Explanation of Gabriel Lozada’s BearRiverScenarios.xlsx spreadsheet.

The spreadsheet only analyzes “Combination B.” It is the less expensive of the two Combinations which the engineering report recommended.[[1]](#footnote-1)

**Sheet 1, “JdnWbr.”** This sheet only uses the data from Table 12-5 (page 12-7) of the engineering report, and only the columns “West Haven WTP,” “Finished Water pipeline to WBWCD/JVWCD,” and “Finished Water Reservoir and Pump Station” (all under the “Project Costs” heading). So nothing on this sheet deals with Cache County or the Bear River WCD. The purpose of the sheet is to divide these costs into a portion for the Weber Basin WCD and another portion for the Jordan Valley WCD for each of the 15 scenarios.

The total cost of the West Haven WTP is in cell I3. In scenarios having both Weber and Jordan participate, this total cost is divided half-half between them; for example see cells D19 and E19. This half-half split is the same as in Table 12-5’s “West Haven WTP” column. However in scenarios in which only one of those two districts participate, the participating district has to pay the entire cost; for example see cells D16 and E16, for scenario 5, in which Weber participates and Jordan does not.

This explains the first of each vertical pair of numbers in columns D and E, for example, D4 and E4, D7 and E7, D10 and E10, D13 and E13, etc.

That completes analysis of Table 12-5’s “West Haven WTP” figures.

Now turn to the other two columns of interest from Table 12-5 (“Finished Water pipeline to WBWCD/JVWCD,” and “Finished Water Reservoir and Pump Station”). Those figures (reflecting a cost assignment of “26% WBWCD and 74% JVWCD” according to note 2 of Table 12-5, “based on the February 2004 Cost Allocation Study for the Wasatch Front Regional Water Project”) are transferred to cells K5 to L6 of the spreadsheet. The sum of those costs for each district is in cells K7 for Weber and L7 for Jordan. Then the K7 number represents costs for Weber in cells D5, D8, D11, D17, etc. Similarly, the L7 number represents costs for Jordan in cells E5, E8, E11, E14, etc.

To finish, each pair of costs---for example, D4 and D5, E4 and E5, D7 and D8, E7 and E8, etc.---has to be add together. This is done in the Summary section, so for example cell K18 is the sum of D4 and D5, cell L18 is the sum of E4 and E5, etc. The costs in the Summary section, I18 to L32, will be carried forward onto other sheets on the way to getting grand totals for costs on those other sheets.

**Sheet 2, “Reservoirs.”**  From Table 10-11 (page 10-23) of the engineering report, the reservoirs Combination B has are Cub River, Fielding, and Weber Bay. Table 10-8 (page 10-19) has details about their volume (repeated in cells L5, L6, and L7; total volume in L8) and cost (repeated in cells O12—O15).

Cells B6—E6 pull the annual water flows for each district from the “Project Water Right” column of Table 12-5; total annual water flows in G6. Water flows for the other scenarios are copied from this row, leaving out non-participating districts. So for example C9, D9, and E9 just repeat C6, D6, and E6, but B9 says “No” instead of repeating B6 because in Scenario 2, Cache County doesn’t participate. Column G gives the total AF/year for each scenario.

Cell L9 is total annual water flows (G6) divided by total storage capacity (L8); this allows us to convert storage capacity (AF) to water flows (AF/yr). The water flows (AF/yr) made possible by each reservoir are calculated in L12, L13, and L14.

Cell O12 is the cost of the Cub River reservoir, calculated by multiplying its volume (L5) by its cost per acre-foot (N12). The costs for the other two reservoirs are obtained analogously, and appear in cells O13 and O14. However these costs for Fielding and for Weber Bay contradict Table 10-11 and Table 12-2, and those two sources agree with each other, so I decided to use the latter figures (T13, T14) instead.

Cells L15 to O19 give the water flows (AF/yr, L17—L19) and costs (O17—O19) of all possible pairs of reservoirs. (The water flows come from L12—L15 and the costs from O12, T13, and T14, previously calculated.)

The set of numbers given in Column G represent all possible combinations of needed water flow. This set is listed (from greatest to smallest, with no repetitions) in cells L22 to L29. Then considering carefully cells L12 to L19 and O12 to O19 (and T13, T14), I figured out, for each of the water flow needs in L22—L29, the cheapest combination of reservoirs which would supply at least those flows. I did not write an algorithm to do this; I just did the calculations in my head and recorded the results in L23—O29. So these give the least-cost reservoirs needed to satisfy the flow requirements of each of the scenarios.

I got the L22—O29 results into Columns H and I not by hand, but by constructing a lookup table (S22—T29, greyed out) and then using the value in Column G to populate Columns H and I.

Now that Column H has the cost of each scenario’s reservoirs, that cost has to be apportioned to each district according to the water flows in cells B6—E6, though a district pays nothing if it does not participate. For example, C10, the reservoir cost of the Bear River WCD in Scenario 2, is calculated by multiplying the total reservoir cost of Scenario 2, cell H9, by the ratio of the water flow to the Bear River WCD, namely C6 = C9, to the total water supplied in Scenario 2, namely G9.

Proceeding in the same way, reservoir costs are allocated as shown in B7—E7, B10—E10, B13—E13, etc. These results are collected together in the summary section, L38—P53, but since the reservoir costs from Table 12-2 clearly do not include overhead, overhead is added to the entries in the summary table.

**Sheet 3, “T12dash2.”** This concerns Table 10-11. Its second column, “Description,” gives five categories of costs. The first, “Reservoir Site and Facitility [sic],” is made irrelevant by the calculations in our “Reservoirs” sheet.

The fourth category of costs, “Mobilization/Field Oversight Expenses,” is just 10% of the previous three categories; the fifth category of costs, “Project Administration & Management,” is “10% + 5% + 25%” of the previous four categories.

The figure included in the spreadsheet is very useful in what follows.

The second category of costs are: “North Box Elder Co. Reach,” “South Box Elder Co. Reach,” and the “Collinston Connection.” Their sum is in H4 (with overhead, K4). They have to be unevenly divided between Box Elder, Weber, and Jordan Valley according to their water shares (60,000, 50,000, and 50,000 respectively). The map shows that if any of these three districts sign on, all of these facilities have to be built. (Collinston is in Cache County but it serves the other districts.) The uneven division is coded in columns C, D, and E, with the help of integers 5 and 6 (e.g., in C5, D5, and E5, representing the water shares) to do the division.

I assign the “Weber Co. Reach” 50%/50% to Weber Basin and to Jordan Valley if both participate, else 100% to whichever one participates (and no cost if neither Weber Basin nor Jordan Valley participate). This in my cell H6/K6. The reason is that even if Weber does not participate, the pipeline still needs to be built if Jordan Valley participates.

The third category of costs, “Cache County Project Facilities,” has just Collinston, which was assigned elsewhere as explained above; however I included here the "Cache County Facilities" "Total Price" from Table 12-2, p. 12-4 (PDF p. 194) (they do not include the Collinston Connection so there is no double-counting). The reason is that Table 10-11 seems to focus on costs which differ between different combinations, rather than including all costs, and Table 12-2’s detailed listing of costs seems persuasive.

Cells K4, K6, and K8 are obtained by adding the overhead costs of the fourth and fifth categories described three paragraphs ago to the direct cost in cells H4, H6, and H8.

Next, Cells K4, K6, and K8 are multiplied by $1,000,000 and then transferred to their appropriate places in Columns B, C, D and E, suitably divided; and those are summarized in the Summary section I41—L55. However, there is no written justification for assigning these costs to the districts which benefit from each expenditure (unlike for the JdnWbr sheet), so in cells I21—L35 the costs were reallocated in proportion to the acre-feet of water.

**Sheet 4, “Totals.”** First, cells K3 to K5 contain data from the source listed in K1 and K2, and cell K6 contains the assumed $/AF cost for operations and maintenance, as discussed extensively in L7 and below.

Each of the previous three sheets had a summary section showing, for the type of cost they dealt with, how much each district had to pay in each scenario. Step 1 of this sheet adds up all those numbers to get totals (C5 to F19), and then H5 to H19 give the overall total cost of each scenario. (These overall costs for Scenario 1 are much higher than Table 12-2 and Table 12-5’s grand totals because those do not include the Jordan Valley/Weber Basin part from our first sheet.)

Step 2 lists water flows to each district in each scenario; environmental mitigation repayments will be proportional to these water flows. Step 10 turns the Step 2 numbers into percentages which, for each scenario, add up to 100%.

Step 3 uses cell K6 to calculate operations and maintenance (“O&M”) costs. Step 4 adds Step 3 and Step 1. Then I5 to I19 add Step 4’s capitalized value of operations and maintenance costs to the overall construction costs of H5—I19.

Each entry of Step 5 calculates the annual “mortgage” payment required to pay off the corresponding entry in Step 4 at an interest rate of 4% (cell O14) over 50 years (cell Q13).

In reality, given expected population growth, it would be better for the districts to back-load debt repayment; that is, instead of paying a constant yearly amount, pay less in early years and pay more in later years. If this is taken to the extreme, early-years payments may be insufficient even to cover interest payments, leading to negative amortization. A more complicated and realistic analysis would model this type of flexibility, perhaps aiming to keep payments per year per capita constant (in present value terms). However that is beyond the scope of this study. The consequence is that this study probably overestimates the costs that would be experienced in the near future, and this study probably correspondingly underestimates overall interest costs.

Step 6 adjusts all of Step 5’s numbers to account for inflation, using the Construction Cost Index numbers of cells K16 and K15, although adjustment by other inflators is possible by replacing the index number in cell L64 with one of the choices in cells M60 to M63.

Step 7 ignores Step 6’s inflation and calculates Step 5’s annual payments divided by Step 2’s water flows to get dollars per acre-foot of water. Step 8 does the same thing, obtaining dollar cost per acre-foot of water, but this time taking Step 6’s inflation factor into account.

Cells I102, I103, and I104 give the minimum and maximum values of Step 8. Cell I103 ignores Scenario 15 because Scenario 15 is weird: it is a tiny project only supplying water to Cache County.[[2]](#footnote-2)

Steps 9 (wetland mitigation at $100,000/acre, adjustable via cell E109), 11 (annualized mitigation costs), 12 (annualized mitigation and, adjusted for inflation, construction and O&M costs), and 13 (Step 12 converted to dollars per acre-foot) are straightforward.

**Sheet 5, “Presentation.”** Sheet 4’s annual amortizing debt payments are compared to each district’s current level of debt payments. The Row 3 “current annual debt loads” come from J2—M2, which in turn come from the audited financial statements just below cell I4. The Cache WD has no audited financial statement, just a budget showing funds received from the Cache County government, which it spends all of; it carries no current debt. Cells A8—E22 come from Sheet “Totals” Step 12. They, together with the current debt service numbers in B3—E3, in turn generate the rest of the bars in the bar graphs of Rows 24—39 (left of Column U). The orange bars represent additional, Bear-River-Project-generated debt servicing costs. The current debt service numbers are nil in Cache WCD and are so small in the Bear River WCD that the vertical scale of the graph has to be unusually large in order to be able to see the tiny blue bar.

Below Row 40 are tables and stacked bar charts showing how net revenues would have to change to cover Bear River costs. The current net revenues are from J3—M3. The additional net revenue required is the same as the “additional annual debt servicing plus O&M costs” from the A5—E22 table. In the charts, blue represents current net revenue. This is nil in Cache WCD and is so small in the Bear River WCD that the vertical scale of the graph has to be unusually large in order to be able to see the tiny blue portion of the bars. The percent increase in net revenue is calculated in D43—D114.

For a given increase in net revenue, a corresponding wholesale price increase can be calculated. Assuming a constant-elasticity fixed (i.e., not reflecting any population growth) demand curve, Q = P^(elast.), so total revenue TR = PQ = P^(1+elast.), and TR^(1/(1+elast.)) = P, so

P2/P1 = (TR2/TR1)^(1/(1+elast.)) .

The E43—E114 cells (new price divided by old price) make this calculation, assuming the elasticity given in cell E40. (For Cache WD, Excel’s IFERROR function returns #VALUE! because it apparently evaluates its last argument even though that argument throws a “division by zero” error.) Prices would not have to increase so much if population growth were included, and would be even more modest if repayment were back-loaded (see the discussion of Step 5 of Sheet 4), but this spreadsheet does not take either into account.

Given these wholesale price increases, since Q = (P^elast.),

Q2/Q1 = (P2/P1)^(elast.)

shows the fall in quantity of water demanded (cells F43—F114). As in the previous paragraph, these numbers would become more moderate if population growth were included in this analysis and even more modest if project repayment were back-loaded.

Finally, below and to the right of G96, the C100—C114 required net revenue increases for the Jordan Valley WCD are apportioned to the cities which are part of the JVWCD in proportion to their projected shares of the JVWCD’s 2060 water deficits. The source of the 2060 water deficits is Table 17 of "Jordan River Basin Planning for the Future," June 2010, Utah Division of Water Resources, Utah State Water Plan.

1. Recommendation: Section 10.14 (p. 10-30); cost estimates, Table 10-11 (page 10-23); both from “Bear River Pipeline Concept Report—Final, Volume I of II” July 2014, Bowen Collins & Associates, Inc. and HDR Engineering, for the Utah Division of Water Resources. [↑](#footnote-ref-1)
2. An aside about how to interpret the numbers in Step 8: consider Scenario 1, Cache County, $432/af. It will be cheaper to engage in one-time upfront conservation measures, instead of building the Bear River Project, if the required conservation measures can be financed, at a 4% (cell C43) interest rate over 50 (cell F43) years, at a smaller annual cost than $432/af. If the required conservation expenditures are instead a mixture of one-time and continuing expenses, then denoting by “T” the one-time Year 2019 costs and by “A” the ongoing annual expenses, then the $432/af should be compared to “A plus the `mortgage payment’ costs to pay off T.” If the conservation expenditures have a more complicated time pattern than that, it would probably be easier to compute their present value (over an appropriate time horizon) and compare that to the total cost figures of Step 1 of sheet “Totals” to see whether conservation or the Bear River Project is cheaper. These types of calculations are correctly done in e.g. Eric C. Edwards et al., “Economic Insight from Utah’s Water Efficiency Supply Curve,” *Water*, 2017, 9, 214, see p. 4 of 17.

   If “conservation” is free, as in willing-buyer-willing-seller agricultural land conversion, no calculations of its costs have to be undertaken. And the “willing buyer” could be the State, if it wanted to get more cheap water for urban areas without letting real estate development sprawl into currently-agricultural land. [↑](#footnote-ref-2)