Exhibit A

BURNS McDONNELL

City of Columbia Landfill Site Master Plan

City of Columbia, Missouri

Project No. 95073

Revision 1
April 2017

City of Columbia Landfill Site Master Plan

prepared for

City of Columbia, Missouri

Project No. 95073

Revision 1
April 2017

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

City of Columbia, Missouri
City of Columbia Landfill
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Project No. 95073

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the City of Columbia, Missouri or others without specific verification or adaptation by the Engineer.

08/01/17

Brian C. Weis, P.E., Missouri, No. 2011000962

Date: 08/01/2017

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0.0 EXECUTIVE SUMMARY

Burns & McDonnell was retained by the City of Columbia, Missouri to provide a Master Plan for the City's Landfill Site. The City's residents and businesses enjoy the benefit of comprehensive solid waste services provided at low costs and in a manner which prioritizes the protection of the environment and natural resources. The 107-acre existing Landfill is estimated to reach capacity between 2026 and 2031. The expansion of the existing landfill at the southern portion of the Site is believed to be the best apparent alternative for the City of Columbia to continue providing solid waste services to citizens and businesses.

A new South Landfill conceptualized on the existing site is estimated to add 40 to 80 years of disposal capacity. If the new South Landfill is constructed, opportunities exist to enhance and conserve the biological community and natural resources cost effectively while developing the landfill over time. The intent is to preserve, enhance, and create sufficient high value wildlife habitat in and around the development to support the existing wildlife populations that occur in the area.

Landfill gas from the new South Landfill can be beneficially utilized for electrical power generation beyond the life of the new facility. Utilization of landfill gas is an integral part of the City's Renewable Energy Portfolio; without this energy generation extending into the future, the City would be faced with purchasing renewable energy from other renewable sources at a higher cost.

The City's long-term transportation plan has been incorporated into the South Landfill conceptual design. The infrastructure required for the development has been evaluated and is determined to be feasible. Adequate soil is likely available onsite and in adjacent, City-owned parcels to support the long-term operation of the new South Landfill.

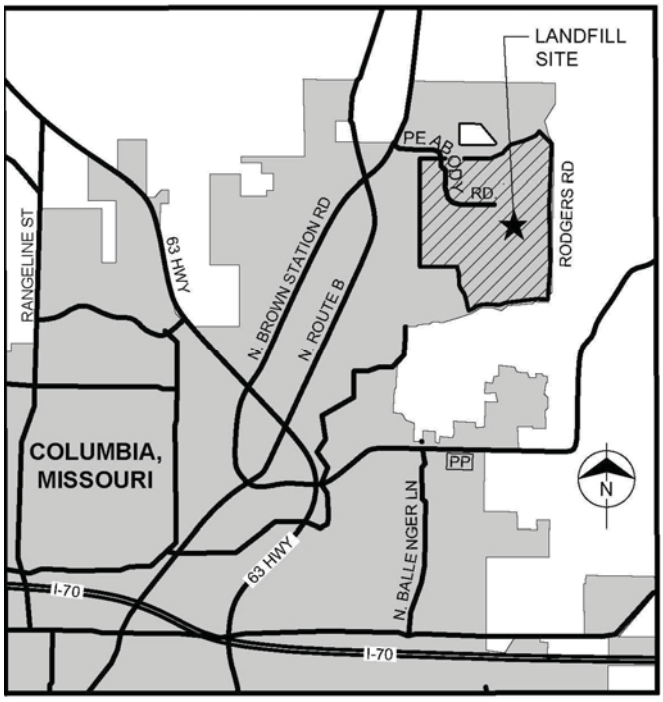
The permitting and development of the South Landfill will require significant time and effort to plan and design. It is recommended that for planning purposes, the City assume the first cell will need to be constructed prior to 2026. Design and permitting tasks should begin in the fall of 2017 to enable the construction of the first cell of the South Landfill prior to 2026.

1.0 INTRODUCTION

1.1 General

The City of Columbia, Missouri (City) owns and operates a sanitary landfill in Boone County, Missouri. The Columbia Sanitary Landfill is located in northeast Columbia, approximately 1 mile east of Route B at 5700 Peabody Road in the Northeast 1/4 of Section 22, Township 49 North, Range 12 West. The site is bordered by Rogers Road to the east, Hinkson Creek to the north and west, and North Wyatt Lane to the south. A location map of the Landfill site is provided below:

Figure 1-1: Site Location Map



1.2 Purpose

Burns & McDonnell was retained by the City of Columbia to provide a Master Plan for the City's Landfill Site. The City's residents and businesses enjoy the benefit of comprehensive solid waste services at low costs, provided in a manner which prioritizes the protection of the environment and natural resources. Operating the Landfill in close proximity to the residents and businesses is a significant driver of low costs and quality service for the City of Columbia solid waste rate payers. In order for the Solid Waste Utility to continue this quality and cost efficient service, it is in the City's interest to sustain the long-term operation of the Landfill Site.

The purpose of this Landfill Site Master Plan (Plan) is to demonstrate the need for an onsite Landfill Expansion, examine the beneficial environmental features that can be incorporated into the Site development, and conceptualize a long term development plan for the Site.

1.3 Plan Organization

This Plan is organized into the following sections:

- Section 2: Site Background & Existing Conditions
- Section 3: Need for Expansion
- Section 4: Ecological & Natural Resource Assessment
- Section 5: Clean Power Generation Potential
- Section 6: South Landfill Development Plan
- Section 7: Permitting & Schedule
- Section 8: Conclusions

2.0 SITE BACKGROUND & EXISTING CONDITIONS

The Site was previously owned by the Peabody Coal Company, which strip-mined the Site for coal until the early 1970s. The mined coal was used to fuel trains and satisfy industrial demands including a source of heat to enable electric power production. The City acquired the site and initially permitted the Landfill for solid waste disposal in August 1985 (Missouri Department of Natural Resources [MDNR] Solid Waste Permit No. 101908).

2.1 Existing Landfill Site

The Columbia Landfill property contains approximately 720 acres, which consists of 160 acres of property west of Hinkson Creek and 560 acres of property east of Hinkson Creek.

The 160 acres of Landfill property located west of Hinkson Creek was purchased to provide a buffer for the Landfill. The property could be used as a source for cover material (soil) in the future. It is not anticipated that this property would be used for waste disposal.

The 560 acres of Landfill property located east of Hinkson Creek contains the current permitted area for solid waste disposal activities and several support facilities. The current permitted solid waste disposal area contains approximately 107 acres and is located in the northeastern portion of the property. Located south and west of the current permitted area are several facilities that support the Landfill and the Solid Waste Utility. South of these facilities is an undeveloped area of the property consisting of open crop fields, ponds resulting from prior strip mining, and forested areas. The south, undeveloped portion of the Site has been envisioned by the City for many years as a potential Landfill expansion area. The Existing Landfill Property is shown in Figure 2-1.

The existing Landfill is divided into two sections: a 51-acre pre-Subtitle D section in the north, and a 56-acre Subtitle D section to the south. The 56-acre Subtitle D disposal area is divided into six cells. Cells 1-5 are constructed, with current disposal operations occurring in Cell 5. Cell 6 (final cell) has been designed and will be constructed in 2017 or 2018. Filling will progress to Cell 6 and then into areas with remaining airspace within the permitted boundary to bring the Landfill to the permitted final grades.

In 2009, the City modified their solid waste permit to operate Cells 4, 5 and 6 as an anaerobic bioreactor landfill. This progressive design allows the City to inject liquid into the Landfill's waste mass in order to accelerate the degradation of waste, thereby increasing landfill gas production and providing increased available airspace over the life of the Landfill.

Decomposition and biological stabilization of the waste in a bioreactor landfill is designed to occur much faster than in a traditional "dry tomb" landfill. Decomposition and stabilization at a faster rate results in a decrease in long-term environmental risks and landfill operating and post-closure costs. Potential advantages of bioreactors include the following:

- Decomposition and biological stabilization in tens of years versus potentially hundreds of years in "dry tombs"
- Landfill airspace gains (lower costs) due to an increase in waste density
- Increased LFG generation rates for beneficial use in renewable power generation on-site
- Lower waste toxicity and mobility
- Reduced post-closure costs
- Potential reduced leachate disposal costs

2.2 Population Served

The Landfill serves a population of approximately 120,000 residents. In addition to residential waste, the Landfill accepts waste from businesses, communities, and colleges located in and around Columbia.

2.3 Onsite Services and Facilities

The Landfill Site has developed over recent years to become the Solid Waste Utility (Utility) headquarters. A new Solid Waste Administration Facility (Administration Facility) is currently under construction on the site and scheduled for completion in 2017. This Facility includes shelters for the Utility's Fleet vehicle parking and a garage area for light Fleet vehicle maintenance. Upon commissioning of this Facility, most of the Utility's essential operations and facilities will be located on this Site. At this time the on-site facilities will include:

- Existing (North) Landfill
- Landfill Operations Building
- Landfill Scalehouse
- Public Drop-off Facility (waste drop off area for small vehicles)
- Landfill Gas (LFG) to Energy Power Plant (operated by City's Water & Light Department, with support from the Solid Waste Utility)
- Composting Facility
- Material Recovery Facility
- Container Storage and Repair Yard
- Collection Fleet Vehicle Storage and Fueling

- Collection Fleet Vehicle Maintenance
- Solid Waste Utility Administration, Management, and Dispatching

The location of these facilities, including the new Administration Facility, can be found on Figure 2-1.

2.4 Site Characteristics

2.4.1 Topography, Drainage, and Permitted Outfalls

The Landfill Site generally slopes topographically from east to west towards Hinkson Creek with the exception of the south, undeveloped end of the site, which slopes to the south and drains under North Wyatt Lane to Nelson Creek. Surface runoff from Landfill operations is treated and released from permitted National Pollutant Discharge Elimination System (NPDES) Outfall points. The NPDES program in the State of Missouri is administered by the MDNR; the site's NPDES permit number is MO-0112640. All runoff from the current operations area drains to Hinkson Creek.

The City of Columbia is the Floodplain Administrator for the area and regulates development within the Floodplain corridor along Hinkson Creek. The 100-Year Floodplain and Floodway lines are shown approximately on Figure 2-1.

2.4.2 Site Wastewater and Utilities

Landfill leachate and municipal wastewater from onsite facilities are currently combined into a site lift station which pumps the combined wastewater over one mile west to the City's existing gravity sewer system. From there the wastewater is conveyed to the City's Wastewater Treatment Plant (WWTP), located in the southern part of the City.

A gravity sewer system extension is planned for construction in 2017 or 2018. The gravity main extension would serve the landfill site, allowing for direct gravity discharge and abandonment of the force main.

In addition, to help improve the wastewater quality for the City's WWTP, the City plans to construct a voluntary Leachate Treatment System in 2017 or 2018. Leachate would be treated in the existing onsite leachate storage ponds prior to being discharged to the gravity system. The City is pursuing voluntary leachate pretreatment as a proactive step towards managing landfill leachate effluent constituent concentrations currently monitored under the existing pretreatment permit. Operational performance information will be collected over time from the treatment system, which is a simple aeration system. A supplemental long-term benefit of the pretreatment system is that ammonia levels within bioreactor

feedwater will be lower and therefore improve the leachate water quality produced from the bioreactor cells. This benefit is anticipated to reduce the long-term risk associated with the Landfill.

Other site utilities are routed to the site along the Peabody Road corridor, including water, gas, overhead power, and fiber optic lines. Green renewable electric power is generated from the landfill gas produced by the Landfill. This system is discussed in greater detail in Section 5.0 of this Plan.

2.4.3 Site Access and Traffic

Traffic currently enters and exits the site via Peabody Road. This two-lane paved road is approximately 1.2 miles long and is the only access road for the Landfill. Inbound traffic turns east onto Peabody Road off of Brown Station Road, travels east, and then curves south and back east before crossing Hinkson Creek over a two-lane bridge and entering the Site. When approaching the Site, traffic carrying waste continues onto the scale adjacent to the Landfill Scalehouse to be weighed. Other traffic may veer left and bypass the Scalehouse. Beyond the Scalehouse, traffic may continue east to access the Landfill, LFG to Energy Plant, or Compost Facility, or turn south to access other facilities.

3.0 NEED FOR EXPANSION

3.1 Remaining Life of Existing Landfill

The remaining life of the existing Landfill was estimated by Burns & McDonnell as part of the 2016 Vertical Permit Modification. The Remaining Life was derived by calculating the remaining disposal volume and then applying an assumed waste generation rate and an airspace utilization factor (AUF) to calculate the approximate amount of airspace consumed at the Landfill each year, until no volume remains. The Remaining Life Calculations were updated with current information to provide an estimated remaining life range for the purposes of this Plan. From these calculations, the existing Landfill is estimated to reach capacity between 2026 and 2031 (approximately nine to fourteen years from the date of this publication). The calculations are included in Appendix A. The paragraphs below describe the methodology in which the "minimum" and "maximum" remaining life durations were estimated. It should be understood the terms "minimum" and "maximum" are not used in the absolute sense and merely describe the lower and upper ends of the estimated remaining life range.

The waste generation rate is the annual waste tonnage that will be received by the Landfill in a given year. This rate must be projected for future years in Remaining Life calculations. Considerations when determining the projected rates include the City's ongoing waste reduction efforts, the City's projected overall growth, and the cost of alternative disposal methods versus the Columbia Landfill's tipping fees (market forces). For the minimum remaining life calculation, the waste generation rate assumed in these calculations was projected using 2015 tonnage, thereafter increasing at 2% each year. For the maximum remaining life calculation, the 2015 tonnage was held steady in the coming years, reflecting a 0% increase. An anticipated tipping fee increase in the near future has the potential to keep tonnage down in the coming years.

The AUF is an approximation of the amount of waste placed in each cubic yard of landfill airspace and can be impacted by factors such as compaction methods, daily cover soil usage, and the types of waste disposed. An AUF of 1,123 lbs. per cubic yard was used in the minimum remaining life calculation, which is an average of the two previous years' calculated AUF, measured quarterly. Because the short-term volume calculations do not take into account longer-term consolidation, the AUF was increased to 1,350 lbs. per cubic yard for the maximum remaining life calculation.

Another factor that was considered in the maximum remaining life calculation was the possibility that additional airspace may be reclaimed in the coming years. The MDNR is currently considering approval of alternative final covers that may reduce the cover thickness by up to 2 feet. The approval of such a

cover could add up to 290,000 cubic yards of airspace to the existing Landfill. In addition, it is believed that up to 20,000 cubic yards of soil was stockpiled years ago in the Pre-Subtitle D area of the landfill. It is the intent of the City to remove this soil and utilize the airspace. Therefore, these quantities were added to Total Airspace in the calculations.

Based on these methods and assumptions, the existing Landfill will reach capacity as early as 2026. Under this scenario, the first new landfill cell will need to be constructed and operational by 2026 or earlier, as revised projections may dictate. Due to several uncertainties in projecting remaining life, it is advised that for planning purposes the City assume the first cell will need to be constructed prior to 2026.

3.2 Expansion Alternatives

The City acquired the current site with the intention of utilizing it for landfilling in phases over a period of time and as area allows. For many years, it has been the vision of the Solid Waste Utility management to continue Landfill development on the southern portion of the site, where there is ample acreage for the new Landfill footprint. Currently, no alternative sites have been identified that are thought to be either feasible or more cost-effective. The current Site is in an ideal location: in close proximity to collection routes within the City limits, but isolated from other City developments. Utilizing outside solid waste services through a transfer station or by direct transport to another Landfill is not thought to be consistent with the City's goal of providing low-cost solid waste services in a manner which prioritizes the protection of the environment and the City's natural resources. The next nearest landfill is a privately-owned facility located near Jefferson City. According to City personnel, tipping fees at this facility are approximately 50% higher than the Columbia Landfill tipping fees, even before adding the costs of transportation. In addition, the carbon footprint associated with transporting Columbia's waste to this facility would be substantial. The expansion of the existing landfill at the southern portion of the Site is the best apparent alternative for City of Columbia and is evaluated further herein.

4.0 ECOLOGICAL & NATURAL RESOURCE ASSESSMENT

4.1 Project Setting

The ecological and natural resources present in the proposed landfill expansion area were evaluated to gain an understanding of predevelopment and existing conditions so these resources could potentially be enhanced long term as part of the landfill expansion project.

The proposed landfill expansion area is located in the Claypan Prairie ecoregion of the Central Irregular Plains of Missouri.[1] The Claypan Prairie ecoregion has a more level, gently rolling topography than surrounding ecoregions. Expansive cropland and pastureland, with an emphasis on livestock production, is common. The natural vegetation communities that once occurred in the Claypan Prairie ecoregion were a grassland/woodland mosaic dominated by big Bluestem-Indian grass prairie, little bluestem-sideoats grama prairie, and white oak dry woodlands. Although prairies may have been more extensive in the northeastern part of Boone County in the area of the proposed landfill expansion.

4.2 Vegetation

Based on the July 19, 2016 Burns & McDonnell site visit, the four main vegetation communities within the vicinity of the proposed landfill expansion site area include riparian forest located along Hinkson Creek on the far west, crop fields located on the west and northeast, upland forest in the southeast, and early successional woodland around the strip mine ponds in the center of the site and in other surrounding areas that were disturbed in recent history.

4.3 Wildlife Species

Several common wildlife species were observed during the July 19, 2016, site visit. Species observed within the riparian forest and along Hinkson Creek include turkey vulture (*Cathartes aura*), great blue heron (*Ardea herodias*), white-tailed deer (*Odocoileus virginianus*), five-lined skink (*Plestiodon fasciatus*), Blanchard's cricket frog (*Acris crepitans blanchardi*), and American toad (*Anaxyrus americanus*). Opossum (*Didelphis virginiana*) and raccoon (*Procyon lotor*) tracks were observed in the mud and silt along Hinkson Creek. Fox squirrels (*Sciurus niger*) and wild turkey (*Meleagris gallopavo*) feathers were observed in the upland forest areas. Northern mockingbird (*Mimus polyglottos*), killdeer (*Charadrius vociferus*), American robin (*Turdus migratorius*), eastern bluebird (*Sialia sialis*), eastern

[1] Chapman, S.S., Omernik, J.M., Griffith, G.E., Schroeder, W.A., Nigh, T.A., and Wilton, T.F., 2002, Ecoregions of Iowa and Missouri (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,800,000).

cottontail rabbit (*Sylvilagus floridanus*), and prairie kingsnake (*Lampropeltis calligaster*) were observed in edge habitats where the upland forest and early successional woodland meet crop fields.

4.4 Protected Species

Available information for Boone County was obtained from the U.S. Fish & Wildlife Service (USFWS) and the Missouri Department of Conservation (MDC) Natural Heritage Program. According to the USFWS and MDC, eleven state-listed or federally listed protected species are known or likely to occur in Boone County. (Table 1).

Table 4-1: Missouri Natural Heritage Database for Boone County

Species	State Status	Federal Status
Flathead Chub (*Platygobio gracilis*)	Endangered	None
Gray Bat (*Myotis grisescens*)	Endangered	Endangered
Indiana Bat (*Myotis sodalis*)	Endangered	Endangered
Lake Sturgeon (*Acipenser fulvescens*)	Endangered	None
Least Tern (*Sterna antillarum*)	Endangered	Endangered
Northern Long-eared Bat (*Myotis septentrionalis*)	None	Threatened
Pallid Sturgeon (*Scaphirhynchus albus*)	Endangered	Endangered
Piping Plover (*Charadrius melodus*)	Not Listed	Threatened
Running Buffalo Clover (*Trifolium stoloniferum*)	Endangered	Endangered
Rufa Red Knot (*Calidris canutus rufa*)	Not Listed	Threatened
Topeka Shiner (*Notropis topeka*)	Endangered	Endangered

Source: U.S. Fish and Wildlife Service – https://www.fws.gov/midwest/endangered/lists/missouri-cty.html; Missouri Department of Conservation, Natural Heritage Program – https://mdc.mo.gov/property/greener-communities/heritage-program/results/county/

The flathead chub, lake sturgeon, pallid sturgeon, and Topeka shiner are protected fish species that occur in perennial streams and rivers. The least tern, piping plover, and rufa red knot are protected bird species that migrate and nest along the sandbars and beaches of large rivers. Running buffalo clover occurs in mesic forests and woodlands in partial to filtered sunlight where there is a pattern of moderate periodic

disturbance for a prolonged period, such as mowing, trampling, or grazing. Gray bats, Indiana bats, and northern long-eared bats hibernate in caves in winter. During the spring, summer, and fall, Indiana bats and northern long-eared bats forage and roost in upland forests and woodland stream corridors with snags and tree species with exfoliating bark. In the summer, gray bats roost in caves and forage for insects in upland forests and along woodland stream corridors.

Based on the July 19, 2016, site visit, potential summer roosting habitat for the Indiana bat and northern long-eared bat was the only potential habitat for protected species that was observed within the vicinity of the proposed landfill expansion. The forested area in the southeast corner of the property includes potential summer roosting habitat for the Indiana bat and northern long-eared bat. The forested area consists of an oak-hickory forest and includes shagbark hickory (*Carya ovata*) trees greater than four inches in diameter at breast height. The areas beneath the exfoliating bark of the shagbark hickory provide suitable summer roost sites for the Indiana bat and northern long-eared bat. Any tree removal should occur between October 1 and March 31 to prevent disturbing the Indiana bat and northern long-eared bat during the maternity season. Additionally, the USFWS may require mitigation for removal of potential summer roost trees.

No caves were observed during the July 19, 2016, site visit; however, a more thorough survey for the presence of caves should be conducted within the footprint and in the vicinity of the proposed landfill expansion project to determine if caves are present that could be used by the gray bat, Indiana bat, and northern long-eared bat.

4.5 Cultural Resources

A cultural resources survey was not conducted during the July 19, 2016, site visit. A cultural resource field survey should be conducted to determine if any previously unknown cultural resources occur within the footprint and/or the vicinity of the proposed landfill expansion project.

4.6 Streams and Wetlands

According to the U.S. Geological Survey (USGS) 7.5-minute topographic maps, Hinkson Creek occurs along the western boundary of the property surveyed, and Nelson Creek, a tributary to Hinkson Creek, is located on the adjacent property to the south of the proposed landfill expansion project.[2,3] Based on the USFWS National Wetland Inventory (NWI) data, two forested wetlands occur along the west bank of Hinkson Creek, three emergent wetlands occur in the crop field along the west edge of the property, and

[2] U.S. Geological Survey. 2014 *Browns, MO*. Topographic Map 1:24,000. 7.5 Minute Series. Washington D.C.
[3] U.S. Geological Survey. 2014 *Hallsville, MO*. Topographic Map 1:24,000. 7.5 Minute Series. Washington D.C.

several ponds (strip-mine ponds) are present within the middle of the proposed project area. Based on the July 19, 2016, site visit, the two strip-mine ponds are connected to each other and to Nelson Creek by a small intermittent stream. An additional intermittent stream that is connected to Nelson Creek is present in the eastern portion of the upland, oak-hickory forest.

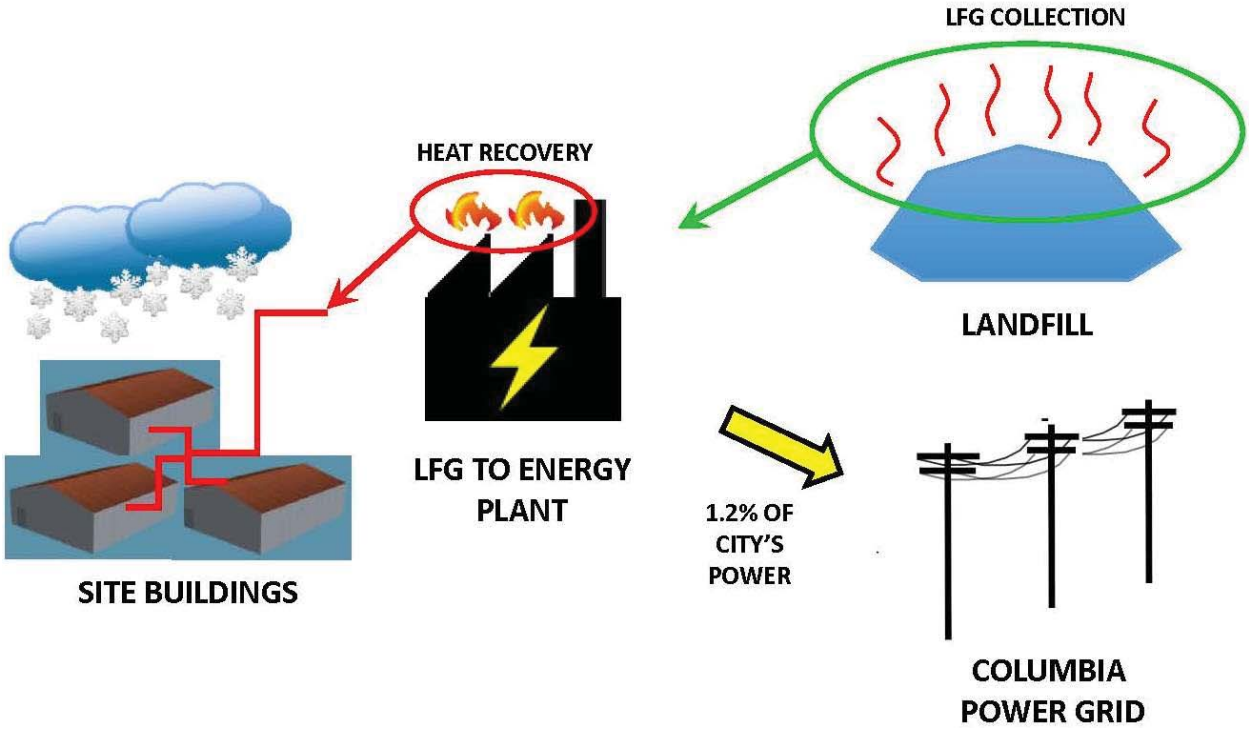
Because the two strip-mine ponds and the two intermittent streams are connected to Nelson Creek, any impacts to these ponds and streams would likely require a permit from the U.S. Army Corps of Engineers (USACE). Any project requiring a USACE permit must comply with the conditions of the permit regarding no adverse impacts to protected species or cultural resources. Significant opportunities exist on site to mitigate any impacts to potential existing wetlands associated with the two strip-mine ponds and the two intermittent streams connected to Nelson Creek.

5.0 CLEAN POWER GENERATION POTENTIAL

5.1 Overview of Landfill Gas to Energy System

The City's Water & Light Department operates a Landfill Gas (LFG) to Energy Plant on the Site with cooperation from the Solid Waste Utility, who operates the LFG collection system on the Landfill. The LFG collection system consists of LFG wells, a piping network, and a blower. The blower, located near the LFG to Energy Plant, applies vacuum to the waste mass to extract LFG from the wells and convey it, through the piping network to generator engines, located in the Plant. From combustion of the LFG in the engines, renewable energy is produced and sent to the City's power grid. The electricity produced by the Plant currently represents approximately 1.2% of the total electrical load consumed by the City on an annual basis. A supplemental benefit of this system is the Heat Recovery System, which captures heat from the generator engines and utilizes it to heat several onsite buildings. A schematic diagram of this system is shown below in Figure 5-1.

Figure 5-1: Landfill Gas Utilization System Diagram



5.2 Columbia Water & Light Renewable Energy Portfolio

In 2004, the City adopted an ordinance with aggressive renewable energy goals. The City has committed to generate or purchase electricity generated from eligible renewable energy sources at the following levels by the dates indicated*:

- Two (2) percent of electric retail sales by December 31, 2007;
- Five (5) percent of electric retail sales by December 31, 2012;
- Fifteen (15) percent of electric retail sales by December 31, 2017;
- Twenty-five (25) percent of electric retail sales by December 31, 2022;
- Thirty (30) percent of electric retail sales by December 31, 2028.

* This renewable energy shall be added up to these levels only to the extent that it is possible without increasing electric rates more than three (3) percent higher than the electric rates that would otherwise be attributable to the cost of continuing to generate or purchase electricity generated from one hundred (100) percent non-renewable sources.

In 2016, approximately 6.6 percent of the City's electric consumption was produced from renewable sources. Of this, approximately 0.1 percent was produced from solar resources, 3.1 percent from landfill gas utilization, and 3.4 percent from wind resources. Of the 3.1 percent derived from LFG utilization, the City of Columbia LFG to Energy Plant contributed 1.2 percent and the Jefferson City LFG to Energy Plant contributed 1.9 percent. The Columbia LFG to Energy Plant has the capacity to generate a greater load; however, extended periods of system maintenance during 2016 kept total energy production lower than normal.

5.3 Near-Term Power Generation Capacity

The power generation capacity of the City's LFG to Energy Plant depends on the quantity of LFG the landfill produces, how much of that LFG can be collected and delivered to the Plant, and how much power can be produced from the LFG delivered. The current total flow rate of LFG captured by the LFG system and delivered to the Plant is approximately 1,050 scfm.

With three generating engines fueled by approximately 350 scfm of LFG each, the Columbia LFG to Energy Plant has the capacity to produce approximately 3 MW, which could contribute up to 2.1 percent of the City's annual load when engine downtime is minimized. The City is currently permitting a fourth engine, which would increase the Plant capacity to approximately 4 MW. The LFG collection system would need to deliver approximately 1,400 scfm to operate four engines. LFG modeling of the existing landfill confirms that flow rates could exceed 1,400 scfm in the coming years, if the LFG collection system is expanded after Cell 6 is constructed and filled. Therefore, utilizing LFG from the existing landfill, the planned system has the potential to produce as much as 2.8 percent of the City's annual load

in the coming years, if engine down time is minimized and the investment in the necessary infrastructure is made.

5.4 Long-Term Power Generation Scenarios

The future expansion of the Landfill and the continued utilization of LFG for energy will have a significant long-term impact on the City's renewable energy portfolio. From LFG modeling of the existing landfill, LFG production will begin to decrease rapidly within two to three years of the landfill reaching capacity, projected to occur in 2026. Therefore, the beginning of the rapid decline of LFG from the existing landfill will correspond approximately with the time that the City ordinance requires renewable energy usage to increase to 30% of the City's total load in 2028.

To compare the expansion and non-expansion scenarios, modeling was projected for each case. Approximately 1,600 scfm could be captured from the existing landfill at the peak of production in 2027 or 2028. If the expansion is not constructed, the LFG collection flow from the existing landfill will have dropped to as little as 400 scfm by the year 2040. This is only enough LFG to fuel one of the existing generating engines, with a yield of approximately 1 MW of power. The power generated under this scenario would only contribute 0.7 percent of the City's total load. By 2045, under this scenario, the flow will have dropped below that required to operate one engine, and no energy would likely be produced at the Site.

By comparison, if the expansion is constructed, LFG collection of both landfills could be over 1900 scfm in the year 2040, according to LFG modeling. This would be enough flow to fuel five engines, assuming the investment in infrastructure is made. Five engines would be capable of producing 5 MW, or approximately 3.5% of the City's total load at full capacity. It is also possible that the existing engine models could be replaced with larger, more efficient engines in the future, thereby increasing capacity. Under this scenario, there would be enough flow sustained to continue producing approximately 5 MW through site closure, potentially as late as 2082 or after, depending on several factors.

Therefore, in the years 2045 through 2082, the LFG to Energy Plant could be producing 12% of the City's mandated renewable energy if the landfill is expanded, or 0% if the landfill is not expanded. Making up the additional 12% would reportedly come at a higher cost, if current relative costs are projected out in future years. From the City's 2016 Renewable Energy Report, the cost of other renewables, including solar and wind resources, come at a higher cost than utilizing LFG. In 2016, the cost of power from these other renewables was two to five times the additional cost per MWH of that generated at the LFG to Energy Plant (additional cost = renewable cost – non-renewable cost).

To quantify the additional renewable cost that would be potentially incurred for the non-expansion scenario, the average additional cost of power from solar and wind resources was calculated and compared to the additional cost of power from the City's LFG to Energy Plant. From the 2016 Renewable Energy Report, the average additional cost of solar power was $27.81 per MWH, the average additional cost of wind power was $41.45 per MWH, and the additional cost of power from the City's Plant was $8.25 per MWH. One year of 5 MW of power at full capacity yields approximately 44,000 MWH. Assuming that the additional power would be derived from a combination of solar and wind, this projects to an additional $900,000 to $1.5 million in cost for renewable energy annually for over 35 years (in 2016 dollars).

An infographic with LFG Utilization information and these projected scenarios is included in Appendix B.

6.0 SOUTH LANDFILL DEVELOPMENT PLAN

6.1 Expansion Concept

Burns & McDonnell has collaborated with the City to develop a concept design for the South Landfill expansion. The South Landfill conceptual design is depicted with base grades (base of the landfill) in Figure 6-1. The conceptual South Landfill footprint is approximately 145 acres and has an approximate capacity of 20 million cubic yards (gross volume, not including 1-foot leachate collection layer and not including an assumed 3.5-foot final cover layer). The constraints encountered when designing the South Landfill footprint included the floodplain of Hinkson Creek on the west, providing adequate buffers along Rodgers Road and Wyatt Lane on the east and south, and allowing a roadway corridor for a planned extension of Waco Road on the north, shown in Figure 6-2. In addition, areas were allocated around the perimeter of the landfill for sedimentation basins and leachate storage/treatment ponds. The area in and near the floodplain on the west portion of the site has been identified as a Constructed Wetland and Mitigation Banking area.

The base grades of the South Landfill were developed such that there are four (4) major phases, which represent four base grade elevation levels that are stepped according the site topography. Each phase would include multiple individual landfill cells. In addition to elevation levels, the phasing loosely indicates an active operational area. For example, there are three cells conceptualized as part of Phase 1; the area of all three cells may be dewatered, cleared and grubbed to provide a soil borrow area for the active cell. Temporary sedimentation basins may be located within each phase. As Phase 2 is developed, a portion of Phase 1 would be restored. A total of 14 cells have been conceptualized within these four phases. The cells are approximately the same size on average as the North Landfill cells, typically 9-11 acres. Phase 1 is shown to begin in the northwest corner of the footprint, near the new Administration Facility. As shown in Figure 6-1, access can initially be provided from the existing landfill access route.

The conceptual final grades of the South Landfill, depicted in Figure 6-2, represent the filled and closed landfill. The conceptual final grades have been designed to have approximately the same peak elevation as the North Landfill. Other aspects of the South Landfill Development Plan are described below.

6.2 Life of Site

The life of the South Landfill, in terms of years of capacity, will depend on several variables, including the airspace utilization factor (AUF) and the growth or reduction in annual waste tonnage. The AUF is the effective in-place density of waste placed in the landfill airspace in terms of lbs. per cubic yard. The quarterly Airspace Utilization calculations that the City performs on an annual basis have measured the

AUF in recent years to be approximately 1,120 lbs. per cubic yard. This density gives a good indication of compaction initially achieved at the landfill working face; however, this does not account for settlement and consolidation of underlying waste beyond the year that was measured. For waste compacted to this degree, it is reasonable to assume that consolidation would result in an approximate increase of 5% to 10% or more in AUF over the operating life of the landfill. Therefore, to attain a more accurate life of site estimate with liquids addition, the AUF was increased by approximately 10% to 1,230 lbs. per cubic yard. This AUF represents a number more representative of the consolidated waste over tens of years, rather than the one year of consolidation that is measured annually. Note that liquids addition, such as that done for the permitted Bioreactor cells in the existing Landfill, will have a significant impact on the rate at which waste degrades and consolidates over time, and thus will affect the life of the landfill. Liquids addition is discussed further in Section 6.9.

Another significant variable is the projected waste tonnage growth or decline. Future tonnage could vary greatly depending on the growth of the Columbia Metropolitan Area and resource recovery efforts which reduce the tonnage of the waste stream. The recent trend in tonnage is upward at approximately 1.5%. However, the City is always considering ways to increase resource recovery efforts and is planning to increase the capacity of its MRF in the coming years. At the current approximate trend of 1.5% growth with an assumed AUF of 1,230 lbs. per cubic yard, the life of the South Landfill would be approximately 40 years. If an AUF of 1,350 with 0% growth and an alternative final cover is assumed, the life of the new facility is estimated to be 80 years. The minimum and maximum South Landfill life of site calculations are provided in Appendix C.

6.3 Topography & Drainage

The drainage patterns of the North Landfill area are largely unaffected by the South Landfill development. Runoff from the North Landfill will continue to drain through permitted and monitored sedimentation ponds and discharge to Hinkson Creek. The general topography of the South site generally slopes from north to south on the western portion of the site and from east to west on the eastern portion of the site. At one location on the east, offsite drainage is routed to the site through a culvert under North Rogers Road. This drainage, along with the majority of the South Landfill site, eventually drains under North Hinkson Creek Road through a culvert at the south end of the Site to Nelson Creek. Nelson Creek then converges with Hinkson Creek approximately one-quarter mile to the east; the confluence of these Creeks is located just a few hundred feet southeast of the southeast corner of the Site (south of North Hinkson Creek Road).

Existing drainage patterns will be maintained to the extent possible. A stormwater study will be necessary as part of the South Landfill permitting phase to determine the controls necessary to achieve this end and satisfy applicable rules and regulations. The study will include analysis of optimum stormwater routing, stormwater quality and sedimentation basin sizing, and allowable peak flows at the site outfalls. The stormwater study will enable a design such that the landfill development does not result in an increase in stormwater discharge rate or a reduction in water quality.

The South Landfill development plan was arranged such that the Landfill and its access roads, sedimentation ponds, and leachate treatment ponds are located outside of the floodplain. Although it may be possible to develop these features within the floodplain, no significant development is planned in the floodplain other than wetlands, site restoration, and ecological habitat enhancements.

The lower lying floodplain areas may be utilized for constructed wetlands, wetland mitigation banking, and riparian corridor preservation. These wetlands would be located downstream of the site NPDES Outfalls, would serve to further polish runoff from the landfill (beyond the constituent limits set forth in the permit), and would serve as a buffer to the Riparian Corridor of Hinkson Creek. This flow of Landfill runoff through multiple treatment Best Management Practices (BMPs) represents what is referred to as a "Treatment Train" and is illustrated in the infographic provided in Appendix D.

6.4 Wastewater & Utilities

The utilities needed to serve the South Landfill expansion may initially be limited to electric power required for leachate sump pumping and site lighting. The existing infrastructure to provide this power is available in the area of the Administration Facility. Columbia Water & Light can easily facilitate an extension of this service. The leachate treatment system planned for the existing North Landfill can potentially be utilized for the leachate collected at the South Landfill, at least for the initial phases, as capacity allows.

If future leachate treatment is constructed in the area of the South Landfill, a more substantial electric service may be required. Columbia Water & Light will need to be consulted regarding the final load to provide this service. A new sanitary discharge pipe may be required for this system as well, and can be routed via gravity to the planned Hinkson Creek sewer main to the West.

If the Scalehouse is moved to an alternate primary entrance, such as that shown in Figure 6-2, sanitary sewer, electric power, water, and potentially gas service would need to be provided. Depending on the final location, these utilities can also easily be extended from the area of the Administrative Facility.

In summary, all utilities needed to serve the South Landfill Expansion are available nearby in the area of the Administration Facility. Extension of these utilities are thought to be feasible and relatively economical compared with an alternative development site.

6.5 Site Access & Transportation

The Site is located in the northeast corner of the City. As such, the majority of traffic to the Site travels from the south, up Route B to Brown Station Road, and then to Peabody Road. From a high level, direct route perspective, this route requires vehicles to travel approximately 2,700 feet further North past the site than is necessary before turning back south on Peabody Road. In total, traffic travels over one mile greater than would be necessary with a direct route to the site.

An alternate route can be provided by the extension of Waco Road, which currently intersects Route B and dead-ends approximately 2,000 feet to the west. As shown in Figure 6-3, Waco Road could be extended from its current dead-end point west over Hinkson Creek, through the middle of the Landfill Site, and realign to converge with Palmer Road beyond the east boundary of the Landfill Site. This improvement would be consistent with the Columbia Area Transportation Study Organization (CATSO) Major Roadway plan, provided in Appendix E.

The Waco Road extension would provide a direct route to the Site from Route B. With development of the South Landfill, the inefficiency in transportation would be even greater with the existing route, with vehicles traveling over 1.3 miles further than a direct route. The Waco Road route would eliminate one stopping intersection turn, two significant curves, and two railroad crossings. Significant savings may be realized in fuel, vehicle maintenance, and carbon footprint, with the elimination of 5 slow down/acceleration points and 1.3 miles of additional travel distance (one way).

The extension of Waco Road would require another bridge to be constructed over Hinkson Creek. The extension could be completed in phases such that one phase extends Waco Road to the site and another future phase continues the road east to converge with Palmer Road.

Regardless of the primary site entrance route, there are several options to provide access to the South Landfill. Access infrastructure may be designed and built with the multiple phases of the South Landfill development, similar to the access modification being made with the current North Landfill Cell 6 project.

6.6 Ecological Preservation and Restoration Plan

The phasing and development of the South Landfill is planned to be carried out incrementally to minimize the impact to area ecology. The planned phasing, initially working from the north to the south, will allow wildlife to adapt and relocate gradually and incrementally over tens of years as opposed to being cleared out in one action. A substantial part of the Phase 1 cells are located in the crop field on the low lying west end. Development in this area will have minimal impact on wildlife since it is currently being farmed and is located close to the industrial operations on the site. The South Landfill has been conceptualized to continue development in a counterclockwise manner for subsequent Phases. The Ecology Infographic included as Appendix F illustrates how, over time, mitigation and restoration projects can be planned in surrounding areas to further minimize the impact of development.

Natural resource enhancement and ecological restoration plans are easily incorporated into the environmental engineering systems that support the overall Landfill site design. The Landfill Expansion is a long term project and therefore presents an opportunity to evaluate the existing ecological and natural resource attributes and build upon those attributes through long term planning, cost effective incremental site enhancement, and ecological restoration projects.

Opportunity exists to create new habitat and enhance existing habitat for a variety of wildlife species, as shown in Table 6-1. The intent is to preserve, enhance, and create sufficient high value wildlife habitat to support the existing wildlife populations that may occur in the area during and after operation of the South Landfill. For example, creating emergent wetland and upland grassland habitat on reclaimed farmland in the southwest corner of the property would provide habitat for native foraging pollinators and seed dispersers (i.e., native bees, native butterflies, native grassland birds, etc.). Preserving the existing stream habitat and riparian enhancement along Hinkson Creek and creating open water habitat (i.e., water quality sediment ponds) would provide aquatic habitats for fish, amphibians, waterfowl, and aquatic insect species. Preserving and restoring the existing Hinkson Creek riparian forest and upland forest would provide migration corridors, forest, and edge habitats for many forest dwelling migratory birds, mammals, and reptiles.

Table 6-1: Potential Conservation and Restoration Opportunities

Feature	Location	Habitats Preserved, Created, and/or Enhanced	Species Benefiting from Habitat Resource
Water Quality Sedimentation Ponds	Northwest, Southwest, and Southeast Corners of Site	Creates Open Water Aquatic, Benthic, and Shoreline Habitats	Fish, Amphibians, Turtles, Waterfowl, and Benthic and Aquatic Invertebrates, Including Aquatic Insects.
Wildlife Corridor Preservation/Restoration	North, East, and South Edges of Site	Preserves and Enhances Existing Upland Forest Habitat and Creates New Upland Forest Habitat to Connect Existing Forest Habitats	Forest Dwelling Migratory Birds, Insects, Reptiles, and Mammals
Stream Preservation	West Edge of Site Along Hinkson Creek	Preserves Stream Habitat	Fish, Amphibians, Turtles, Waterfowl, and Benthic and Aquatic Invertebrates, Including Aquatic Insects.
Riparian Corridor Restoration	West Edge of Site along Hinkson Creek	Preserves Riparian Forest Habitat, Including Potential Roost Trees for Protected Bat Species	Forest Dwelling Migratory Birds, Insects, Reptiles, and Mammals, Including Protected Bat Species
Wetland Restoration of Reclaimed Farmland	Farmland along West Edge of Site	Creation of Emergent Wetland Habitat and Upland Grassland Habitat, Including Habitat for Foraging Pollinators and Seed Dispersers	Open Grassland Dwelling Migratory Birds, Insects, Reptiles, and Mammals, Including native bees and butterfly Species

Seed mixes and planting plans that include native trees, shrubs, grasses, and high-nectar wildflower species that will bloom from spring to fall (e.g., bluebells, coneflowers, asters) can be incorporated into the South Landfill's planned site expansion and ecological preservation and restoration plan. Wildflowers can be planted in large drifts in the emergent wetland and in upland grassland habitat of the reclaimed farmland area to provide ample foraging opportunities for native bees and butterflies. A monitoring plan to remove and control invasive exotic plant species should also be a part of the implemented plan to protect existing and restored habitats. Additional enhancements to the ecological preservation and restoration plan could include the addition of nest boxes for eastern bluebirds, American kestrels (*Falco sparverius*), and barn owls (*Tyto alba*). Barn owls and American kestrels prey on rodents and small mammals that could potentially be considered a nuisance to landfill operations.

In the long term, the Landfill site will eventually reach capacity and the Landfill will enter into a long term care period. Through master planning and the execution of individual cell development projects during the Landfill Expansion life, the City endeavors to position the Site in a fully restored state that results in the greatest degree of enhanced terrestrial and aquatic ecological habitat and conservation of the natural resources present on the Site. The focus on Site resource conservation and enhancement through cost effective incremental ecological restoration projects is anticipated to position the Site property for potential future public access and associated recreational uses.

6.7 Landfill Gas Utilization

LFG collection infrastructure generally follows the development of landfill cells. Horizontal wells are installed while filling in the active cells, and vertical wells can be installed once cells are brought to final or intermediate grades. LFG collection in the South Landfill would likely begin as early as 4 years after the time waste filling begins. As the landfill develops and cell filling is completed, more collection infrastructure will be installed, thereby incrementally increasing the quantity of LFG that may be utilized for clean power production, as discussed in Section 5. In 10 to 15 years from the time which waste filling begins, the South Landfill could be producing more LFG than the North Landfill.

In order to utilize the LFG collected at the South Landfill, alternatives include conveying LFG through a pipeline to the existing LFG to Energy Plant, or constructing a new plant near the South Landfill. A LFG pipeline from the South Landfill to the existing Plant would be approximately 2,500 feet and would likely require condensate collection at the topographic low points along the pipeline. Air emissions permitting will need to be considered and could have an impact on the viability of alternatives. Further modeling and evaluation will need to be performed to determine the cost-benefit, and advantages and disadvantages of each alternative, at various intervals over time.

6.8 Soil Balance

An important consideration when siting a landfill is determination of the amount of soil available compared to the amount of soil required for landfill development. Suitable soil will be needed to complete the final cover of the North Landfill, construct the liner of the south landfill, provide intermediate cover material for the south landfill, and construct the final cover of the South Landfill.

A rough order of magnitude volume calculation was performed to determine the amount of material that would be excavated to achieve the conceptual base grades shown in Figure 6-1. This calculation shows approximately 9,242,000 cubic yards of excavated (cut) material. Based on the soil profile in the North Landfill, and considering what is known of the south area, it is reasonable to assume that approximately

60% of this material, or 5,545,000 cubic yards, could be used as intermediate cover. The remaining 40% of material is assumed to be rock, shale, and other material. It is unknown how much of the estimated 60% of intermediate cover material will be determined as suitable for liner or final cover material.

The amount of soil material needed is approximately estimated as follows:

- Final cover material for North Landfill: 700,000 cubic yards
- Liner material for South Landfill: 480,000 cubic yards
- Intermediate cover material for South Landfill (assumed soil to waste ratio = 4.5) : 4,445,000 cubic yards
- Final cover material for South Landfill: 885,000 cubic yards

The total soil needed is approximately calculated to be 6,510,000 cubic yards; of this, approximately 2,065,000 cubic yards may be needed as liner-grade material. This estimate assumes the existing landfill borrow area contains (or will contain after excavation of Cell 6) adequate material to provide the intermediate cover needed to complete filling in the North Landfill.

From the simplistic assumptions made for this study, there is an apparent soil deficiency of approximately 1 million cubic yards. The apparent deficiency does not affect the feasibility of the project. Further investigation is needed to more accurately estimate the soil balance and will be done during the permitting phase. The actual volumes can be affected by many contributing factors. These factors include the actual percent of usable material realized from the gross volume and the actual soil to waste ratio achieved through landfill operation. Further, potential permit modifications could affect the final cover or liner profiles (such as the use of engineered turf cover systems or geosynthetic clay liners) and resulting soil volumes.

If an actual deficiency is suspected after further investigation in future planning phases, mitigating measures can be planned to more closely balance soil. Optimized designs for the landfill liner to include the use of a geosynthetic clay liner and alternative cover systems can significantly impact the soil balance. The conceptual base grades could potentially be lowered in areas to produce more usable soil and rock. The Waco Road project could potentially be designed to contribute a cut of material that can be utilized. As a final measure, the City could borrow soil from the neighboring properties it owns on the west side of Hinkson Creek. This would require a relatively short haul of material and would likely only be needed when closing the South Landfill at the end of its useful life.

6.9 Design & Operation

As explained in Section 2, Bioreactor landfill cells are those which inject liquid in the waste mass internally through piping or drainage media. The City has made a significant investment in permitting, engineering, infrastructure, and personnel to operate the North Landfill Cells 4, 5, and 6 as Bioreactor cells. The City is anticipated to realize the return on this investment through increased usable airspace, accelerated LFG production, reduced post-closure care costs, and potentially a significantly reduced post-closure care term. Further evaluation will be necessary to quantify the return on investment (ROI) of the Bioreactor project. The project is still in the early phases, and the City is still working towards full-scale operation of the liquids injection in these cells.

It is believed that an evaluation may show that the benefits justify the investment made in the North Landfill Bioreactor cells. In addition, the project's design, operation, and management team has acquired valuable institutional knowledge to more efficiently implement and operate this technology in the South Landfill, which would allow for an even greater ROI. Therefore, the City may choose to approach the South Landfill permitting as a Bioreactor Landfill. The City may conduct an economic and cost-benefit study to evaluate the permitting and development of the South Landfill as a Bioreactor.

7.0 PERMITTING & SCHEDULE

The development of the South Landfill will require significant time, effort, and the project will planned in several project phases. The laws, rules and regulations governing the development of a landfill in Missouri include the Federal Resource Conservation and Recovery Act, the Missouri Solid Waste Management Statutes, and the Missouri Code of State Regulations. A project schedule has been developed and included is as Appendix E. This project schedule is based on the regulatory framework and with consideration of the professional services required, City review times, regulatory review process times, and construction durations.

The Project Phases and expected durations are summarized below:

1. Preliminary Design and Public Outreach Phase: October 2017 to December 2019
2. Permitting and Design Phase: February 2019 to September 2022
3. Air Construction/Operating Permit Modification Application: September 2022 to January 2024
4. Final Design Phase: September 2022 to March 2024

The City's internal processes will need to be considered to meet the projected start dates and funding requirements.

8.0 CONCLUSIONS

This Landfill Site Master Plan is intended to provide information to stakeholders and guidance for the expansion of the Columbia Sanitary Landfill. Landfill expansion enables the City to sustain long-term and low cost operation of the Landfill Site for the City of Columbia solid waste rate payers. The expansion concepts offered are intended to place a high value on the conservation of natural resources and conceptualize specific site and ecological restoration approaches.

The existing Landfill will reach capacity in 2026 depending on assumptions made in the remaining life calculations. The first New Landfill cell will therefore need to be operational prior to 2026. The total time required for planning, permitting, and construction could be seven years or longer (possibly up to ten years) depending on permitting challenges encountered. Burns & McDonnell recommends the City initiate the planning and permitting phase in 2017 to enable sufficient time for project development and construction prior to 2026.

Site enhancements planned along the lower lying floodplain areas along Hinkson Creek include constructed wetlands, wetland mitigation banking, and riparian corridor preservation. Constructed wetlands would be located downstream of the site NPDES Outfalls and would serve to further polish runoff water quality from the landfill. Stormwater BMPs would be designed and located throughout the site upstream of sedimentation ponds. The combined use of stormwater BMPs, sedimentation ponds, and constructed wetlands will protect Hinkson Creek water quality.

Natural resource enhancements and ecological restoration concepts are an important development feature easily incorporated into the environmental engineering systems supporting the overall Landfill site design. The Landfill Expansion is a long-term project ultimately owned by the City of Columbia solid waste rate payers. Opportunities exist to enhance and conserve the biological community and natural resources cost effectively while building the landfill development over time. The intent is to preserve, enhance, and create sufficient high value wildlife habitat to support the existing wildlife populations that occur in the area during and after operation of the South Landfill. The ultimate goal for this landfill site long term is create a community asset that can be enjoyed by the public in the future for recreational or other purposes.

The future expansion of the Landfill and the continued utilization of LFG for energy will have a significant long-term impact on the City's renewable energy portfolio. In the years starting in about 2045, the LFG to Energy Plant could produce approximately 12% of the City's current mandated renewable energy, compared with 0% if the landfill is not expanded. Making up the additional 12% with other

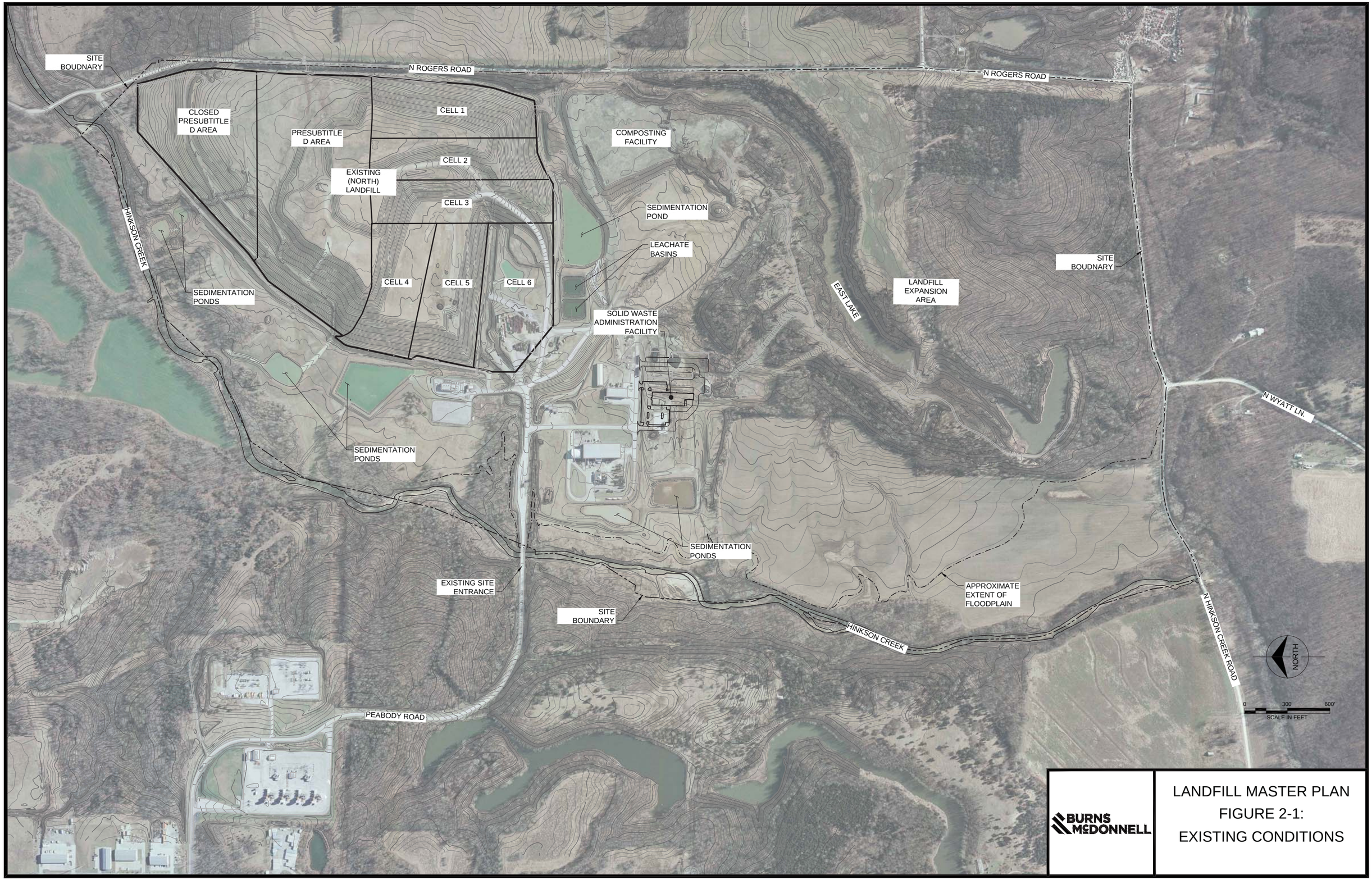
renewable sources would reportedly come at a higher cost to power customers, if current relative costs are projected in future years.

While specific landfill site alternatives were not evaluated in this Study, developing the South Landfill is anticipated to cost solid waste rate payers less per ton compared with other alternatives. Developing the South Landfill is anticipated to cost less because: 1) the City currently owns the planned expansion property, 2) the site is relatively close in proximity to the population served, 3) existing infrastructure including power, water, sewer, and roads currently exist on-site.

8.1 Plan Limitations

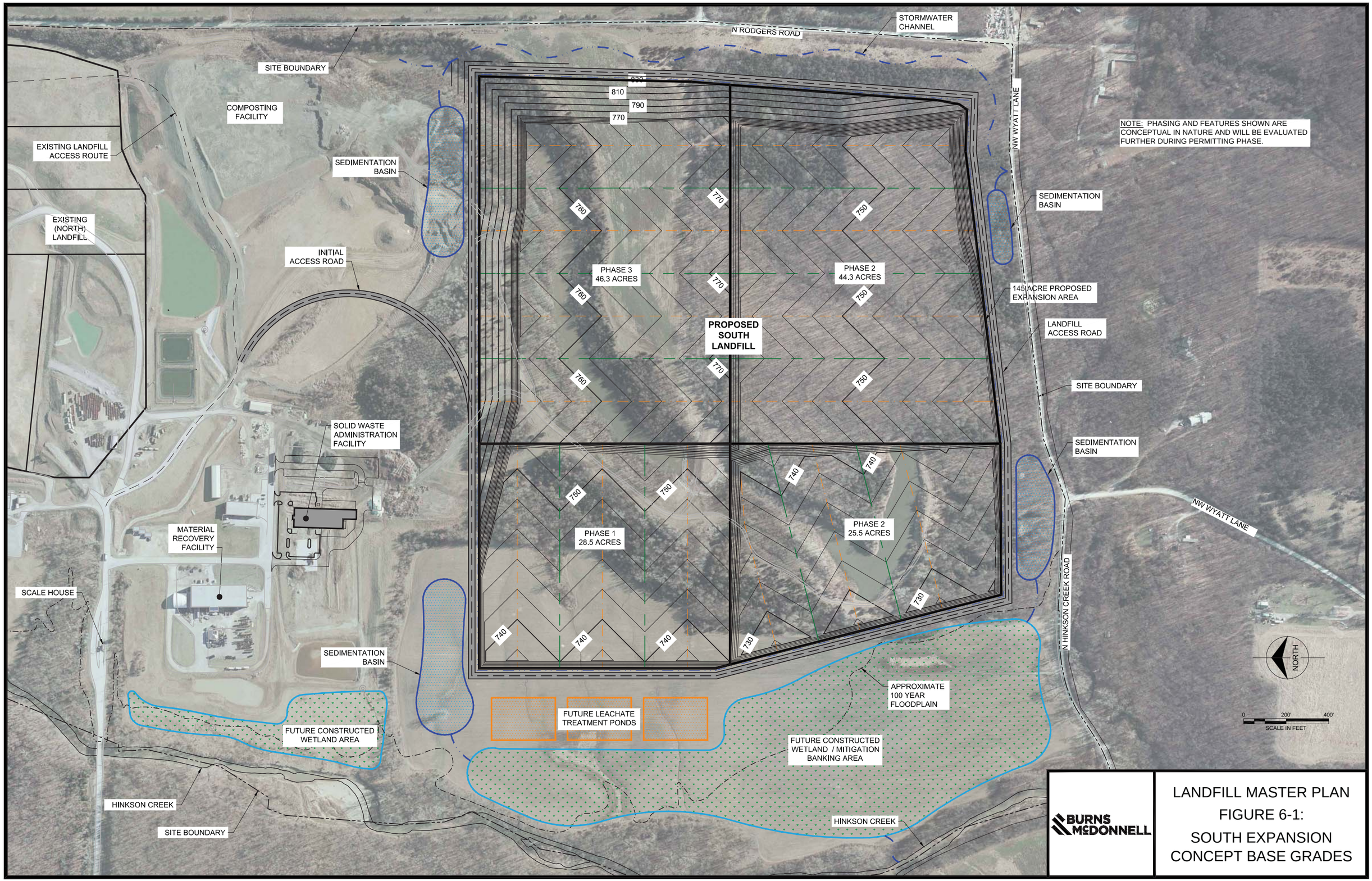
Unforeseen changes in variables considered during planning, such as waste received and operation methods, may require modifications to this Plan prior to it being fully implemented. As such, it is important to note that this report serves only as a planning document and should be reviewed frequently to determine if assumptions have changed and if updates are necessary.

FIGURES



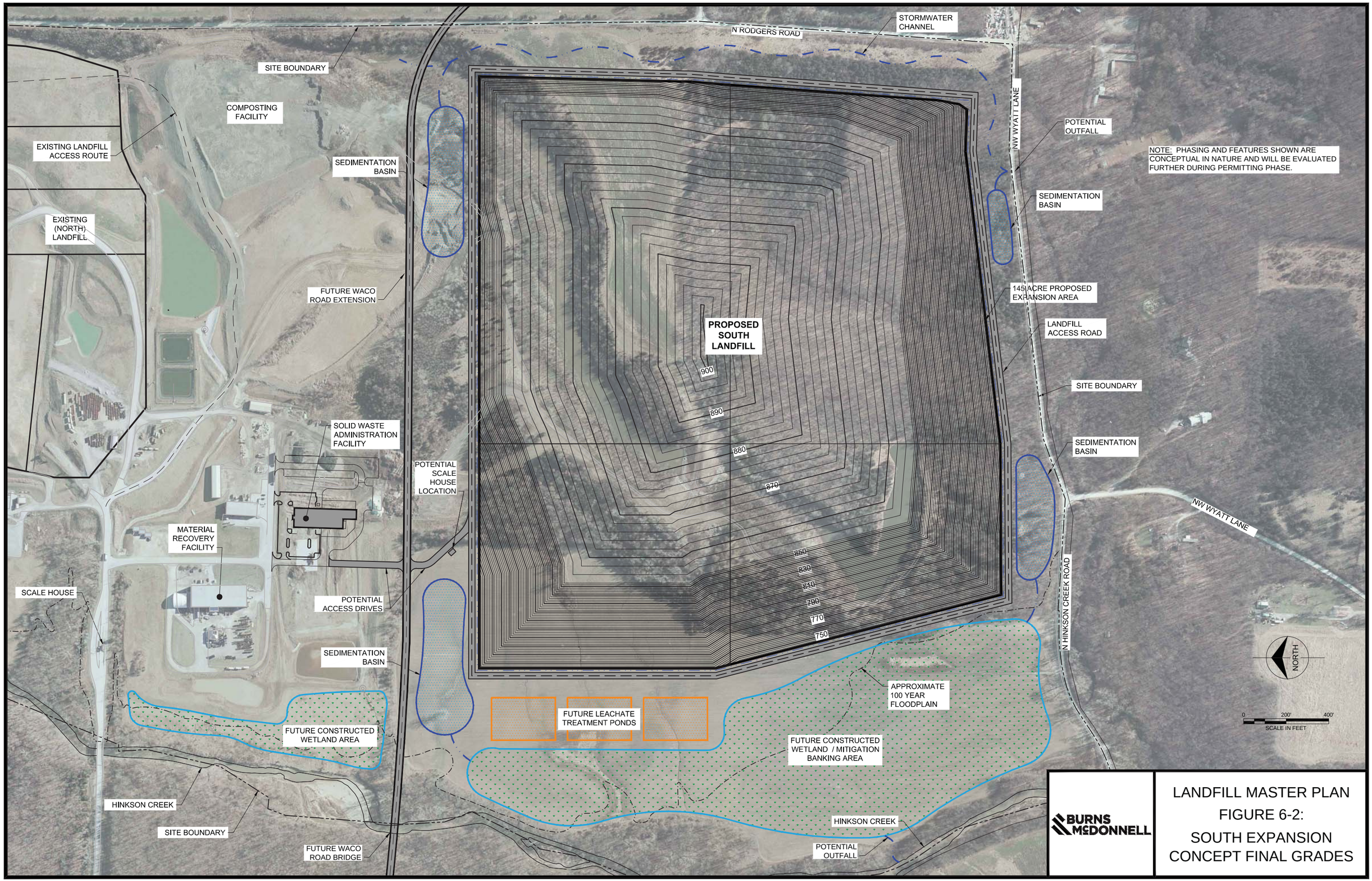
BURNS McDONNELL

LANDFILL MASTER PLAN
FIGURE 2-1:
EXISTING CONDITIONS



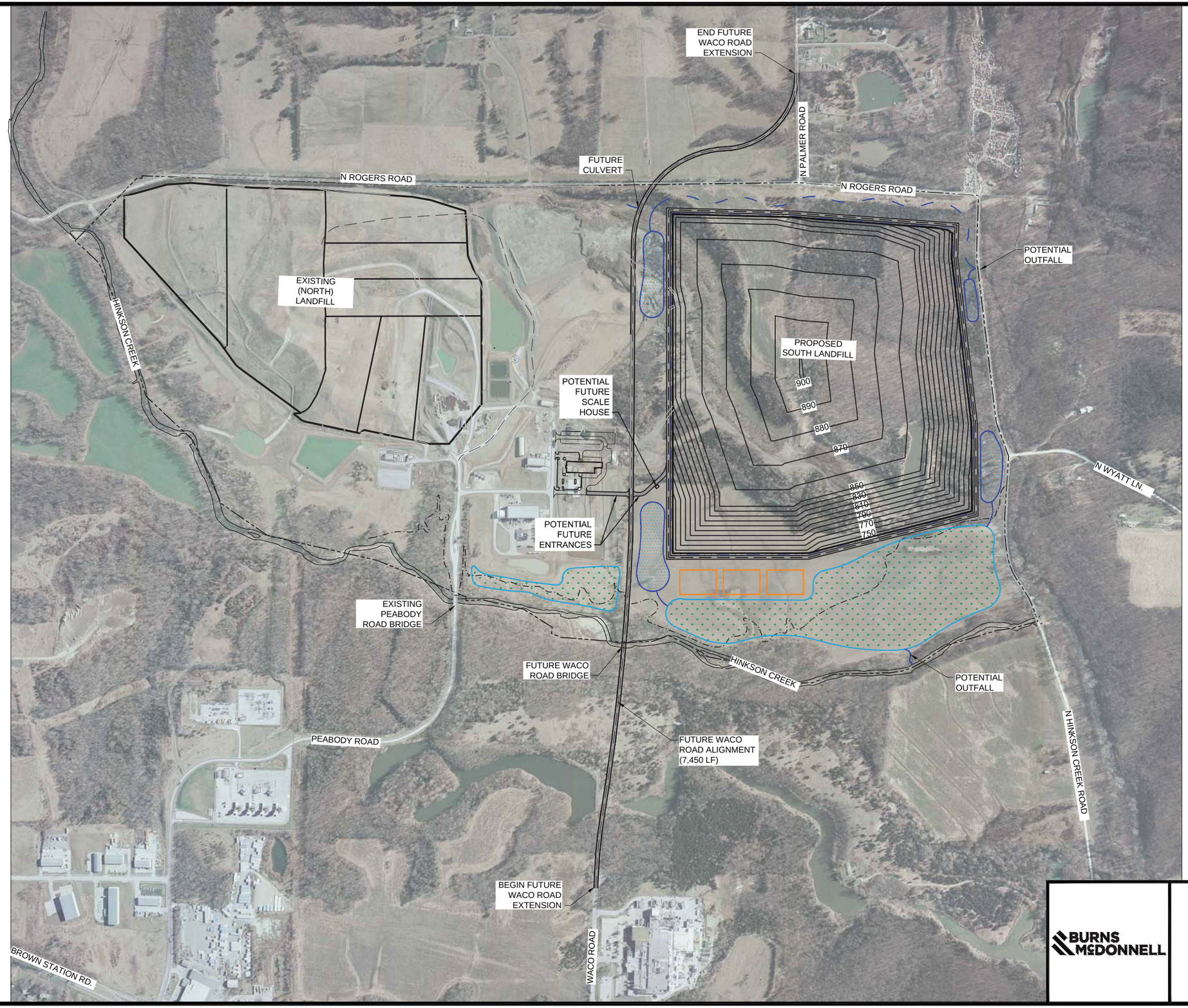
BURNS McDONNELL

LANDFILL MASTER PLAN
FIGURE 6-1:
SOUTH EXPANSION CONCEPT BASE GRADES



BURNS McDONNELL

LANDFILL MASTER PLAN
FIGURE 6-2:
SOUTH EXPANSION CONCEPT FINAL GRADES



NORTH

0 400' 800'

SCALE IN FEET

BURNS McDONNELL

LANDFILL MASTER PLAN
FIGURE 6-3:
SOUTH EXPANSION
WACO ROAD EXTENSION

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APPENDIX A – EXISTING LANDFILL REMAINING LIFE CALCULATIONS

Existing Landfill Remaining Life Calculation Minimum

Tonnage 2015 =	172,447	ton	
Average AUF =	1,123	lb/cy	Assumed average AUF
Growth % =	2.0%		
Average TPY =	189699	lb/cy	
Average Asp. Consumed =	337842	cy	
Remaining Existing Site Capacity =	3,842,078	cy	From March 2015 Survey (per Biennal Estimate) + Vertical Expansion

Year	Tonnage	Airspace Consumed (cy)	Airspace Remaining Year End (cy)	
2015*	135,955	242,128	3,599,950	*Tonnage includes the last three quarters, after the
2016	175,896	313,261	3,286,689	"datum" survey in March, 2015
2017	179,414	319,526	2,967,163	
2018	183,002	325,917	2,641,246	
2019	186,662	332,435	2,308,812	
2020	190,395	339,084	1,969,728	
2021	194,203	345,865	1,623,863	
2022	198,087	352,783	1,271,080	
2023	202,049	359,838	911,242	
2024	206,090	367,035	544,207	
2025	210,212	374,376	169,831	
2026	214,416	381,863	-212,032	Remaining Existing Site Capacity Depleted 2026

Existing Landfill Remaining Life Calculation Maximum

Tonnage 2015 =	172,447	ton	
Average AUF =	1,350	lb/cy	Assumed average AUF
Growth % =	0.0%		
Average TPY =	172447	lb/cy	
Average Asp. Consumed =	250972	cy	
Remaining Existing Site Capacity =	4,152,078	cy	From March 2015 Survey (per Biennal Estimate) + Vertical Expansion + Alternative Final Cover Saving 1.5' + 35,000 CY potential dirt stockpile

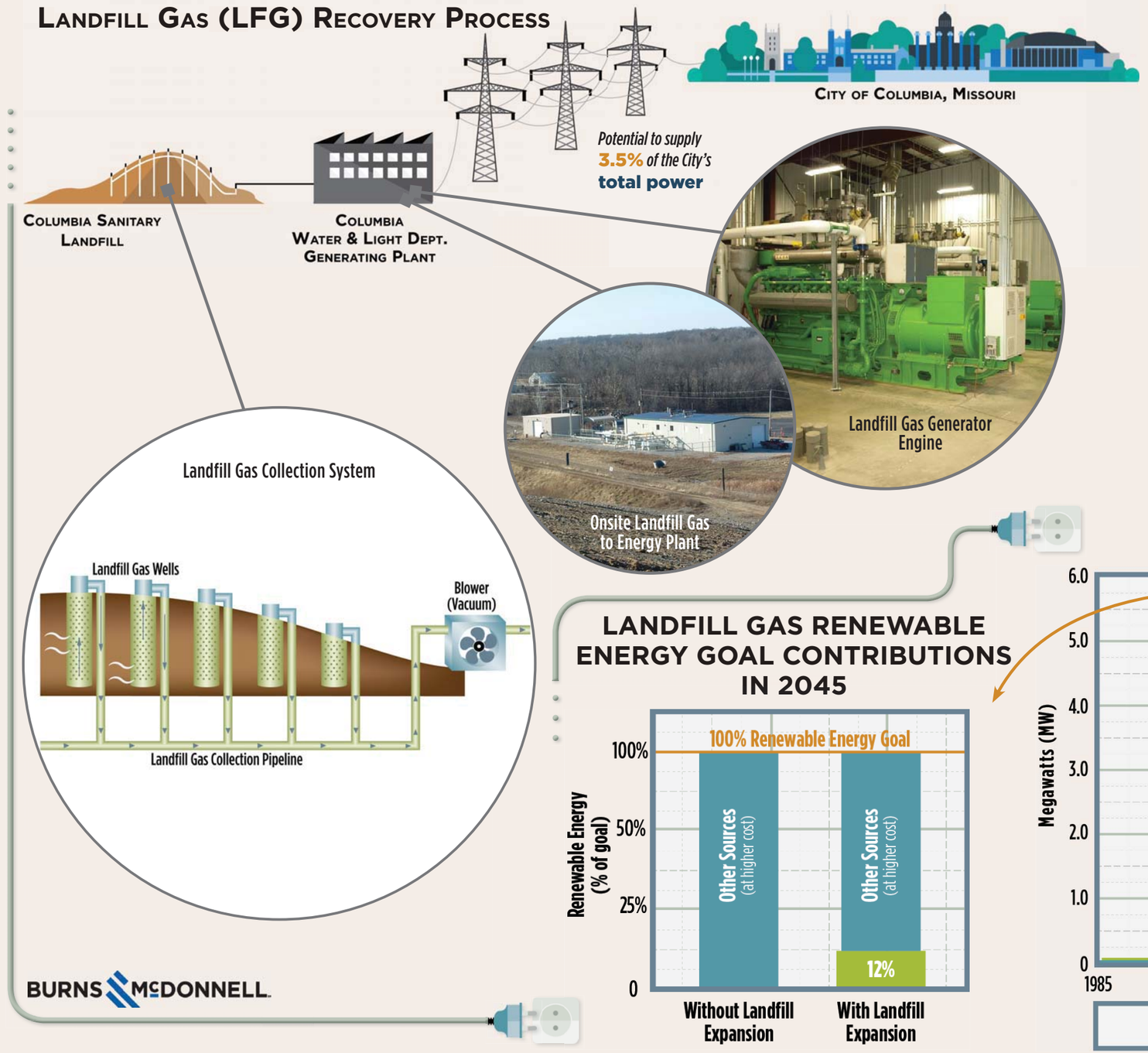
Year	Tonnage	Airspace Consumed (cy)	Airspace Remaining Year End (cy)	
2015*	135,955	201,415	3,950,663	*Tonnage includes the last three quarters, after the
2016	172,447	255,477	3,695,186	"datum" survey in March, 2015
2017	172,447	255,477	3,439,709	
2018	172,447	255,477	3,184,232	
2019	172,447	255,477	2,928,755	
2020	172,447	255,477	2,673,278	
2021	172,447	255,477	2,417,801	
2022	172,447	255,477	2,162,324	
2023	172,447	255,477	1,906,847	
2024	172,447	255,477	1,651,370	
2025	172,447	255,477	1,395,893	
2026	172,447	255,477	1,140,416	
2027	172,447	255,477	884,939	
2028	172,447	255,477	629,462	
2029	172,447	255,477	373,985	
2030	172,447	255,477	118,508	
2031	172,447	255,477	-136,969	Remaining Existing Site Capacity Depleted 2031

APPENDIX B – LANDFILL GAS INFOGRAPHIC

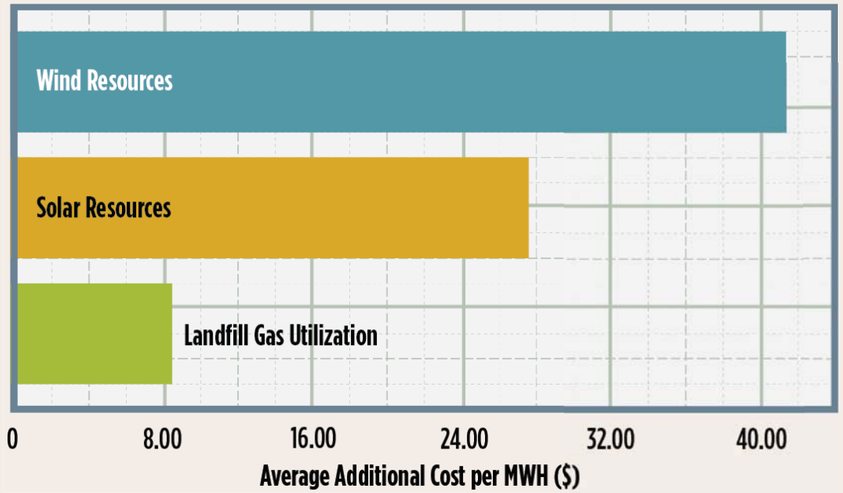
LANDFILL GAS UTILIZATION

Expansion Helps Meet Renewable Energy Goals

Landfill Gas (LFG) Recovery Process



Average Additional Cost of Renewable Energy*

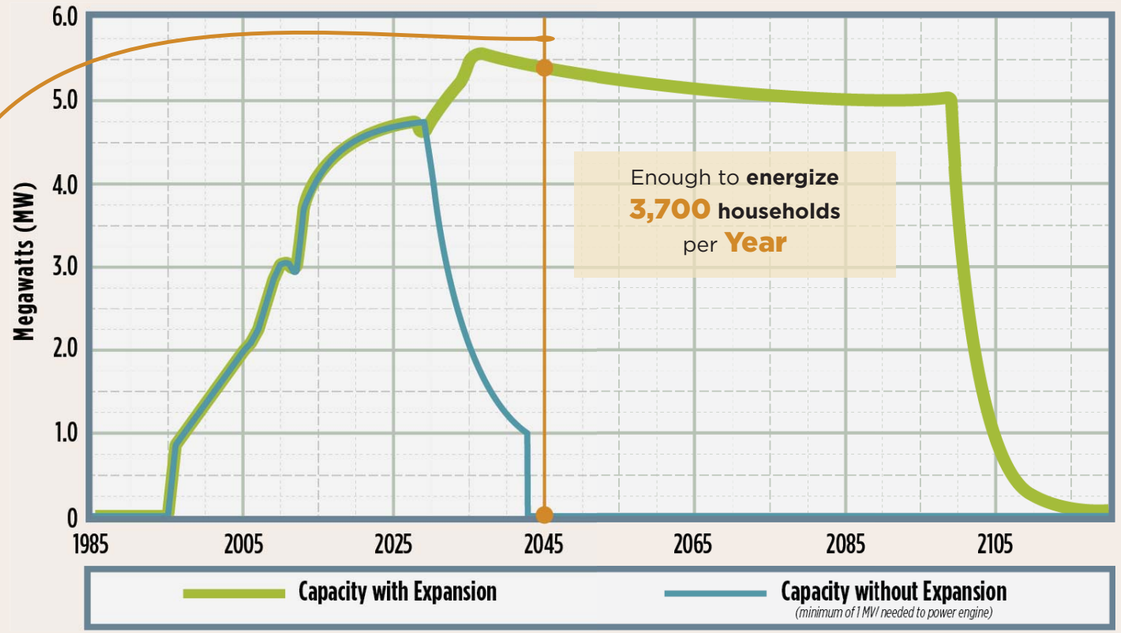


*Per 2016 Columbia Water & Light Renewable Energy Report Data

Landfill Gas Renewable Energy Goal Contributions in 2045

Power Output Comparison

with & without Landfill Expansion



BURNS McDONNELL

APPENDIX C – SOUTH LANDFILL LIFE OF SITE CALCULATION

South Landfill Remaining Life Calculations Minimum

North (Existing) Landfill

Tonnage 2015 =	172,447	ton	
Average AUF =	1,123	lb/cy	Assumed average AUF
Growth % =	2.0%		
Average TPY =	194584	lb/cy	
Average Asp. Consumed =	337842	cy	
Remaining Existing Site Capacity =	3,842,078	cy	From March 2015 Survey (per Biennal Estimate) + Vertical Expansion

South Landfill Expansion

Tonnage 2015 =	172,447	ton	
Average AUF =	1,230	lb/cy	Assumed average AUF with consolidation
Growth % =	1.5%		
Average TPY =	290898	lb/cy	
Average Asp. Consumed =	395967	cy	
Expansion Site Capacity =	20,000,000	cy	South Expansion Area Capacity (Waste Volume)

Year	Tonnage	Airspace Consumed (cy)	Airspace Remaining Year End (cy)	
2015*	135,955	242,128	3,599,950	*Tonnage includes the last three quarters, after the
2016	175,896	313,261	3,286,689	"datum" survey in March, 2015
2017	179,414	319,526	2,967,163	
2018	183,002	325,917	2,641,246	
2019	186,662	332,435	2,308,812	
2020	190,395	339,084	1,969,728	
2021	194,203	345,865	1,623,863	
2022	198,087	352,783	1,271,080	
2023	202,049	359,838	911,242	
2024	206,090	367,035	544,207	
2025	210,212	374,376	169,831	
2026	214,416	381,863	19,787,968	Remaining Existing Site Capacity Depleted 2026
2027	217,632	387,591	19,400,377	
2028	220,897	393,405	19,006,972	
2029	224,210	399,306	18,607,666	
2030	227,574	405,296	18,202,370	
2031	230,987	411,375	17,790,995	
2032	234,452	417,546	17,373,450	
2033	237,969	423,809	16,949,641	
2034	241,538	430,166	16,519,475	
2035	245,161	436,619	16,082,856	
2036	248,839	443,168	15,639,688	
2037	252,571	449,815	15,189,873	
2038	256,360	456,563	14,733,311	
2039	260,205	463,411	14,269,900	
2040	264,108	470,362	13,799,537	
2041	268,070	477,418	13,322,120	
2042	272,091	484,579	12,837,541	
2043	276,172	491,848	12,345,693	
2044	280,315	499,225	11,846,468	
2045	284,520	506,714	11,339,755	
2046	288,787	514,314	10,825,440	
2047	293,119	522,029	10,303,411	
2048	297,516	529,859	9,773,552	
2049	301,979	537,807	9,235,744	
2050	306,509	545,874	8,689,870	
2051	311,106	554,063	8,135,807	
2052	315,773	562,374	7,573,434	

2053	320,509	570,809	7,002,625	
2054	325,317	579,371	6,423,253	
2055	330,197	588,062	5,835,192	
2056	335,150	596,883	5,238,309	
2057	340,177	605,836	4,632,473	
2058	345,280	614,924	4,017,549	
2059	350,459	624,147	3,393,402	
2060	355,716	633,510	2,759,892	
2061	361,051	643,012	2,116,880	
2062	366,467	652,657	1,464,223	
2063	371,964	662,447	801,775	
2064	377,544	672,384	129,391	
2065	383,207	682,470	-553,079	South Expansion Area depleted 2065

South Landfill Remaining Life Calculations Maximum

North (Existing) Landfill

Tonnage 2015 =	172,447	ton	
Average AUF =	1,350	lb/cy	Assumed average AUF
Growth % =	0.0%		
Average TPY =	172447	lb/cy	
Average Asp. Consumed =	255477	cy	
Remaining Existing Site Capacity =	4,152,078	cy	From March 2015 Survey (per Biennal Estimate) + Vertical Expansion + Alternative Final Cover Saving 1.5' + 35,000 CY potential dirt stockpile

South Landfill Expansion

Tonnage 2015 =	172,447	ton	
Average AUF =	1,350	lb/cy	Assumed average AUF with consolidation
Growth % =	0.0%		
Average TPY =	172447	lb/cy	
Average Asp. Consumed =	255477	cy	
Expansion Site Capacity =	20,468,000	cy	South Expansion Area Capacity (Waste Volume) + Alternative Final Cover

Year	Tonnage	Airspace Consumed (cy)	Airspace Remaining Year End (cy)	
2015*	135,955	201,415	3,950,663	*Tonnage includes the last three quarters, after the
2016	172,447	255,477	3,695,186	"datum" survey in March, 2015
2017	172,447	255,477	3,439,709	
2018	172,447	255,477	3,184,232	
2019	172,447	255,477	2,928,755	
2020	172,447	255,477	2,673,278	
2021	172,447	255,477	2,417,801	
2022	172,447	255,477	2,162,324	
2023	172,447	255,477	1,906,847	
2024	172,447	255,477	1,651,370	
2025	172,447	255,477	1,395,893	
2026	172,447	255,477	1,140,416	
2027	172,447	255,477	884,939	
2028	172,447	255,477	629,462	
2029	172,447	255,477	373,985	
2030	172,447	255,477	118,508	
2031	172,447	255,477	20,331,031	Remaining Existing Site Capacity Depleted 2031
2032	172,447	255,477	20,075,554	
2033	172,447	255,477	19,820,077	
2034	172,447	255,477	19,564,599	
2035	172,447	255,477	19,309,122	
2036	172,447	255,477	19,053,645	
2037	172,447	255,477	18,798,168	
2038	172,447	255,477	18,542,691	
2039	172,447	255,477	18,287,214	
2040	172,447	255,477	18,031,737	
2041	172,447	255,477	17,776,260	
2042	172,447	255,477	17,520,783	
2043	172,447	255,477	17,265,306	
2044	172,447	255,477	17,009,829	
2045	172,447	255,477	16,754,352	
2046	172,447	255,477	16,498,875	
2047	172,447	255,477	16,243,398	
2048	172,447	255,477	15,987,921	
2049	172,447	255,477	15,732,444	
2050	172,447	255,477	15,476,967	
2051	172,447	255,477	15,221,490	
2052	172,447	255,477	14,966,013	
2053	172,447	255,477	14,710,536	
2054	172,447	255,477	14,455,059	
2055	172,447	255,477	14,199,582	

2056	172,447	255,477	13,944,105	
2057	172,447	255,477	13,688,628	
2058	172,447	255,477	13,433,151	
2059	172,447	255,477	13,177,674	
2060	172,447	255,477	12,922,197	
2061	172,447	255,477	12,666,719	
2062	172,447	255,477	12,411,242	
2063	172,447	255,477	12,155,765	
2064	172,447	255,477	11,900,288	
2065	172,447	255,477	11,644,811	
2066	172,447	255,477	11,389,334	
2067	172,447	255,477	11,133,857	
2068	172,447	255,477	10,878,380	
2069	172,447	255,477	10,622,903	
2070	172,447	255,477	10,367,426	
2071	172,447	255,477	10,111,949	
2072	172,447	255,477	9,856,472	
2073	172,447	255,477	9,600,995	
2074	172,447	255,477	9,345,518	
2075	172,447	255,477	9,090,041	
2076	172,447	255,477	8,834,564	
2077	172,447	255,477	8,579,087	
2078	172,447	255,477	8,323,610	
2079	172,447	255,477	8,068,133	
2080	172,447	255,477	7,812,656	
2081	172,447	255,477	7,557,179	
2082	172,447	255,477	7,301,702	
2083	172,447	255,477	7,046,225	
2084	172,447	255,477	6,790,748	
2085	172,447	255,477	6,535,271	
2086	172,447	255,477	6,279,794	
2087	172,447	255,477	6,024,317	
2088	172,447	255,477	5,768,839	
2089	172,447	255,477	5,513,362	
2090	172,447	255,477	5,257,885	
2091	172,447	255,477	5,002,408	
2092	172,447	255,477	4,746,931	
2093	172,447	255,477	4,491,454	
2094	172,447	255,477	4,235,977	
2095	172,447	255,477	3,980,500	
2096	172,447	255,477	3,725,023	
2097	172,447	255,477	3,469,546	
2098	172,447	255,477	3,214,069	
2099	172,447	255,477	2,958,592	
2100	172,447	255,477	2,703,115	
2101	172,447	255,477	2,447,638	
2102	172,447	255,477	2,192,161	
2103	172,447	255,477	1,936,684	
2104	172,447	255,477	1,681,207	
2105	172,447	255,477	1,425,730	
2106	172,447	255,477	1,170,253	
2107	172,447	255,477	914,776	
2108	172,447	255,477	659,299	
2109	172,447	255,477	403,822	
2110	172,447	255,477	148,345	
2111	172,447	255,477	-107,132	South Expansion Area depleted 2111

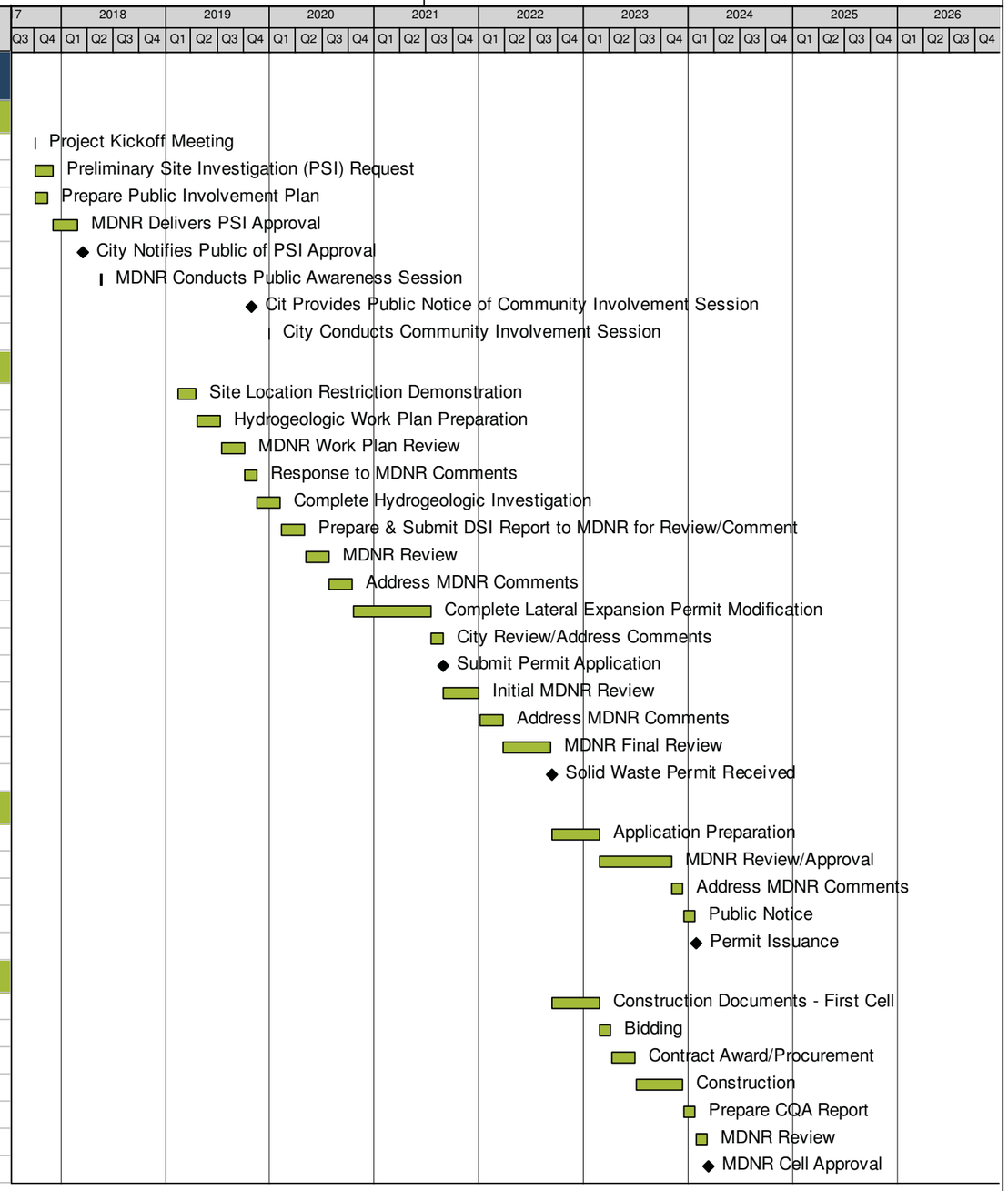
APPENDIX D – PROJECT SCHEDULE

City of Columbia, Missouri - Bioreactor Landfill Expansion

DRAFT - 3/23/2017

BURNS McDONNELL

Activity ID	Activity Name	Original Duration	Start	Finish	Predecessors	Successors
Bioreactor Landfill Expansion		1680	02-Oct-17	11-Mar-24		
Preliminary Design & Public Outreach Phase		586	02-Oct-17	30-Dec-19		
A1010	Project Kickoff Meeting	1	02-Oct-17*	02-Oct-17		A1020, A1030
A1020	Preliminary Site Investigation (PSI) Request	45	03-Oct-17	04-Dec-17	A1010	A1040
A1030	Prepare Public Involvement Plan	30	06-Oct-17	16-Nov-17	A1010	
A1040	MDNR Delivers PSI Approval	60	05-Dec-17	26-Feb-18	A1020	A1050, A1060
A1050	City Notifies Public of PSI Approval	0	20-Mar-18		A1040	
A1060	MDNR Conducts Public Awareness Session	1	22-May-18	22-May-18	A1040	
A1070	Cit Provides Public Notice of Community Involvement Session	0	29-Oct-19		A1080	
A1080	City Conducts Community Involvement Session	1	30-Dec-19	30-Dec-19	A1150	A1070
Permitting & Design Phase		933	13-Feb-19	12-Sep-22		
A1100	Site Location Restriction Demonstration	60	13-Feb-19*	19-Apr-19		A1110
A1110	Hydrogeologic Work Plan Preparation	60	22-Apr-19	12-Jul-19	A1100	A1120
A1120	MDNR Work Plan Review	60	15-Jul-19	04-Oct-19	A1110	A1130
A1130	Response to MDNR Comments	30	07-Oct-19	15-Nov-19	A1120	A1140
A1140	Complete Hydrogeologic Investigation	60	18-Nov-19	07-Feb-20	A1130	A1150
A1150	Prepare & Submit DSI Report to MDNR for Review/Comment	60	10-Feb-20	01-May-20	A1140	A1080, A1160
A1160	MDNR Review	60	04-May-20	24-Jul-20	A1150	A1170
A1170	Address MDNR Comments	60	27-Jul-20	16-Oct-20	A1160	A1180
A1180	Complete Lateral Expansion Permit Modification	195	19-Oct-20	16-Jul-21	A1170	A1190
A1190	City Review/Address Comments	30	19-Jul-21	27-Aug-21	A1180	A1200
A1200	Submit Permit Application	0	30-Aug-21		A1190	A1210
A1210	Initial MDNR Review	90	30-Aug-21	31-Dec-21	A1200	A1220
A1220	Address MDNR Comments	60	03-Jan-22	25-Mar-22	A1210	A1230
A1230	MDNR Final Review	120	28-Mar-22	09-Sep-22	A1220	A1240
A1240	Solid Waste Permit Received	0	12-Sep-22		A1230	A1260, A1320
Air Construction/Operating Permit Modification Application		360	12-Sep-22	29-Jan-24		
A1260	Application Preparation	120	12-Sep-22	24-Feb-23	A1240	A1270
A1270	MDNR Review/Approval	180	27-Feb-23	03-Nov-23	A1260	A1280
A1280	Address MDNR Comments	30	06-Nov-23	15-Dec-23	A1270	A1290
A1290	Public Notice	30	18-Dec-23	26-Jan-24	A1280	A1300
A1300	Permit Issuance	0	29-Jan-24		A1290	
Final Design Phase		390	12-Sep-22	11-Mar-24		
A1320	Construction Documents - First Cell	120	12-Sep-22	24-Feb-23	A1240	A1330
A1330	Bidding	30	27-Feb-23	07-Apr-23	A1320	A1340
A1340	Contract Award/Procurement	60	10-Apr-23	30-Jun-23	A1330	A1350
A1350	Construction	120	03-Jul-23	15-Dec-23	A1340	A1360
A1360	Prepare CQA Report	30	18-Dec-23	26-Jan-24	A1350	A1370
A1370	MDNR Review	30	29-Jan-24	08-Mar-24	A1360	A1380
A1380	MDNR Cell Approval	0	11-Mar-24		A1370	



Actual Work — Critical Remaining Work

Remaining Work — Milestone

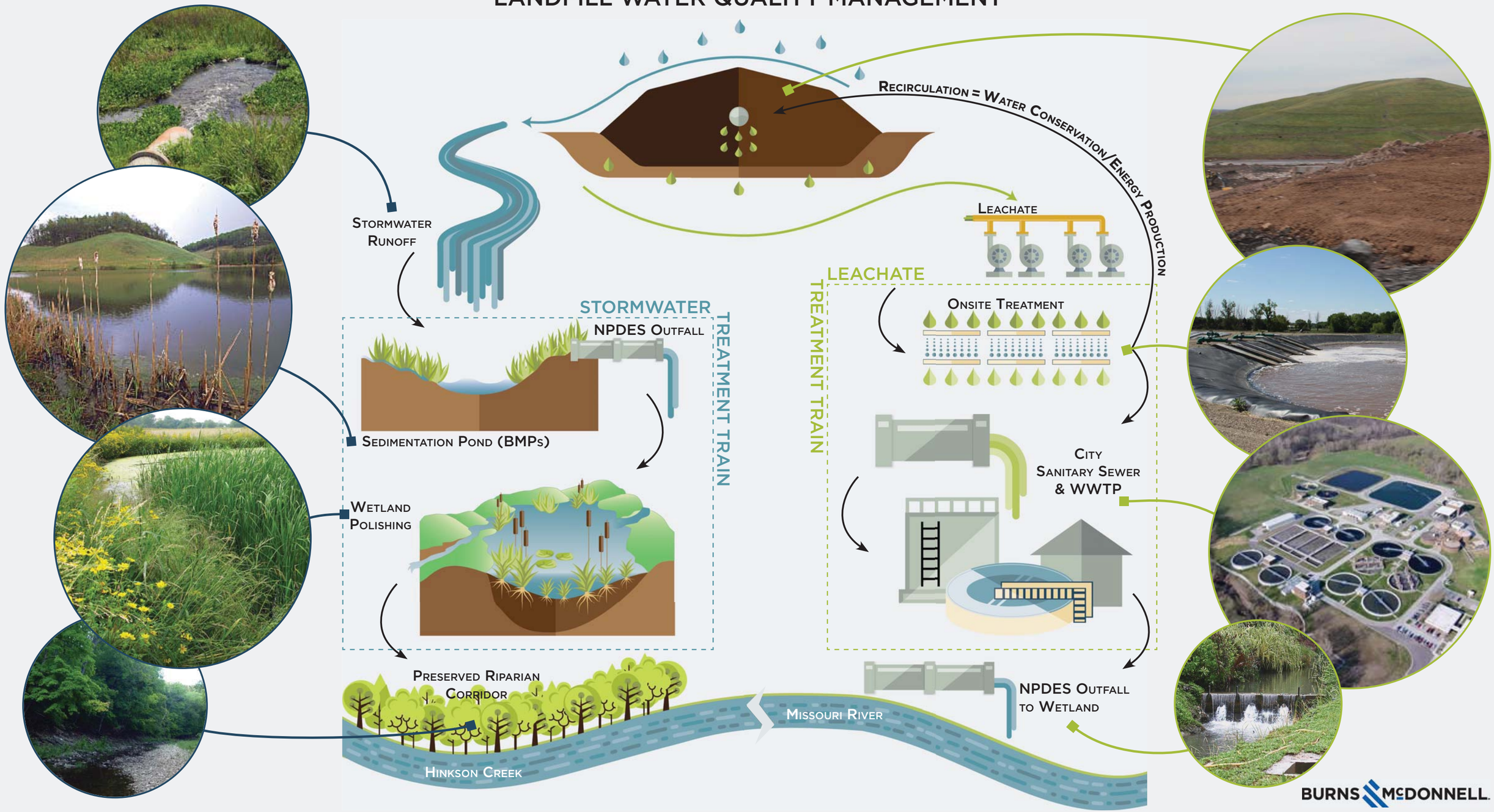
Date	Revision	Checked	Approved
23-Mar-17	DRAFT Schedule	SP	

APPENDIX E – WATER TREATMENT INFOGRAPHIC

ENHANCING WATER QUALITY

with Best Management Practices and Treatment Systems

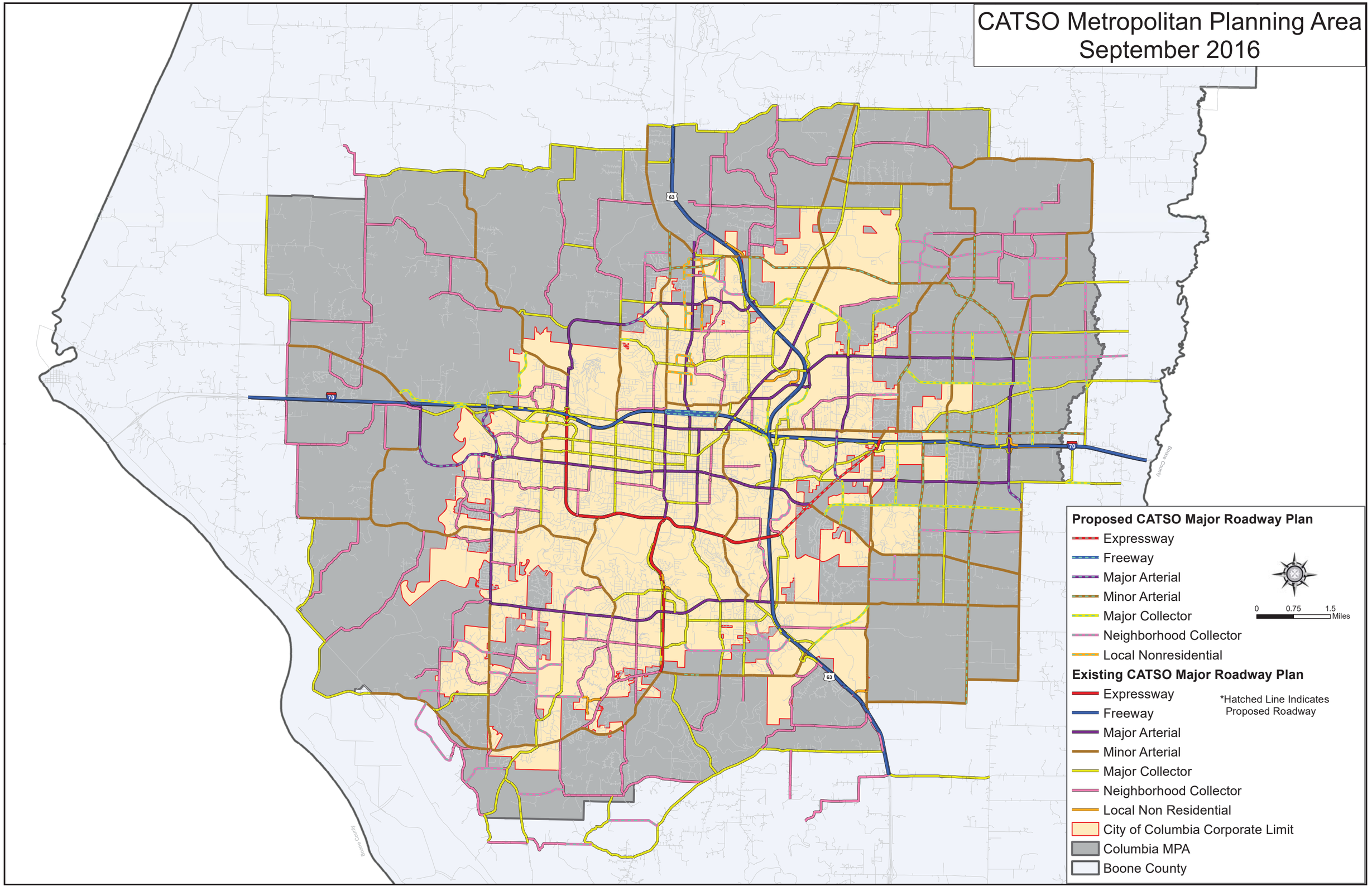
LANDFILL WATER QUALITY MANAGEMENT



BURNS McDONNELL

APPENDIX F – CATSO MAJOR ROADWAY PLAN

CATSO Metropolitan Planning Area
September 2016



Proposed CATSO Major Roadway Plan

- Expressway
- Freeway
- Major Arterial
- Minor Arterial
- Major Collector
- Neighborhood Collector
- Local Nonresidential

Existing CATSO Major Roadway Plan

- Expressway
- Freeway
- Major Arterial
- Minor Arterial
- Major Collector
- Neighborhood Collector
- Local Non Residential
- City of Columbia Corporate Limit
- Columbia MPA
- Boone County

*Hatched Line Indicates Proposed Roadway

0 0.75 1.5 Miles

APPENDIX G – ECOLOGY INFOGRAPHIC

LANDFILL SITE EXPANSION

Ecological Preservation & Restoration Plan

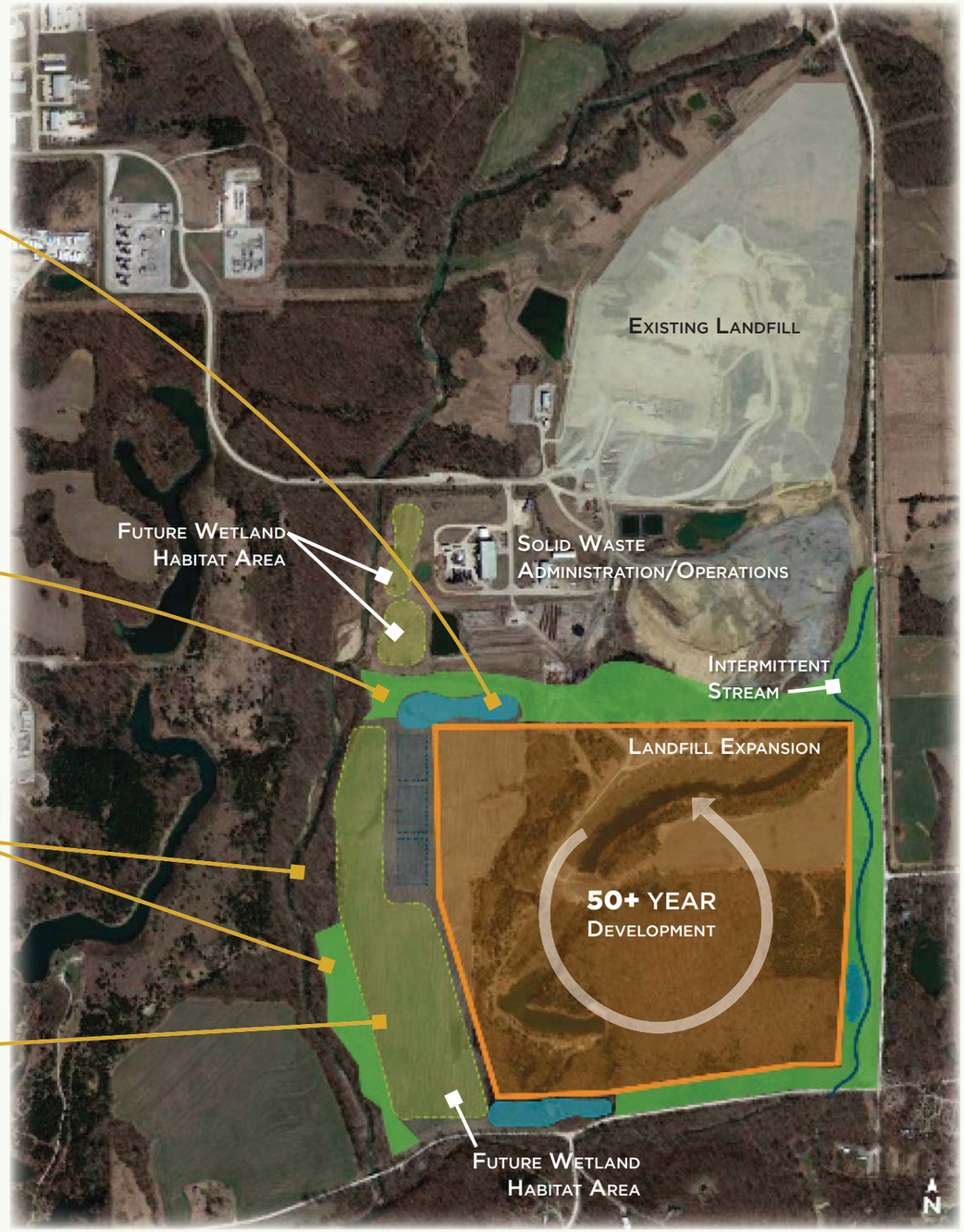
Project Features

Water Quality Sedimentation Pond

Wildlife Corridor Preservation/ Restoration (Upland Forest)

Stream Preservation & Riparian Corridor Restoration (Reclaimed Farmland)

Wetland Habitat Area (Reclaimed Farmland)



Strategic, Long-term Development to Preserve Wildlife Habitat

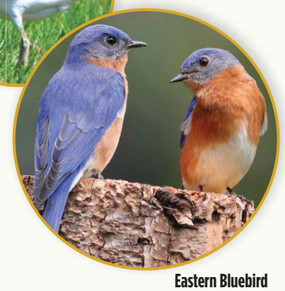
Wild Turkey
(Meleagris gallopavo)

Northern Mockingbird
(Mimus polyglottos)

Great Blue Heron
(Ardea herodias)

Killdeer

Blanchard's Cricket Frog
(Acris crepitans blanchardi)



Eastern Bluebird
(Sialia sialis)

Five-lined Skink
(Plestiodon fasciatus)

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