>
<td>Tensleep/Amesden at embankment and in pool; Madison/Darby in basin</td>
<td>C+</td>
<td>C+</td>
<td>D</td>
<td>Field verify Tensleep condition</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3
Nowood River Watershed: Geologic Hazards

Legend

- Fault Line
- Limestone Bearing Formations
- Landslide

Streams
Cities
Nowood Watershed
County Boundary
Figure 4

NOWOOD-CRAWFORD SITE PHOTOS

NOWOOD RIVER
WATERSHED STUDY

NOTES:
1. PHOTOS TAKEN ON JULY 27, 2009.
NOTES:

1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:

1. PHOTOS TAKEN ON JULY 28, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 29, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
NOTES:
1. PHOTOS TAKEN ON JULY 30, 2009.
ATTACHMENT B

HOLLINGSWORTH ASSOCIATES, INC.
TECHNICAL MEMORANDUM (2010)
Date: November 24, 2010

Subject: Results of Preliminary Geotechnical Engineering Investigations of Seven Potential Irrigation Water Storage Sites for the Nowood River Storage Project, Level II Study, Washakie and Big Horn Counties, Wyoming

Job No.: 10-149

Mr. J. Joel Farber, PG & PE
Trihydro Corporation
1252 Commerce Drive
Laramie, Wyoming 82070

Dear Mr. Farber:

As requested, Hollingsworth Associates, Inc. conducted a review of available geologic, geotechnical, and soils data pertinent to the watershed and a field reconnaissance of seven potential water storage sites with you on September 29 and 30, 2010. The geotechnical engineering services were provided for Task 11 of the Nowood River Storage Project Level II Study. The project location is the watershed of the Nowood River in Washakie and Big Horn Counties, Wyoming.

The purpose of this letter is to report the results of the field reconnaissance studies of each of the seven sites. The following is a brief description of each of the sites and an initial evaluation of the type(s) of dams appropriate for the sites. Included are photographs of each site prepared by Trihydro as Figures 1 through 7.

Lower Lumen Creek Site: The Lower Lumen Creek Site, shown in Figure 1, is located in a fairly well defined V-shaped valley with Lumen Creek flowing through a meandering channel. The left abutment is significantly steeper than right abutment. The bedrock is sandstone of the Tensleep sandstone and Amsden Formation. The right abutment was mantled with fine grained silty sand which appeared to be at least 10 feet thick. Fine grained silty sand was exposed in the stream cut in the valley bottom for a depth in excess of 10 feet. The left abutment had a similar mantle of fine grained silty sands to just above the valley bottom and then exposed well cemented, fairly coarse
grained brown sandstone. The site has a good grass cover with scattered shrubs and small trees, especially in the valley bottom.

The site appears to be suitable for a homogeneous earthfill dam if the silty sands have sufficient fines. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 15 feet on the right abutment, 20 feet to 30 feet in the valley bottom, and essentially nil on the left abutment. The foundation bedrock may require grouting to control under seepage depending on the permeability. The maximum possible height of dam will be governed by the elevation of the right abutment which would be the logical location for a spillway.

Upper Lumen Creek Site: The Upper Lumen Creek Site, shown in Figure 2, is located in a fairly broad U-shaped valley with Lumen Creek flowing through a meandering channel. The left abutment is significantly steeper than the right abutment. The bedrock is sandstone of the Tensleep sandstone and Amsden Formation. There were rock outcrops on both abutments. Both abutments were mantled with fine grained silty sand and scattered boulders. Fine grained silty sand with minor lenses of gravel was exposed in the stream cut in the valley bottom for a depth in excess of 10 feet. The site has a good cover of grass and scattered trees.

The site appears to be suitable for a homogeneous earthfill dam if the silty sands have sufficient fines. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 20 feet to 30 feet in the valley bottom. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The right abutment would be the logical location for a spillway because the slope is less steep than the left abutment.

Paint Rock Creek Site: The Paint Rock Creek Site, shown in Figure 3, is located in a broad U-shaped valley with Paint Rock Creek running through on the left side of the valley at a fairly steep
gradient. The bedrock is limestone and dolomite of the Madison limestone and shale and siltstone of the Darby Formation. The right abutment is an essentially vertical outcrop starting at the valley floor. The left abutment is slightly less steep with bedrock outcrops at the stream level and a minor soil mantle on the slope up to the vertical face. The valley bottom has sandy clay soils and the stream channel has sand and gravel with numerous cobble and boulders. It is very difficult to estimate the depth of soil in the valley bottom. Because the site is fairly high up on the stream and the stream has a fairly steep gradient, a fairly shallow depth of soil would be expected. However, the wide valley leads to an estimate of a significant depth of soil in the valley. Depth to bedrock is probably 30 feet or greater in the valley bottom, nil on the right abutment and 5 feet to 15 feet on the left abutment. The dam site is a maintained meadow.

The site appears to be suitable for an earthfill dam, either homogeneous or zoned, or a roller compacted concrete dam. Foundation preparation may not require excavation of the soils from beneath the entire footprint of the dam down to the bedrock for the earthfill dam, depending on the permeability and consolidation characteristics of the dam foundation soils when wetted. Foundation preparation for the roller compacted concrete dam will require excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 10 feet to 15 feet on the left abutment, 30 feet in the valley bottom and nil on the right abutment. The foundation bedrock may not require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The left abutment would be the logical location for a spillway for an earthfill dam because the slope is less steep than the right abutment.

**Alkali Creek Site:** The Alkali Creek Site, shown in Figure 4, is located in a very wide, U-shaped valley with Alkali Creek running on the right side of the valley in a channel approximately 15 feet deep. It appeared that Alkali Creek has been channelized through the site to provide room for the irrigated meadow which occupies the dam site. The bedrock is sandstone of the Cloverly and Morrison Formations. There were rock outcrops on both abutments with the right abutment steeper than the left abutment. The Anita Ditch flows into the valley upstream of the dam site and drops approximately 10 feet over a sandstone ledge into a sandstone stilling basin in the valley floor. The soils in the valley bottom are sandy clays at least 15 feet in depth. There is a large
exposure of claystone in the Alkali Creek drainage well upstream of the dam site which is most likely the source of the sandy clays at the dam site.

The site appears to be suitable for a homogeneous earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam for a depth sufficient to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 30 feet in the valley bottom and essentially nil on the abutments. The bedrock in the abutment may require a sandy clay blanket to control seepage through the abutments depending on the permeability. The maximum possible height of dam will be governed by the elevation of the right abutment which would be the logical location for a spillway.

**Big Trails Site:** The Big Trails Site, shown in Figure 5, is located in a somewhat wide V-shaped valley with the Nowood River running through a meandering channel. The bedrock is sandstone and shale of the Sundance Formation and interbedded shale, dolomite and gypsum of the Gypsum Springs Formation. The left abutment was a relatively steep soil slope with scattered bedrock outcrops. The valley bottom was essentially flat with at least 15 feet of soil exposed in a cut bank on the left side. The soils exposed in the cut bank were mainly sandy silt with sand and gravel layers. The right abutment was a very steep bedrock outcrop. The site has a good cover of grass and scattered trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the left abutment, 30 feet in the valley bottom and nil on the right abutment. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The left abutment would be the logical location for a spillway because the slope is less steep than the right abutment.

**Cornell Gulch Site:** The Cornell Gulch Site, shown in Figure 6, is located in a very wide V-
shaped valley with Cornell Gulch cutting through. Cornell Gulch was dry at the time of the field reconnaissance. The bedrock on the left abutment is the Nugget sandstone and siltstone of the Chugwater Formation. The bedrock is sandstone and shale of the Sundance Formation on the right abutment. Starting at Cornell Gulch, the left abutment is a soil mantled approximately 4H:1V slope rising to a near vertical sandstone outcrop. Starting at Cornell Gulch, the right abutment is a soil mantled approximately 6H:1V slope rising to a much steeper slope. There were no rock outcrops on the dam centerline on the right abutment but sandstone was exposed in an erosion gully just upstream of the dam centerline. The surface soils in the reservoir area were red sandy silt. Approximately 10 feet of grey sandy clay were exposed in Cornell Gulch which appeared to have originated from a grey claystone outcrop upstream of the reservoir area. There was a rather thin sand and gravel deposit in the left side of the reservoir upstream of the dam site that has been worked. The site has a good grass cover and scattered trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 30 feet in the valley bottom. The foundation bedrock may require grouting to control under seepage depending on the permeability. The site topography will not influence the maximum possible height of dam. The right abutment would be the logical location for a spillway because the slope is less steep than the left abutment.

**Lower Brokenback Site:** The Lower Brokenback Site, shown in Figure 7, is located in a fairly broad U-shaped valley with Brokenback Creek flowing through a meandering channel and several small (approximately 30 feet diameter) marshy areas. The bedrock is sandstone and shale of the Sundance Formation and interbeded shale, dolomite and gypsum of the Gypsum Springs Formation. There were minor rock outcrops on both abutments. Both abutments were mantled with silty sand and gravel that appeared to be terrace deposits. Downstream of the dam centerline on the right side of the valley, a granular terrace deposit is currently being commercially mined. Sandy clay was exposed in the stream cut in the valley bottom upstream of the dam centerline for a depth of approximately 10 feet. The site has a good cover of grass on the abutments and in the
reservoir area above the stream channel. The stream channel has extensive wetlands vegetation and numerous trees.

The site appears to be suitable for either a homogeneous or zoned earthfill dam. Foundation preparation will most likely consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock to avoid excessive consolidation of the dam foundation soils when wetted. The excavation depths are estimated to be 10 feet to 15 feet on the abutments and 30 feet in the valley bottom. The foundation bedrock may require grouting or a clay blanket to control under seepage depending on the permeability. The site topography will limit the maximum possible height of dam. The spillway may be located on either abutment.

If we can provide further information at this time, please call.

Sincerely,

HOLLINGSWORTH ASSOCIATES, INC.

[Signature]

Harold Hollingsworth, P.E.

HH: WY

Reviewed By: TRH

Figures 1 through 7
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 1
LOWER LUMEN CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC  Checked By: JF  Scale: NONE  Date: 10/5/10  File: 06N_LUMENCREEK2010
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 2
UPPER LUMEN CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT LEVEL II STUDY

Drawn By: PC  Checked By: JP  Scale: NONE  Date: 10/5/10  File: 06N_ULUMENCREEKISCO1010
NOTE: PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

A VIEW OF LEFT ABUTMENT

B VIEW OF RIGHT ABUTMENT

FIGURE 3
PAINT ROCK CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC Checked By: JT Scale: NONE Date: 10/5/10 File: 06N_PAINTROCKCREEK201001
NOTE: PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 4
ALKALI CREEK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT LEVEL II STUDY

Drawn By: PC Checked By: JF Scale: NONE Date: 10/5/10 File: 09A_ALKALICREEK301010
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 5
BIG TRAILS (REVISED) SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC
Checked By: JT
Suite: NONE
Date: 16/5/10
File: 009_BIGTRAILLEVELII1010

VIEW OF LEFT ABUTMENT

VIEW OF RIGHT ABUTMENT

NOTE:
EXPLANATION
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 5
BIG TRAILS (REVISED) SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC
Checked By: JT
Suite: NONE
Date: 16/5/10
File: 009_BIGTRAILLEVELII1010

VIEW OF LEFT ABUTMENT

VIEW OF RIGHT ABUTMENT
NOTE: PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 6
LOWER BROKENBACK SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC
Checked By: JF
Scale: NONE
Date: 10/5/10
File: 06N_LBROKENBACK201010
NOTE:
PHOTOGRAPHS TAKEN ON SEPTEMBER 29, 2010

EXPLANATION
A LOCATION WHERE PHOTOGRAPH WAS SHOT

FIGURE 7
CORNELL GULCH SITE PHOTOGRAPHS
NOWOOD RIVER STORAGE PROJECT
LEVEL II STUDY

Drawn By: PC   Checked By: JF   Scale: NONE   Date: 10/15/10   File: 09N_CORNELLGULCH201010
ATTACHMENT C

WYOMING BUREAU OF LAND MANAGEMENT
PROJECT AUTHORIZATION FLOW CHART
Figure 1

WY BLM Greater sage-grouse Project Authorization Screen
Prior to Mapping and Modeling Sage-grouse Habitat

- Are habitat and project setting suitable for sage-grouse?
  - Yes
    - In Core Area?
      - Yes
        - In Core Area, but no habitat (minimum patch size 725 acres), >1 disturbance per 640 acre, land ownership patterns, etc., option to reduce restrictions
        - Coordinate with WGFD for authorization
      - No
        - In non-Core Area, but important for connectivity, consider options for greater restrictions
        - Coordinate with WGFD for authorization
    - No
      - Are habitat and project setting suitable for Sage-grouse?
        - Yes
          - Seasonal habitat exists but project setting allows for lesser restrictions, for example:
            - Distance restriction of .25 mile
            - Timing restriction to 2 miles
        - No
          - No habitat — no sage-grouse restrictions apply

- No
  - Apply greater restrictions, for example:
    - Density of 1 disturbance per 640 acres and 5% of cumulative disturbance to sagebrush habitat
    - Timing restriction on all seasonal habitats
    - Distance restriction of 0.6 mile from lek

- If not feasible, proponent provides development, mitigation and monitoring plan to BLM and WGFD to conserve sage-grouse.
Figure 2

WY BLM Greater sage-grouse Project Authorization Screen
In Mapped and Modeled Sage-grouse Habitat

- Habitat Timing Limitation Stipulations (TLS)
- 0.6 mile Controlled Surface Use (CSU)
- Other appropriate Best Management Practices (BMP)/Conditions of Approval (COA)
- Effectiveness Monitoring

Workflow:

1. Mapped/Modeled?
   - Yes → Core Area?
   - No → Figure 1

2. Core Area?
   - Yes → Suitable/Occupied Habitat?
   - No → Suitable/Occupied Habitat?

3. Suitable/Occupied Habitat?
   - Yes → Habitat important for connectivity?
   - No → Consider Proposal –
     - Access
     - Connectivity
     - Migration
     - WGFD

4. Habitat important for connectivity?
   - Yes → WGFD reviews proponent conservation plan
   - No → Authorize – no COA

5. Authorize – no COA
   - Yes → Effectiveness Monitoring
   - No → Defer – Proponent Resubmit

6. WGFD reviews proponent conservation plan
   - Yes → Authorize per plan
   - No → Defer – Proponent Resubmit

Additional Review:
- Relocate
- .25 mile CSU
- Habitat Based TLS
- Buried Power
- Reduced activity
- Consolidate disturbance
- Appropriate site-specific BMP/COA
- Adjacent project coordination
- Effectiveness monitoring
- Phased development
- WGFD Coordination
APPENDIX G

AGENCY COORDINATION

G1. DECEMBER 2011 AGENCY COORDINATION MEETING
G2. WGFD CORRESPONDENCE
G3. FWS CORRESPONDENCE
G4. BLM CORRESPONDENCE
G5. FISH AND WILDLIFE RANGES AND HABITAT
SUMMARY OF MEETING DISCUSSIONS

Several hardcopy maps were used to support meeting discussions. The maps included three full-size watershed maps showing the location of temporary stream gages, irrigated acreage, USGS topography, the 37 potential storage sites investigated, and highlighting the top five-ranked storage sites. One map included federal landownership, the second included a representation of late season shortages by drainage, and the third included delineation of the sage grouse core areas. In addition, Sage Grouse Density and Disturbance Calculation (DDT) figures were presented for the Luman, Alkali, and Taylor Draw sites.

The meeting discussion was also supported with a Google Earth Pro project that included relevant project information such as site locations, proposed embankments and contours, proposed diversion alignments, NWI wetlands mapping, and terrestrial and fisheries layers. Copies of the Google Earth KMZ file will be provided to the Wyoming Game and Fish (WyG&F) with the official request for input, and to the US Army Corps of Engineers (USACE) under separate cover.

1. Meeting Intent

The meeting was organized to inform the Wyoming Game and Fish Department (WyG&F) and the U.S. Army Corps of Engineers (USACE) about the Nowood River Storage Level II Study and to solicit their input regarding potential storage sites.

2. Project Background

a. The Water Development Office (WWDO) and Trihydro provided an overview of the project and the WWDO project development process.

   i. The WWDO provided a handout (attached to these minutes) outlining the WWDO Dam and Reservoir Division Project Development flow chart and explained that a Level I Study had been completed and that the project is currently in a Level II, Phase I Study.

   ii. The WWDO explained the project was undertaken in response to an inquiry from a group of local landowners headed by Cecil Mullins. This group voiced concerns with low flows and negative impacts on the watershed. When the project commenced, this group of landowners formed a project Steering Committee.

   iii. A Level I Watershed Study was completed between 2008 and 2010, which identified a preliminary list of storage opportunities. This Study also looked at watershed-level
rehabilitation and small water development projects. The WWDO provided a handout (attached to these minutes) that outlined standard Level I Watershed Study objectives.

iv. Based on the information compiled in the Level I Study, which identified late-season irrigation shortages, the Steering Committee requested the WWDO proceed with a Level II storage project (current project). Trihydro explained that the Level II project commenced in the spring of 2010 and has included temporary stream gaging throughout the watershed, development of a watershed-wide hydrology model (StateMod), and review of potential storage sites. The preliminary results of the StateMod model support the late season irrigation shortages identified in the Level I Study. The temporary stream gage data have been used as qualitative checks on the model results.

v. A long-list of 37 potential storage sites was developed based on information presented in the Level I Study and additional review during the Level II project. Through review of site characteristics this list of 37 sites was reduced to five sites. Conceptual-level designs are being compiled for these sites, and the WWDO is seeking input from agencies on potential issues and permitting requirements.

vi. The WWDO will be going to the legislature to request funding for a Level II, Phase II project that will include more detailed investigations and drilling.

vii. Landowners/watershed user will need to form a formal entity prior to the project moving to a Level II, Phase III project. Part of the current work is identifying beneficiaries to aid in entity formation.

3. General Fisheries Discussions

Sauger are a high priority fish species that use the lower portion of the Nowood River. Sauger move up the Nowood in April through May. The WyG&F expressed concerns with the potential to entrain these fish in the reservoirs due to stream and reservoir diversions. The affect of reservoirs on late season flows and water temperatures are less of a concern. Diversions structures would need to include measures/screens to limit fish entrainment.

4. Meadowlark Lake

a. This alternative would include utilizing existing water stored in the reservoir or enlarging the capacity of the existing reservoir through an upstream raise. Enlargements would be on the order of a 3 to 5 feet increase in the high water level.

b. Aquatic discussion

i. The WyG&F’s primary concern with this site was fish loss. Fish tend to leave the reservoir during high flows and become trapped downstream of the dam as the fish ladder at this site no longer functions. Fish that leave the reservoir tend to stay between the dam and the confluence with West Tensleep Creek and die out. The WyG&F expressed concern that a reservoir enlargement would increase flows from the reservoir and increase fish loss.

ii. The WyG&F also raised concerns with an approximately 100-yard losing stream section/sink downstream of the reservoir, as well as other losing reaches downstream.
iii. The group discussed that year-round flow releases would be best for fisheries, but that due to the downstream sinks this would not be an effective practice.

iv. The WyG&F would like to see methods to limit fish leaving the reservoir as well as a means (e.g., rebuilt fish ladder) for fish that do leave to return to the reservoir. WyG&F previously looked at installing a sill to limit fish loss.

v. The WyG&F have a rough bathometric survey and would be willing to provide this to the WWDO to assist with evaluations.

vi. Potential concerns were also raised relative to the Wigwam Rearing Station. This hatchery complex is fed by springs in the area. WyG&F would like to see a better understanding of flows relative to Meadowlark Lake site. They want to avoid impacts to the quality or quantity of the spring water.

vii. A new boat ramp was recently constructed that could raising the water level.

c. Terrestrial discussion

i. Meadowlark Lake does not fall within the Sage Grouse Core Area and sage grouse concerns were not raised for this site.

ii. The site does not appear to affect wildlife crucial range.

d. USACE discussion

i. The USACE indicated the project would likely require a standard permit.

ii. The group discussed wetlands mitigation and whether mitigation could be off-site. The USACE indicated wetland mitigation should be looked at in more detail after the ability to permit the project is determined. The USACE stated that on-site wetland mitigation is preferred and should be investigated prior to looking at off-site mitigation.

5. Alkali Creek

a. This alternative would encompass construction of a new reservoir site on Alkali Creek upstream of its confluence with Paint Rock Creek. The Alkali Creek drainage is small and would not provide sufficient water to support a reservoir by itself. Water would be diverted from Medicine Lodge Creek via the existing Anita Ditch. A new pipe/ditch would need to be constructed near the embankment to bring flow from the Anita Ditch to the reservoir site.

b. Aquatic discussion

i. The WyG&F brought up minimum pools. The WyG&F guidelines/rule of thumb is 25% to 30% of storage should be associated with the minimum pool. 25% of the area should be 12 to 15 feet deep. Minimum pools had not yet been evaluated. The topography at some of the sites may not allow for a minimum pool, for example the maximum embankment height allowed by the topography has been modeled for Alkali Creek. The result is a fairly small reservoir (~ 4,000 acre-ft). There may not be sufficient storage to allow for meeting late season irrigation demands and maintaining a minimum pool.

ii. WyG&F was concerned with the potential for fish entrainment in the reservoir due to the diversion from Medicine Lodge Creek. They recommended that the diversion structure include some form of screen. A screen at the diversion from Medicine Lodge Creek is
preferred, as opposed to installing a screen on the downstream diversion from the Anita Ditch near the reservoir embankment.

iii. The area (Medicine Lodge Creek and Paint Rock Creek) is a productive game fishery.

iv. The WyG&F also raised concerns with the amount of water diverted. They would not want to have Medicine Lodge Creek dry up during diversions to the reservoir. The WWDO and Trihydro explained that a minimum flow would be left in the stream and that they did not envision pulling an amount of flow that would significantly deplete the flow in Medicine Lodge Creek.

c. Terrestrial discussion

i. The WyG&F believes the DDCT calculation should be rerun for sage grouse. Briefly reviewing the maps showing the DDCT calculations, they did not think all the disturbances were properly accounted for in the calculation. They thought the disturbance would be close to, if not above, the 5% limit. Trihydro will coordinate with the WyG&F to update the DDCT calculations.

d. USACE discussion

i. The USACE noted that wetlands disturbed by diversion pipes or ditches should be accounted. They raised the example of replacing a ditch with a pipe. Ditches tend to seep and wetlands can be created downslope; converting an existing ditch to a pipe can remove the water source and dry-up the wetlands.

ii. The USACE indicated that anything with surface flow should be considered as jurisdictional this early in the process.

e. The WyG&F also brought up the question of providing public access. The funding for a reservoir project requires that public access be provided to the reservoir. For a site such as Alkali Creek this access route, if it crosses public land, could in turn provide an access point to public (BLM) lands that were previously not accessible due to surrounding private lands. This may be viewed as an additional benefit, but may cause concern for landowners.

6. Luman Creek

a. Two potential new reservoir sites were investigated on Luman Creek. The upper site was deemed not to be efficient. Conceptual designs have moved forward for the lower site. Luman Creek is an ephemeral drainage. Water would be diverted via a pipeline from the South Fork Paint Rock Creek to Laddie Creek. The water would then be diverted from Laddie Creek through a tunnel to Luman Creek.

b. Aquatic discussion

i. The WyG&F’s biggest concern is Yellowstone Cutthroat Trout. The South Fork Paint Rock Creek is a critical stream to this fish. The WyG&F is currently working on a restoration project in the upper end of this drainage. They highlighted this as their biggest fisheries concern of any of the sites.

ii. Similar to other diversions, possible entrainment of fish in the diversion/reservoir is a concern and some means of screening fish should be incorporated into the design.

c. Terrestrial discussion
i. The site does fall within some big game crucial ranges (elk and mule deer). The WyG&F will review the location relative to big game ranges and migration routes in more detail after they receive the formal input request.

ii. The same concerns were raised for the sage grouse DDCT calculations for Luman Creek as were raised for Alkali Creek. The DDCT areas for these two sites overlap.

d. USACE discussion

i. Trihydro noted that the wetlands downstream of the proposed diversion alignment were included in the wetlands disturbance areas for this site.

7. Taylor Draw

a. This site would involve construction of a new reservoir in the ephemeral Taylor Draw drainage. The reservoir would be filled by a diversion, likely a pipe, from Otter Creek. The landowners/operators along the diversion alignment are concerned with this site and have not yet provided their consent for further investigations. The WWDO is investigating the option of partially filling the reservoir during the winter months to reduce landowners concerns with diverting a portion of the early-season irrigation water.

b. Aquatic discussion

i. The WyG&F strongly recommended that flows not be diverted during the winter months, which are tough times for fish. Their studies have shown that winter flows are critical to fish survival and reducing the flows during winter months could be detrimental to the Otter Creek fishery.

ii. Lower Otter Creek is a productive fishery. The WyG&F would again request that diversion structures incorporate some form of fish screen to reduce fish entrainment.

c. Terrestrial discussion

i. Similar to Alkali Creek and Luman Creek, the WyG&F requested rerunning the sage grouse DDCT calculations.

d. USACE discussion

i. The USACE questioned the effect of this site on other drainages due to water exchanges. Their point was that a junior water right on another drainage (e.g., Spring Creek) that would not have been able to pull water later in the year might now be able to pull water as a result of exchanges or downstream, senior rights being satisfied. Under this scenario less flow might then be in the stream than would have been present under previous practice. The USACE suggested this possibility be reviewed as part of site analysis.

8. Willow Creek

a. Willow Creek is the largest of the sites discussed. The site is located on an ephemeral drainage and would be filled with water diverted from the Nowood. This site has not been evaluated to the same level as the other sites discussed and may not be viable due to geotechnical concerns.

b. Aquatic discussions
i. The WyG&F would like to see how this reservoir alters downstream flows (due to diversion and release). However, they felt that due to its location, and if flow was diverted during peak flows, this site would have minimal effect on Sauger.

ii. As with the others sites, the WyG&F requested that the diversion structure incorporate some form of fish screen to reduce fish entrainment.

c. Terrestrial discussion
   i. Similar to Alkali Creek and Luman Creek, the WyG&F requested rerunning the sage grouse DDCT calculations.

9. Closing discussions
   a. The WyG&F raised instream flows as an important issue for these potential sites. An instream flow study should be completed for streams that will have flow diverted to a reservoir. These studies take an entire summer for the WyG&F to complete and are scheduled in March. The WyG&F suggested that the WWDO request any instream flow studies as soon as possible.
   
b. The USACE indicated they would prefer to review and comment on the draft report as opposed to a separate submittal. However, they would like a copy of the Google Earth kmz file.
   
c. The WyG&F would like a formal letter requesting their input. Project information can be provided in digital format (pdfs, shapefiles, and kmz files). They requested 2 CDs be provided with the letter. Their comment period is 30 days.

ACTION ITEMS
1. Trihydro to work with WyG&F (Mary and Matt) to revise sage grouse DDCT
2. Trihydro/WWDO will submit a formal letter requesting comment on the sites and 2 CDs to the WyG&F (Rick)
3. Trihydro/WWDO will submit the draft project report to the USACE for review and comment
4. WWDO will coordinate with the WyG&F (Tom) when appropriate to have instream flow studies completed
5. Trihydro will forward diversion shapefiles to the WyG&F (Rick)
6. Trihydro will forward the Google Earth kmz file to both the WyG&F (Rick) and the USACE (Tom)
APPENDIX G2

WGFD CORRESPONDENCE
February 20, 2012

Mr. Rick Huber  
Wyoming Game and Fish Department  
5400 Bishop Blvd.  
Cheyenne, WY  82006  

RE: Request for Comment - Nowood River Storage, Level II Study  

Dear Mr. Huber:

On behalf of the Wyoming Water Development Office (WWDO), Trihydro requests the Wyoming Game and Fish Department (WGFD) comment on two potential reservoir sites identified as part of the Nowood River Storage, Level II Study (Study). We are enclosing hard copy figures illustrating the location of the storage sites in the Nowood Watershed, a site matrix for the two sites, and two CDs containing an ArcGIS Map Package and a Google Earth .kmz file to assist with your review.

The WWDO undertook evaluation of watershed conditions and storage opportunities in the Nowood Watershed in response to inquiries from local landowners and watershed users relative to low flows and watershed impacts. A Level I Watershed Study (Level I Study) was completed between 2008 and 2010 to identify potential late season water shortages as well as a list of preliminary storage alternatives. In addition, the Level I Study incorporated a vast amount of technical information describing conditions and assessments of the watershed, and developed a management and rehabilitation plan outlining site-specific projects that may remediate existing issues and address opportunities beneficial to the health and functionality of the watershed. The Level I Study report is available online at http://library.wrds.uwyo.edu/wwdcrept/Nowood_River/Nowood_River-Storage_Watershed_Study_Level_I-Final_Report-2010.html.

The purpose of the current Study is to expand upon the list of potential storage sites identified during the Level I Study, and to develop a short-list of viable storage sites based on an evaluation of engineering feasibility, permitting considerations, potential environmental impacts, water availability and beneficial use, and public and landowner input.

Trihydro and the WWDO met with the WGFD and the US Army Corps of Engineers (USACE) on December 2, 2012, to discuss the project background and goals, the list of top-ranked sites, concerns/issues associated with those sites, and the appropriate approach for gaining agency input on the sites. During this meeting, five sites were reviewed, including:

1. Meadowlark Lake enlargement, located on East Fork Tensleep Creek in the Bighorn National Forest.  
2. Alkali Creek, located on Alkali Creek upstream of its confluence with Paint Rock Creek.  
3. Luman Creek, located on an ephemeral drainage upstream of its confluence with Paint Rock Creek.  
4. Taylor Draw, located on an ephemeral drainage adjacent to Otter Creek that flows into the Nowood River from the east.  
5. Willow Creek, located on an ephemeral drainage in the upper (southern) portion of the watershed that flows into the Nowood River from the west.
Based on issues discussed during the meeting, further engineering evaluation, and additional discussions with landowners, Luman Creek, Taylor Draw, and Willow Creek are not being advanced for further consideration at this time. The WWDO is moving forward with evaluation of the Meadowlark Lake enlargement and Alkali Creek sites (Figures 1 and 2) and requests the WGFD’s input on these two storage options.

Meadowlark Lake is an existing reservoir located on East Fork Tensleep Creek upstream of the confluence with Tensleep Creek in the Bighorn National Forest (Figure 3). The WWDO is evaluating an enlargement of the existing reservoir to provide additional storage that would be used to offset late season irrigation shortages. The reservoir enlargement would likely consist of raising the existing dam embankment. The height of the embankment raise, and resulting increase in highwater elevation would be based on potential impacts to existing infrastructure and wetlands, as well as downstream benefits. The embankment raise would include construction of a new spillway and fish passage structure. Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting include:

- The site is located on USFS managed lands and is widely used for recreation and fisheries.
- Several known cultural areas exist within the existing pool area and along the edges of the current reservoir.
- The existing embankment, spillway, and fish ladder may have historical significance.
- Raising the water level could impact existing structures along the edge of the reservoir, including a newly constructed boat ramp.
- The enlargement would impact wetlands and would require wetland mitigation.
- A form of fish screen to reduce fish loss downstream as well as a fish ladder or other means to allow fish to re-enter the reservoir should be components of the enlargement.
- A losing stream reach exists downstream of the reservoir which could affect the efficiency of flows released from the reservoir.
- The site is located near the Wigwam Rearing Station and potential impacts, if any, should be evaluated.

The Alkali Creek storage site would entail the construction of a new reservoir on Alkali Creek, upstream of its confluence with Paint Rock Creek. The dam embankment and the downstream portion of the reservoir pool area are located on private land. The upstream pool area is located on lands managed by the Bureau of Land Management (Figure 4). Alkali Creek is a small stream and the reservoir would be filled primarily by diversions from Medicine Lodge Creek and Paint Rock Creek via the Anita Ditch. A small section of new conveyance would need to be constructed from the current Anita Ditch alignment along an abandoned alignment to bring water to the reservoir (Figure 4). The embankment would be approximately 75 feet high; 2,000 feet long and impound 4,000 acre feet (inundating approximately 216 acres, including 9 acres of irrigated land). Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting include:
Divisions should incorporate some form of fish screen to limit fish entrainment.

- Medicine Lodge Creek and Paint Rock Creek are both productive game fisheries.
- Minimum stream flow studies will be required to evaluate flows that could be diverted without negatively impacting Medicine Lodge Creek or Paint Rock Creek.
- Minimal wetlands would be disturbed, which would need to be mitigated.
- The site falls partially within the Sage Grouse Core Area and a preliminary Sage Grouse Density and Disturbance Calculation (DDTC) estimates the current disturbance at 11.7%, above the 5% disturbance guideline (Figure 5).

With the configuration of the Nowood Watershed and its tributaries, no one storage site will alleviate water shortages, rather a combination of storage sites will likely be appropriate. If possible, WWDO’s goal is to develop storage that is multipurpose in nature; providing not only late season irrigation opportunities and drought protection, but also allowing for recreational, water quality, flood control and fish and wildlife enhancement opportunities. The Meadowlark Lake and Alkali Creek sites fit the Study goals well. Trihydro and the WWDO would appreciate the WGFD’s feedback regarding these sites. Furthermore, we are looking for guidance in how we may be able to work through the sage grouse concerns on Alkali Creek, particularly considering our proposed site is only partially located within the Sage Grouse area and results in 0.2% disturbance as compared to the existing 11.7% disturbance.

We appreciate the time you and other WGFD staff have spent reviewing these sites with us, and we would like to thank you in advance for your further review and input on the Meadowlark Lake and Alkali Creek storage sites. Please contact me at (307) 745-7474 or m donner@trihydro.com or Jason Mead with the WWDO at (307) 777-7626 or jason.mead@wyo.gov if there is additional information that we can provide to assist your review or if you have questions regarding the Study, the individual sites, or the enclosed figures or files.

Sincerely,
Trihydro Corporation

Mark Donner, P.E.
Project Manager

06N-002-001

Attachments

cc: Jason Mead, Wyoming Water Development Office
TABLE
<table>
<thead>
<tr>
<th>Site Name</th>
<th>Ranked Priority</th>
<th>Meadowlark Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Creek (reservoir)</td>
<td>46.1597°F</td>
<td>49.057°F</td>
<td></td>
</tr>
<tr>
<td>Lake Creek (reservoir)</td>
<td>96.1°F</td>
<td>96.1°F</td>
<td></td>
</tr>
</tbody>
</table>

### Site Evaluation Matrix: Nowood River Storage Level II Study

#### Category A: Environmental Issues

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality (BOD, TSS, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedimentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Habitat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category B: Watershed

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topography</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category C: Reservoir Statistics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Water Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Water Level</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category D: Dam Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embankment Length</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category E: Hydrology

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snowfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runoff</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category F: Geology

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratigraphy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tectonics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category G: Infrastructure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Lines</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Category H: Ownership

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Summary

- **Location:** 201202_SiteEvaluationMatrix_TBL 1 of 1
- **Correspondence:** Correspondence 201202_EnvSummary
- **Reference:** Reference: Trihydro memo dated October 2009
- **Reference:** Reference: HAI memo dated 11/24/10

---

**Note:** The table contains detailed information on various parameters such as latitude, longitude, supply sources, basin perimeter, relief, precipitation, and other relevant data for the Nowood River Storage Level II Study.
**FIGURE 5**

ALKALI CREEK PROJECT IMPACT ANALYSIS AREA (PIAA) USING THE DENSITY AND DISTURBANCE CALCULATION TOOL (DDCT)

**NOWOOD RIVER STORAGE LEVEL II STUDY**

**EXPLANATION**

- TOWNS
- STATE HIGHWAY
- COUNTY ROADS
- RIVERS & STREAMS
- PROPOSED PROJECT BOUNDARY
- PROJECT DISTURBANCE
- IRRIGATED LANDS
- EXISTING BUILDINGS
- COUNTY ROAD BUFFER
- EXISTING RESERVOIR
- DDCT FINAL BOUNDARY
- SAGE-GROUSE LEKS - MARCH 18, 2011
- SAGE-GROUSE CORE AREA - VERSION 3, JUNE 29, 2010

**SURFACE DISTURBANCE**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>ACRES</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL DDCT BOUNDARY</td>
<td>39,554.2</td>
<td>100.00</td>
</tr>
<tr>
<td>TOTAL DISTURBED</td>
<td>4,677.0</td>
<td>11.9</td>
</tr>
<tr>
<td>DISTURBED - PROJECT ONLY</td>
<td>65.9</td>
<td>0.2</td>
</tr>
<tr>
<td>DISTURBED - PRIOR TO PROJECT</td>
<td>4,611.1</td>
<td>11.7</td>
</tr>
</tbody>
</table>

**EXECUTIVE ORDER LIMIT: 5% OF DDCT AREA**

**SURFACE DISRUPTION**

| TOTAL DISRUPTIONS | DISRUPTION PER 640 | NA - THIS ONLY APPLIES TO OIL AND GAS AND MINING ACTIVITIES **EXECUTIVE ORDER LIMIT: AVERAGE OF 1 PER 640 ACRES WITHIN DDCT AREA** |

**PROPOSED ALKALI CREEK SITE**
May 1, 2012

WER 12850
Trihydro Corporation
Environmental Review
Nowood River Storage, Level II Study
Wyoming Water Development Office
Bighorn and Washakie Counties

Mark Donner
Project Manager
Trihydro Corporation
1252 Commerce Drive
Laramie, WY 82070

Dear Mr. Donner:

The staff of the Wyoming Game and Fish Department has reviewed the Environmental Review for the Nowood River Storage, Level II Study on behalf of the Wyoming Water Development Office in Bighorn and Washakie Counties. We offer the following comments for your consideration.

Terrestrial Considerations:

The Alkali Creek site is yearlong habitat for pronghorn antelope (Big Horn herd unit) and winter-yearlong habitat for mule deer (Paintrock herd unit) and white-tailed deer (Bighorn Basin herd unit). Both deer and pronghorn occur at and near the proposed reservoir site. Development of riparian habitat on the edges of the reservoir should mitigate for any loss of existing upland habitats for big game species. However, there are predation concerns with having more deer or pronghorn on the adjacent private crop land.

The Alkali site is within (near the edge) of a sage-grouse core area. A DDCT was completed and revealed a surface disturbance amount of 11.7%. Our staff reviewed and performed an additional DDCT which resulted in 11.9% surface disturbance. In either case, the surface disturbance (disruption) figure for this proposed project is over twice the threshold of 5% as provided in the Governor’s Sage Grouse Executive Order 2011-05 (SGEO). Thus, per the information provided through the DDCT analysis, this project, as currently proposed, does not conform to the current SGEO. For future consideration of this project, we recommend it be significantly reconfigured to meet compliance with the SGEO.
**Aquatic Considerations:**

We did not notice any mention of a minimum pool for each of these waters plus guaranteed public access to the Alkali Reservoir site. Since most of this proposed site is mostly on public land, a road designated for public access should be part of the mitigation.

Thank you for the opportunity to comment. If you have any questions or concerns, please contact Scott Gamo, Staff Terrestrial Biologist, at 307-777-4509.

Sincerely,

John Emmerich  
Deputy Director

JE/mf/gb

cc: USFWS  
Steve Yekel- Cody Region  
Tim Woolley, Cody Region  
Tom Easterly, Cody Region  
Steve Yekel- Cody Region
APPENDIX G3

FWS CORRESPONDENCE
February 24, 2012

Ms. Ann Belleman
U.S. Fish & Wildlife Service
800 Meadow Lane
Cody, WY 82414

RE: Request for Technical Assistance - Nowood River Storage, Level II Study

Dear Ms. Belleman:

On behalf of the Wyoming Water Development Office (WWDO), Trihydro requests the U.S. Fish and Wildlife Service’s (USFWS) technical assistance regarding two potential reservoir sites identified as part of the Nowood River Storage, Level II Study (Study). We are enclosing hard copy figures illustrating the location of the storage sites in the Nowood Watershed, individual site figures for the two sites of interest, and a site matrix for the two sites, as well as a CD containing an ArcGIS Map Package and a Google Earth .kmz file to assist with your review. This request is a follow-up to our phone conversation on January 13, 2012 regarding this project.

The WWDO undertook evaluation of watershed conditions and storage opportunities in the Nowood Watershed in response to inquiries from local landowners and watershed users relative to low flows and watershed impacts. A Level I Watershed Study (Level I Study) was completed between 2008 and 2010 to identify potential late season water shortages as well as a list of preliminary storage alternatives. In addition, the Level I Study incorporated a vast amount of technical information describing conditions and assessments of the watershed, and developed a management and rehabilitation plan outlining site-specific projects that may remediate existing issues and address opportunities beneficial to the health and functionality of the watershed. The Level I Study report is available online at http://library.wrds.uwyo.edu/wwdcrept/Nowood_River/Nowood_River-Storage_Watershed_Study_Level_I-Final_Report-2010.html.

The purpose of the current Study is to expand upon the list of potential storage sites identified during the Level I Study, and to develop a short-list of viable storage sites based on an evaluation of engineering feasibility, permitting considerations, potential environmental impacts, water availability and beneficial use, and public and landowner input.

Trihydro and the WWDO met with the Wyoming Game and Fish Department (WGFD) and the US Army Corps of Engineers (USACE) on December 2, 2011, to discuss the project background and goals, the list of top-ranked sites, and preliminary concerns/issues associated with those sites. Based on issues (fisheries, terrestrial wildlife, and permitting) discussed during the meeting, further engineering evaluation, and additional discussions with landowners, the list of five sites discussed with the WGFD in December has been reduced to two sites. The WWDO is moving forward with evaluation of an enlargement to Meadowlark Lake and a new storage site on Alkali Creek (Figures 1 and 2). We are requesting the USFWS’s technical input on these two storage options.
Meadowlark Lake is an existing reservoir located on East Fork Tensleep Creek upstream of the confluence with Tensleep Creek in the Bighorn National Forest (Figure 3). The WWDO is evaluating an enlargement of the existing reservoir to provide additional storage that would be used to offset late season irrigation shortages. The reservoir enlargement would likely consist of raising the existing dam embankment. The height of the embankment raise, and resulting increase in highwater elevation would be based on potential impacts to existing infrastructure and wetlands, as well as downstream benefits. The embankment raise would include construction of a new spillway and fish passage structure.

Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting with the WGFD include:

- The site is located on USFS managed lands and is widely used for recreation and fisheries.
- Several known cultural areas exist within the existing pool area and along the edges of the current reservoir.
- The existing embankment, spillway, and fish ladder may have historical significance.
- Raising the water level could impact existing structures along the edge of the reservoir, including a newly constructed boat ramp.
- The enlargement would impact wetlands and would require wetland mitigation.
- A form of fish screen to reduce fish loss downstream as well as a fish ladder or other means to allow fish to re-enter the reservoir should be components of the enlargement.
- A losing stream reach exists downstream of the reservoir which could affect the efficiency of flows released from the reservoir.
- The site is located near the Wigwam Rearing Station and potential impacts, if any, should be evaluated.

The Alkali Creek storage site would entail the construction of a new reservoir on Alkali Creek, upstream of its confluence with Paint Rock Creek (Figure 4). The dam embankment and the downstream portion of the reservoir pool area are located on private land. The upstream pool area is located on lands managed by the Bureau of Land Management. Alkali Creek is a small stream and the reservoir would be filled primarily by diversions from Medicine Lodge Creek and Paint Rock Creek via the Anita Ditch. A small section of new conveyance would need to be constructed from the current Anita Ditch alignment along an abandoned alignment to bring water to the reservoir (Figure 4). The embankment would be approximately 75 feet high; 2,000 feet long and impound 4,000 acre feet (inundating approximately 216 acres, including 9 acres of irrigated land). Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting with the WGFD include:

- Diversions should incorporate some form of fish screen to limit fish entrainment.
- Medicine Lodge Creek and Paint Rock Creek are both productive game fisheries.
Minimum stream flow studies will be required to evaluate flows that could be diverted without negatively impacting Medicine Lodge Creek or Paint Rock Creek.

Minimal wetlands would be disturbed, which would need to be mitigated.

The site falls partially within the Sage Grouse Core Area and a preliminary Sage Grouse Density and Disturbance Calculation (DDTC) estimates the current disturbance at 11.7%, above the 5% disturbance guideline (Figure 5).

With the configuration of the Nowood Watershed and its tributaries, no one storage site will alleviate water shortages, rather a combination of storage sites will likely be appropriate. If possible, WWDO’s goal is to develop storage that is multipurpose in nature; providing not only late season irrigation opportunities and drought protection, but also allowing for recreational, water quality, flood control and fish and wildlife enhancement opportunities. The Meadowlark Lake and Alkali Creek sites fit the Study goals well. Trihydro and the WWDO would appreciate the USFWS’s feedback regarding these sites. Furthermore, we are looking for guidance in how we may be able to work through the sage grouse concerns on Alkali Creek, particularly considering our proposed site is only partially located within the Sage Grouse area and results in 0.2% disturbance as compared to the existing 11.7% disturbance.

We appreciate your time and would like to thank you in advance for your review and input on the Meadowlark Lake and Alkali Creek storage sites. Please contact me at (307) 745-7474 or mdonner@trihydro.com or Jason Mead with the WWDO at (307) 777-7626 or jason.mead@wyo.gov if there is additional information that we can provide to assist your review or if you have questions regarding the Study, the individual sites, or the enclosed figures or files.

Sincerely,
Trihydro Corporation

Mark Donner, P.E.
Project Manager

06N-002-001

Attachments

cc: Jason Mead, Wyoming Water Development Office w/out encl
**TABLE 1. SITE EVALUATION MATRIX**

**NOWOOD RIVER STORAGE**  
**LEVEL II STUDY**

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Ranked Priority</th>
<th>Reservoir Name</th>
<th>Aklat Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. RESERVOIR DESCRIPTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. WATERSHED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. RESERVOIR STATISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. DAM DESCRIPTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. HYDROLOGY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F. INFRASTRUCTURE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G. ENVIRONMENTAL ISSUES/INFRASTRUCTURE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Dam Statistics

- **Proposed Type**: Earthen Enlargement, Earthen
- **Dam Height (feet)**: 36, 75
- **Capacity (acre-feet)**: 1,362, 4,091
- **Embankment Length (feet)**: 401, 2,325
- **Total Dam Volume (cy)**: 26,074, 539,000
- **Total Spillway Volume (cy)**: NA, 113,200
- **Total Diversion Volume (cy)**: NA, NA
- **Storage Efficiency (ac-ft/1000 cy fill)**: 52.2, 7.6
- **Method of Reservoir Fill**: None / On channel, Diversion via exist. irrigation ditch
- **Appurtenances**: 4,200’ of Old Anita Ditch Improvements
- **Size Class**: Small, Small
- **Hydrology Method**: Level II Nowood River StateMOD Model, Level II Nowood River StateMOD Model

## Storage Availability

- **Normal Year (ac ft)**: Physically in the stream 15,049, 390
- **Dry Year (ac ft)**: Physically in the stream 13,794, 426
- **Normal Year (Available)**: 11,224, 385
- **Dry Year (Available)**: 9,730, 416

## Infrastructure

- **Transportation**: USFS, Private / BLM
- **Location Relative to Demand (Irrigated Acres downstream)**: 6,871, 4,370
- **Potential for flood protection**: Low, Low

## Environmental Issues

- **WDEQ Stream Classification**: Fishery Classification, 3B0 and 3B1, Fishery Classification, 3B1 and 3B2
- **Game**: Mule Deer, White Tailed Deer, Sage Grouse Leks within 2 miles
- **Sage Grouse Leks**: Inside Core Areas: Within 0.6 miles, Site within 5 miles, Within 3 miles
- **Wetlands (acres impacted)**: From NWI data

---

### Notes and References

- Reference: Trihydro memo dated October 2009
- Reference: 913 memo dated 11/3/10
- Reference: HAI memo dated 11/3/10

---

### Additional Details

- **Seasonal Range**: None of pool in buffered area, 0%
- **Residences**: No new residences
- **Transportation**: 4,200’ of Old Anita Ditch Improvements
- **Elevations**: 4,200’ of Old Anita Ditch Improvements
FIGURES
POTENTIAL STORAGE SITES
SAGE-GROUSE AND LAND MANAGEMENT AREAS
NOWOOD RIVER STORAGE
LEVEL II STUDY

EXPLANATION

- POTENTIAL STORAGE SITE
- TOWNS
- RIVERS & STREAMS
- PROPOSED DIVERSION SUPPLY DITCH/PIPE
- IRRIGATION DITCHES
- US HIGHWAY
- STATE HIGHWAY
- PROPOSED SHORT-LIST SITE
- POTENTIAL STORAGE SITE

TOWNSHIP
SAGE-GROUSE LEKS - MARCH 16, 2011
SAGE-GROUSE CORE AREAS - VERSION 2, JUNE 29, 2010
WILDERNESS STUDY AREA
WILDLIFE REFUGE
NATURE CONSERVANCY PRESERVE
USFS NATIONAL FOREST
WILDERNESS AREA/SCENIC RIVER

NOTE:
SITES PROPOSED FOR FURTHER EVALUATION ARE MARKED INITIAL.

FILE: 20120213_SageGrouse_FIG2.mxd

Drawn By: DRT
Checked By: BR
File: 20120213_SageGrouse_FIG2.mxd

FIGURE 2
POTENTIAL STORAGE SITES
SAGE-GROUSE AND LAND MANAGEMENT AREAS
NOWOOD RIVER STORAGE
LEVEL II STUDY

Not to Scale
**FIGURE 5**

ALKALI CREEK PROJECT IMPACT ANALYSIS AREA (PIAA) USING THE DENSITY AND DISTURBANCE CALCULATION TOOL (DDCT)

**NOWOOD RIVER STORAGE LEVEL II STUDY**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>ACRES</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL DDCT BOUNDARY</td>
<td>39,554.2</td>
<td>100.00</td>
</tr>
<tr>
<td>TOTAL DISTURBED</td>
<td>4,677.0</td>
<td>11.9</td>
</tr>
<tr>
<td>DISTURBED - PROJECT ONLY</td>
<td>65.9</td>
<td>0.2</td>
</tr>
<tr>
<td>DISTURBED - PRIOR TO PROJECT</td>
<td>4,611.1</td>
<td>11.7</td>
</tr>
</tbody>
</table>

**EXECUTIVE ORDER LIMIT: 5% OF DDCT AREA**

**EXECUTIVE ORDER LIMIT: AVERAGE OF 1 PER 640 ACRES WITHIN DDCT AREA**

- **EXPLANATION**
  - TOWNS
  - STATE HIGHWAY
  - COUNTY ROADS
  - RIVERS & STREAMS
  - PROPOSED PROJECT BOUNDARY
  - PROJECT DISTURBANCE
  - IRRIGATED LANDS
  - EXISTING BUILDINGS
  - COUNTY ROAD BUFFER
  - EXISTING RESERVOIR
  - DDCT FINAL BOUNDARY
  - SAGE-GROUSE LEKS - MARCH 16, 2011
  - SAGE-GROUSE CORE AREA - VERSION 3, JUNE 29, 2010

**SURFACE DISRUPTION**

- **TOTAL DISRUPTIONS**
- **DISRUPTION PER 640**
  - NA - THIS ONLY APPLIES TO OIL AND GAS AND MINING ACTIVITIES

**SURFACE DISTURBANCE**

- **TOTAL DISRUPTIONS**
- **DISRUPTION PER 640**
In Reply Refer To:
06E13000/WY12TA0159

Mark Donner, Project Manager
Trihydro Corporation
1252 Commerce Drive
Laramie, Wyoming 82070

Dear Mr. Donner:

Thank you for your letter dated February 24, 2012, regarding the Nowood River Storage, Level II Study located primarily in Big Horn County, Wyoming. On behalf of the Wyoming Water Development Office, Trihydro Corporation has requested U.S. Fish and Wildlife Service (Service) technical assistance concerning expanded or new water storage in one of two potential sites: The Meadowlark Lake site, an existing reservoir which straddles the Big Horn and Washakie County line within Bighorn National Forest, is approximately 12 miles northeast of Ten Sleep, Wyoming, and the Alkali Creek site, located on private and Bureau of Land Management land, is approximately 3 miles northwest of Hyattville, Wyoming and also borders sage-grouse core area.

In response to your request, my staff reviewed your information pursuant to the Endangered Species Act (Act) of 1973 as amended, (16 U.S.C. 1531 et seq.), Migratory Bird Treaty Act (MBTA), 16 U.S.C. 703, and the Bald and Golden Eagle Protection Act (BGEPA), 16 U.S.C. 668. Other fish and wildlife resources are considered under the Fish and Wildlife Coordination Act and the Fish and Wildlife Act of 1956, as amended, 70 Stat. 1119, 16 U.S.C. 742a-742j. Based on the location of the project, my staff has agreed that no threatened or endangered species are likely to occur in the area; however, we are providing comments on migratory birds for both sites and greater sage-grouse and water quality concerns specific to the Alkali Creek site.

**Migratory Birds:** Under the MBTA, BGEPA and Executive Order 13186 (66 FR 3853; January 17, 2001), Federal agencies have an obligation to protect all species of migratory birds, including eagles and other raptors, which may occur on lands under their jurisdiction. Of particular focus are the species identified in the Service’s Birds of Conservation Concern 2008. In accordance with the Fish and Wildlife Coordination Act (16 USC 2912 (a)(3)), this report...
identifies "species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing" under the Act. This report is intended to stimulate coordinated and proactive conservation actions among Federal, State, and private partners and is available at http://library.fws.gov/bird_publications/bcc2008.pdf.

The Migratory Bird Treaty Act (MBTA), enacted in 1918, prohibits the taking of any migratory birds, their parts, nests, or eggs except as permitted by regulations, and does not require intent to be proven. Section 703 of the MBTA states, "Unless and except as permitted by regulations ... it shall be unlawful at any time, by any means or in any manner, to ... take, capture, kill, attempt to take, capture, or kill, or possess ... any migratory bird, any part, nest, or eggs of any such bird...." The Bald and Golden Eagle Protection Act (BGEP A) prohibits knowingly taking, or taking with wanton disregard for the consequences of an activity, any bald or golden eagles or their body parts, nests, or eggs, which includes collection, molestation, disturbance, or killing. Work that could lead to the take of a migratory bird or eagle, their young, eggs, or nests (e.g., if you are going to erect new roads, or power lines in the vicinity of a nest), should be coordinated with our office before any actions are taken.

Removal or destruction of such nests, or causing abandonment of a nest could constitute violation of one or both of the above statutes. Removal of any active migratory bird nest or nest tree is prohibited. For golden eagles, inactive nest permits are limited to activities involving resource extraction or human health and safety. Mitigation, as determined by the local Service field office, may be required for loss of these nests. No permits will be issued for an active nest of any migratory bird species, unless removal of an active nest is necessary for reasons of human health and safety. Therefore, if nesting migratory birds are present on or near the project area, timing is a significant consideration and needs to be addressed in project planning.

If nest manipulation is proposed for this project, the project proponent should contact the Service's Migratory Bird Office in Denver at 303-236-8171 to see if a permit can be issued for this project. No nest manipulation is allowed without a permit. If a permit cannot be issued, the project may need to be modified to ensure take of a migratory bird or eagle, their young, eggs or nest will not occur.

**Greater Sage-grouse:** The Service has determined that the greater sage-grouse (Centrocercus urophasianus) warrants listing under the Act, but the development of a proposed listing rule is precluded by other higher priority listing actions. As a result, the greater sage-grouse has been placed on the list of candidate species. Candidates are reviewed annually to determine if they continue to warrant listing or to reassess their listing priority. Ideally, sufficient threats can be removed to eliminate the need for listing, in which case sage-grouse would no longer be a candidate. If threats are not addressed or the status of the species declines, a candidate species can move up in priority for a listing proposal.

Please see our recent Federal Register notice (75 FR 13910; March 23, 2010: available at http://www.fws.gov/wyominges/Pages/Species/Findings/GrtSageGrouse_CandidateBulletin.html) on greater sage-grouse for detailed information concerning the status of the species. Greater sage-grouse are dependent on sagebrush habitats year-round. Habitat loss and degradation, as well as
loss of population connectivity have been identified as important factors contributing to the decline of greater sage-grouse populations rangewide. Therefore, any activities that result in loss or degradation of sagebrush habitats that are important to this species should be closely evaluated for their impacts to sage-grouse.

We recommend you contact the Wyoming Game and Fish Department to identify important greater sage-grouse habitats, recommended seasonal restrictions within the project area, and appropriate measures to minimize potential impacts from the proposed project. The Service recommends surveys and mapping of important greater sage-grouse habitats where local information is not available. The results of these surveys should be used in project planning to minimize potential impacts to this species. No project activities that may exacerbate habitat loss or degradation should be permitted in important habitats.

The State of Wyoming has adopted a “Greater Sage-grouse Core Area Protection” Executive Order 2011-5 to ensure greater sage-grouse conservation. The recommendations of the State Sage-grouse Implementation Team and State of Wyoming’s Greater sage-grouse “Greater Sage-grouse Core Area Protection” Executive Order 2011-5 state that development of any type in the identified core areas is done only when no decline to the species can be demonstrated. Executive Order 2011-5 further states the burden of proof for showing development does not affect sage-grouse rests with the industry or proponent in question, and any research they feel is necessary to convey this, should be conducted outside of core areas. If a proposed project is located in an area designated by the State of Wyoming as a core sage-grouse population area, we recommend you pursue additional consultation with the Wyoming Game and Fish Department on the core area strategy as appropriate.

**Water Quality:** The Alkali Creek site may have some potential water quality concerns due to the geological substrate. The proposed water storage project is located in a watershed with potentially seleniferous geologic formations (Cloverly and Morrison shale and Mowry and Thermopolis shale) (Love and Christianson 1985). Impoundment of streams receiving water that has come into contact with seleniferous formations could create a hazard for sensitive species of fish and aquatic birds. Water quality impacts, selenium in particular, should be assessed for this proposed project. Waterborne selenium greater than 2 μg/L could result in impacts to fish and aquatic birds inhabiting the impoundment or downstream receiving waters.

To protect fish, waterfowl, shorebirds, and other wildlife from adverse effects, waterborne selenium concentrations should be 2 μg/L or less (Skorupa and Ohlendorf 1991; Lemly 1993; Hamilton 2002). Fish can bioaccumulate selenium directly from the water as well as from their diet. Top level consumers in aquatic systems, such as waterfowl, can readily accumulate selenium to concentrations that lead to low reproduction, embryonic deformities and increased mortality (Ohlendorf et al 1988). Selenium bioaccumulates in aquatic vegetation and invertebrates. Aquatic invertebrates can contain concentrations 2 to 6 times those found in aquatic plants. Selenium can concentrate in the food chain up to 300,000 times the concentration in the water (Besser et al. 1993). For example, the Kendrick irrigation project, located west of Casper, Wyoming, has documented deformities and poor reproductive success in American avocets and eared grebes resulting from elevated selenium concentrations. The median concentration of dissolved selenium in water samples from two closed basin ponds were 38 and
54 μg/L (See et al. 1992). Due to the bioaccumulation of selenium in food items from these ponds, aquatic birds suffered from impaired reproduction and embryonic deformities (See et al. 1992).

Chronic effects of selenium toxicity to sensitive species of fish and aquatic migratory birds are subtle and not readily observed. Chronic effects manifest themselves in immune suppression to birds (Fairbrother et al. 1994) which can make affected birds more susceptible to disease and predation. Selenium toxicity will also cause embryonic deformities and mortality (See et al. 1992, Skorupa 1991, Ohlendorf 2002). The toxic effects of selenium to sensitive species of fish include: damage to gills and internal organs, teratogenic deformities, and impaired reproduction (Lemly 2002). These effects can go undetected because the “primary point of impact is the egg” which receives the selenium from the female (Lemly 2002). Selenium effects to internal organs can also cause an increase in energy requirements thus making fish more susceptible to Winter Stress Syndrome which occurs when the water temperature drops in the autumn and causes increased metabolism (Lemly 2002). Mortality usually occurs as a result of Winter Stress Syndrome.

Thank you for your efforts to ensure the conservation of threatened, endangered, and other species in Wyoming. If you have further questions regarding this letter, please contact our office at the letterhead address or phone Ann Belleman at (307) 578-5116.

Sincerely,

R. Mark Sattelberg
Field Supervisor
Wyoming Field Office

cc:  WGFD, Lander, Non-Game Coordinator (B. Oakleaf)
     WGFD, Cheyenne, Statewide Habitat Protection Coordinator (M. Flanderka)
References


APPENDIX G4

BLM CORRESPONDENCE
March 1, 2012

Mr. Jared Dalebout  
Bureau of Land Management  
101 South 23rd Street  
Worland, WY 82401

RE: Request for Technical Assistance - Nowood River Storage, Level II Study

Dear Mr. Dalebout:

On behalf of the Wyoming Water Development Office (WWDO), Trihydro requests the Bureau of Land Management’s (BLM) technical input regarding potential reservoir sites identified as part of the Nowood River Storage, Level II Study (Study). We are enclosing hard copy figures illustrating the location of the potential storage sites in the Nowood Watershed, individual site figures for the two sites the WWDO is investigating in more detail, and a site matrix for the two sites, as well as a CD containing an ArcGIS Map Package and a Google Earth .kmz file to assist with BLM’s review. This request is a follow-up to our phone conversation on February 29, 2012 regarding this project.

The WWDO undertook evaluation of watershed conditions and storage opportunities in the Nowood Watershed in response to inquiries from local landowners and watershed users relative to low flows and watershed impacts. A Level I Watershed Study (Level I Study) was completed between 2008 and 2010 to identify potential late season water shortages as well as a list of preliminary storage alternatives. In addition, the Level I Study incorporated a vast amount of technical information describing conditions and assessments of the watershed, and developed a management and rehabilitation plan outlining site-specific projects that may remediate existing issues and address opportunities beneficial to the health and functionality of the watershed. The Level I Study report is available online at [http://library.wrds.uwyo.edu/wwdcrept/Nowood_River/Nowood_River-Storage_Watershed_Study_Level_I-Final_Report-2010.html](http://library.wrds.uwyo.edu/wwdcrept/Nowood_River/Nowood_River-Storage_Watershed_Study_Level_I-Final_Report-2010.html).

The purpose of the current Study is to expand upon the list of potential storage sites identified during the Level I Study, and to develop a short-list of viable storage sites based on an evaluation of engineering feasibility, permitting considerations, potential environmental impacts, water availability and beneficial use, and public and landowner input.

Trihydro and the WWDO met with the Wyoming Game and Fish Department (WGFD) and the US Army Corps of Engineers (USACE) on December 2, 2011, to discuss the project background and goals, the list of top-ranked sites, and preliminary concerns/issues associated with those sites. Based on issues (fisheries, terrestrial wildlife, and permitting) discussed during the meeting, further engineering evaluation, and additional discussions with landowners, the list of five sites discussed with the WGFD in December has been reduced to two sites. The WWDO is moving forward with evaluation of an enlargement to Meadowlark Lake and a new storage site on Alkali Creek (Figures 1 and 2). We are
providing information on both sites for your understanding of the Study. However, only the Alkali Creek site directly affects BLM administered lands.

Meadowlark Lake is an existing reservoir located on East Fork Tensleep Creek upstream of the confluence with Tensleep Creek in the Bighorn National Forest (Figure 3). The WWDO is evaluating an enlargement of the existing reservoir to provide additional storage that would be used to offset late season irrigation shortages. The reservoir enlargement would likely consist of raising the existing dam embankment. The height of the embankment raise, and resulting increase in highwater elevation would be based on potential impacts to existing infrastructure and wetlands, as well as downstream benefits. The embankment raise would include construction of a new spillway and fish passage structure. Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting with the WGFD include:

- The site is located on USFS managed lands and is widely used for recreation and fisheries.
- Several known cultural areas exist within the existing pool area and along the edges of the current reservoir.
- The existing embankment, spillway, and fish ladder may have historical significance.
- Raising the water level could impact existing structures along the edge of the reservoir, including a newly constructed boat ramp.
- The enlargement would impact wetlands and would require wetland mitigation.
- A form of fish screen to reduce fish loss downstream as well as a fish ladder or other means to allow fish to re-enter the reservoir should be components of the enlargement.
- A losing stream reach exists downstream of the reservoir which could affect the efficiency of flows released from the reservoir.
- The site is located near the Wigwam Rearing Station and potential impacts, if any, should be evaluated.

The Alkali Creek storage site would entail the construction of a new reservoir on Alkali Creek, upstream of its confluence with Paint Rock Creek (Figure 4). The dam embankment and the downstream portion of the reservoir pool area are located on private land. The upstream pool area is located on lands managed by the BLM. Alkali Creek is a small stream and the reservoir would be filled primarily by diversions from Medicine Lodge Creek and Paint Rock Creek via the Anita Ditch. A small section of new conveyance would need to be constructed from the current Anita Ditch alignment along an abandoned alignment to bring water to the reservoir (Figure 4). The embankment would be approximately 75 feet high; 2,000 feet long and impound 4,000 acre feet (inundating approximately 216 acres, including 9 acres of irrigated land). Considerations for this site identified during the Study and/or discussed during the December 2, 2012 meeting with the WGFD include:
Diversions should incorporate some form of fish screen to limit fish entrainment.

- Medicine Lodge Creek and Paint Rock Creek are both productive game fisheries.
- Minimum stream flow studies will be required to evaluate flows that could be diverted without negatively impacting Medicine Lodge Creek or Paint Rock Creek.
- Minimal wetlands would be disturbed, which would need to be mitigated.
- The site falls partially within the Sage Grouse Core Area and a preliminary Sage Grouse Density and Disturbance Calculation (DDTC) estimates the current disturbance at 11.7%, above the 5% disturbance guideline (Figure 5).

With the configuration of the Nowood Watershed and its tributaries, no one storage site will alleviate water shortages, rather a combination of storage sites will likely be appropriate. If possible, WWDO’s goal is to develop storage that is multipurpose in nature; providing not only late season irrigation opportunities and drought protection, but also allowing for recreational, water quality, flood control and fish and wildlife enhancement opportunities. The Meadowlark Lake and Alkali Creek sites fit the Study goals well. Trihydro and the WWDO would appreciate the BLM’s feedback regarding these sites. Furthermore, we are looking for guidance in how we may be able to work through the sage grouse concerns on Alkali Creek, particularly considering our proposed site is only partially located within the Sage Grouse area and results in 0.2% disturbance as compared to the existing 11.7% disturbance.

We appreciate BLM’s time and would like to thank the BLM in advance for their review and input on the Alkali Creek storage site. Please contact me at (307) 745-7474 or mdonner@trihydro.com or Jason Mead with the WWDO at (307) 777-7626 or jason.mead@wyo.gov if there is additional information that we can provide to assist BLM’s review or if BLM has questions regarding the Study, the individual sites, or the enclosed figures or files.

Sincerely,

Trihydro Corporation

Mark Donner, P.E.
Project Manager

06N-002-001

Attachments

cc: Jason Mead, Wyoming Water Development Office w/out encl
## Table 1: Site Evaluation Matrix

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Ranked Priority</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category A: Reservoir Description

<table>
<thead>
<tr>
<th>Available</th>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Channel</td>
<td>Ten Sleep Creek</td>
<td></td>
<td>Alkali Creek</td>
</tr>
<tr>
<td>Off-Channel</td>
<td>Paintrock Creek</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category B: Watershed

<table>
<thead>
<tr>
<th>Available</th>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>Ten Sleep Creek</td>
<td></td>
<td>Alkali Creek</td>
</tr>
<tr>
<td>NA</td>
<td>Paintrock Creek</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category C: Reservoir Statistics

<table>
<thead>
<tr>
<th>Available</th>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>Ten Sleep Creek</td>
<td></td>
<td>Alkali Creek</td>
</tr>
<tr>
<td>NA</td>
<td>Paintrock Creek</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category E: Hydrology

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off Channel</td>
<td>Dimension via exist. irrigation ditch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Category G: Environmental Issues / Infrastructure

<table>
<thead>
<tr>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands (acres impacted)</td>
<td>1.24</td>
<td>0.20</td>
</tr>
<tr>
<td>Game: Antelope</td>
<td>Seasonal Range</td>
<td>Seasonal Range</td>
</tr>
<tr>
<td>Game: Elk</td>
<td>Seasonal Range</td>
<td>Seasonal Range</td>
</tr>
<tr>
<td>Game: Moose</td>
<td>Seasonal Range</td>
<td>Seasonal Range</td>
</tr>
<tr>
<td>Game: Mule Deer</td>
<td>Seasonal Range</td>
<td>Seasonal Range</td>
</tr>
<tr>
<td>Game: White Tailed Deer</td>
<td>Seasonal Range</td>
<td>Seasonal Range</td>
</tr>
<tr>
<td>Sage Grouse Leks inside Core Areas: Site within 0.6 miles</td>
<td>None of pool in core area</td>
<td>None of pool in core area</td>
</tr>
<tr>
<td>Sage Grouse Leks inside Core Areas: Within 4 miles</td>
<td>None of pool in core area</td>
<td>None of pool in core area</td>
</tr>
<tr>
<td>Sage Grouse Leks Project Impact Analysis Area (PIAA)</td>
<td>2.5%</td>
<td>11.9%</td>
</tr>
<tr>
<td>Sage Grouse Core Population Area</td>
<td>None of pool in core area</td>
<td>None of pool in core area</td>
</tr>
</tbody>
</table>

### Category I: Potential Benefits

<table>
<thead>
<tr>
<th>Description</th>
<th>Meadowloch Lake Enlargement</th>
<th>Alkali Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Relative to Demand (irrigated Acres downstream)</td>
<td>4,370</td>
<td>4,370</td>
</tr>
<tr>
<td>Potential for flood protection</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
FIGURE 4
ALKALI CREEK SITE MAP

NOWOOD RIVER STORAGE LEVEL II STUDY

EXPLANATION
- TOWNS
- PROPOSED DIVERSION
- IRRIGATION DITCH
- STATE HIGHWAY
- COUNTY ROADS
- PROPOSED STORAGE SITE
- TOWNSHIP

- BUREAU OF LAND MANAGEMENT
- NATURE CONSERVANCY PRESERVE
- PRIVATE LANDS
- STATE WILDLIFE HABITAT MANAGEMENT AREA
- USFS NATIONAL FOREST
- WILDERNESS AREA/SCENIC RIVER
- STATE OF WYOMING
Trihydro Corporation
Mark Donner, P.E. Project Manager
1252 Commerce Drive
Laramie, WY 82070

Dear Mr. Donner:

Thank you for the opportunity to submit technical input regarding potential reservoir sites identified as part of the Nowood River Storage, Level II study. We do not have any additional input regarding the proposed Meadowlark site. We have identified the following potential resource concerns or issues regarding the proposed Alkali Creek site as outlined in figure 4 that was submitted to our office on March 5, 2012.

Realty

- The reservoir and ditch on public land would need to be authorized under a right-of-way.
- If the “holder” of the right-of-way will be charging customers for the product (water), they are not exempt from paying our cost recovery fees and rental under 43 CFR §2804.16(a) and 43 CFR §2806.14(2)(ii).
- The facility may or may not require bonding.

Cultural- Paleontology

- The area has not been inventoried for cultural resources so a Class III would be necessary. At the moment, there is one known site within the project area.
- The project area is within the viewshed of sites potentially of interest to the tribes.
- Surface formations include Cloverly, which generally triggers a paleontology inventory.

Soils

- Any test or pit holes drilled or dug on public land to determine adequacy for embankment or foundation can be authorized under a categorical exclusion (CX).

Grazing

- The area is located in the North of Ditch (#00204) and Black Hills (#00136) grazing allotments and would possibly require a change in the allotted animal unit months (AUM’s).
Wildlife

- No additional issues in addition to the Wyoming Game & Fish comments.

Hydrology/Riparian

- There is a riparian segment on public land (P0076A) that was inventoried and assessed in 1999 that is 0.69 miles in length that was rated to be in proper functioning condition. This wetland area would need to be mitigated.
- There has also been stream flow measurements, continuous water quality, and soil moisture data collected on Alkali Creek upstream of the site from 2009-present that would be beneficial to increase the accuracy of the flow model and water quality parameters.

Recreation

- Potential recreation benefits would be contingent upon a minimum pool agreement and public access to the site. The area is in BLM-administered public lands that are not managed as a recreation management area (Extensive or Special Recreation Management Area). Recreation use is recognized as an existing and valid use, but management does not elevate recreational use or resources as a priority in this area, only to address resource protection, use and user conflicts, and public health and safety. The proposed project will enhance water related recreational activities and experiences, as well as access to additional BLM-administered public lands, as well as potentially increase the amount of trespass issues. The area is managed under Visual Resource Management Class III objectives, which the potential project will be within Class III objectives. There are no WSAs, Lands with Wilderness Characteristics, BLM Natural Areas, ACECs, or Wild and Scenic Rivers (eligible or suitable).

If you have any questions or concerns, please contact Jared Dalebout, Hydrologist of my staff at the above address or telephone (307)-347-5100.

Sincerely,

Michael J. Phillips
Assistant Field Manager
Resources

cc: Wyoming Water Development Office
c/o Jason Mead
6920 Yellowtail Road
Cheyenne, WY 82002
APPENDIX G5

FISH AND WILDLIFE RANGES AND HABITAT