# Green Business Case Memorandum

*To:* *State Revolving Fund Loan Program*

*From:* *Bob Huguenard*

*Date:* *June 30, 2016*

*Project:* *Franklin WRF Modifications & Expansion Project*
*CG5 2017-375, SRF 2017-376*

*Subject:* *Green Business Case 1 of 4 – UV Disinfection System*

This memorandum establishes a business case for construction of a new ultraviolet (UV) disinfection system for the Franklin WRF site.

## Background

The Franklin WRF's existing UV system was constructed in 1997, and it is nearing the end of its service life. The system is also not large enough to treat projected future flows; the existing system is rated at an average daily flow (ADF) of 12 mgd, while the target capacity for future conditions is 16 mgd ADF. The UV equipment model installed at the Franklin WRF is no longer supported by the manufacturer, which means that obtaining parts and technical support has become difficult and costly. In addition, UV disinfection equipment has become much more energy efficient over time, thus allowing the realization of significant energy and cost savings through the replacement of older model UV equipment with newer, more energy efficient models.

## Analysis

**Table 1** provides a comparison of energy usage and operating cost between the existing system and the proposed new system. This table compares the energy use and costs from Year 1 (2020) to Year 20 (2039). This analysis makes the following assumptions.

- A unit power consumption in kilowatt-hours (kWh) per mgd was calculated for each system. This unit consumption was based on information provided by the equipment manufacturers.
- The power cost of $0.11 per kWh in 2020 escalates at a rate of 3 percent per year.
- The flow to the Franklin WRF is 13 mgd ADF in 2020, and it increases by 0.42 mgd per year.
- The discount rate is 4 percent, and the inflation rate is 3 percent.

**Table 1 Comparison of Energy Use and Operating Costs – Existing and New UV Systems**

| Year | Existing UV System | | Proposed UV System | | Energy & Cost Savings | | |
|---|---|---|---|---|---|---|---|
| | Est. Annual Energy Use (kWh) | Est. Annual Cost | Est. Annual Energy Use (kWh) | Est. Annual Cost | Est. Annual Energy Savings (kWh) | Est. Annual Cost Savings | Present Value of Cost Savings |
| 2020 | 911,000 | $113,000 | 313,000 | $39,000 | 598,000 | $74,000 | $71,000 |
| 2021 | 940,000 | $120,000 | 323,000 | $41,000 | 617,000 | $79,000 | $75,000 |
| 2022 | 970,000 | $127,000 | 333,000 | $44,000 | 637,000 | $83,000 | $78,000 |
| 2023 | 999,000 | $135,000 | 344,000 | $46,000 | 655,000 | $89,000 | $83,000 |
| 2024 | 1,029,000 | $143,000 | 354,000 | $49,000 | 675,000 | $94,000 | $87,000 |
| 2025 | 1,058,000 | $152,000 | 364,000 | $52,000 | 694,000 | $100,000 | $92,000 |
| 2026 | 1,088,000 | $161,000 | 374,000 | $55,000 | 714,000 | $106,000 | $96,000 |
| 2027 | 1,117,000 | $170,000 | 384,000 | $58,000 | 733,000 | $112,000 | $101,000 |
| 2028 | 1,147,000 | $180,000 | 394,000 | $62,000 | 753,000 | $118,000 | $105,000 |
| 2029 | 1,176,000 | $190,000 | 404,000 | $65,000 | 772,000 | $125,000 | $110,000 |
| 2030 | 1,205,000 | $201,000 | 414,000 | $69,000 | 791,000 | $132,000 | $115,000 |
| 2031 | 1,235,000 | $212,000 | 424,000 | $73,000 | 811,000 | $139,000 | $120,000 |
| 2032 | 1,264,000 | $223,000 | 435,000 | $77,000 | 829,000 | $146,000 | $125,000 |
| 2033 | 1,294,000 | $235,000 | 445,000 | $81,000 | 849,000 | $154,000 | $131,000 |
| 2034 | 1,323,000 | $248,000 | 455,000 | $85,000 | 868,000 | $163,000 | $137,000 |
| 2035 | 1,353,000 | $261,000 | 465,000 | $90,000 | 888,000 | $171,000 | $142,000 |
| 2036 | 1,382,000 | $275,000 | 475,000 | $94,000 | 907,000 | $181,000 | $149,000 |
| 2037 | 1,411,000 | $289,000 | 485,000 | $99,000 | 926,000 | $190,000 | $155,000 |
| 2038 | 1,441,000 | $304,000 | 495,000 | $104,000 | 946,000 | $200,000 | $162,000 |
| 2039 | 1,470,000 | $319,000 | 505,000 | $110,000 | 965,000 | $209,000 | $167,000 |
| | | | | **Totals** | **15,600,000** | **n/a** | **$2,301,000** |

# Conclusions

The proposed UV system capital cost is estimated to be about $2.3 million and is expected to result in an operating cost savings of approximately $2.3 million over a 20-year time period. Compared to the existing, less efficient UV technology, the proposed new UV system will also reduce power consumption by approximately 15.6 million kWh over 20 years.

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*Date:* *June 30, 2016*

*Project:* *Franklin WRF Modifications & Expansion Project*
*CG5 2017-375, SRF 2017-376*

*Subject:* *Green Business Case 2 of 4 – Sludge Management*

This memorandum establishes a business case for construction of a new sludge management system for treatment of wastewater sludges at the Franklin WRF site.

## Background

The City of Franklin currently manages its wastewater sludges by dewatering unstabilized sludge and hauling the dewatered material to a lined landfill located 43 miles from the treatment plant (86 miles round trip). The sludge has to be hauled such a distance because there are very few landfills that will accept unstabilized sludges, and no other disposal options exist. This current method of sludge management is unsustainable because it depends on continuing acceptance of unstabilized sludges by landfills and requires significant use of resources for hauling of sludges. In addition, by burying the material in a landfill, its associated nutrients are removed from the nutrient cycle, unable to be reused beneficially.

The Franklin WRF's proposed sludge treatment system will greatly reduce the volume of sludge to be disposed, significantly expand the range of potential reuse and disposal options, open up disposal options that require much shorter hauling distances, and produce a sludge that can be beneficially reused. In addition to several ancillary components, the proposed sludge management system will include a thermal hydrolysis process (THP), anaerobic digestion, dewatering and a solar dryer. THP breaks the sludge down using heat and pressure to make it more completely digestible by the anaerobic digesters, which then stabilize the sludge and reduce its volume. Dewatering after digestion further reduces the volume by pressing the sludge to remove excess water, and the solar dryer even further reduces the volume by using solar energy to evaporate moisture.

# Analysis

**Table 1** compares the total number of miles of hauling for the sludge produced by the existing system versus the sludge produced by the proposed process, and **Table 2** compares the hauling and disposal costs between the existing and proposed sludge management systems. The cost comparison is made using the following assumptions.

- Sludge production estimates are based on previously constructed mass balances and wastewater treatment process models.
- Costs for diesel fuel, driver labor, landfill tipping fees, truck maintenance and insurance escalate at 3 percent per year.
- All of the Class A biosolids produced by the new treatment process will be given away. For this analysis, it was assumed that the City will haul the Class A biosolids to the end users. Furthermore, it is assumed that end users of the biosolids will be located closer to the Franklin WRF, and the trucks will have to travel half as far (43 miles round trip) versus the 86 miles round trip they currently travel to the landfill.
- The trucks have a capacity of 20 cubic yards (CY) and an average fuel economy of 6 miles per gallon of diesel fuel.
- The discount rate is 4 percent, and the inflation rate is 3 percent.

**Table 1 Sludge Hauling Comparison**

| Year | Existing System | | | Proposed System | | | Net Reduction | | |
|---|---|---|---|---|---|---|---|---|---|
| | WT/ Year | Truck-loads/ Year | Total Miles | WT/ Year | Truck-loads/ Year | Total Miles | WT/ Year | Truck-loads/ Year | Total Miles |
| 2020 | 25,900 | 1,540 | 132,000 | 5,900 | 350 | 15,000 | 20,000 | 1,190 | 117,000 |
| 2021 | 27,000 | 1,600 | 138,000 | 6,300 | 380 | 16,000 | 20,700 | 1,220 | 122,000 |
| 2022 | 28,200 | 1,670 | 144,000 | 6,700 | 400 | 17,000 | 21,500 | 1,270 | 127,000 |
| 2023 | 29,400 | 1,740 | 150,000 | 7,200 | 430 | 18,000 | 22,200 | 1,310 | 132,000 |
| 2024 | 30,500 | 1,810 | 156,000 | 7,600 | 450 | 19,000 | 22,900 | 1,360 | 137,000 |
| 2025 | 31,700 | 1,880 | 162,000 | 8,000 | 470 | 20,000 | 23,700 | 1,410 | 142,000 |
| 2026 | 32,900 | 1,950 | 168,000 | 8,400 | 500 | 21,000 | 24,500 | 1,450 | 147,000 |
| 2027 | 34,000 | 2,020 | 174,000 | 8,800 | 520 | 22,000 | 25,200 | 1,500 | 152,000 |
| 2028 | 35,200 | 2,090 | 180,000 | 9,200 | 550 | 24,000 | 26,000 | 1,540 | 156,000 |
| 2029 | 36,400 | 2,160 | 186,000 | 9,600 | 570 | 25,000 | 26,800 | 1,590 | 161,000 |
| 2030 | 37,500 | 2,230 | 192,000 | 10,100 | 600 | 26,000 | 27,400 | 1,630 | 166,000 |
| 2031 | 38,700 | 2,300 | 198,000 | 10,500 | 620 | 27,000 | 28,200 | 1,680 | 171,000 |
| 2032 | 39,900 | 2,370 | 204,000 | 10,900 | 650 | 28,000 | 29,000 | 1,720 | 176,000 |
| 2033 | 41,000 | 2,440 | 210,000 | 11,300 | 670 | 29,000 | 29,700 | 1,770 | 181,000 |
| 2034 | 42,200 | 2,510 | 216,000 | 11,700 | 690 | 30,000 | 30,500 | 1,820 | 186,000 |
| 2035 | 43,400 | 2,580 | 221,000 | 12,100 | 720 | 31,000 | 31,300 | 1,860 | 190,000 |
| 2036 | 44,500 | 2,640 | 227,000 | 12,500 | 740 | 32,000 | 32,000 | 1,900 | 195,000 |
| 2037 | 45,700 | 2,710 | 233,000 | 12,900 | 770 | 33,000 | 32,800 | 1,940 | 200,000 |
| 2038 | 46,900 | 2,780 | 239,000 | 13,400 | 790 | 34,000 | 33,500 | 1,990 | 205,000 |
| 2039 | 48,100 | 2,850 | 245,000 | 13,800 | 820 | 35,000 | 34,300 | 2,030 | 210,000 |
| | | | | | | **Totals** | **542,000** | **32,000** | **3,300,000** |

**Table 2 Hauling and Disposal Cost Savings**

| Year | Estimated Disposal Cost – Existing System ($/year) | Estimated Disposal Cost – Proposed System ($/year) | Estimated Annual Cost Savings ($/year) | Present Value of Annual Cost Savings ($/year) |
|---|---|---|---|---|
| 2020 | $1,825,000 | $113,000 | $1,712,000 | $1,647,000 |
| 2021 | $1,964,000 | $124,000 | $1,840,000 | $1,753,000 |
| 2022 | $2,110,000 | $136,000 | $1,974,000 | $1,863,000 |
| 2023 | $2,263,000 | $148,000 | $2,115,000 | $1,977,000 |
| 2024 | $2,424,000 | $161,000 | $2,263,000 | $2,095,000 |
| 2025 | $2,592,000 | $174,000 | $2,418,000 | $2,217,000 |
| 2026 | $2,767,000 | $188,000 | $2,579,000 | $2,341,000 |
| 2027 | $2,951,000 | $202,000 | $2,749,000 | $2,472,000 |
| 2028 | $3,143,000 | $218,000 | $2,925,000 | $2,605,000 |
| 2029 | $3,344,000 | $234,000 | $3,110,000 | $2,743,000 |
| 2030 | $3,553,000 | $250,000 | $3,303,000 | $2,885,000 |
| 2031 | $3,772,000 | $268,000 | $3,504,000 | $3,031,000 |
| 2032 | $4,001,000 | $286,000 | $3,715,000 | $3,183,000 |
| 2033 | $4,241,000 | $305,000 | $3,936,000 | $3,340,000 |
| 2034 | $4,490,000 | $325,000 | $4,165,000 | $3,500,000 |
| 2035 | $4,751,000 | $346,000 | $4,405,000 | $3,666,000 |
| 2036 | $5,023,000 | $368,000 | $4,655,000 | $3,837,000 |
| 2037 | $5,307,000 | $391,000 | $4,916,000 | $4,013,000 |
| 2038 | $5,603,000 | $415,000 | $5,188,000 | $4,195,000 |
| 2039 | $5,912,000 | $439,000 | $5,473,000 | $4,382,000 |
| | | | **Total** | **$58,000,000** |

# Conclusions

The following conclusions are drawn from this analysis:

- The proposed biosolids treatment system is expected to provide a 20-year net present worth hauling and disposal cost savings of approximately $58 million.
- In addition to the hauling and disposal cost savings, the new system will eliminate approximately 3.3 million miles of truck travel over 20 years, which results in a significant reduction in vehicle emissions and diesel fuel consumption.
- The single disposal option for sludge produced by the existing system is unsustainable and is tenuous, because it is dependent on the disposal facility permit continuing to allow disposal of unstabilized sludge and the disposal facility continuing to agree to acceptance of unstabilized sludge. The proposed biosolids management system will eliminate this dependency and produce sludge that can be beneficially reused or disposed of in multiple ways.

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*Date:* *June 30, 2016*

*Project:* *Franklin WRF Modifications & Expansion Project*
*CG5 2017-375, SRF 2017-376*

*Subject:* *Green Business Case 3 of 4, Combined Heat and Power System*

This memorandum establishes a business case for construction of a new combined heat and power (CHP) system at the Franklin WRF site.

## Background

Wastewater sludges are currently managed by dewatering unstabilized sludge and hauling the dewatered sludge to a lined landfill. The City proposes to upgrade the sludge management system to include stabilizing the sludge using anaerobic digestion. A byproduct of anaerobic digestion is biogas, which is composed mainly of methane. The City proposes to capture the biogas from the anaerobic digestion process and use it to power an engine, which will generate electricity and hot water. The electricity will be used onsite and will reduce the amount of electricity that must be purchased. The hot water will also be used onsite to heat the digester building, heat the fats, oils and grease (FOG) storage tanks, and generate steam for injection into the thermal hydrolysis process (THP). The THP system pretreats the sludge prior to anaerobic digestion that lyses the biological material in the sludge to make it more easily and more completely digestable in the anaerobic digesters, which in turn allows generation of more biogas. Without the CHP system, the biogas produced by the digesters would be burned in a waste gas flare.

## Analysis

**Table 1** provides an estimate of biogas production over time and associated power generation. The cost savings realized from the CHP power generation is also provided along with a present worth value of the cost savings. The following assumptions are used for the cost analysis:

- 2020 (Year 1 of operation) power cost if purchased from the grid = $0.124 per kWh.
- Inflation rate = 3 percent
- Discount rate = 4 percent
- Analysis period = 20 years

**Table 1 Power Cost Offset Analysis**

| Year | Average Biogas Production (SCF/Min) | Associated Power Generation (kWh) | Power Cost Offset ($/year) | 2020 Present Worth of Power Cost Offset ($/year) |
|---|---|---|---|---|
| 2020 | 74.8 | 301 | $326,000 | $326,000 |
| 2021 | 78.0 | 314 | $350,000 | $337,000 |
| 2022 | 81.2 | 327 | $376,000 | $348,000 |
| 2023 | 84.4 | 339 | $402,000 | $357,000 |
| 2024 | 87.6 | 352 | $430,000 | $368,000 |
| 2025 | 90.8 | 365 | $459,000 | $377,000 |
| 2026 | 94.4 | 380 | $492,000 | $389,000 |
| 2027 | 98.0 | 394 | $526,000 | $400,000 |
| 2028 | 101.6 | 409 | $561,000 | $410,000 |
| 2029 | 105.2 | 423 | $599,000 | $421,000 |
| 2030 | 108.8 | 437 | $638,000 | $431,000 |
| 2031 | 112.4 | 452 | $678,000 | $440,000 |
| 2032 | 116.0 | 466 | $721,000 | $450,000 |
| 2033 | 119.6 | 481 | $766,000 | $460,000 |
| 2034 | 123.2 | 495 | $813,000 | $469,000 |
| 2035 | 126.8 | 510 | $861,000 | $478,000 |
| 2036 | 130.4 | 524 | $912,000 | $487,000 |
| 2037 | 134.0 | 539 | $966,000 | $496,000 |
| 2038 | 137.6 | 553 | $1,022,000 | $504,000 |
| 2039 | 141.2 | 568 | $1,080,000 | $513,000 |
| **Totals** | | | **$13,000,000** | **$8,500,000** |

In addition to the offset in power costs, the hot water generated by the CHP system also results in cost savings by eliminating the need for the purchase of electricity or natural gas to produce the necessary heat.

# Conclusions

The following conclusions are drawn from this analysis:

- The proposed CHP system will provide a net present worth savings in electricity of about $8,500,000.
- Heat generated by the CHP system will result in significant additional savings.
- Generation of electricity onsite using a CHP system (as opposed to a generation of electricity at a central station power plant) will result in about a 60 percent reduction in greenhouse gas emissions.

# Green Business Case Memorandum

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*From:* *Bob Huguenard*

*Date:* *June 30, 2016*

*Project:* *Franklin WRF Modifications & Expansion Project*
*CG5 2017-375, SRF 2017-376*

*Subject:* *Green Business Case 4 of 4 – Fats, Oils and Grease (FOG) Management*

This memorandum establishes a business case for construction of a new fats, oils and grease (FOG) management system at the Franklin WRF site.

## Background

FOG collected from permitted food service establishments in the City of Franklin is currently hauled via tanker truck by third-party haulers to a private facility in Nashville, approximately 26 miles from Franklin, for treatment and disposal. The FOG receiving station proposed for the Franklin WRF, paired with the City's planned implementation of a FOG receiving program, will reduce FOG hauling distances by giving the hauling companies a local disposal option. The added volatile solids in the FOG, when co-digested in the proposed anaerobic digesters, will contribute to the production of additional biogas. This additional biogas will then be used to generate more heat and power for use on the Franklin WRF site. For more information on the combined heat and power (CHP) system, refer to the Green Business Case 3 of 4, the Memorandum for Combined Heat and Power.

## Analysis

**Table 1** compares the total number of miles of current FOG hauling versus the reduced miles of FOG hauling after construction of a new FOG receiving station at the Franklin WRF. **Table 2** compares the biogas production volumes with and without introduction of FOG into the proposed digesters. These calculations incorporate the following assumptions.

- Projected FOG quantities are based on estimates of FOG production per capita and population projections provided by the City of Franklin. Only FOG generated within the City of Franklin will be collected at the WRF.
- The average tanker truck load is 2,200 gallons.
- Tanker trucks will travel 15 miles round trip to the FOG receiving station at the Franklin WRF versus 52 miles round trip to the private disposal facility in Nashville.

- Volatile solids reduction in the proposed anaerobic digesters is 60 percent for sludge volatile solids and 75 percent for FOG volatile solids.
- Biogas production is 15 cubic feet (CF) per pound of sludge volatile solids reduced and 27 CF per pound of FOG volatile solids reduced.

**Table 1 Estimated Reduction in FOG Hauling Miles**

| Year | Projected Volume of FOG Hauled (gallons/year) | Projected Tanker Loads per Year | Projected Truck Miles – Existing Scenario (miles/year) | Projected Truck Miles – Proposed Scenario (miles/year) | Reduction in Truck Miles (miles/year) |
|---|---|---|---|---|---|
| 2020 | 764,000 | 350 | 18,100 | 5,200 | 12,900 |
| 2021 | 786,000 | 360 | 18,600 | 5,400 | 13,200 |
| 2022 | 807,000 | 370 | 19,100 | 5,500 | 13,600 |
| 2023 | 829,000 | 380 | 19,600 | 5,700 | 13,900 |
| 2024 | 851,000 | 390 | 20,100 | 5,800 | 14,300 |
| 2025 | 873,000 | 400 | 20,600 | 6,000 | 14,700 |
| 2026 | 898,000 | 410 | 21,300 | 6,100 | 15,100 |
| 2027 | 922,000 | 420 | 21,800 | 6,300 | 15,500 |
| 2028 | 947,000 | 430 | 22,400 | 6,500 | 15,900 |
| 2029 | 972,000 | 440 | 23,000 | 6,600 | 16,400 |
| 2030 | 997,000 | 450 | 23,600 | 6,800 | 16,800 |
| 2031 | 1,025,000 | 470 | 24,200 | 7,000 | 17,200 |
| 2032 | 1,053,000 | 480 | 24,900 | 7,200 | 17,700 |
| 2033 | 1,080,000 | 490 | 25,600 | 7,400 | 18,200 |
| 2034 | 1,108,000 | 500 | 26,200 | 7,600 | 18,600 |
| 2035 | 1,136,000 | 520 | 26,900 | 7,800 | 19,100 |
| 2036 | 1,168,000 | 530 | 27,600 | 8,000 | 19,600 |
| 2037 | 1,200,000 | 550 | 28,400 | 8,200 | 20,200 |
| 2038 | 1,232,000 | 560 | 29,100 | 8,400 | 20,700 |
| 2039 | 1,264,000 | 580 | 29,900 | 8,600 | 21,300 |
| **Totals** | **19,900,000** | **9,100** | **471,000** | **136,000** | **335,000** |

**Table 2 Comparison of Biogas Generation With and Without Co-Digestion of FOG**

| Year | Biogas Production Without FOG (kCF/year) | Biogas Production With FOG (kCF/year) | Increase in Biogas Production (kCF/year) | Increase in Biogas Production (percent) |
|---|---|---|---|---|
| 2020 | 46,200 | 50,600 | 4,400 | 10% |
| 2021 | 48,300 | 52,800 | 4,500 | 9% |
| 2022 | 50,400 | 55,000 | 4,600 | 9% |
| 2023 | 52,500 | 57,300 | 4,800 | 9% |
| 2024 | 54,600 | 59,500 | 4,900 | 9% |
| 2025 | 56,700 | 61,700 | 5,000 | 9% |
| 2026 | 58,700 | 63,900 | 5,200 | 9% |
| 2027 | 60,800 | 66,100 | 5,300 | 9% |
| 2028 | 62,900 | 68,400 | 5,500 | 9% |
| 2029 | 65,000 | 70,600 | 5,600 | 9% |
| 2030 | 67,100 | 72,800 | 5,700 | 8% |
| 2031 | 69,200 | 75,100 | 5,900 | 9% |
| 2032 | 71,300 | 77,300 | 6,000 | 8% |
| 2033 | 73,300 | 79,600 | 6,300 | 9% |
| 2034 | 75,400 | 81,800 | 6,400 | 8% |
| 2035 | 77,500 | 84,000 | 6,500 | 8% |
| 2036 | 79,600 | 86,300 | 6,700 | 8% |
| 2037 | 81,700 | 88,600 | 6,900 | 8% |
| 2038 | 83,800 | 90,800 | 7,000 | 8% |
| 2039 | 85,900 | 93,100 | 7,200 | 8% |
| **Totals** | **1,321,000** | **1,435,000** | **114,000** | **9%** |

# Conclusions

The following conclusions can be drawn from this analysis:

- Implementing FOG receiving at the Franklin WRF is expected to reduce FOG hauling mileage by approximately 335,000 miles over a 20-year period. While this reduction does not result in a cost savings to the City of Franklin, it does represent reductions in both diesel fuel consumption and tanker truck emissions.

- The construction of a FOG receiving station at the Franklin WRF, the implementation of a FOG receiving program, and the subsequent co-digestion of FOG in the anaerobic digesters will result in the production of approximately 114 million CF (114,000 kCF) of additional biogas over a 20-year period. This biogas will be used to generate heat and power and offset energy costs at the Franklin WRF.

- See the Green Business Case 3 of 4 for Combined Heat and Power for cost savings associated with biogas capture and use.