ATTACHMENT 24

AR # 320

Summary of Financial Responsibility Estimates for FutureGen Based on Cost Tool Outputs (March 2014)

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Summary of Financial Responsibility Estimates for FutureGen Based on Cost Tool Outputs

March 2014

Purpose

This document describes the application of the Cost Tool[1] to develop financial responsibility (FR) estimates for the FutureGen Industrial Alliance, Inc. (FutureGen IL-137-6A-0001,-0002,-0003,-0004) project in Jacksonville, Illinois. These estimates were then compared to the FR estimates developed by Patrick Engineering, Inc. and to the value of the FR instruments recommended by McGriff, Seibels & Williams, Inc. in their insurance review (both provided by FutureGen in the permit application revision dated March 2013).

Cost Tool

The FutureGen project consists of four UIC wells within a single area of review (AoR) of 1,814 square miles, which includes a CO_2 plume predicted to extend to 6.46 square miles. 1.1 million metric tonnes of CO_2 is estimated to be injected annually over 20 years (total for four injection wells). Note that the Cost Tool is designed to develop a range of FR estimates based on one injection well within the AoR. Therefore, the range of FR estimates developed by the Cost Tool for one injection well ().

Exhibit 1, Column A) was adjusted as necessary to estimate FR costs for four injection wells ().

Exhibit 1, Column B).

Exhibit 1. Summary of FutureGen Financial Responsibility Estimates (Millions, 2012$).

Financial Responsibility Categories	1 injection well ($/Project; includes 20% G&A)	4 injection wells ($/Project; includes 20% G&A)
	A	B
Performing Corrective Action on Deficient Wells in AoR	$ -	$ -
Plugging Injection Well	$0.07 - $0.20	$0.28 - $0.79
PISC	$20.3 - $36.2	$20.3 - $36.2
Site Closure	$0.55 - $1.5	$0.55 - $1.5
Emergency and Remedial Response	$6.1 - $66.6	$14.7 - $77.9

[1] The Cost Estimation Tool for Class VI Financial Responsibility Demonstrations (the Cost Tool) was developed in July 2012 to provide an "acceptable range of costs" for Class VI financial responsibility activities based on information submitted with a permit application. Documentation and assumptions for the Cost Tool are provided in Appendix A.

The Cost Tool inputs were determined based on project data[2] provided in the permit application and all updated information[3] EPA received as of February 7, 2014. Inputs include: maximum extent of the CO_2 plume, amount of CO_2 injected, duration of post-injection site care (PISC) period, presence of underground sources of drinking water (USDWs) in the AoR, the depths and diameters of the injection and monitoring wells in the AoR, and the characteristics of any deficient wells in the AoR requiring corrective action. For cost estimation purposes, the depths and diameters of the four injection wells were assumed to be identical in the Cost Tool. Additionally, equal amounts of CO_2 were assumed to be injected by all four injection wells. Detailed output tables (for FR estimates based on one injection well and for four injection wells) that show the subcomponents of the FR categories are provided in Appendix B.

[2] FutureGen may refine their project data (e.g., AoR calculation). FR estimates developed by Patrick Engineering, Inc. and generated by the Cost Tool should be revised if project data are refined.

[3] The estimates provided by Patrick Engineering are assumed to be based on the original permit application. EPA has since received some revised project information; however it does not appear that the updated information would significantly change the cost estimates.

Exhibit 2 shows the Cost Tool inputs used.

Exhibit 2. Cost Tool Inputs.

Contact Information

Variable Name	Value	
Name of Permit Applicant (Corporate Entity)	FutureGen Industrial Alliance, Inc.	
Project Address	Morgan County Office 73 Central Park Plaza East Jacksonville, IL 62650	[Note: Plant's mailing address used, not the address of the injection site]
Name of Project Operator (Individual Person)	Not provided	
Contact Information for Project Operator	(217) 243-8215	

Project Data (IL-137-6A-0001,-0002,-0003,-0004. FutureGen 2.0 Morgan County UIC Wells 1, 2, 3, and 4.)

Variable Name	Value	Units (Click in Cell for Dropdown List)	
Size of CO_2 Plume	6.46	Square Miles	*[Note: Maximum plume extent, which occurs at 22 years after the start of injection (2 years after the cessation of injection).]*
Are There Underground Sources of Drinking Water (USDWs) in the AoR?	Yes		*Instruction: If there are no USDWs, but there are other (non-USDW) types of groundwater in the AoR that the operator would be required to remediate (if contaminated by a well failure), select 'Yes'.* *[Note: Actual drinking water source (SW), but for the case of the permit the lowermost USDW (St. Peter Sandstone) is used.]*
Mass of CO_2 Injected into Site to Date	5,500,000	Metric Tonnes	*Note: 1.1 million metric tonnes of CO_2 injected annually over 20 years (total for 4 injection wells). For cost purposes assume equal amounts of CO_2 injected by injection wells 1-4. Based on information in permit application (Table 3.11) estimated amount of CO_2 injected annually by each well:* *Injection well #1: 0.2063 million metric tons/year* *Injection well #2: 0.3541 million metric tons/year* *Injection well #3: 0.3541 million metric tons/year* *Injection well #4: 0.1856 million metric tons/year*
Duration of Post-Injection Site Care	50	Years	
Depth of Injection Well	4,030	Feet	*[Note: True vertical depth (design) of injection wells 1-4 assumed to be identical; FutureGen Permit Application (figure 4.4)]*
Diameter of Injection Well	7.0	inches	*Note: Diameter represents outside diameter of the long string casing of injection wells 1-4 (assumed to be identical), which is assumed to be cemented to the well (and is therefore assumed to be left in the well during plugging). FutureGen Permit Application (Section 4.2.2).*

Note: The actual depth of the St. Petersberg Formation #1 monitoring well is 2,000 ft (FutureGen Permit Application, App. C, Table 3a). Cost to clean out monitoring wells is based on a regression equation that is only valid for well depths greater than 2,000 ft. For modeling purposes assumed St. Petersburg Formation #1 well to be 2,001 ft.

Note: Monitoring well depths are provided in FutureGen's Jan. 2014 submission, App. B, Table 1. Monitoring well diameters (BPJ).

7 ←Number of Monitoring Wells

Enter in Names, Depths (Feet), and Diameters (inches) of Monitoring Wells in the Table Below. Delete default information from unneeded columns.

Well Name	Mt. Simon SLR #1 [Stratigraphic Well, Pre-existing]	Mt. Simon SLR #2 [Drilled for project]	Mt. Simon RAT #1 [Drilled for project]	Mt. Simon RAT #2 [Drilled for project]	Ironton Sandstone #1 [Above Confining Zone, drilled for project]	Ironton Sandstone #2 [Above Confining Zone, drilled for project]	St. Peters Sandstone #1 [USDW, drilled for project]	[Well Name]	[Well Name]
Well Depth (feet)	4,150	4,150	4,465	4,465	3,470	3,470	2,001		
Well Diameter (in)	4.0	4.0	4.0	4.0	4.0	4.0	4.0		

Characteristics of Deficient Wells in the AoR Requiring Corrective Action

0 ←Number of Deficient Wells in the AoR that will be Remediated in the Next Year

Enter in Names, Depths (Feet), and Diameters (in) of Deficient Wells in the AoR Requiring Corrective Action in the Table Below. Delete default information from unneeded columns.

Well Name	[Well Name]	[Well Name]	[Well Name]	[Well Name]	[Well Name]	[Well Name]	[Well Name]	[Well Name]	[Well Name]
Well Depth (feet)									
Well Diameter (in)									

Alliance does not expect to need to undertake any corrective actions before the start of injection or during the injection period of 20 years. Based on this information Cadmus assumes that there are no deficient wells in the AoR that will need correction action. Note that this is inconsistent with the assumption made in the third-party cost estimate that during the injection or post-injection period one previously unidentified well penetrating the confining zone is assumed to need to undergo corrective action to protect USDWs.

Comparison of Financial Responsibility Cost Estimates

Exhibit 3 compares the FR cost estimates provided by FutureGen, the estimates generated by the Cost Tool, and the recommended value of the FR instruments. The costs estimated by the Cost Tool (Exhibit 3, Column B) can serve as a point of discussion between the UIC Program Director and the owner or operator in the financial responsibility demonstration review process. The cost estimates for each financial responsibility activity are intended to be accurate enough for UIC Program Directors to assess whether or not the cost estimate provided by the owner or operator (Exhibit 3, Column A) is likely to be adequate.

In the permit application revision dated March 2013, FutureGen provided an independent FR cost estimate developed by Patrick Engineering, Inc. (Appendix C of the permit application). FutureGen plans to use a trust fund to cover the costs of corrective action, injection well plugging, and PISC and site closure, and insurance for emergency and remedial response (E&RR). Exhibit 3, Column C provides recommendations for the value of the insurance policy developed by McGriff, Seibels & Williams, Inc. (Appendix D of the permit application).

However, in March 2014, FutureGen informed EPA that, instead of using two separate FR instruments, they would use a single FR instrument (a Trust Fund/Agreement) valued at $51,768,000.00 to cover all costs for which financial responsibility is required. Note that FutureGen's March 2013 approach to use two separate FR instruments, and their revised approach to use a single FR instrument (March 2014), are provided in Exhibit 3 and discussed throughout this document.

It is important to note that while the FR categories shown below (and discussed in this document) correspond to those used in the Cost Tool, the specific line items and assumptions considered by the two sets of estimates do not directly correspond to each other. However they are sufficiently close to support discussions of the adequacy of the FR cost estimates. A discussion of the comparison of financial responsibility estimates is provided below.

Exhibit 3. Comparison of FR cost estimates provided by FutureGen and generated by the Cost Tool to the recommended value of the FR instruments (Millions, 2012$).

Financial Responsibility Categories	FutureGen Submission (Millions, 2012$)	Cost Tool (Millions, 2012$)	Proposed Value of FR Instrument (Millions, 2012$)
	A	B	C
Performing Corrective Action on Deficient Wells in AoR	$0.62	$ -	**Trust Fund** $25.0
Plugging Injection Wells	$2.7	$0.28 - $0.79	
PISC	$18.3	$20.3 - $36.2	
Site Closure	$3.4	$0.55 - $1.5	
Subtotal for Trust Fund Activities	**$25.0**	**$21.1 - $38.4**	**$25.0**
Emergency and Remedial Response	$26.7 [(2)]	$14.7 - $77.9	**Total Recommended Value of PLL Policy** $50.0 - $100.0
Total (All activities, to be covered by a Trust Agreement), and based on final cost estimates	$51.77	$35.8 - $116.3	**$51.77**

Notes:

(1) FR categories shown correspond to those used in the Cost Tool. Specific line items considered by the two sets of estimates do not directly correspond to each other; therefore, direct comparisons of subsets of costs cannot be made. Additionally, assumptions used to develop unit costs for project activities may vary between the two estimates.

(2) E&RR costs are provided in the FutureGen submission (see Appendix C, Exhibit C-5). However, total FR costs reported by Patrick Engineering, Inc. do not include E&RR costs. For completeness and ease of comparison, E&RR costs are included in the total FR costs. EPA and FutureGen have discussed and agreed upon revising the E&RR cost estimate of $6.1 million provided in FutureGen's submission to $26.7 million. This revised figure was based on the middle cost estimate calculated using the Cost Tool (see Exhibit B-2).

(3) McGriff, Seibels & Williams, Inc. developed the recommended value for the PLL insurance policy in September 2012. This estimate is based on Patrick Engineering's March 2013 estimates, which are in 2012 dollars. Therefore the value of the FR instruments is assumed to be in 2012 dollars. The policy was also intended to cover potential legal and liability costs and damages beyond the E&RR engineering cost estimates developed by Patrick Engineering, Inc. .

(4) Detail may not add due to independent rounding.

FR Instrument #1: Trust Fund

FutureGen has proposed a trust fund with a value of $25 million as the instrument to cover FR activities corresponding most closely with the first four categories from Exhibit 3. The value of the trust fund is based on FutureGen's FR estimate for these FR categories, and falls within the range estimated by the Cost Tool ($21.1 million - $38.4 million). The subsections below discuss some assumptions that contribute to differences between these FR estimates.

Performing Corrective Action on Deficient Well(s) in AoR

FutureGen's submission indicates no deficient wells in the AoR; therefore, the Cost Tool does not calculate any costs for this FR category. Note that this differs from the assumption made by Patrick Engineering, Inc. that one previously unidentified well penetrating the confining zone will need to undergo corrective action.

Plugging Injection Wells

Patrick Engineering Inc.'s cost estimate ($2.7 million) is well above the range generated by the Cost Tool ($0.28 million - $0.79 million). Patrick Engineering Inc.'s cost estimate for this FR category includes costs for the following: 1) injection well plugging; 2) land reclamation; and 3) well remediation. However, the Cost Tool does not include costs for land reclamation (such activities are more closely related to the site closure process) and well remediation in this FR category.

PISC

Both Patrick Engineering, Inc.'s PISC costs and those generated by the Cost Tool are based on a PISC timeframe of 50 years. Patrick Engineering Inc.'s cost estimate ($18.3 million) falls slightly below the low-end estimate of the range generated by the Cost Tool ($20.3 million - $36.2 million). Specific line items considered by the two sets of estimates do not directly correspond to each other; however, they seem to cover similar overall activities.

The range of costs generated by the Cost Tool assume that post-injection seismic surveys would only be conducted within the extent of the CO_2 plume (6.46 square miles) not on the entire AoR (1,814 square miles) which encompasses the pressure front, because pressure changes cannot be appropriately monitored using seismic surveys. EPA considered the effects of additional monitoring wells (depth and diameter identical to Mt. Simon RAT #1 and #2) for increased pressure front monitoring. Additional monitoring wells slightly increase the range generated by the Cost Tool (one additional monitoring well: $21.8 million - $38.6 million; two additional monitoring wells $23.3 million - $41.1 million). This would result in a total PISC cost estimate range generated by the Cost Tool that is slightly higher than Patrick Engineering Inc.'s cost estimate ($18.3 million).

The Cost Tool conservatively assumes no discounting for any activities that occur after CO_2 injection ceases (see Appendix A for additional information). The FutureGen submission does not indicate whether discounting is performed or what discount rate may be used. Assuming a 0% discount rate results in higher costs than using a discount rate greater than 0% (e.g., 3% or 7%). If a 3% discount rate were used, the range generated by the Cost Tool for PISC would be $10.7 million - $19.2 million. Patrick Engineering Inc.'s cost estimates are similar to the upper end of this range, so it may be possible that Patrick Engineering, Inc. is discounting these costs.

Site Closure

Patrick Engineering Inc.'s cost estimate ($3.4 million) is well above the range generated by the Cost Tool ($0.55 million - $1.5 million). Specific line items considered by the two sets of estimates do not directly correspond to each other; therefore, direct comparisons of subsets of costs cannot be made. Additionally, assumptions used to develop unit costs for project activities may vary between the two estimates.

As described in the PISC sub-section above, EPA considered the effects of additional monitoring wells (with depth and diameter identical to Mt. Simon RAT #1 and #2) for pressure front monitoring. Plugging the additional monitoring wells slightly increases the range generated by the Cost Tool (one additional monitoring well: $0.63 million - $1.7 million; two additional monitoring wells ($0.70 million - $1.9 million). However, Patrick Engineering Inc.'s cost estimate ($3.4 million) for site closure would still be well above the range generated by the Cost Tool, even if the cost of this monitoring were included.

FR Instrument #2: Pollution Legal Liability (PLL) Insurance Policy (now replaced by additional funding in Trust Fund)

Emergency and Remedial Response[4]

McGriff, Seibels & Williams, Inc. recommended a PLL insurance policy with a value of $10 million during the drilling phase, increasing to $100 million once injection begins. This insurance policy would cover FR activities corresponding most closely to the E&RR category in Exhibit 3. The value of the insurance policy during the drilling phase is sufficient to cover E&RR costs in the FutureGen submission, but is below the lower end estimate generated by the Cost Tool. (This may be acceptable, given that the potential for an adverse event is lower before injection commences.) The value of the PLL insurance policy during the injection phase exceeds the engineering costs estimated for E&RR by FutureGen and the Cost Tool. This is because the insurance policy is intended to cover costs associated with potential damages and liabilities in addition to the engineering costs. In March 2014, FutureGen informed EPA that, instead of using two separate FR instruments, they would use a Trust Fund/Agreement to cover the E&RR costs as well.

Section 8.1 of FutureGen's submission provides a detailed list of possible E&RR scenarios that could occur following injection. These scenarios, as articulated in the permit application, include:

- Loss of mechanical integrity (monitoring wells)
- Migration of CO_2 from injection zone through faults and fractures
- Migration of CO_2 from injection zone through undocumented wells
- Migration of CO_2 from injection zone through failure of the confining zone (loss of containment)
- Monitoring equipment failure or malfunction
- Movement of brine from injection zone
- Earthquake.

Patrick Engineering Inc.'s E&RR cost estimate only covers costs resulting from any one of the possible scenarios involving movement of CO_2 into a USDW. The Cost Tool also develops E&RR cost estimates based on a scenario in which CO_2 moves into the USDW (which is

[4] As mentioned in Appendix A, although only a small fraction of GS sites are expected to require E&RR, all sites need to be financially capable of facing an emergency. As such, the Cost Tool will overestimate the actual E&RR costs incurred by most sites, but not overestimate the funds required for E&RR financial responsibility. Specifically for E&RR Scenario B in the Cost Tool (applicable to sites where USDWs are present in the AoR), GS sites are expected to use the same pump-and-treat techniques in case of contamination, but will likely require less complex treatment. So, assuming the same costs is likely an overestimate of the 'Treat Contaminated Water from USDW" cost component under E&RR scenario B.

generally the costliest event to remediate). However, Patrick Engineering, Inc.'s cost estimate[5] is $6.1 million for such a scenario, which is well below the $14.7 million - $77.9 million estimate produced by the Cost Tool. A brief discussion of assumptions that may contribute to differences between the E&RR estimate provided in FutureGen's submittal and that developed by the Cost Tool is provided below. It should be noted that specific line items considered by the two sets of estimates do not directly correspond to each other. Additionally, assumptions used to develop unit costs may vary between the two estimates.

- The Cost Tool conservatively assumes that all CO_2 injected could leak into the USDW. The FutureGen submission does not specify the amount of CO_2 assumed to leak into the USDW.
- Unit costs for creating a hydraulic barrier are a key contributor to the E&RR costs in the Cost Tool. The Cost Tool generates a range of $11.4 million - $14.9 million for this individual activity (these costs are based on American Petroleum Institute data), which exceeds FutureGen's total E&RR estimate.
- FutureGen estimated that pump and treat activities would occur for 2 years, whereas the Cost Tool estimates that pump and treat activities may continue for anywhere between 2 and 30 years. The middle cost estimate used to provide the basis for the E&RR estimate assumes that pump and treat activities would continue for 18 years.

Summary

Based on the information shown in Exhibit 3, FutureGen's final cost estimate provided in March 2014 ($51.768 million) falls within the range of costs generated by the Cost Tool ($35.8 million - $116.3 million). The specific comparisons of costs are as follows:

- For corrective action, FutureGen's final cost estimate ($0.623 million) is above estimate generated by the Cost Tool ($0 million).
- For injection well plugging FutureGen's final cost estimate of $2.723 million is well above the range generated by the Cost Tool ($0.28 million - $0.79 million).
- For post-injection site care and site closure FutureGen's final cost estimate of $21.722 million (the sum of $18.3 million for PISC and $3.4 million for site closure) is within the range of the sum of the ranges generated by the Cost Tool for both of these activities ($20.85 million - $37.70 million).
- For emergency and remedial response the final cost estimate $26.7 million is at the middle of the range of costs generated by the Cost Tool ($14.7 million - $77.9 million).

Especially because of the conservatism built into the Cost Tool assumptions, the proposed trust fund is sufficient to demonstrate financial responsibility.

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[5] EPA and FutureGen have discussed and agreed upon revising the E&RR cost estimate provided in FutureGen's submission to $26.7 million. This revised figure was based on the middle cost estimate calculated using the Cost Tool (see Exhibit B-2). FutureGen's final E&RR cost estimate was revised upward by approximately $700,000 after that agreement was reached. The subsequent revision was small enough that the trust agreement funding remains sufficient, especially since the cost estimates and financial responsibility mechanisms will be regularly revisited over the life of the project.

Appendix A

Cost Estimation Tool for Class VI Financial Responsibility Demonstrations

UIC Class VI Program Financial Responsibility

Summary of Design Characteristics, Assumptions, and Potential Sources of Uncertainty

July 17, 2012 (revised February 2014)

Purpose of the Cost Tool

The Cost Estimation Tool for Class VI Financial Responsibility Demonstrations (Cost Tool) is designed to provide an "acceptable range of costs" for GS financial responsibility activities based on information submitted with a permit application. The cost estimates for each financial responsibility activity are intended to be accurate enough for UIC Program Directors to assess whether or not the cost estimate provided by the owner or operator is likely to be adequate.[6] Therefore, the costs estimated by the tool can serve as a point of discussion between the UIC Program Director and the owner or operator in the financial responsibility demonstration review process.

Given a set of simple data inputs, which the Director should be able to obtain from a permit application, the Cost Tool estimates a range of costs for site abandonment and Emergency and Remedial Response (ERR). However, the Cost Tool can only supplement, not substitute for the Director's judgment, therefore it is important that any user of the Cost Tool understand assumptions and uncertainties underpinning the Cost Tool before applying its output to regulatory decisions. This memorandum documents the design characteristics, assumptions, and potential sources of uncertainty associated with the Cost Tool.

Design Characteristics

To reflect the uncertainty[7] in many of the inputs to Cost Tool, and the anticipated natural variation in costs for particular GS activities, a low, middle and high cost estimate is generated. The approach for approximating these cost components/algorithms was as follows:

1. If available, multiple datasets from a single database were used; one dataset for each cost estimate/algorithm. For example, the Energy Information Administration (EIA) lists costs for well operations and maintenance nationally and by region. From these datasets, a regression equation could be developed for the highest cost region, the whole country, and the lowest cost region. These regression equations were then used in the Cost Tool to obtain low, medium, and high estimates.
2. If multiple datasets were not available, a single dataset was used, such as the Petroleum Services Association of Canada (PSAC) well cost study, or the American Petroleum Institute (API) Joint Association Survey.
3. If neither of the above was available, data from the GS Cost Model (which represent an average, or point-estimate), or data from a case study (e.g., some portions of the PSAC study) were used.

[6] The goal is to provide a check on the owner or operator's cost estimate based on pre-established national data, not to reproduce exact results based on site specific conditions.

[7] An example of uncertainty is the extent to which GS costs are equivalent to oil and gas well costs. The Cost Tool assumes they are equivalent.

4. If none of the above were available, best professional judgment was used to develop unit cost estimates. *[used infrequently]*

Assumptions Used in Developing Unit Costs

- GS wells are assumed to be similar to oil and gas wells and therefore have similar costs. As a result, most of the costs in the Cost Tool are derived from oil/gas industry statistics.
- The number of days a maintenance rig takes to clean out a well is a regression based on data from a 1983 EPA study. Due to technological changes, this could either be an underestimate or an overestimate for all the well-cleaning cost components.
- The number of days (three) for a maintenance rig to repair a well: one day mobilization/demobilization, one day to pull tubing, and one day to perform cement squeeze. This is based on best professional judgment of standard practices, but some non-standard wells could take more or less time to repair. This could lead to an overestimate or underestimate of rig rental costs under ERR scenario A (detailed below).
- The number of cement plugs and plug retainers (three) to seal a well: one in the injection zone, one in the lowermost Underground Source of Drinking Water (USDW), and one at the surface. Some very deep wells might require more plugs and retainers, in which case the Cost Tool would underestimate two cost components: plugging injection wells and plugging monitoring wells.
- The Cost Tool includes ERR costs. Although only a small fraction of GS sites are expected to require ERR, all sites need to be financially capable of facing an emergency. As such, the Cost Tool will overestimate the actual ERR costs incurred by most sites, but does not overestimate the funds required for ERR financial responsibility.
- To avoid mis-estimation of ERR costs, the user should be certain to select the correct ERR scenario:
    - In the 'Inputs' tab of the Cost Tool, if the user indicates that there are USDWs in the Area of Review (AoR), the ERR costs include groundwater remediation (scenario B).
    - If the user indicates no USDWs in the AoR, the ERR costs do not include groundwater remediation (scenario A). Scenario A includes costs to repair a leaking well, and is assumed to be representative of the many ERR scenarios that do not include groundwater remediation.[8]
- The costs of pump operations and maintenance to create a hydraulic barrier assume an equal mass of water injected as the mass of CO_2 that has been injected in the site to date, and that the pressure differential the pump must overcome is due to the difference in pressure between a water column in the injection well and the pressure due to the weight of the surrounding rock. These two assumptions may be an overestimate or an underestimate, but will have a negligible effect on overall costs, because the cost to create a hydraulic barrier is relatively low compared to the other cost items.
- The costs to drill and run extraction wells to treat contaminated water from a USDW are derived from EPA studies of Superfund groundwater remediation. A GS well failure is not expected to produce the same kinds of toxic contamination as found in a Superfund site. Based on research conducted to date, this is the best available source for costs of

[8] If there are other types of groundwater in the AoR that the operator would be required to remediate (if contaminated by a well failure), then scenario A would be a severe underestimate, and the user should select scenario B instead by indicating that there are USDWs in the AoR.

pump-and treat operations. GS sites are expected to use the same pump-and-treat techniques in case of contamination, but will likely require less complex treatment. So, assuming the same costs is likely an overestimate of the 'Treat Contaminated Water from USDW" cost component under ERR scenario B.

Assumptions in Developing Total Costs

Costs must be expressed in common units so they can be added together to calculate their total present value. Future costs are frequently discounted (i.e., costs incurred in the future are reduced to the amount that would need to be saved now to pay for them in the future given a particular interest rate above inflation). However, the Cost Tool assumes 0% interest above inflation (no discounting) for all activities that occur after CO_2 injection ceases. The decision to not discount future costs in the Cost Tool is based on financial responsibility strategies such as self-insurance (updated each year for inflation) or ultra-low risk investments such as Treasury Inflation-Protected Securities (TIPS), which are assumed to have very low or negligible interest rates above inflation. Assuming a 0% discount rate results in higher total costs, which are most noticeable in the costs for Post Injection Site Care activities. As an example, if a site is scheduled for 50 years of Post Injection Site Care, approximately double the amount of money would need to be set aside for financial responsibility using 0% discounting verses 3% discounting.

> **Policy Implications of Discounting**
> - The Cost Tool assumes no discounting for all activities that occur after CO_2 injection ceases.
> - This 0% discount rate results in higher total costs, which are most noticeable in the costs for Post Injection Site Care activities.
>
> *Example Implications*
> - If a site is scheduled for a 50 year PISC period, using a 3% discount rate reduces the estimated cost for PISC by approximately 50% compared to using a 0% discount rate.

Total costs are presented in 2010 dollars[9]. To accomplish this, all source data used to calculate the unit costs are adjusted for inflation in the Cost Tool. If the best source for a particular data point was published prior to 2010 it was adjusted to 2010 dollars using either: the Building Cost Index for materials, or the Employment Cost Index for labor (note that information from the PSAC study, which is in 2008 Canadian dollars, was first converted from 2008 Canadian to 2008 American dollars and then inflated to 2010 US dollars). Going forward, cost indices could be used to update the model output to a future dollar year. The use of cost indices is most appropriate when inflating costs over a small number of years and in a stable industry. However, in a rapidly changing industry like GS, inflation adjustments will not fully capture the true changes in cost that occur due to new technologies, economies of scale, etc. Therefore, if it is possible, it is preferable to obtain current data to update the Cost Tool in future years.

Lastly, the Cost Tool also used the following adjustment for costs: 60% overhead cost for labor rates (in accordance with 2005 ICR Handbook), and 20% General and Administrative cost for all items (in accordance with the GS Cost Model).

[9] The Cost Tool output was updated from 2010 dollars to 2012 dollars using cost indices to enable comparison to the FR cost estimates provided by Patrick Engineering, Inc. in the FutureGen permit application.

Appendix B

Cost Tool Output Tables

Exhibit B-1: Amount Needed to Show Financial Responsibility (2012$) (1 injection well in the AoR)

Project Task	Low End Cost Estimate ($/Project; includes 20% G&A)	Middle Cost Estimate ($/Project; includes 20% G&A)	High End Cost Estimate ($/Project; includes 20% G&A)
Performing Corrective Actions on Deficient Well(s) in AoR			
Maintenance Rig Rental (Clean Out Deficient Wells)	$ -	$ -	$ -
Flush Deficient Wells	$ -	$ -	$ -
Plug Deficient Wells	$ -	$ -	$ -
Log Deficient Wells	$ -	$ -	$ -
Subtotal: Corrective Actions Cost	**$ -**	**$ -**	**$ -**
Plugging Injection Well			
Maintenance Rig Rental (Clean Out Injection Well)	$ 28,000	$ 61,000	$ 69,000
Perform Mechanical Integrity Test Before Plugging Injection Well	$ 25,000	$ 25,000	$ 25,000
Flush Injection Well with a Buffer Fluid Before Plugging	$ 200	$ 1,700	$ 5,000
Plug Injection Well	$ 15,000	$ 19,000	$ 80,000
Log Injection Well	$ 4,000	$ 4,000	$ 18,000
Subtotal: Injection Well Plugging Cost	**$ 71,000**	**$ 111,000**	**$ 197,000**
Post-Injection Site Care (assume 0% discount rate)†			
Post-Injection O&M for Monitoring Wells Post-Injection Seismic Survey Post-Injection Groundwater Monitoring Post-Injection Monitoring Reports to Regulators	**$ 20,252,000**	**$ 28,795,000**	**$ 36,193,000**
Site Closure			
Maintenance Rig Rental (Clean Out Monitoring Wells)	$ 86,000	$ 189,000	$ 214,000
Perform Mechanical Integrity Test Before Plugging Monitoring Wells	$ 163,000	$ 163,000	$ 163,000
Flush Monitoring Wells	$ -	$ 4,000	$ 10,000
Plug Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 101,000	$ 126,000	$ 520,000
Log Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 25,000	$ 31,000	$ 125,000
Remove Surface Equipment and Restore Vegetation for Injection Wells	$ 19,000	$ 35,000	$ 50,000
Remove Surface Equipment and Restore Vegetation for Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 136,000	$ 242,000	$ 348,000
Document Plugging and Closure Process	$ 19,000	$ 19,000	$ 19,000
Subtotal: Site Closure Cost	**$ 551,000**	**$ 809,000**	**$ 1,450,000**
Emergency and Remedial Response, Scenario B: Remediate Underground Source of Drinking Water (USDW) Contamination			
Stop CO2 Injection	$ 1,000	$ 1,000	$ 3,000
Create Hydraulic Barrier	$ 2,845,000	$ 3,238,000	$ 3,730,000
Install Chemical Sealant to Stop CO2 Leaks	$ 11,000	$ 24,000	$ 32,000
Treat Contaminated Water from USDW	$ 3,254,000	$ 14,419,000	$ 62,841,000
Subtotal: Scenario B	**$ 6,110,000**	**$ 17,683,000**	**$ 66,606,000**
Total Amount Needed to Show Financial Responsibility	**$ 26,985,000**	**$ 47,397,000**	**$ 104,446,000**

Note: Results may not add due to independent rounding.

Exhibit B-2: Amount Needed to Show Financial Responsibility (2012$)
(4 injection wells in the AoR)

Project Task	Low End Cost Estimate ($/Project; includes 20% G&A)	Middle Cost Estimate ($/Project; includes 20% G&A)	High End Cost Estimate ($/Project; includes 20% G&A)
Performing Corrective Actions on Deficient Well(s) in AoR			
Maintenance Rig Rental (Clean Out Deficient Wells)	$ -	$ -	$ -
Flush Deficient Wells	$ -	$ -	$ -
Plug Deficient Wells	$ -	$ -	$ -
Log Deficient Wells	$ -	$ -	$ -
Subtotal: Corrective Actions Cost	**$ -**	**$ -**	**$ -**
Plugging Injection Well			
Maintenance Rig Rental (Clean Out Injection Well)	$ 112,000	$ 244,000	$ 276,000
Perform Mechanical Integrity Test Before Plugging Injection Well	$ 100,000	$ 100,000	$ 100,000
Flush Injection Well with a Buffer Fluid Before Plugging	$ 800	$ 6,800	$ 20,000
Plug Injection Well	$ 60,000	$ 76,000	$ 320,000
Log Injection Well	$ 16,000	$ 16,000	$ 72,000
Subtotal: Injection Well Plugging Cost	**$ 284,000**	**$ 444,000**	**$ 788,000**
Post-Injection Site Care (assume 0% discount rate)[1]			
Post-Injection O&M for Monitoring Wells Post-Injection Seismic Survey Post-Injection Groundwater Monitoring Post-Injection Monitoring Reports to Regulators	**$ 20,252,000**	**$ 28,795,000**	**$ 36,193,000**
Site Closure			
Maintenance Rig Rental (Clean Out Monitoring Wells)	$ 86,000	$ 189,000	$ 214,000
Perform Mechanical Integrity Test Before Plugging Monitoring Wells	$ 163,000	$ 163,000	$ 163,000
Flush Monitoring Wells	$ -	$ 4,000	$ 10,000
Plug Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 101,000	$ 126,000	$ 520,000
Log Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 25,000	$ 31,000	$ 125,000
Remove Surface Equipment and Restore Vegetation for Injection Wells	$ 19,000	$ 35,000	$ 50,000
Remove Surface Equipment and Restore Vegetation for Monitoring Wells (occurs at end of PISC; use 3% discounting)	$ 136,000	$ 242,000	$ 348,000
Document Plugging and Closure Process	$ 19,000	$ 19,000	$ 19,000
Subtotal: Site Closure Cost	**$ 551,000**	**$ 809,000**	**$ 1,450,000**
Emergency and Remedial Response, Scenario B: Remediate Underground Source of Drinking Water (USDW) Contamination			
Stop CO2 Injection	$ 4,000	$ 4,000	$ 12,000
Create Hydraulic Barrier	$ 11,380,000	$ 12,952,000	$ 14,920,000
Install Chemical Sealant to Stop CO2 Leaks	$ 44,000	$ 96,000	$ 128,000
Treat Contaminated Water from USDW	$ 3,254,000	$ 14,419,000	$ 62,841,000
Subtotal: Scenario B	**$ 14,682,000**	**$ 27,471,000**	**$ 77,901,000**
Total Amount Needed to Show Financial Responsibility	**$ 35,769,000**	**$ 57,519,000**	**$ 116,332,000**

Note: Results may not add due to independent rounding.

Appendix C

Patrick Engineering, Inc. Cost Estimates
(Submitted with permit application revisions dated March 2013)

Exhibit C-1: Corrective Action on Wells in Area of Review

Activity	Unit			Unit Cost ($)			Total Costs ($)
a. Review existing plume model (every five years)	1,600	hrs	@	153	per hour	=	245,000
b. Remodel plume (once)	1,500	hrs	@	153	per hour	=	230,000
c. Review of state databases of known wells and abandoned mines (every five years)	200	hrs	@	153	per hour	=	31,000
d. Well integrity testing	1	well	@	26,000	per well	=	26,000
e. Plug deficient wells	1	well	@	15,000	per well	=	15,000
f. Perform remedial cementing of defective wells	1	well	@	15,000	per well	=	15,000
g. Project management and oversight (every five years)	400	hrs	@	153	per hour	=	61,000
Total Corrective Action on Wells in AoR over 50-year Post-injection Period							**623,000**

Exhibit C-2: Injection Wells & Monitoring Wells Plugging & Site Reclamation Summary

Activity	Total Cost ($)
a. Injection wells plugging	1,633,000
b. Land reclamation	1,037,000
c. Well remediation	53,000
Total Injection Wells & Monitoring Wells Plugging & Site Reclamation	**2,723,000**

Exhibit C-3: Post-injection Site Care Summary

Activity	Total Cost ($)
a. Monitoring wells for geochemical and geophysical analyses	10,870,000
b. Monitoring well mechanical integrity testing	3,650,000
c. Site management and EPA reporting	3,800,000
Total post-injection site care	**$18,320,000**

Exhibit C-4: Site Closure Summary

Activity	Total Cost ($)
a. Non-endangerment demonstration	26,000
b. LUSDW monitoring well plugging	319,000
c. Injection-zone monitoring well plugging	1,609,800
d. Above-confining zone monitoring well plugging	1,288,500
e. Remove surface features and reclaim land	140,000
f. Document plugging and closure process	17,000
Total site closure	**3,402,000**

Exhibit C-5: Emergency and Remedial Response Estimate Costs

Event	Estimated Cost ($)
1. Post-injection USDW contamination	
Acidification due to migration of CO_2	305,000
Toxic metal dissolution and mobilization	5,865,000
Displacement of groundwater with brine due to CO_2 injection	270,000
2. Post-injection failure scenarios (acute)	
Upward leakage through CO_2 injection well	3,343,000
Upward leakage through deep oil and gas wells	2,111,000
Upward leakage through undocumented, abandoned, or poorly constructed wells	2,111,000
3. Post-injection failure scenarios (chronic)	
Upward leakage through caprock through gradual failure	5,865,000
Release through existing faults due to effects of increased pressure	5,865,000
Release through induced faults due to effects of increased pressure	6,100,000
Upward leakage through CO_2 injection well	821,000
Upward leakage through deep oil and gas wells	411,000
Upward leakage through undocumented, abandoned, or poorly constructed deep wells	411,000
4. Other	
Catastrophic failure of caprock	6,100,000
Failure of caprock/seals or well integrity due to seismic event	6,100,000

(1) Note: This Exhibit is based on FutureGen's original submission, which has been revised based on conversations with EPA in March 2014. EPA and FutureGen have discussed and agreed upon revising the E&RR cost estimate of $6.1 million to $26.7 million. This revised figure was based on the middle cost estimate calculated using the Cost Tool (see Exhibit B-2).

Exhibit C-6: Total Financial Responsibility Cost by Category

Activity	Total Cost ($)
Corrective action on wells in AoR	623,000
Injection wells & monitoring wells plugging & site reclamation	2,723,000
Post-injection site care	18,320,000
Site closure	3,402,000
Total Financial Responsibility	**25,068,000**