Debt Repayment Obligations Created by the Proposed Bear River Development Project

CAKE Talk

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February 14, 2020

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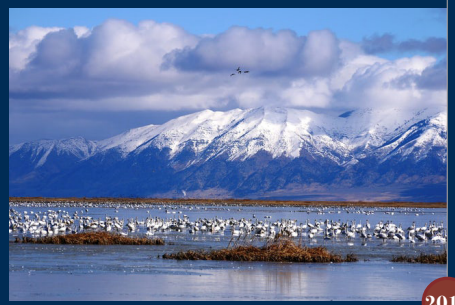


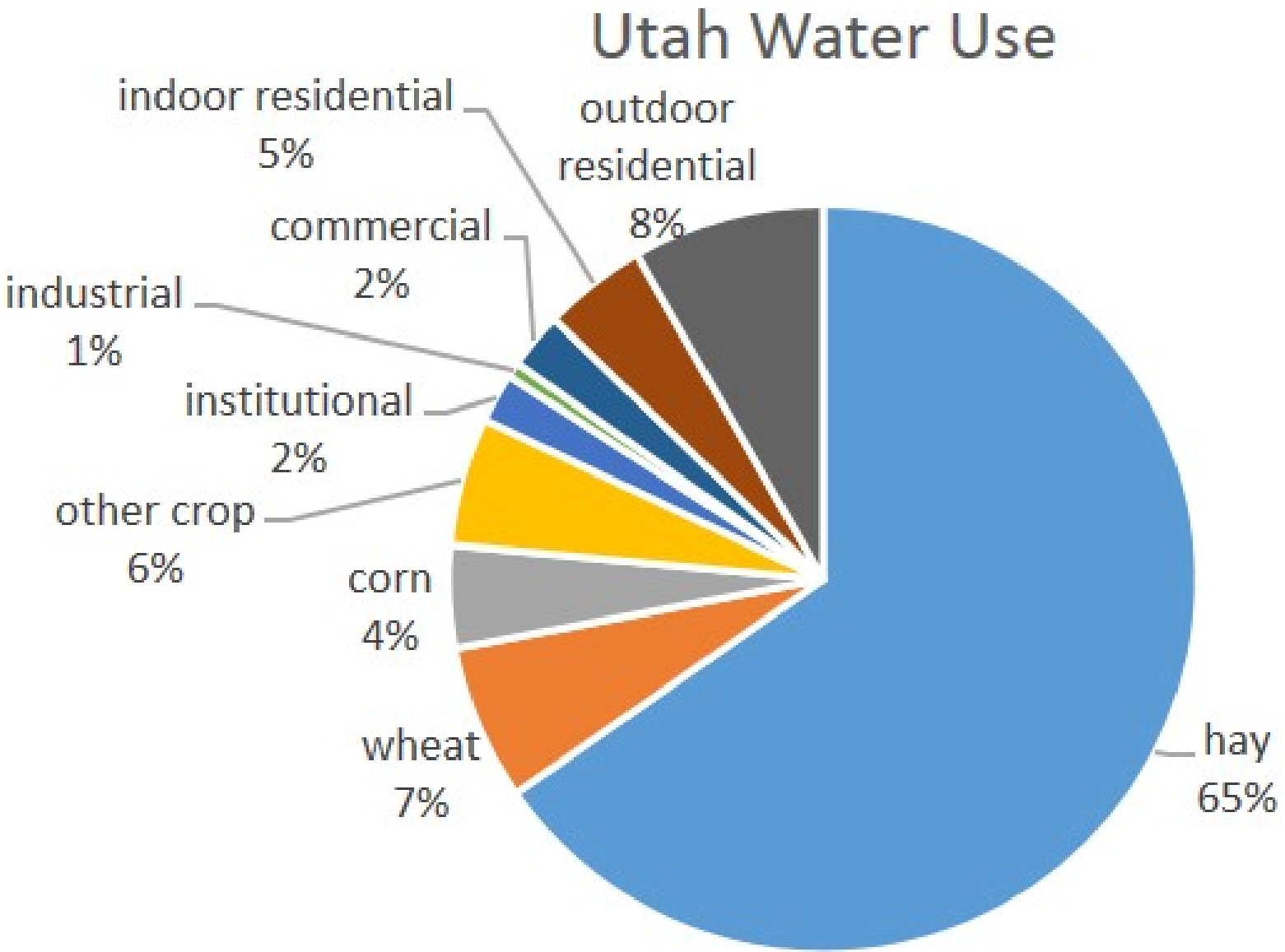
2019

Thanks to
U.S. Magnesium
for commissioning this research through the
"Economic Evaluation Unit"
of the
University of Utah's
Department of Economics.

`https://eeu.utah.edu`

Thanks also to Steve Bannister for his assistance.

Setting the Stage



Bear River Basin

©Karl Musser, https://upload.wikimedia.org/wikipedia/commons/c/c6/Bearrivermap.png

Bear River Development

A series of reservoirs and pipelines to divert water from the Bear River to serve:

1. the Cache Water District;
2. the Bear River Water Conservancy District (Box Elder County);
3. the Weber Basin Water Conservancy District; and
4. the Jordan Valley Water Conservancy District (primarily southern Salt Lake County).

Salt Lake City's Metropolitan Water District is not involved.

Financing

Utah Code 73-26 ["Bear River Development Act"]-503 (1) states that

> *"Construction and environmental mitigation costs allocated to municipal or industrial uses shall be entirely repaid by the entities contracting for water designated for those uses"*

and 73-26-505 states that

> *"Interest on the unpaid balance of reimbursable construction and environmental mitigation costs shall be charged at a rate set by the Board [of Water Resources]."*

How affordable would this be?

Intuition about Financial Burdens

	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
water alloc. ac-ft/yr	60,000	60,000	50,000	50,000
			Burden Measure 1	
# customers	127,068	54,950	620,000	700,000
"water $\propto$ cost"/customers	0.256	0.696	0.081	0.001
			Burden Measure 2	
District "Δ net position"	\$0	\$420,689	\$9,151,195	\$12,763,020
"revenues"/"water $\propto$ cost"	0	7	183	255

Sources:

- Changes in net position: for Cache, 2019 Approved Budget; others, their audited financial statements
- # Customers: people served, for Weber Basin (`https://weberbasin.com/index.php/about-us/about-us`) and Jordan Valley (page 08 of `https://jvwcd.org/file/940d06aa-fbce-4eb3-804f-a6ba678384ce/2018-Annual-Report.pdf`); population, for Cache and Bear River/Box Elder.

Key Insight

- What options do the smaller districts have?
- Participation is not mandatory.
- Then this becomes a 4-"person" game.

A formal description is difficult because:

- we do not know benefits, only costs (though see Utah Code 73-26-502, "The division shall. . . calculate the economic benefits and costs of the developed water"), so net payoffs are unavailable;
- the sequential nature of the moves in the extensive form version of the game ("participate," "don't participate," "undecided") is unclear (when is a move irrevocable?)
- how can one describe a four-dimensional payoff (or cost) matrix?

Participation Scenarios (illustration of all possible final states of the 4-person game in normal form)

Scenarios	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
1	✓	✓	✓	✓
2		✓	✓	✓
3	✓		✓	✓
4	✓	✓		✓
5	✓	✓	✓	
6			✓	✓
7		✓		✓
8		✓	✓	
9	✓			✓
10	✓		✓	
11	✓	✓		
12				✓
13			✓	
14		✓		
15	✓			

Calculating the Payoffs: Intuition

- As Districts opt out, do marginal or average costs rise or fall?
- Each time a neoclassical textbook draws an upward-sloping or flat supply curve it reinforces the idea that falling output causes marginal costs to fall or remain constant.
- If that were true, Districts opting out will make the Bear River Development easier for the remaining Districts to afford.
- If by contrast the BRD has increasing returns to scale, Districts opting out will make the Bear River Development harder for the remaining Districts to afford. I conjecture that is the case. Let's see.

Calculating the Payoffs: Rigorous Details

- Data Source: Bear River Pipeline Concept Report–Final, July 2014, by Bowen Collins & Associates, Inc., and HDR, for the Utah Division of Water Resources. (Vol. I: 327 pages; Vol. II: 280 pages.)
- This State report gives aggregate costs and costs of individual components of the project (e.g., reservoirs, pipelines, pumping stations, a water treatment plant).
- But which components of the project can be dropped under different scenarios of lack of participation?

Components of "Combination B"

We analyzed the State's "Combination B" reservoir combinations.

- Cub River Reservoir
- Fielding Reservoir
- Weber Bay Reservoir
- Cache County Project Facilities
- North Box Elder County Reach Pipeline, South Box Elder County Reach Pipeline, Collinston Connection
- Weber County Reach Pipeline
- West Haven WTP
- Weber Basin WCD Pump Station and Pipeline
- Jordan Valley WCD Pump Station and Pipeline
- Cache County Project Facilities

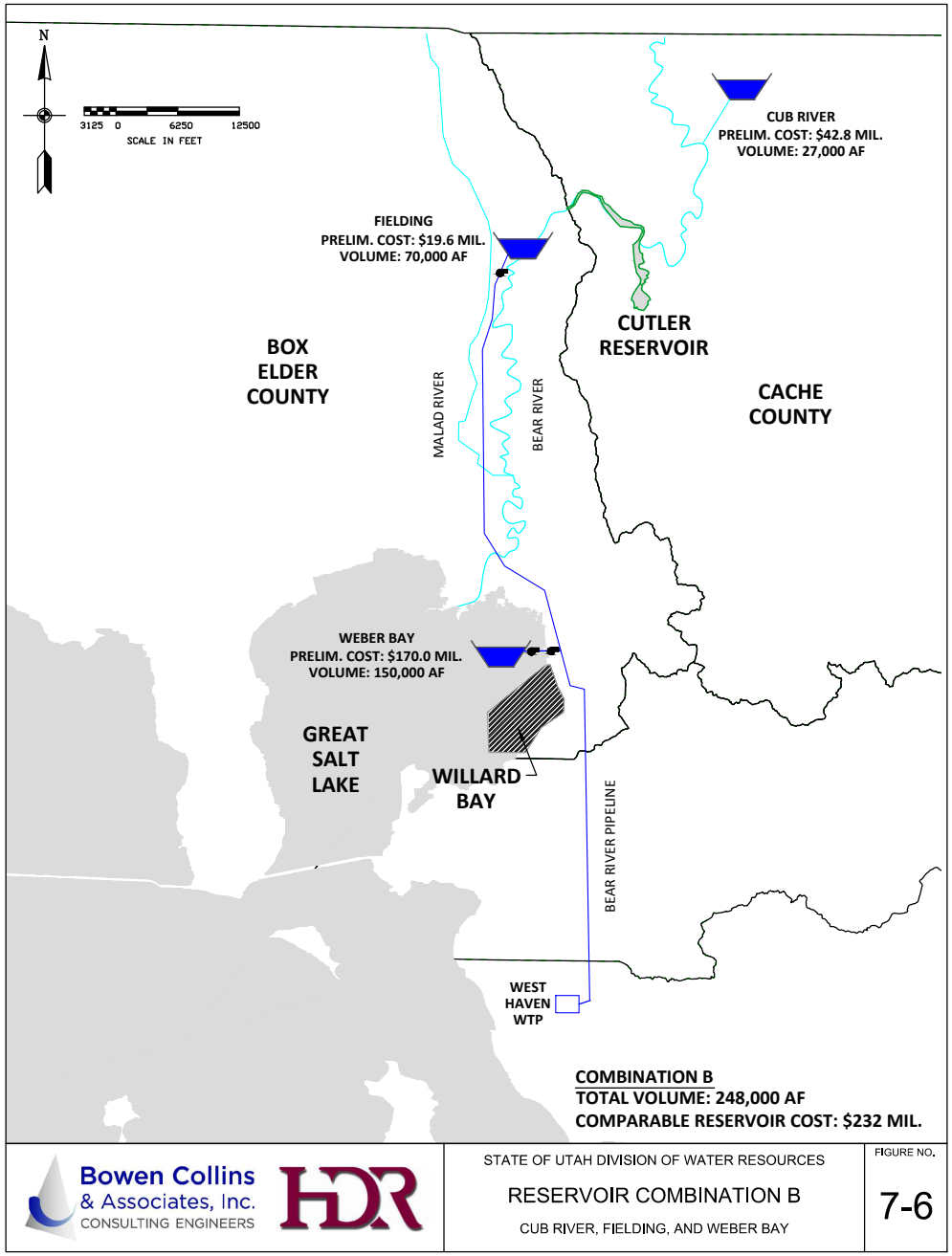
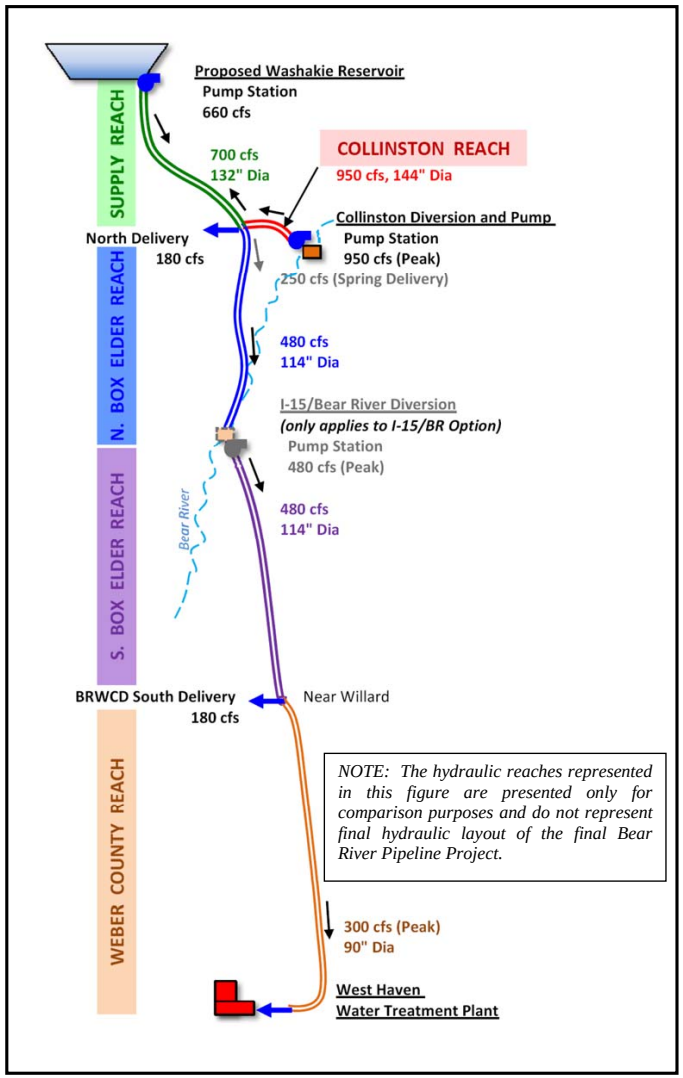
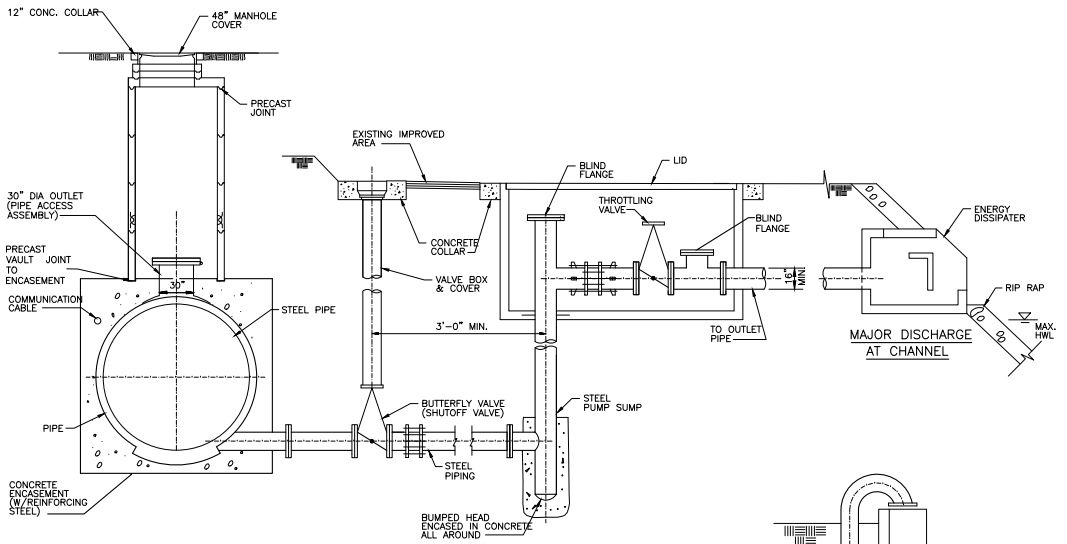
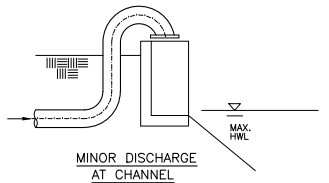

N
3125 0 6250 12500
SCALE IN FEET
CUB RIVER
PRELIM. COST: $42.8 MIL.
VOLUME: 27,000 AF
FIELDING
PRELIM. COST: $19.6 MIL.
VOLUME: 70,000 AF
CUTLER
RESERVOIR
BOX
ELDER
COUNTY
MALAD RIVER
BEAR RIVER
CACHE
COUNTY
WEBER BAY
PRELIM. COST: $170.0 MIL.
VOLUME: 150,000 AF
GREAT
SALT
LAKE
WILLARD
BAY
BEAR RIVER PIPELINE
WEST
HAVEN
WTP
COMBINATION B
TOTAL VOLUME: 248,000 AF
COMPARABLE RESERVOIR COST: $232 MIL.
Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS
HDR
STATE OF UTAH DIVISION OF WATER RESOURCES
RESERVOIR COMBINATION B
CUB RIVER, FIELDING, AND WEBER BAY
FIGURE NO.
7-6

Figure 6-22
Assumed Hydraulic Reach Schematic for the Short List Analysis



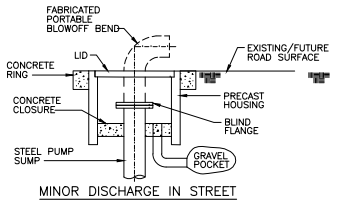
The 607 pages of this State engineering report are extensive. . .



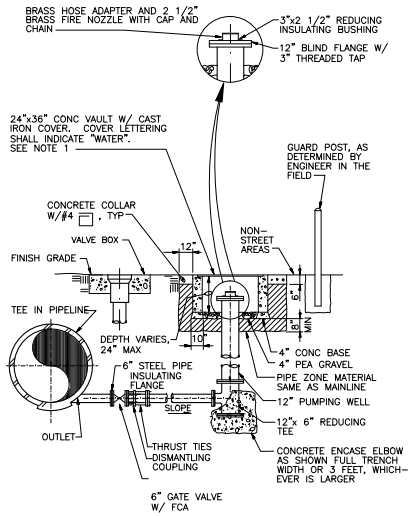


SPECIAL DESIGN CRITERIA

1. SIZE THE DRAIN VALVES TO MEET THE CRITERIA IN THE SPECIFICATIONS AND DESIGN CRITERIA.
2. LOCATE THE PUMP SUMP IN THE PARKING STRIP WHERE APPLICABLE, EXTEND THE OUTLET TO THE APPROPRIATE DISCHARGE POINT.
3. DESIGN CONSULTANT SHALL DETERMINE ACTUAL LOCATION, DIMENSIONS, GRADES, ELEVATION STRUCTURAL REQUIREMENTS AND OTHER INFORMATION AS REQUIRED FOR A COMPLETE DESIGN.
4. DRAIN VALVE PIPING AND APPURTENANCES SHALL MEET THE PRESSURE CLASS OF THE ADJACENT PIPE.
5. MANWAY ACCESS ASSEMBLY NOT REQUIRED IF DRAIN ASSEMBLY IS LOCATED WITHIN 500-FT OF AN ADJACENT MANWAY.



DRAIN VALVE ASSEMBLY 1
NTS



NOTES:
1. VAULT AND COVER SHALL BE TRAFFIC RATED WITH BOLT DOWN COVER. CONTRACTOR SHALL SUBMIT DETAIL OF BOX AND LID TO ENGINEER PRIOR TO ORDERING MATERIALS.
2. BACKFILL CLASS SHALL BE EQUAL TO THE ADJACENT PIPELINE.

MINOR BLOWOFF ASSEMBLY 2
NTS

Bowen Collins & Associates, Inc.

CONCEPTUAL PLAN

NO.	DATE	REV. BY	DESCRIPTION
			REVISIONS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING

STATE OF UTAH
BEAR RIVER PIPELINE
CONCEPT REPORT
REVIEW
CHECKED T. CLARK
APPROVED M. COLLINS
DESIGN J. OYLER
DRAWN ED SCOTT

CIVIL
DRAIN VALVE (BLOWOFF) ASSEMBLY
PROJECT NUMBER 233-09-01
DATE: DECEMBER 2010

DRAWING NO. D-03
SHEET 6 OF 23

P:\State of Utah\Division of Water Resources\Bear River Project\Drawings\Final Design\Sht\2330901_05_P_D03.dwg Dec16,2010 - 8:29am

Cost Factor Calculation - Utility Rating

Utility Congestion Condition 1
No utilities (base factor)

Utility Congestion Condition 2
Below Average Utilities
(1-2 utilities no relocations)

Factor = 1.02 Applied to Length
Cost = $ 1,720 /LF
Base Cost = $ 1,690 /LF

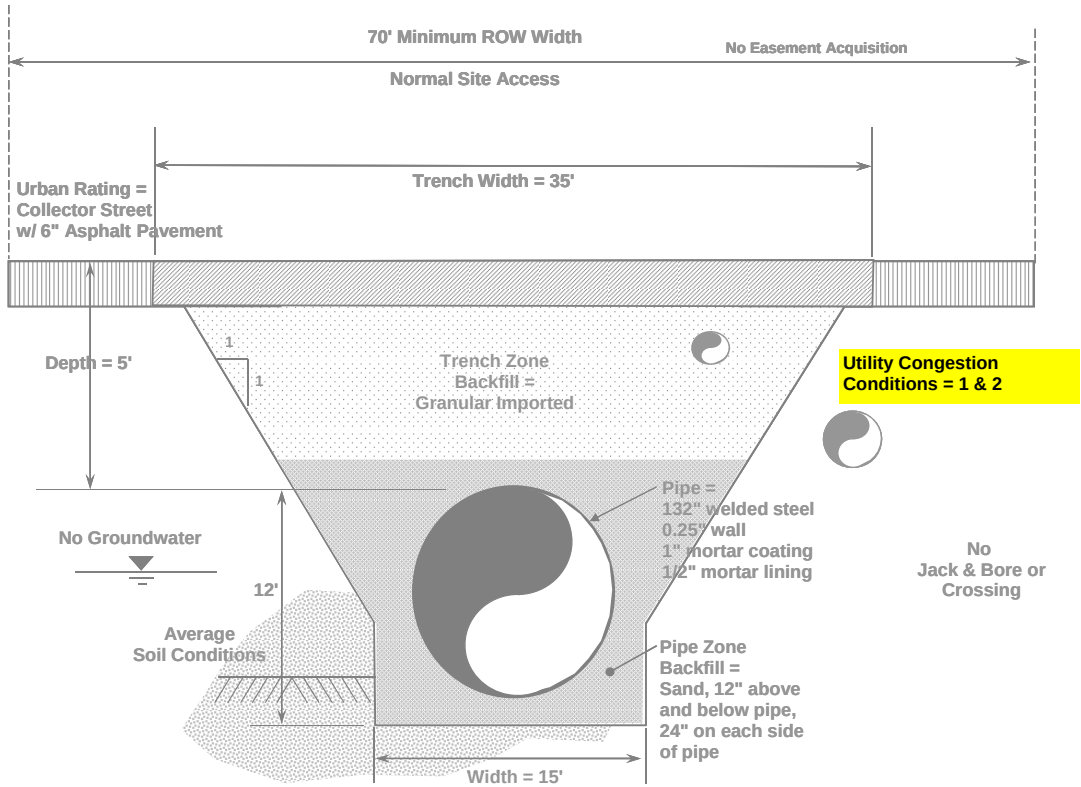
Item	Unit	Qty	Unit Cost	Total Cost
Pipeline				
Baseline Cost	LF	1	$1,690	$1,690
Utilities *	LF	0.5	**$59**	$30
Pipeline Subtotal				**$1,720**

* Assume that the Utility Condition 2 has about half the utilities present as the Average Utilities Congestion Condition (3)

Utility Congestion Condition 3
Average Utilities
(3-4 utilities, some relocations)

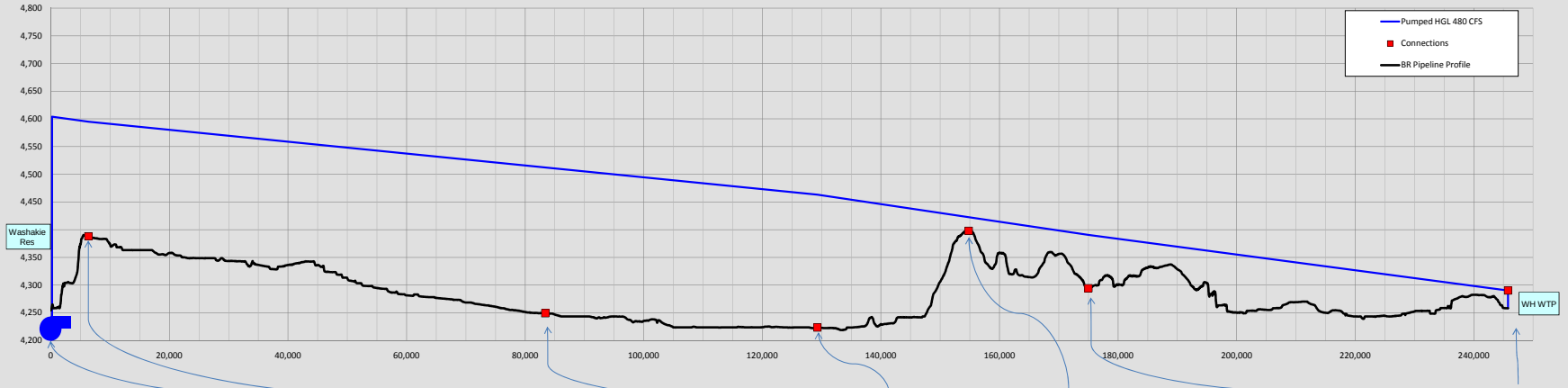
Factor = 1.03 Applied to Length
Cost = $ 1,749 /LF
Base Cost = $ 1,690 /LF

Item	Unit	Qty	Unit Cost	Total Cost
Pipeline				
Baseline Cost	LF	1	$1,690	$1,690
Utilities *	LF	1.0	**$59**	$59
Pipeline Subtotal				**$1,749**



Bear River Pipeline Hydraulic Calculations

Final Alignment
Collinston Pump Station to West Haven WTP



COLLINSTON DIVERSION		Collinston PS		Collinston Pipeline Jct		Collinston Pipeline Jct		Bear River City		Brigham City		High Point		BRWCD South		West Haven WTP	
High WSE =	4,255 ft	PS Elev =	4,230 ft	Ground Elev. =	4,388 ft	Ground Elev. =	4,388 ft	Ground Elev. =	4,249 ft	Ground Elev. =	4,223 ft	Ground Elev. =	4,398 ft	Ground Elev. =	4,294 ft	Req'd HGL =	4,290 ft
Low WSE =	4,240 ft	Static Suction Head =	10 ft	Station =	6,333	Station =	6,333	Station =	83,385	Station =	129,274	Station =	154,804	Station =	175,004	Ground Elev. =	4,258 ft
Bottom =	4,235 ft	Static Disch Head =	28 ft		0											Station =	245,773

Total Pipe Length =	245,773	Lowest Elev =	4,219
Miles	46.55	Highest Elev =	4,400

	Collinston PS	Collinston Pipeline Jct	Collinston Pipeline Jct	Bear River City	Brigham City	High Point	BRWCD South	West Haven WTP
	AT COLLINSTON DIVERSION							
		Diameter = 108 in	Diameter = 108 in *	Diameter = 114 in	Diameter = 114 in	Diameter = 90 in	Diameter = 90 in	Diameter = 90 in
		Length = 6,333 ft	Length = - ft	Length = 77,052 ft	Length = 45,889 ft	Length = 25,530 ft	Length = 20,200 ft	Length = 70,769 ft
	Station = 200	Station = 6,333	Station = 6,333	Station = 83,385	Station = 129,274	Station = 154,804	Station = 175,004	Station = 245,773
		1.20 mi	0.00 mi	14.59 mi	8.69 mi	4.84 mi	3.83 mi	13.40 mi
			* Sized for 660 & 700 cfs					
Global "C" coeff = 120	**Peak Flow =** 480 cfs	Outflow = 0.00 cfs	Outflow = 0.00 cfs	Outflow = 0.00 cfs	Outflow = 162.00 cfs	Outflow = 0.00 cfs	Outflow = 18.00 cfs	
Pump Efficiency = 88%	Discharge HL_{fric} = 314 ft	Reach Flow = 480.00 cfs	Reach Flow = 480.00 cfs	Reach Flow = 480.00 cfs	Reach Flow = 480.00 cfs	Reach Flow = 318.00 cfs	Reach Flow = 318.00 cfs	WTP Flow = 300.00 cfs
Motor Efficiency = 94%	**TDH_{pump} =** 364 ft	Friction HL = 9 ft	Friction HL = 0 ft	Friction HL = 83 ft	Friction HL = 49 ft	Friction HL = 40 ft	Friction HL = 32 ft	Friction HL = 101 ft
	HP = 23,959 HP	Velocity = 7.5 fps	Velocity = 5.5 fps	Velocity = 6.8 fps	Velocity = 6.8 fps	Velocity = 7.2 fps	Velocity = 7.2 fps	Velocity = 6.8 fps
Hazen-Williams Head Loss & Pump Equations:	**HGL at Pump Discharge** 4,604 ft	HGL at Conn. 4,595 ft	HGL at Conn. 4,595 ft	HGL at Conn. 4,512 ft	HGL at Conn. 4,463 ft	HGL at Conn. 4,423 ft	HGL at Conn. 4,391 ft	**HGL at WHWTP** 4,290 ft
$HL = 0.002083*L*(100/C)^{1.85}*(Q*448.83)^{1.85}/D^{4.8655}$	Suction Head at Pump 10 ft	Head = 207 ft	Head = 207 ft	Head = 263 ft	Head = 240 ft	Head = 25 ft	Head = 96 ft	Head = 32 ft
$PUMP\ HP_{(electrical)} = (SG*62.4*Q*TDH)/(550*Eff_{pump}*Eff_{motor})$	TDH Pressure = 158 psi	Pressure = 90 psi	Pressure = 90 psi	Pressure = 114 psi	Pressure = 104 psi	Pressure = 11 psi	Pressure = 42 psi	Pressure = 14 psi
L (ft), Q (cfs), D (in), TDH (ft), NOTE: no minor losses computed in these calculations						*Keeping high point pressure at 10 psi*		

Input Cells
Linked to input cells
Output Cells
Fixed Parameters

CACHE COUNTY EXCHANGE OUTFLOW TO WESTSIDE CANAL (180 CFS)

BRWCD DELIVERY TO BRIGHAM CITY (162-180 CFS)

BRWCD DELIVERY TO WILLARD (18 CFS MAX)

Hydraulic Profile - Final Align.xlsx CD PS Main Pipeline

Printed: 10/16/2010

- Features Dropped & Cost Assignment: Southern Districts' Infrastructure
- Features Dropped & Cost Assignment: Reservoirs
- Features Dropped & Cost Assignment: Misc. Northern Infrastructure
- Features Dropped & Cost Assignment: Summary
- Additional Costs
- These Costs in Perspective
- Conclusion for September Report

Features Dropped & Cost Assignment: Southern Districts' Infrastructure

West Haven Water Treatment Plant Needed if either Jordan Valley or Weber Basin participate. Cost assigned 50/50 if both participate, otherwise full cost on the single participating district.

Weber Basin Pump Station & Pipeline Needed if either Jordan Valley or Weber Basin participate.

Jordan Valley Pump Station & Pipeline Needed if Jordan Valley participates.

Cost of the last two items were assigned "26% WBWCD and 74% JVWCD" according to note 2 of Table 12-5 (PDF p. 197 of 327), "based on the February 2004 Cost Allocation Study for the Wasatch Front Regional Water Project." The item was dropped if the corresponding district does not participate.

Features Dropped & Cost Assignment: Southern Districts' Infrastructure—the West Haven WTP

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	0	0	123,125,000	123,125,000	246,250,000
2.	0	0	123,125,000	123,125,000	246,250,000
3.	0	0	123,125,000	123,125,000	246,250,000
4.	0	0	0	246,250,000	246,250,000
5.	0	0	246,250,000		246,250,000
6.	0	0	123,125,000	123,125,000	246,250,000
7.	0	0	0	246,250,000	246,250,000
8.	0	0	246,250,000		246,250,000
9.	0	0	0	246,250,000	246,250,000
10.	0	0	246,250,000		246,250,000
11.	0	0	0		0
12.	0	0	0	246,250,000	246,250,000
13.	0	0	246,250,000		246,250,000
14.	0	0	0		0
15.	0	0	0		0

This probably overestimates the cost of having only one district participate.

Features Dropped & Cost Assignment: Southern Districts' Infrastructure—the Pump Stations & Pipelines

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	0	0	51,194,000	145,706,000	196,900,000
2.	0	0	51,194,000	145,706,000	196,900,000
3.	0	0	51,194,000	145,706,000	196,900,000
4.	0	0	0	145,706,000	145,706,000
5.	0	0	51,194,000		51,194,000
6.	0	0	51,194,000	145,706,000	196,900,000
7.	0	0	0	145,706,000	145,706,000
8.	0	0	51,194,000		51,194,000
9.	0	0	0	145,706,000	145,706,000
10.	0	0	51,194,000		51,194,000
11.	0	0	0		0
12.	0	0	0	145,706,000	145,706,000
13.	0	0	51,194,000		51,194,000
14.	0	0	0		0
15.	0	0	0		0

This probably underestimates the cost of having only Jordan Valley participate.

- Features Dropped & Cost Assignment: Southern Districts' Infrastructure
- Features Dropped & Cost Assignment: Reservoirs
- Features Dropped & Cost Assignment: Misc. Northern Infrastructure
- Features Dropped & Cost Assignment: Summary
- Additional Costs
- These Costs in Perspective
- Conclusion for September Report

Features Dropped & Cost Assignment: Reservoirs

Possible combinations of the reservoirs at Cub River, Fielding, and Weber Bay:

1. Cub River;
2. Fielding;
3. Weber Bay;
4. Cub River & Fielding;
5. Cub River & Weber Bay;
6. Fielding & Weber Bay;
7. Cub River, Fielding, & Weber Bay.

For each scenario, eliminate the combinations which supply insufficient water, then choose the least-cost combination among the ones left. Assign costs in proportion to water delivered.

Features Dropped & Cost Assignment: Reservoirs

=VLOOKUP(G6,$S$22:$T$29,2,FALSE)

G	H	I	J	K	L	M	N	O	P	Q	R	S	T
12, and G12; etc. Step 2: Cells L3 to O29. Step 3: columns G and H.					Last step: cells B7 to E7, B10 to E10, etc.								
	constr. cost	Inundated acres			Reservoirs, from **Table 10-8**, p. 10-19 (PDF p. 175) and Table 10-14, p. 10-27 (PDF p. 183) of July 2014 Volume I of II, Bear River Pipeline Concept Repo								
	of reservoirs	of reservoirs	namely these		storage capacity in AF	Wetlands inundated							
Total AF/yr	using L22--P29	using L22-P29	reservoirs		27,000	297	Cub River						
220,000	$278,122,000	7928	need all three reservoirs		70,000	790	Fielding						
					124,000	6841	Weber Bay						
					221,000	7928	Combined						
160,000	$235,300,000	7631	Fielding & Weber Bay		0.995475113	conversion of AF of storage capacity to AF/year of water flow							
					capacity to provide flow, AF/year								
							cost, $/AF	cost, $					
160,000	$235,300,000	7631	Fielding & Weber Bay		26,878	Cub River	1586	42,822,000	<-consistent with Table 10-11 and Table 12-2				
					69,683	Fielding	280	~~19,600,000~~	<-inconsistent with Table 10-11 and Table 12-2, which agree on:				38,3
					123,439	Weber Bay	1277	~~158,348,000~~	<-inconsistent with Table 10-11 and Table 12-2, which agree on:				197,0
170,000	$235,300,000	7631	Fielding & Weber Bay		Various Combinations								
					AF/yr			cost					
					96,561	Cub River & Fielding		81,122,000					
170,000	$235,300,000	7631	Fielding & Weber Bay		150,317	Cub River & Weber Bay		239,822,000					
					193,122	Fielding & Weber Bay		235,300,000					
100,000	$197,000,000	6841	Weber Bay		Requried AF/yr	inferred Least-cost Reservoir combination			Inundated Wetlands				values fo
					220,000	need all three reservoirs		$278,122,000	7928			220,000	$278,12
					170,000	Fielding & Weber Bay		$235,300,000	7631			170,000	$235,30
110,000	$197,000,000	6841	Weber Bay		160,000	Fielding & Weber Bay		$235,300,000	7631			160,000	$235,30
					120,000	Weber Bay		$197,000,000	6841			120,000	$197,00
					110,000	Weber Bay		$197,000,000	6841			110,000	$197,00
110,000	$197,000,000	6841	Weber Bay		100,000	Weber Bay		$197,000,000	6841			100,000	$197,00
					60,000	Fielding		$38,300,000	790			60,000	$38,30
					50,000	Fielding		$38,300,000	790			50,000	$38,30
110,000	$197,000,000	6841	Weber Bay										
110,000	$197,000,000	6841	Weber Bay										
120,000	$197,000,000	6841	Weber Bay										
					Summary of this Sheet, Adjusted to include Overhead								
						Cache County	Bear River WCD	Weber Basin WC	Jordan Valley WCD				
50,000	$38,300,000	790	Fielding		1	$116,811,240	$116,811,240	$97,342,700	$97,342,700		$428,307,880		
					2	#VALUE!	$135,885,750	$113,238,125	$113,238,125				
					3	$135,885,750	#VALUE!	$113,238,125	$113,238,125				

JdnWbr | Reservoirs | T12dash2 | Totals | Presentation | DSCRatios | PerCap

Error in the Engineering Report: Vol. I, Table 10-8 p. 175

Table 10-8
Short List of Potential Reservoir Sites

#	Name	Elevation	Volume (AF)		Cost/AF	Characterize	Comparison Cost $M
1	Above Cutler Dam	4,432	51,000	Medium	$927	Difficult environment	$47
2	Cub River	4,465	27,000	Small	$1,586	Cache	$43
3	East Promontory	4,231	238,000	Large	$1,106	Large site	$263
4	Fielding	4,300	70,000	Medium	$280	Least expensive	$20
5	Hyrum Enlargement	4,715	28,000	Small	$660	Cache	$18
6	Temple Fork	6,167	40,000	Small	$1,279	Cache, difficult enviro	$51
7	Washakie	4,406	158,000	Large	$2,278	Most expensive	$360
8	Whites Valley	5,260	170,000	Large	$1,847	Low impact	$314
9	Weber Bay	4,225	124,000	Medium	$1,277	Addl analysis needed	$158

Two of the sites (Hyrum Enlargement and Washakie) have been studied extensively in the past. The other seven sites have been studied to various levels, although some have very little documentation. Each of these nine sites was studied further to determine what sites best met the long term storage needs of the project. For East Promontory, the entire projects storage needs can be met with the one reservoir. For the other reservoir sites, a combination of several reservoirs will be required to meet the needed storage. An analysis of how each of these reservoirs could fit into the overall Bear River Project helped determine the final reservoirs chosen for the project.

10.9 REVIEW OF POSSIBLE RESERVOIR COMBINATIONS TO MEET PROJECT STORAGE REQUIREMENTS

Preliminary hydrologic modeling conducted by DWRe showed that the Project will require approximately 240,000 acre-feet of storage to reliably deliver the full Bear River Project supply of 220,000 acre-feet per year. Because only one of the short-listed sites is capable of storing the full 240,000 acre-feet of water, the development and evaluation of potential combinations of reservoirs is necessary. The following criteria were applied as an aid in the development of a preliminary list of potential combinations of reservoirs. These criteria were also applied in the evaluation of the reservoir combinations.

- Combined storage volume is at least 220,000 acre-feet
- Phasing of site development should be considered
- Sites must supply all three counties
  - Cache County either needs storage in-county, or
  - Supply must be pumped up from Fielding to Cutler
- Potential site development opposition (public, political, environmental) should be considered
- Overall project cost is critically important
- Overall project performance is critically important

Error in Engineering Report: Vol. I, Table 10-8 p. 175

Table 10-8
Short List of Potential Reservoir Sites

#	Name	Elevation	Volume (AF)		Cost/AF	Characterize	Comparison Cost $M
1	Above Cutler Dam	4,432	51,000	Medium	$927	Difficult environment	$47
2	Cub River	4,465	27,000	Small	$1,586	Cache	$43
3	East Promontory	4,231	238,000	Large	$1,106	Large site	$263
4	Fielding	4,300	70,000	Medium	$280	Least expensive	$20
5	Hyrum Enlargement	4,715	28,000	Small	$660	Cache	$18
6	Temple Fork	6,167	40,000	Small	$1,279	Cache, difficult enviro	$51
7	Washakie	4,406	158,000	Large	$2,278	Most expensive	$360
8	Whites Valley	5,260	170,000	Large	$1,847	Low impact	$314
9	Weber Bay	4,225	124,000	Medium	$1,277	Addl analysis needed	$158

Error in Engineering Report: Vol. I, Table 10-11 p. 179

Bear River Development Project
Potential Reservoir Sites and Analysis Results

Last Update: 11/28/12

Bowen Collins & Associates, Inc. CONSULTING ENGINEERS HDR

DRAFT

Table 10-11

Combination Cost Comparison (in Millions of Dollars)*

Item #	Description	Combo A	Combo B	Combo C	Combo D	Combo E	Combo F	Combo G	Combo H	Combo I	Combo J	Combo K	Combo L	Combo M
	Reservoir Site and Facitility	**$268.0**	**$278.2**	**$251.4**	**$290.4**	**$305.6**	**$350.4**	**$366.2**	**$410.1**	**$245.2**	**$358.6**	**$385.9**	**$485.2**	**$533.7**
8	Above Cutler Dam	$47.3			$47.3					$47.3		$47.3	$47.3	
9	Cub River		$42.8					$42.8		$42.8				$42.8
10	East Promontory						$323.3	$323.3			$319.3	$273.3		
11	Fielding	$36.7	$38.3	$38.3	$38.3	$38.3			$39.3	$31.1	$39.3	$38.3	$38.3	$38.3
12	Hyrum Enlargement			$27.0	$27.0		$27.0			$27.0		$27.0		
13	Temple Fork					$97.0				$97.0				$97.0
14	Washakie												$399.6	
15	Weber Bay	$184.1	$197.0	$186.0	$177.8	$170.3								
16	Whites Valley								$370.8					$355.5
	Bear River Pipeline Construction Costs	**$346.0**	**$365.3**	**$365.3**	**$365.3**	**$365.3**	**$356.1**	**$356.1**	**$300.6**	**$281.6**	**$376.5**	**$372.5**	**$374.9**	**$297.0**
1	North Box Elder Co. Reach	$192.4	$202.8	$202.8	$202.8	$202.8	$105.6	$105.6	$64.5	$136.5	$164.6	$155.6	$202.8	$61.0
2	Elwood to Brigham City	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$95.5	$0.0	$0.0	$0.0	$0.0	$95.5
3	East Promontory to Brigham City	$0.0	$0.0	$0.0	$0.0	$0.0	$47.2	$47.2	$0.0	$0.0	$44.8	$44.8	$0.0	$0.0
4	South Box Elder Co. Reach	$70.4	$79.3	$79.3	$79.3	$79.3	$98.2	$98.2	$57.5	$71.1	$93.2	$98.2	$98.2	$57.5
5	Weber Co. Reach	$83.1	$83.1	$83.1	$83.1	$83.1	$73.9	$73.9	$83.1	$73.9	$73.9	$73.9	$73.9	$83.1
6	Honeyville Diversion Pump Station						$31.2	$31.2						
	Cache County Project Facilities	**$23.6**	**$28.2**	**$28.2**	**$0.0**	**$28.2**	**$28.2**	**$28.2**	**$28.2**	**$0.0**	**$28.2**	**$0.0**	**$0.0**	**$28.2**
7	Collinston Connection	$23.6	$28.2	$28.2		$28.2	$28.2	$28.2	$28.2		$28.2			$28.2
	Running Subtotal:	**$637.6**	**$671.6**	**$644.8**	**$655.7**	**$699.0**	**$734.7**	**$750.5**	**$738.9**	**$526.8**	**$763.2**	**$758.5**	**$860.2**	**$858.9**
	Mobilization/Field Oversight Expenses	**$63.8**	**$67.2**	**$64.5**	**$65.6**	**$69.9**	**$73.5**	**$75.0**	**$73.9**	**$52.7**	**$76.3**	**$75.8**	**$86.0**	**$85.9**
17	Contractor General Conditions (Prime) - 10%	$63.76	$67.2	$64.5	$65.6	$69.9	$73.5	$75.0	$73.9	$52.7	$76.3	$75.8	$86.0	$85.9
	Running Subtotal:	**$701.3**	**$738.8**	**$709.3**	**$721.2**	**$768.9**	**$808.2**	**$825.5**	**$812.8**	**$579.4**	**$839.6**	**$834.3**	**$946.2**	**$944.7**
	Project Administration & Management	**$280.5**	**$295.5**	**$283.7**	**$288.5**	**$307.6**	**$323.3**	**$330.2**	**$325.1**	**$231.8**	**$335.8**	**$333.7**	**$378.5**	**$377.9**
18	Legal & Admin - 10%	$70.13	$73.9	$70.9	$72.1	$76.9	$80.8	$82.6	$81.3	$57.9	$84.0	$83.4	$94.6	$94.5
19	Engineering - 5%	$35.1	$36.9	$35.5	$36.1	$38.4	$40.4	$41.3	$40.6	$29.0	$42.0	$41.7	$47.3	$47.2
20	Scope Contingency/Market Conditions - 25%	$175.3	$184.7	$177.3	$180.3	$192.2	$202.0	$206.4	$203.2	$144.9	$209.9	$208.6	$236.5	$236.2
	Bear River Pipeline Project Grand Total:	**$982**	**$1,034**	**$993**	**$1,010**	**$1,076**	**$1,131**	**$1,156**	**$1,138**	**$811**	**$1,175**	**$1,168**	**$1,325**	**$1,323**

*Costs represent comparison values only

Error in Engineering Report: Vol. I, Table 10-11 p. 179

Table 10-11

Combination Cost Comparison (in Millions of Dollars)*

Item #	Description	Combo A	Combo B	Combo C	Combo D	Combo E	Combo F	Combo G	Combo H
	Reservoir Site and Facitility	**$268.0**	**$278.2**	**$251.4**	**$290.4**	**$305.6**	**$350.4**	**$366.2**	**$410**
8	Above Cutler Dam	$47.3			$47.3				
9	Cub River		$42.8					$42.8	
10	East Promontory						$323.3	$323.3	
11	Fielding	$36.7	$38.3	$38.3	$38.3	$38.3			$39
12	Hyrum Enlargement			$27.0	$27.0		$27.0		
13	Temple Fork					$97.0			
14	Washakie								
15	Weber Bay	$184.1	$197.0	$186.0	$177.8	$170.3			
16	Whites Valley								$370

Error in Engineering Report: Vol. I, Table 12-2 p. 194

Table 12-2
State of Utah
Division of Water Resources
Bear River Project Cost-Reservoir Combination B
Bear River Pipeline Concept Report
Opinion of Probable Construction Costs
20 Cities ENR Index = 8600 - March 2010

				Bear River Project Grand Total:	$ 1,219,830,000	
Item #	Description	Quantity	UOM	Unit Price	Total Price	Comments/Assumptions
	Bear River Pipeline Construction Costs				$367,736,000	
1	North Box Elder Co. Reach - 150" Diam	94,480	LF	$2,147	$202,849,000	Pipeline costs include pipe materials,
2	South Box Elder Co. Reach - 150" Diam	36,950	LF	$2,147	$79,332,000	coatings/linings, installation, est ROW acquisition,
3	Weber Co. Reach - 90" Diam	79,270	LF	$1,049	$83,155,000	surface restoration, utilities relocation, and general
4	Metering Vaults	3	EA	$800,000	$2,400,000	
	Reservoirs (including pump stations)				$306,300,000	
1	Cub River	1	LS	$42,800,000	$42,800,000	
2	Fielding	1	LS	$38,300,000	$38,300,000	
3	Weber Bay	1	LS	$197,000,000	$197,000,000	
4	Collinston Connection	1	LS	$28,200,000	$28,200,000	
	Cache County Project Facilities				$115,239,000	See Chapter 7 for details on Cache County Facilities
1	72" Pipeline to Cutler Reservoir	24,728	LF	$704	$17,409,000	From Collinston Diversion (from Washakie Res)
2	30" Pipeline to Newton Reservoir	23,660	LF	$209	$4,945,000	From a Pump Station at Cutler Reservoir
3	Newton Reservoir Pipeline Pump Station	2,600	HP	$3,000	$7,800,000	Cost per HP derived from Cost Memorandum
4	48" Pipeline to 8th Ward Canal	59,747	LF	$473	$28,231,000	From a Pump Station at Cutler Reservoir
5	8th Ward Canal Pipeline Pump Station	2,900	HP	$2,900	$8,410,000	Cost per HP derived from Cost Memorandum
6	42" Pipeline to Hyrum Reservoir	92,570	LF	$325	$30,067,000	From a Pump Station at Cutler Reservoir
7	Hyrum Reservoir Pipeline Pump Station	3,900	HP	$2,700	$10,530,000	Cost per HP derived from Cost Memorandum
8	24" Pipeline to Richmond Irr. Company	13,150	LF	$201	$2,647,000	From a Pump Station at Cutler Reservoir
9	Richmond Pipeline Pump Station	1,300	HP	$4,000	$5,200,000	Cost per HP derived from Cost Memorandum
				Running Subtotal:	$789,275,000	
	Mobilization/Field Oversight Expenses				$78,928,000	
1	Contractor General Conditions (Prime)	1	LS	10%	$78,928,000	
				Running Subtotal:	$868,210,000	
	Project Administration & Management				$351,620,000	
1	Legal & Admin	1	ls	10%	$86,820,000	
2	Engineering	1	ls	5%	$47,750,000	
4	Scope Contingency/Market Conditions	1	ls	25%	$217,050,000	
				Bear River Project Grand Total:	$1,219,830,000	Total Estimated Constr Costs w/ Contingency

AACE International CLASS 4 Cost Estimate. This estimate is prepared based on information where the preliminary engineering is from 1 to 5 percent complete. Examples of estimating methods used would include equipment and system process factors, scale-up factors, and parametric and modeling techniques. This estimate requires more time expended in its development. The typical expected accuracy range for this class estimate is -15 to -30 percent on the low side and +20 to +50 percent on the high side.

Error in Engineering Report: Vol. I, Table 12-2 p. 194

Table 12-2
State of Utah
Division of Water Resources
Bear River Project Cost-Reservoir Combination B
Bear River Pipeline Concept Report
Opinion of Probable Construction Costs
20 Cities ENR Index = 8600 - March 2010

				Bear River Project Grand Total:	$ 1,219,830,000
Item #	Description	Quantity	UOM	Unit Price	Total Price
	Bear River Pipeline Construction Costs				$367,736,000
1	North Box Elder Co. Reach - 150" Diam	94,480	LF	$2,147	$202,849,000
2	South Box Elder Co. Reach - 150" Diam	36,950	LF	$2,147	$79,332,000
3	Weber Co. Reach - 90" Diam	79,270	LF	$1,049	$83,155,000
4	Metering Vaults	3	EA	$800,000	$2,400,000
	Reservoirs (including pump stations)				$306,300,000
1	Cub River	1	LS	$42,800,000	$42,800,000
2	Fielding	1	LS	$38,300,000	$38,300,000
3	Weber Bay	1	LS	$197,000,000	$197,000,000

Features Dropped & Cost Assignment: Reservoirs

=VLOOKUP(G6,$S$22:$T$29,2,FALSE)

G	H	I	J	K	L	M	N	O	P	Q	R	S	T
12, and G12; etc. Step 2: Cells L3 to O29. Step 3: columns G and H.					Last step: cells B7 to E7, B10 to E10, etc.								
	constr. cost	Inundated acres			Reservoirs, from **Table 10-8**, p. 10-19 (PDF p. 175) and Table 10-14, p. 10-27 (PDF p. 183) of July 2014 Volume I of II, Bear River Pipeline Concept Repo								
	of reservoirs	of reservoirs	namely these		storage capacity in AF	Wetlands inundated							
Total AF/yr	using L22--P29	using L22-P29	reservoirs		27,000	297	Cub River						
220,000	$278,122,000	7928	need all three reservoirs		70,000	790	Fielding						
					124,000	6841	Weber Bay						
					221,000	7928	Combined						
160,000	$235,300,000	7631	Fielding & Weber Bay		0.995475113	conversion of AF of storage capacity to AF/year of water flow							
					capacity to provide flow, AF/year								
							cost, $/AF	cost, $					
160,000	$235,300,000	7631	Fielding & Weber Bay		26,878	Cub River	1586	42,822,000	<-consistent with Table 10-11 and Table 12-2				
					69,683	Fielding	280	~~19,600,000~~	<-inconsistent with Table 10-11 and Table 12-2, which agree on:				38,3
					123,439	Weber Bay	1277	~~158,348,000~~	<-inconsistent with Table 10-11 and Table 12-2, which agree on:				197,0
170,000	$235,300,000	7631	Fielding & Weber Bay		Various Combinations								
					AF/yr			cost					
					96,561	Cub River & Fielding		81,122,000					
170,000	$235,300,000	7631	Fielding & Weber Bay		150,317	Cub River & Weber Bay		239,822,000					
					193,122	Fielding & Weber Bay		235,300,000					
100,000	$197,000,000	6841	Weber Bay		Requried AF/yr	inferred Least-cost Reservoir combination			Inundated Wetlands				values fo
					220,000	need all three reservoirs		$278,122,000	7928			220,000	$278,12
					170,000	Fielding & Weber Bay		$235,300,000	7631			170,000	$235,30
110,000	$197,000,000	6841	Weber Bay		160,000	Fielding & Weber Bay		$235,300,000	7631			160,000	$235,30
					120,000	Weber Bay		$197,000,000	6841			120,000	$197,00
					110,000	Weber Bay		$197,000,000	6841			110,000	$197,00
110,000	$197,000,000	6841	Weber Bay		100,000	Weber Bay		$197,000,000	6841			100,000	$197,00
					60,000	Fielding		$38,300,000	790			60,000	$38,30
					50,000	Fielding		$38,300,000	790			50,000	$38,30
110,000	$197,000,000	6841	Weber Bay										
110,000	$197,000,000	6841	Weber Bay										
120,000	$197,000,000	6841	Weber Bay										
					Summary of this Sheet, Adjusted to include Overhead								
						Cache County	Bear River WCD	Weber Basin WC	Jordan Valley WCD				
50,000	$38,300,000	790	Fielding		1	$116,811,240	$116,811,240	$97,342,700	$97,342,700		$428,307,880		
					2	#VALUE!	$135,885,750	$113,238,125	$113,238,125				
					3	$135,885,750	#VALUE!	$113,238,125	$113,238,125				

JdnWbr | Reservoirs | T12dash2 | Totals | Presentation | DSCRatios | PerCap

Features Dropped & Cost Assignment: Reservoirs

Aggregate Results

Sc.	AF flow	cost, $	inundated ac.	reservoirs
1.	220,000	278,122,000	7928	Fielding, Weber Bay, Cub River
2.	160,000	235,300,000	7631	Fielding, Weber Bay
3.	160,000	235,300,000	7631	Fielding, Weber Bay
4.	170,000	235,300,000	7631	Fielding, Weber Bay
5.	170,000	235,300,000	7631	Fielding, Weber Bay
6.	100,000	197,000,000	6841	Weber Bay
7.	110,000	197,000,000	6841	Weber Bay
8.	110,000	197,000,000	6841	Weber Bay
9.	110,000	197,000,000	6841	Weber Bay
10.	110,000	197,000,000	6841	Weber Bay
11.	120,000	197,000,000	6841	Weber Bay
12.	50,000	38,300,000	790	Fielding
13.	50,000	38,300,000	790	Fielding
14.	60,000	38,300,000	790	Fielding
15.	60,000	38,300,000	790	Fielding

There is some underestimation here (e.g., Cache WD may need Cub River; neither it nor Bear River WCD may be able to use Weber Bay) and some overestimation (reservoirs outside of Combination B might become optimal).

Next we need to disaggregate.

Features Dropped & Cost Assignment: Reservoirs

Assignment by water shares

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
AF	60,000	60,000	50,000	50,000	
1.	27.3%	27.3%	22.7%	22.7%	100.0%
2.	0.0%	37.5%	31.3%	31.3%	100.0%
3.	37.5%	0.0%	31.3%	31.3%	100.0%
4.	35.3%	35.3%	0.0%	29.4%	100.0%
5.	35.3%	35.3%	29.4%	0.0%	100.0%
6.	0.0%	0.0%	50.0%	50.0%	100.0%
7.	0.0%	54.5%	0.0%	45.5%	100.0%
8.	0.0%	54.5%	45.5%	0.0%	100.0%
9.	54.5%	0.0%	0.0%	45.5%	100.0%
10.	54.5%	0.0%	45.5%	0.0%	100.0%
11.	50.0%	50.0%	0.0%	0.0%	100.0%
12.	0.0%	0.0%	0.0%	100.0	100.0%
13.	0.0%	0.0%	100.0%	0.0%	100.0%
14.	0.0%	100.0%	0.0%	0.0%	100.0%
15.	100.0%	0.0%	0.0%	0.0%	100.0%

Features Dropped & Cost Assignment: Reservoirs

Disaggregated costs, $

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	75,851,455	75,851,455	63,209,545	63,209,545	278,122,000
2.	0	88,237,500	73,531,250	73,531,250	235,300,000
3.	88,237,500	0	73,531,250	73,531,250	235,300,000
4.	83,047,059	83,047,059	0	69,205,882	235,300,000
5.	83,047,059	83,047,059	69,205,882	0	235,300,000
6.	0	0	98,500,000	98,500,000	197,000,000
7.	0	107,454,545	0	89,545,455	197,000,000
8.	0	107,454,545	89,545,455	0	197,000,000
9.	107,454,545	0	0	89,545,455	197,000,000
10.	107,454,545	0	89,545,455	0	197,000,000
11.	98,500,000	98,500,000	0	0	197,000,000
12.	0	0	0	38,300,000	38,300,000
13.	0	0	38,300,000	0	38,300,000
14.	0	38,300,000	0	0	38,300,000
15.	38,300,000	0	0	0	38,300,000

- Features Dropped & Cost Assignment: Southern Districts' Infrastructure
- Features Dropped & Cost Assignment: Reservoirs
- Features Dropped & Cost Assignment: Misc. Northern Infrastructure
- Features Dropped & Cost Assignment: Summary
- Additional Costs
- These Costs in Perspective
- Conclusion for September Report

Features Dropped & Cost Assignment: Misc. Northern Infrastructure

1. Cache County Project Facilities: needed if and only if Cache WD participates.
2. North Box Elder County Reach Pipeline, South Box Elder County Reach Pipeline, and Collinston Connection: needed if Box Elder or Weber Basin or Jordan Valley participates [inclusive "or"].
3. Weber County Reach Pipeline: needed if Weber Basin or Jordan Valley participates

Features Dropped & Cost Assignment: Misc. Northern Infrastructure

One could assign Misc. Northern Infrastructure costs according to the districts benefiting from each feature.

Features Dropped & Cost Assignment: Misc. Northern Infrastructure, Cache County Facilities

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	177,468,060	0	0	0	177,468,060
2.	0	0	0	0	0
3.	177,468,060	0	0	0	177,468,060
4.	177,468,060	0	0	0	177,468,060
5.	177,468,060	0	0	0	177,468,060
6.	0	0	0	0	0
7.	0	0	0	0	0
8.	0	0	0	0	0
9.	177,468,060	0	0	0	177,468,060
10.	177,468,060	0	0	0	177,468,060
11.	177,468,060	0	0	0	177,468,060
12.	0	0	0	0	0
13.	0	0	0	0	0
14.	0	0	0	0	0
15.	177,468,060	0	0	0	0

Features Dropped & Cost Assignment: Misc. Northern Infrastructure, Collinston & N&S Box Elder Co. Pipelines

Divide between Box Elder, Weber Basin, & Jordan Valley WCDs proportional to water shares (60/50/50 thousand AF); adjust for opt-outs.

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	0	179,198,250	149,331,875	149,331,875	477,862,000
2.	0	179,198,250	149,331,875	149,331,875	477,862,000
3.	0	0	238,931,000	238,931,000	477,862,000
4.	0	260,652,000	0	217,210,000	477,862,000
5.	0	260,652,000	217,210,000	0	477,862,000
6.	0	0	238,931,000	238,931,000	477,862,000
7.	0	260,652,000	0	217,210,000	477,862,000
8.	0	260,652,000	217,210,000	0	477,862,000
9.	0	0	0	477,862,000	477,862,000
10.	0	0	477,862,000	0	477,862,000
11.	0	477,862,000	0	0	477,862,000
12.	0	0	0	477,862,000	477,862,000
13.	0	0	477,862,000	0	477,862,000
14.	0	477,862,000	0	0	477,862,000
15.	0	0	0	0	0

Features Dropped & Cost Assignment: Misc. Northern Infrastructure, Weber County Reach Pipeline

Divide evenly between Weber & Jordan Valley if both join, else 100% to the joiner.

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	0	0	63,987,000	63,987,000	127,974,000
2.	0	0	63,987,000	63,987,000	127,974,000
3.	0	0	63,987,000	63,987,000	127,974,000
4.	0	0	0	127,974,000	127,974,000
5.	0	0	127,974,000	0	127,974,000
6.	0	0	63,987,000	63,987,000	127,974,000
7.	0	0	0	127,974,000	127,974,000
8.	0	0	127,974,000	0	127,974,000
9.	0	0	0	127,974,000	127,974,000
10.	0	0	127,974,000	0	127,974,000
11.	0	0	0	0	0
12.	0	0	0	127,974,000	127,974,000
13.	0	0	127,974,000	0	127,974,000
14.	0	0	0	0	0
15.	0	0	0	0	0

Features Dropped & Cost Assignment: Misc. Northern Infrastructure

Or one could assign Misc. Northern Infrastructure costs in proportion to water delivered.

Features Dropped & Cost Assignment: Misc. Northern Infrastructure, All, Costs $\propto$ Water

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	213,628,380	213,628,380	178,023,650	178,023,650	783,304,060
2.	0	227,188,500	189,323,750	189,323,750	605,836,000
3.	293,739,023	0	244,782,519	244,782,519	783,304,060
4.	276,460,256	276,460,256	0	230,383,547	783,304,060
5.	276,460,256	276,460,256	230,383,547	0	783,304,060
6.	0	0	302,918,000	302,918,000	605,836,000
7.	0	330,456,000	0	275,380,000	605,836,000
8.	0	330,456,000	275,380,000	0	605,836,000
9.	427,256,760	0	0	356,047,300	783,304,060
10.	427,256,760	0	356,047,300	0	783,304,060
11.	327,665,030	327,665,030	0	0	655,330,060
12.	0	0	0	605,836,000	605,836,000
13.	0	0	605,836,000	0	605,836,000
14.	0	477,862,000	0	0	477,862,000
15.	177,468,060	0	0	0	177,468,060

I chose to allocate these costs this way, proportional to water allocations.

- Features Dropped & Cost Assignment: Southern Districts' Infrastructure
- Features Dropped & Cost Assignment: Reservoirs
- Features Dropped & Cost Assignment: Misc. Northern Infrastructure
- Features Dropped & Cost Assignment: Summary
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- Conclusion for September Report

Summary: Features Dropped (Table C)

Scenarios	Water Districts Dropped	Engineering Features Dropped
1	None	None
2	Cache WD	Cub River Reservoir and Cache County Project Facilities
3	Bear River WCD	Cub River Reservoir
4	Weber Basin WCD	Cub River Reservoir, Weber Basin WCD Pump Station and Pipeline
5	Jordan Valley WCD	Cub River Reservoir, Jordan Valley WCD Pump Station and Pipeline
6	Cache WD and Bear River WCD	Fielding Reservoir, Cub River Reservoir, Cache County Project Facilities
7	Cache WD and Weber WCD	Fielding Reservoir, Cub River Reservoir, Cache County Project Facilities, Weber Basin WCD Pump Station and Pipeline
8	Cache WD and Jordan Valley WCD	Fielding Reservoir, Cub River Reservoir, Cache County Project Facilities, Jordan Valley WCD Pump Station and Pipeline
9	Bear River WCD and Weber Basin WCD	Fielding Reservoir, Cub River Reservoir, Weber Basin WCD Pump Station and Pipeline

Summary: Features Dropped (Table C)

10	Bear River WCD and Jordan Valley WCD	Fielding Reservoir, Cub River Reservoir, Jordan Valley WCD Pump Station and Pipeline
11	Weber Basin WCD and Jordan Valley WCD	Fielding Reservoir, Cub River Reservoir, West Haven WTP, Jordan Valley WCD Pump Station and Pipeline, Weber Basin WCD Pump Station and Pipeline, Weber County Reach
12	Cache WD, Bear River WCD, Weber Basin WCD	Weber Bay Reservoir, Cub River Reservoir, Weber Basin WCD Pump Station and Pipeline, Cache County Project Facilities
13	Cache WD, Bear River WCD, Jordan Valley WCD	Weber Bay Reservoir, Cub River Reservoir, Jordan Valley WCD Pump Station and Pipeline, Cache County Project Facilities
14	Cache WD, Weber Basin WCD, Jordan Valley WCD	Weber Bay Reservoir, Cub River Reservoir, West Haven WTP, Jordan Valley WCD Pump Station and Pipeline, Weber Basin WCD Pump Station and Pipeline, Cache County Project Facilities, Weber County Reach
15	Bear River WCD, Weber Basin WCD, Jordan Valley WCD	All engineering features except Fielding Reservoir and Cache County Project Facilities

Resulting Construction Costs (2010 dollars)

District subtotals suppressed.

Scenario	2010 $
1.	1,654,761,940
2.	1,411,348,000
3.	1,588,816,060
4.	1,537,622,060
5.	1,443,110,060
6.	1,352,366,000
7.	1,301,172,000
8.	1,206,660,000
9.	1,478,640,060
10.	1,384,128,060
11.	958,710,060
12.	1,056,774,000
13.	962,262,000
14.	536,844,000
15.	236,450,060

- Features Dropped & Cost Assignment: Southern Districts' Infrastructure
- Features Dropped & Cost Assignment: Reservoirs
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Additional Costs (all adjustable in the spreadsheet)

- Inflation from 3/2010 to 3/2019: *Engineering News-Record* "20 Cities Index" (about 30%).
- Operations & Maintenance: \$50/AF. Likely an underestimate; State uses \$188/AF in March 2019 dollars (\$145 in March 2010 dollars using the ENR 20-Cities CCI), based on 20% of the capital costs for the Bear River Pipeline to JVWCD.
- Environmental Mitigation: \$100,000 per 'acre of wetlands inundated' (nothing for mitigation of impacts on the Great Salt Lake).

Construction Costs, Updated

Scenario	2010 $	2019 $/Env. Mit./O&M
1.	1,654,761,940	3,180,000,000
2.	1,411,348,000	2,770,000,000
3.	1,588,816,060	3,000,000,000
4.	1,537,622,060	2,950,000,000
5.	1,443,110,060	2,820,000,000
6.	1,352,366,000	2,550,000,000
7.	1,301,172,000	2,490,000,000
8.	1,206,660,000	2,370,000,000
9.	1,478,640,060	2,720,000,000
10.	1,384,128,060	2,600,000,000
11.	958,710,060	2,060,000,000
12.	1,056,774,000	1,500,000,000
13.	962,262,000	1,380,000,000
14.	536,844,000	840,000,000
15.	236,450,060	450,000,000

Last column rounded.

Construction Costs, Updated, by District

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	711,000,000	711,000,000	818,000,000	941,000,000	3,180,000,000
2.	0	823,000,000	911,000,000	1,034,000,000	2,770,000,000
3.	910,000,000	0	984,000,000	1,107,000,000	3,000,000,000
4.	861,000,000	861,000,000	0	1,224,000,000	2,950,000,000
5.	861,000,000	861,000,000	1,102,000,000	0	2,820,000,000
6.	0	0	1,212,000,000	1,335,000,000	2,550,000,000
7.	0	1,082,000,000	0	1,409,000,000	2,490,000,000
8.	0	1,082,000,000	1,288,000,000	0	2,370,000,000
9.	1,209,000,000	0	0	1,515,000,000	2,720,000,000
10.	1,209,000,000	0	1,392,000,000	0	2,600,000,000
11.	1,031,000,000	1,031,000,000	0	0	2,060,000,000
12.	0	0	0	1,504,000,000	1,500,000,000
13.	0	0	1,382,000,000	0	1,380,000,000
14.	0	842,000,000	0	0	840,000,000
15.	453,000,000	0	0	0	450,000,000

Rounded.

Financing Costs (all adjustable in the spreadsheet)

- Interest Rate: 4%
- Debt Repayment Term: 30 years, level payments

Annual Debt Repayments, inclusive of all costs

Sc.	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD	Total
1.	41,100,000	41,100,000	47,300,000	54,400,000	183,900,000
2.	0	47,600,000	52,700,000	59,800,000	160,100,000
3.	52,600,000	0	56,900,000	64,000,000	173,500,000
4.	49,800,000	49,800,000	0	70,800,000	170,400,000
5.	49,800,000	49,800,000	63,700,000	0	163,300,000
6.	0	0	70,100,000	77,200,000	147,300,000
7.	0	62,600,000	0	81,500,000	144,100,000
8.	0	62,600,000	74,500,000	0	137,100,000
9.	69,900,000	0	0	87,600,000	157,500,000
10.	69,900,000	0	80,500,000	0	150,400,000
11.	59,600,000	59,600,000	0	0	119,200,000
12.	0	0	0	87,000,000	87,000,000
13.	0	0	79,900,000	0	79,900,000
14.	0	48,700,000	0	0	48,700,000
15.	26,200,000	0	0	0	26,200,000

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Burden Measure 1: Per Capita Debt Service

Per capita annual debt service based on

- current population for the Cache WD and the Bear River WCD;
- people served for the Weber Basin WCD and the Jordan Valley WCD.

Caveats:

- the water district may not serve the entire county;
- the water district serves businesses as well as households;
- the water districts have various means of raising money;
- the population in the future may be different.

Illustrating Payoffs of a Four-Person Game

How can one illustrate the payoffs of a four-person game, where each person has two strategies, "participate" or "don't participate"?

Conventional two-person representations will not work well:

Per Capita Debt Service: Game 1

Assume neither the Bear River WCD nor the Weber Basin WCD participate.
Then the game between the Cache WC and the Jordan Valley WCD is:

per capita cost (benefits absent): (Cache WD, Jordan Valley WCD)		Jordan Valley WCD	
		participate	*don't participate*
Cache WD	*participate*	$-550, -125$	$-206, 0$
	don't participate	$0, -124$	$0, 0$

(Scenarios 9, 15, 12, and (16).)

Per Capita Debt Service: Game 2

Assume both the Bear River WCD and the Weber Basin WCD participate.
Then the game between the Cache WC and the Jordan Valley WCD is:

per capita gross (benefits absent): (Cache WD, Jordan Valley WCD)		Jordan Valley WCD	
		participate	*don't participate*
Cache WD	*participate*	$-323, -78$	$-392, 0$
	don't participate	$0, -85$	$0, 0$

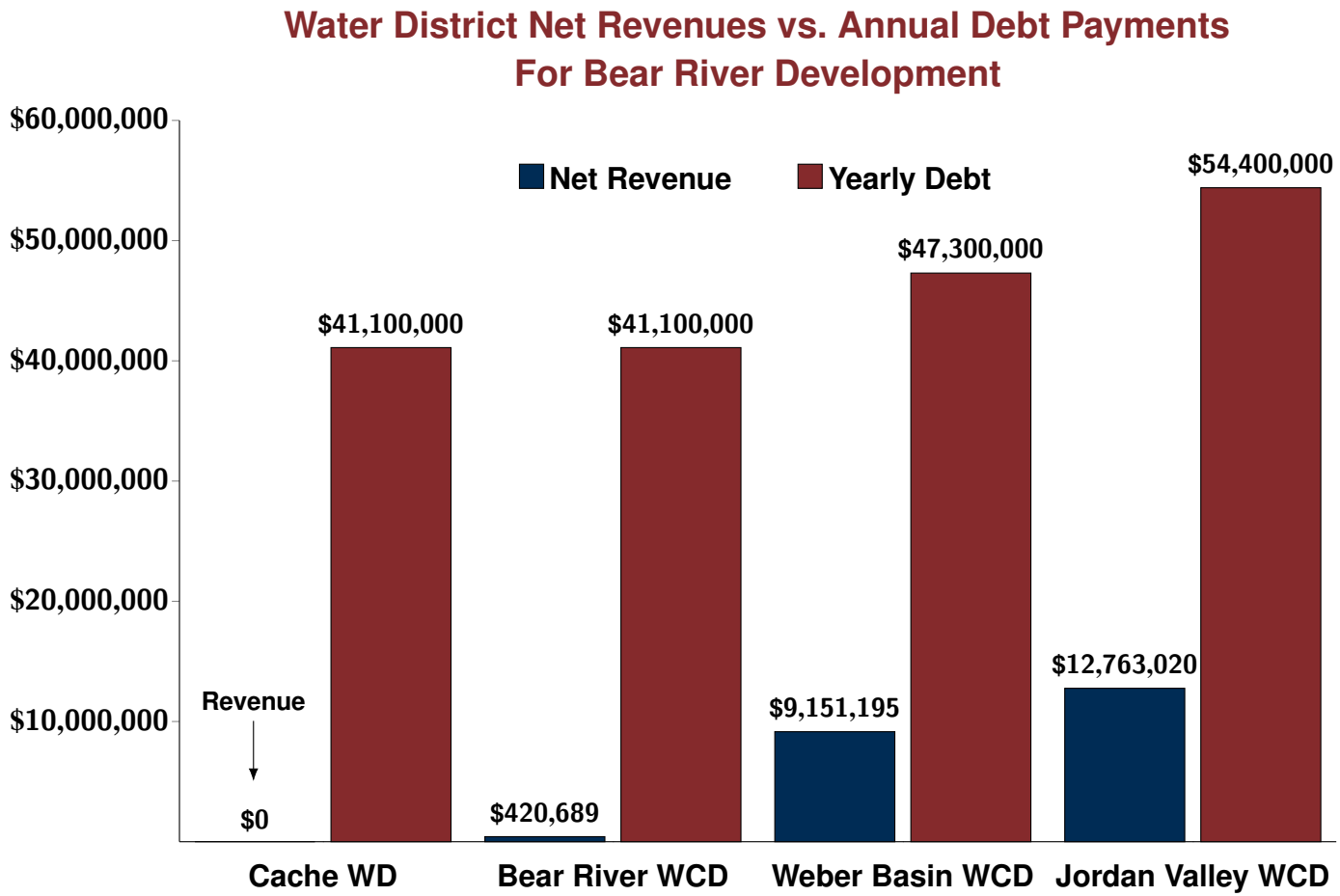
(Scenarios 1, 5, 2, and (16).)

This method, using 2×2 tables to illustrate payoffs, is not going to work.

Per capita annual debt: an alternative representation

	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
Scenario 1	323	748	76	78
Scenario 2		866	85	85
Scenario 3	414		92	91
Scenario 4	392	906		101
Scenario 5	392	906	103	
Scenario 6			113	110
Scenario 7		1139		116
Scenario 8		1139	120	
Scenario 9	550			125
Scenario 10	550		130	
Scenario 11	469	1085		
Scenario 12				124
Scenario 13			129	
Scenario 14		886		
Scenario 15	206			

Burden Measure 2: Annual Revenues and Debt Repayments (inclusive of all costs; Scenario 1)



Debt Service Coverage Ratio

- Ratio of revenues to debt service;
- Higher is better;
- DSCR greater than 2 is compatible with an AAA municipal bond rating;
- DSCR less than 1 corresponds to a junk bond rating.

Debt Service Coverage Ratio: Example

Danyce Steck, CPFO
Finance Director
City of West Jordan,
8000 South Redwood Road
West Jordan, Utah 84088
(801) 569-5100
danyce.steck@westjordan.utah.gov

To: Honorable Mayor and City Council

From: Danyce Steck, Finance Director

Date: July 25, 2019

Re: Water Fund Reserves and Long-term Plan

I've been asked to prepare a memo discussing the City's Water Fund reserves and financial plan. I've chosen to present this information in a question and answer format in hopes of making it easier to answer questions from our citizens. This discussion has several components – best practices, 5-year plan, and the required debt service coverage ratio. I'm available to discuss if needed.

[. . . . .]

Why was there a rate increase if the City has reserves?

The Water Fund has several outstanding bonds (debt) which have certain financial requirements. One of those requirements is a debt service coverage ratio. In short terms, it means the City must have 1.25 times the annual debt payment in net income each year. Below shows that coverage ratio before and after the increase. The increase was critical to maintaining the City's bonding obligations.

	Before rate increase	After rate increase
	FY2017	**FY2018**
Revenue	18,315,350	20,800,974
Less: Operating expenses	(17,415,672)	(16,520,673)
Net income	899,678	4,280,301
Net income	899,678	4,280,301
Divided by: Debt payment	787,192	1,953,296
Debt coverage ratio	1.14	2.19

Debt Service Coverage Ratios (Cache ≈ 0)

	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
Scenario 1	0.01	0.19	0.23
Scenario 2	0.01	0.17	0.21
Scenario 3		0.16	0.20
Scenario 4	0.01		0.18
Scenario 5	0.01	0.14	
Scenario 6		0.13	0.17
Scenario 7	0.01		0.16
Scenario 8	0.01	0.12	
Scenario 9			0.146
Scenario 10		0.11	
Scenario 11	0.01		
Scenario 12			0.147
Scenario 13		0.11	
Scenario 14	0.01		
Scenario 15			

Scenario 12, impact on cities, proportional to projected 2060 water deficits

Water System	Annual Payments for Bear River Development	Total Debt from Bear River Development
Bluffdale	$5,150,000	$79,200,000
Draper City Water	$2,650,000	$40,700,000
Water Pro	$4,380,000	$67,300,000
Granger-Hunter ID	$8,470,000	$130,200,000
Herriman	$6,160,000	$94,700,000
Kearns ID	$15,790,000	$242,700,000
Magna Water	$6,520,000	$100,200,000
Midvale City Water	$1,450,000	$22,300,000
Riverton Water	$6,870,000	$105,600,000
South Jordan	$12,700,000	$195,200,000
South Salt Lake Water	$1,230,000	$18,900,000
Taylorsville-Bennion ID	$3,810,000	$58,600,000
West Jordan City Water	$11,820,000	$181,700,000
Total	$87,000,000	$1,337,000,000

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Caveats & Future Work

- Underestimation of operations & maintenance expenses
- Underestimation of environmental mitigation expenses
- Overestimation of cost of remaining infrastructure under opt-out scenarios
- Future work: water rate increases (requires population growth projections)
- The effect of water rate increases on water demand
- Non-level repayment patterns.

Reception

- Park City, Sept. 5, 2019
- West Valley City, Nov. 21, 2019

(End of externally-funded work.)

October 2019: A new State Report! 1226 p., 3 Vols.

UTAH DIVISION OF WATER RESOURCES

Volume II of III
Bear River Development Report Figures

Consultant Job No. 233-18-01

October 2019

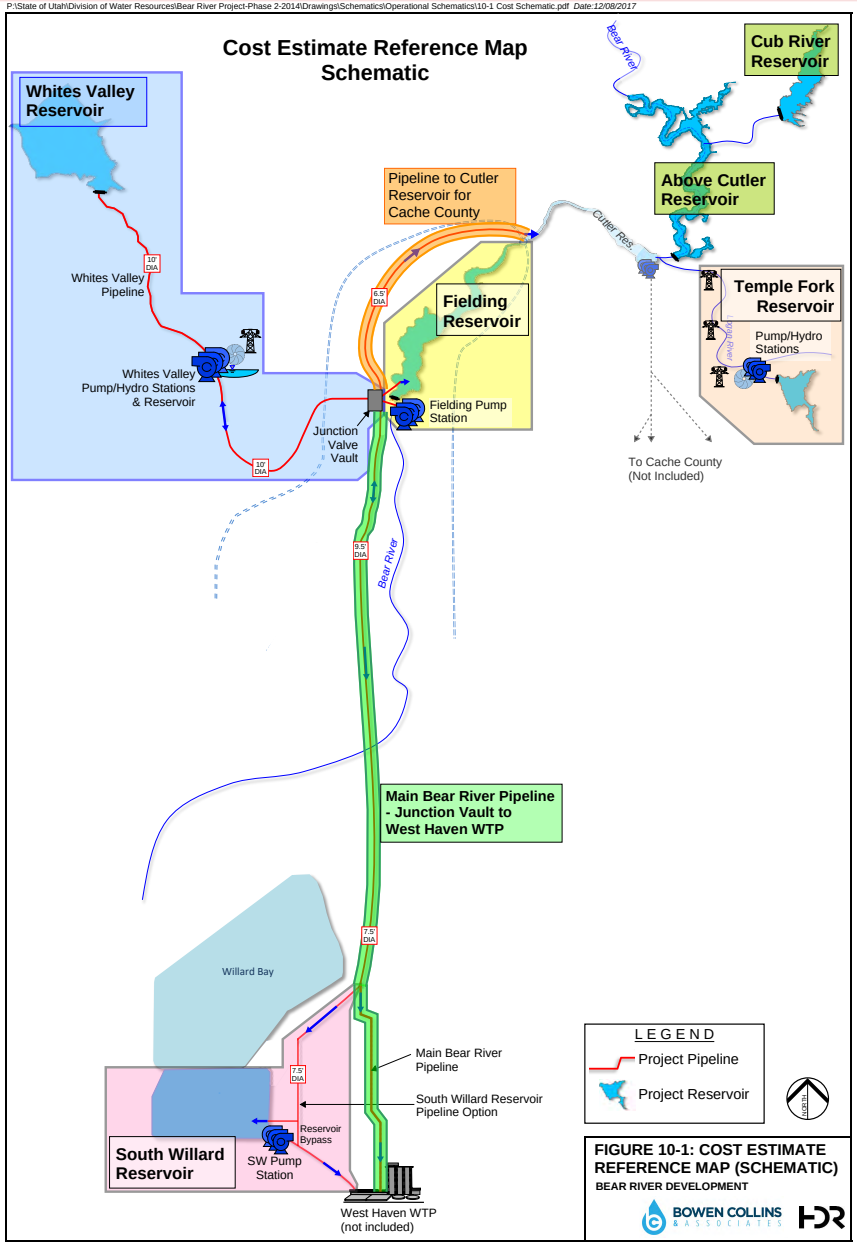
Prepared by: BOWEN COLLINS & ASSOCIATES

In Association with: HDR

The New State Report

- Improvements: incorporation of environmental mitigation costs, at \$100,000/acre, the same as I chose in September; shifting of southern pipeline away from an earthquake fault line.
- Emphasis on siting a reservoir in Whites Valley.
- First complication: flexible reservoir sizes, two for Fielding and ten for Whites Valley. Hence *many* more than seven reservoir combinations ($(2+1)*(10+1)-1=29$ just considering Whites Valley and Fielding).
- Second complication: different reservoir sizes require different pipeline and pump sizes.
- Third complication: extensive pumping of water uphill, and resulting assumptions on the cost of electricity to run the pumps.

2019 State Report Northern Infrastructure Overview



Step 1: Fix Errors in the State Report

1. On pages 98–110 of Vol. II, the cost of building "Fielding 40k" is consistently given as being *higher* than the cost of building "Fielding 70k." Vol. I p. 117 Table 10-1 has a small note at its bottom giving the correct costs.
2. On pages 109–110 of Vol. II, the Pipeline Fielding/Cutler is listed among the needed costs but is missing from the accompanying diagram.

Step 2: Fix Inconsistency in the State Report

1. On pages 17–18 of Vol. I, the State assumed a 4% interest rate and 50-year repayment period.
2. However, on pages 860 and 864 of Vol. III, when calculating the "power cost" line of the State's scenarios, the State used 3% and only considered 20 years' worth of costs.
3. This amounts to inconsistently cherry-picking whichever financing assumptions will make the project look cheaper.
4. Fix: unwind the capitalization of the power costs, extend the power costs to 30 years, then recapitalize them using the same interest rate (4%) and term (30 years) used in the rest of the model.

Step 3a. Build a Set of Rules reflecting the State's Scenarios A–M: Fielding Pump

```
ReservoirsAndPumpsPipes =
    Map[
     If[Cache == True && BoxElder == False && Weber == False &&
        Jordan == False &&
        (#[[CubRPosition, AFPosition]] > 0 ||
          #[[AboveCutlerPosition, AFPosition]] > 0 ||
          #[[TempleForkPosition, AFPosition]] > 0)
       (*then Fielding Pump is unneeded*),
       #, (* else Fielding Pump is needed *)
       If[(#[[CubRPosition, AFPosition]] > 0 ||
            #[[AboveCutlerPosition, AFPosition]] > 0 ||
            #[[TempleForkPosition, AFPosition]] > 0) &&
         #[[WhitesVPosition, AFPosition]] == 0 &&
         #[[FieldingPosition, AFPosition]] > 0,
        AddToCost[FieldingPump - FieldingPumpAdjustment, #],
        (*else*)
        AddToCost[FieldingPump, #]
       ]] &, Reservoirs];
```

Step 3b. Build a Set of Rules reflecting the State's Scenarios A–M: Fielding/Cutler Pipeline

```
ReservoirsAndPumpsPipes = Map[
    If[Cache == False ||
      (#[[CubRPosition, AFPosition]] > 0 &&
        #[[AboveCutlerPosition, AFPosition]] > 0 &&
        #[[TempleForkPosition, AFPosition]] > 0), #,
     (* else Pipeline Fielding/Cutler is needed *)
     If[#[[FieldingPosition, AFPosition]] == 40 000,
      AddToCost[PipeFieldingCutlerShort, #],
      AddToCost[PipeFieldingCutlerLong, #]]
    ] &,
   ReservoirsAndPumpsPipes];
```

Step 3c. Build a Set of Rules reflecting the State's Scenarios A–M: Fielding-WHaven Pipeline; BR Diversion

```
ReservoirsAndPumpsPipes =
    Map[If[Weber == True || Jordan == True,
       AddToCost[PipeFieldingWHaven, #], #] &,
     ReservoirsAndPumpsPipes];
  Export["OutputNewBear3.dat", ReservoirsAndPumpsPipes];
ReservoirsAndPumpsPipes =
    Map[If[#[[FieldingPosition, AFPosition]] == 0 &&
        (BoxElder || Weber || Jordan ||
          (Cache && (#[[CubRPosition, AFPosition]] == 0 &&
              #[[AboveCutlerPosition, AFPosition]] == 0 &&
              #[[TempleForkPosition, AFPosition]] == 0)))
       ,
       AddToCost[BearRDiversion, #], #] &,
     ReservoirsAndPumpsPipes];
```

Step 3 Verification Procedure

Can the *Mathematica* program can duplicate the State's thirteen Scenarios A–M?

1. Remove the corrections for State inconsistencies and errors;
2. Generate all the possible reservoir combinations for our Scenario 1, the only participation scenario the State considers;
3. Check whether present among the 528 possible reservoir combinations generated in the previous step are the thirteen State scenarios, with exactly the same calculated aggregate cost and acre-feet of capacity which the State had for them.

There are, except for Scenario I, which is absent from the *Mathematica* possibilities because it violates the constraint that storage has to be greater than or equal to 400,000 AF when all the Districts participate. (Scenario I only has 244,000 AF of storage.)

Step 3 Results: Least-Cost Reservoir Combinations (528 possible)

Sc.	reservoirs
1	Whites Valley 400k
2	Whites Valley 305k
3	Whites Valley 305k
4	Whites Valley 319k
5	Whites Valley 319k
6	Whites Valley 305k
7	Whites Valley 305k
8	Whites Valley 305k
9	Whites Valley 305k
10	Whites Valley 305k
11	Whites Valley 305k
12	Fielding 70k, Temple Fork
13	Fielding 70k, Temple Fork
14	Fielding 70k, Temple Fork
15	Fielding 70k, Temple Fork

Last Steps

1. Feed the *Mathematica* results back into the spreadsheet.
2. For each scenario the spreadsheet then adds contingency costs, engineering/legal/administrative overhead, inflation from 8/17 to 3/19, and capitalized O&M, then
3. allocates them to the participating districts. This completes analysis of the northern infrastructure.
4. The spreadsheet calculates southern infrastructure costs and allocations with new numbers but with the same procedure as before,
5. then combines the northern and southern analyses to get overall conclusions, again using the same procedure as before.

The new conclusions are:

Per capita annual debt (previous results as subscripts)

	Cache WD	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
Scenario 1	239_{323}	552_{748}	61_{76}	64_{78}
Scenario 2		679_{866}	71_{85}	73_{85}
Scenario 3	306_{414}		73_{92}	75_{91}
Scenario 4	291_{392}	673_{906}		85_{101}
Scenario 5	291_{392}	673_{906}	84_{103}	
Scenario 6			101_{113}	99_{110}
Scenario 7		988_{1139}		106_{116}
Scenario 8		988_{1139}	108_{120}	
Scenario 9	445_{550}			108_{125}
Scenario 10	445_{550}		111_{130}	
Scenario 11	276_{469}	639_{1085}		
Scenario 12				141_{124}
Scenario 13			147_{129}	
Scenario 14		660_{886}		
Scenario 15	255_{206}			

Debt Service Coverage Ratios (Cache ≈ 0; previous results subscripts)

	Bear River WCD	Weber Basin WCD	Jordan Valley WCD
Scenario 1	0.01	$0.24_{0.19}$	$0.28_{0.23}$
Scenario 2	0.01	$0.21_{0.17}$	$0.25_{0.21}$
Scenario 3		$0.20_{0.16}$	$0.24_{0.20}$
Scenario 4	0.01		$0.21_{0.18}$
Scenario 5	0.01	$0.17_{0.14}$	
Scenario 6		$0.15_{0.13}$	$0.18_{0.17}$
Scenario 7	0.01		$0.17_{0.16}$
Scenario 8	0.01	$0.14_{0.12}$	
Scenario 9			$0.17_{0.15}$
Scenario 10		$0.13_{0.11}$	
Scenario 11	0.01		
Scenario 12			$0.13_{0.15}$
Scenario 13		$0.10_{0.11}$	
Scenario 14	0.01		
Scenario 15			

For More Information

Visit

`www.economics.utah.edu/lozada` ,

click on

"Miscellaneous Research Materials,"

and find the section on

"The Bear River Development."

The Bear River Development

Report
Slide Presentation, Nov. 2019
Excel Spreadsheet, Sept. 2019
Explanation of the Spreadsheet
Slide Presentation, Feb. 2020
Analysis of the State's October 2019 report: Excel file and *Mathematica* file in Wolfram notebook and PDF formats.

Working paper "Egalitarian Repayment Plans for Public Projects with an application to the Financing of Water Infrastructure":

With population growth rate g, non-level repayments

$$M_t = M_0 e^{gt}$$

yield straightforward results, but "pay as you go"

$$M_t \propto \frac{\dot{Q}_t}{Q^*} e^{gt}$$

yields

$$XQ_t^Y e^{Wt} - Ze^{-rt} = \dot{Q}_t$$

which *Mathematica* can't solve, so I'll have to switch to discrete time and solve by iteration.