

Appendix A

A User's Guide for Application of the Beef Cattle Nutrient Requirements Model

INTRODUCTION

The Beef Cattle Nutrient Requirements Model (BCNRM) of the *Nutrient Requirements of Beef Cattle, 8th Revised Edition*, was developed using the Microsoft® Excel® 2016 (version 16) electronic spreadsheet of the Microsoft Office 2016 to demonstrate the use of the empirical (ELS) and mechanistic (MLS) levels of solution in the calculations of the dietary supply and requirements of beef cattle for energy and nutrients, which are discussed in detail in Chapter 19 (Model Equations and Sensitivity Analyses). A basic understanding of the operations of the Microsoft® Excel® is necessary to execute the computer software. Similarly, an understanding of ruminant nutrition and knowledge of the underlying biological concepts presented in this report are essential for use and interpretation of the model's results.

Because of the many variables involved and judgments that must be made in choosing inputs and interpreting outputs, the National Academies of Sciences, Engineering, and Medicine make no claim for the accuracy of this software and the user is solely responsible for risk of use.

INSTALLATION

The BCNRM is designed to operate on a computer running Microsoft® Windows 7 or a later version, and Microsoft® Excel® 2010 or a later version. The setup file will install the software in the [C:]Program Files (x86)\National Academies\BCNRM2016 folder and in the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016. The [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder contains the feed library files, the software backup, the batch template file, and user's preferences file. Computer administrator privileges are needed to install the BCNRM. The user should contact their system administrator when installation issues occur. Some files are

created in the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder during the installation, but for restricted computer accounts, these files may not be created. In this case, the user will have to manually unzip them from the [C:]Program Files (x86)\National Academies\BCNRM2016\Default files.zip file into the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder.

USING THE BEEF CATTLE NUTRIENT REQUIREMENTS MODEL

A shortcut to the BCNRM spreadsheet is created in the desktop and another shortcut is created in the *Start/Apps* screen (Windows 8 and later) or *Program Files* in the start menu (Windows 7 and earlier). After the software is installed, the user, if not previously authorized, will be requested to approve the use of active contents (i.e., programming sub-routines) of the software, as shown in FIGURE 1. The user has to enable the active contents for proper functionality of the software.

Subsequently, the following will occur: (1) a splash screen, similar to that depicted in FIGURE 2, will appear, displaying information about the software and the *Terms of Use*, which the user must accept to continue using the software; (2) once the *Terms of Use* are accepted, the software will attempt to load the standard feed library (SFL; "Beef Std 2016.FLF" file) and the user-created feed library (UFL; "Beef User 2016.FLF") located in the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder; (3) the software will read the user's saved preferences and make necessary modifications in the settings of the computer model; and lastly (4) the software will load the final simulation file and the message "Beef Cattle Nutrient Requirements Model 2016 is ready" will appear in the status bar at the lower left corner of the Microsoft® Excel®.

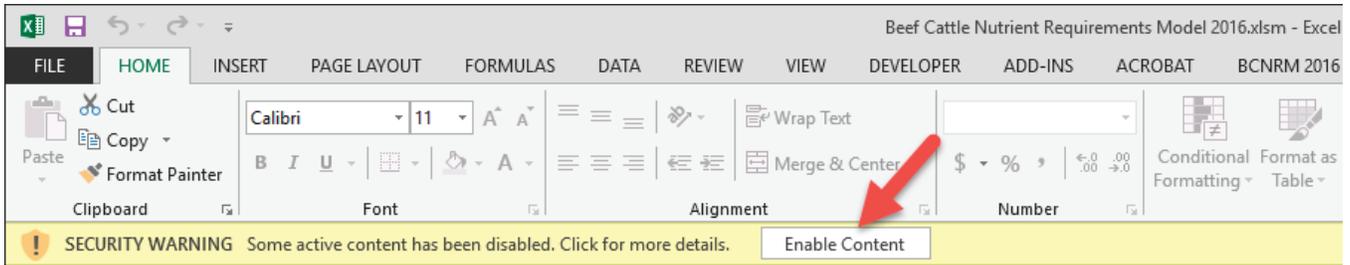


FIGURE 1 Microsoft® Excel® requesting the user to enable active content.

THE BEEF CATTLE NUTRIENT REQUIREMENTS MODEL RIBBON

The Microsoft® Excel® menu will be displayed across the top of the screen; below it is the complete ribbon as shown in FIGURE 3A. This ribbon has six distinct groups, as shown from left to right: *File* (FIGURE 3B), *Inputs* (FIGURE 3C), *Diet* (FIGURE 3D), *Feed Library* (FIGURE 3E), *Calcula-*

tion (FIGURE 3F), and *Advanced* (FIGURE 3G). The ribbon is usually located toward the right of the default ribbons of Microsoft® Excel®, as shown by the arrow in FIGURE 3A. Most of the interactive operations between the user and the software are done through the ribbon, and normal operation of the software is impossible without the ribbon. The ribbon is compatible with Microsoft® Excel® 2010, 2013, and 2016, and all icons in the ribbon are clickable.

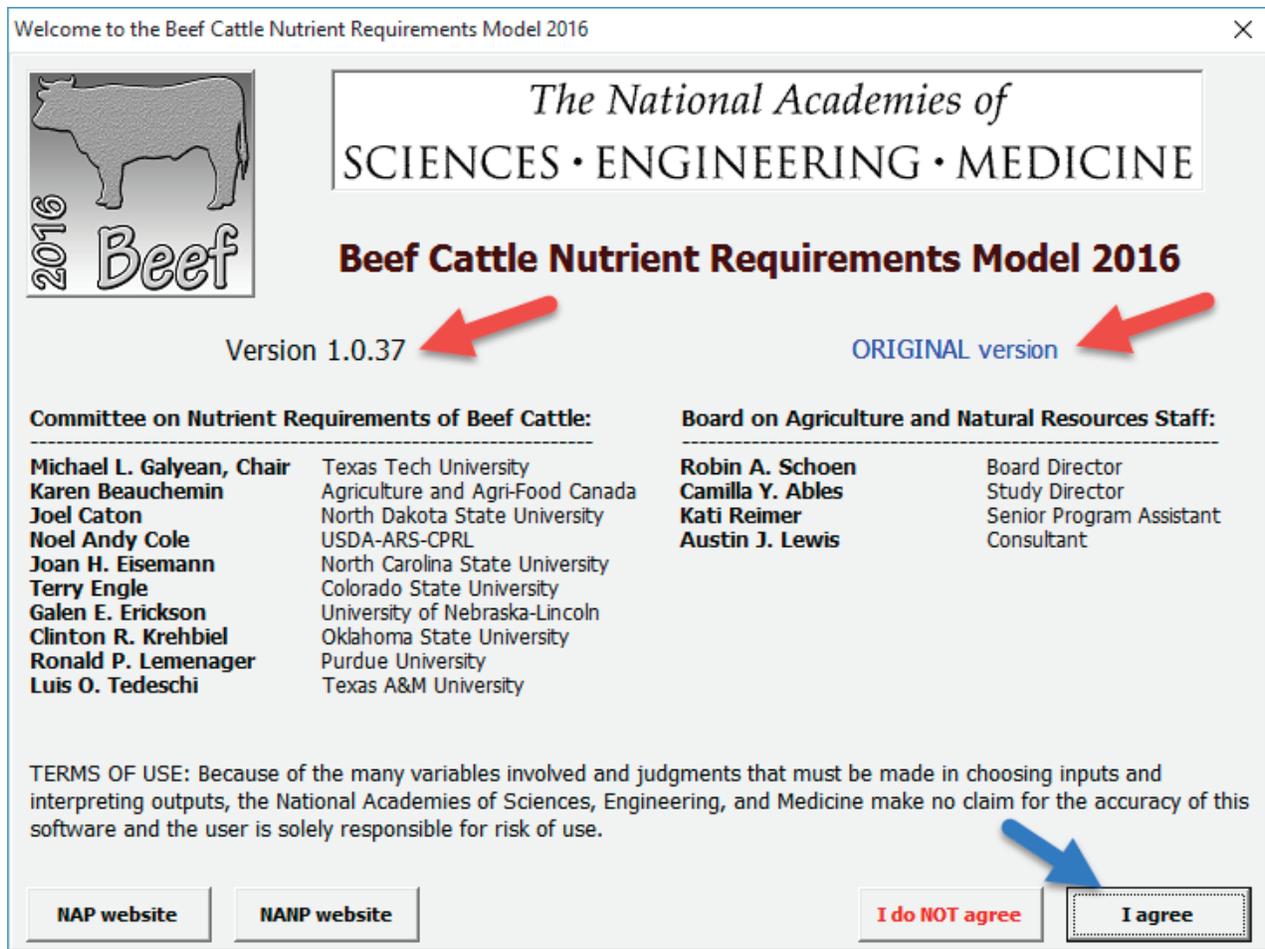


FIGURE 2 The welcome splash screen. The arrows are pointing at the major, minor, and build versions of the Beef Cattle Nutrient Requirements Model (e.g., 1.0.37), the timestamp (e.g., original or modified version), and the “I agree” button, which the user must click to continue loading the software. Clicking on the “I do NOT agree” button will terminate the session and close the software.

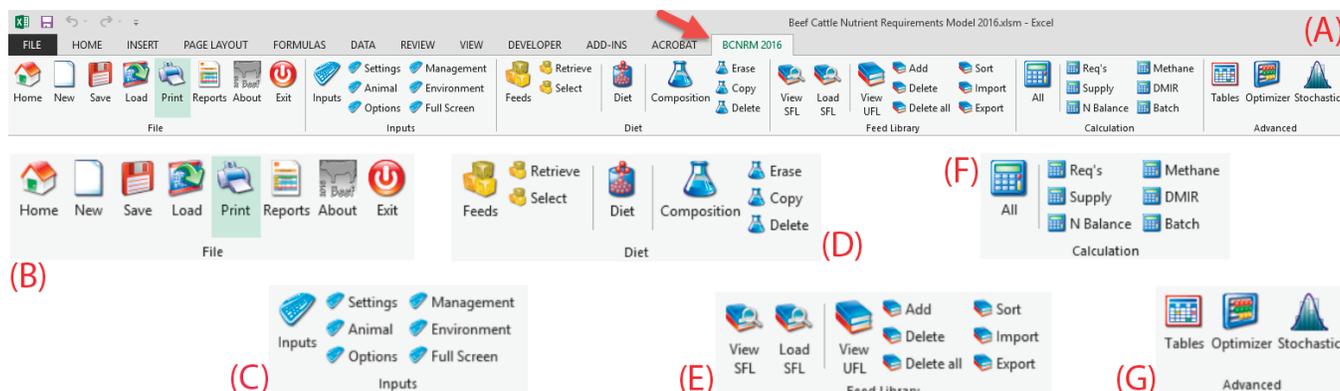


FIGURE 3 (A) The complete ribbon, (B) the *File* options, (C) the *Inputs* options, (D) the *Diet* options, (E) the *Feed Library* options, (F) the *Calculation* options, and (G) the *Advanced* options.

File Options

The *File* options are shown in FIGURE 3B and the detailed descriptions and operations of each button are discussed below. The screens shown are those for the Feedlot Case Study file 5; to retrieve that file, click on *Load* and choose the file from the list of case study files shown.

The Summary Screen (Home)

Clicking on the *Home* button will display the Home worksheet of the software from which the user can visualize important variable predictions and quickly make changes to the computer model inputs or settings. FIGURE 4 shows the Home worksheet from the Feedlot Case Study. This is the initial screen and it will appear frequently after certain operations for a quick review. *When returning to Home in the spreadsheet, be careful not to click on the Excel Home button in the top ribbon.* The top region of the Home worksheet (FIGURE 4) shows the file name (cell C2) and the creator's name, version used, and date created (cell C3). The center top region of the Home worksheet (FIGURE 4) has the calculations for metabolizable energy (ME) and metabolizable protein (MP) available, required, and the balance for five physiological stages (maintenance, pregnancy, lactation, growth, and body reserves). The right region (FIGURE 4) of the Home worksheet has the supply, requirement, and the balance of minerals, vitamins, and amino acids. The bottom portion of the right region has the nitrogen balance and the methane predictions. The center of the Home worksheet (FIGURE 4) contains the following:

- (a) In the left column:
 - i. The ME- and MP-allowable performance, the observed dry matter intake (DMI) and predicted DMI, water intake, and NDF intake; and
 - (b) The diet daily cost (cell I24), common nutrient contents (cells I25 to I36), N-to-S ratio (cell I37),

Ca-to-P ratio (cell I38), physically effective neutral detergent fiber (peNDF; cell I39), and ruminal pH (cell I40). In the right column:

- i. The ruminally degradable protein (RDP) and ruminally undegradable protein (RUP);
- ii. Total digestible nutrients (TDN)- and RDP-allowable microbial crude protein (MCP);
- iii. Sources of MP (feed and ruminal microbes);
- iv. Ruminal nitrogen balance; and
- v. Diet energy values: TDN, digestible energy (DE), ME, NEMA, and NE_g.

The user can quickly make changes to the computer model inputs or settings in the left region of the Home worksheet (FIGURE 4). The user can do any of the following in cells D7 to D28 and cells D31, D32, D34, and D35 (shown by the arrow and box):

- (a) Change the amount or percentage (cells C5 and C6) of each feed ingredient in the diet in cells D7 through D28;
- (b) Set the ration intake (kg/d or lb/d) in cell D31. Type in a value and press enter;
- (c) Scale the ration intake up or down in cell D32. After the intake amount of each diet ingredient (kg/d or lb/d) has been scaled up or down, the scale value changes to 100% again;
- (d) Change the initial or final BW (cells D34 and D35, respectively). These are full (unshrunk) body weights;
- (e) Change the solution type (1 = empirical level of solution, ELS; or 2 = mechanistic level of solution, MLS) in the dropdown box located in cell B37;
- (f) Change the units (1 = metric, or 2 = imperial). As soon as the user changes the units, a query message with three options, similar to that depicted in FIGURE 5, will be shown. Choosing *YES* will change the values and units of interchangeable variables, choosing *NO* will change only the units, and values will remain the same, and choosing *CANCEL* will

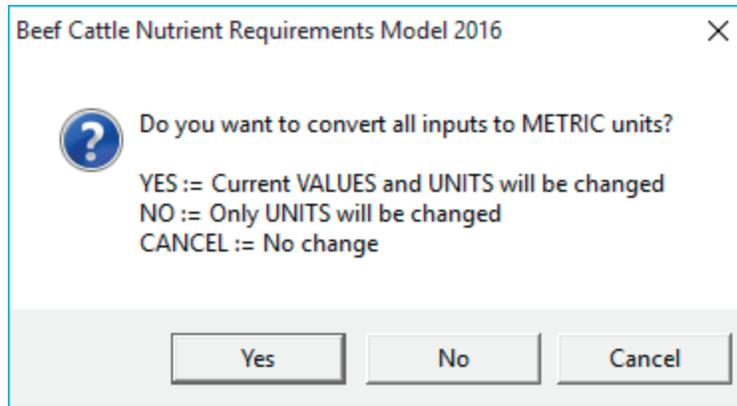


FIGURE 5 Query message for unit change.

abort the unit change process. The *YES* option is likely the one to be used most frequently. The *NO* option is generally used when the user enters values in imperial units when metric units are selected, or vice versa, and needs to match them.

- (g) Change the feed basis (1 = dry matter, or 2 = as-fed basis); and
- (h) Change the animal type (1 = growing/finishing, 2 = lactating cow, 3 = dry cow, or 4 = replacement heifer).

The Home summary can be printed by using the *Print* option. It is in the Reports section as shown in FIGURE 6.

Creating a New Simulation

Clicking on the *New* button will clear all user inputs and change the settings to their default values. The user’s preferences are applied. This action cannot be undone, and unsaved simulations will be lost.

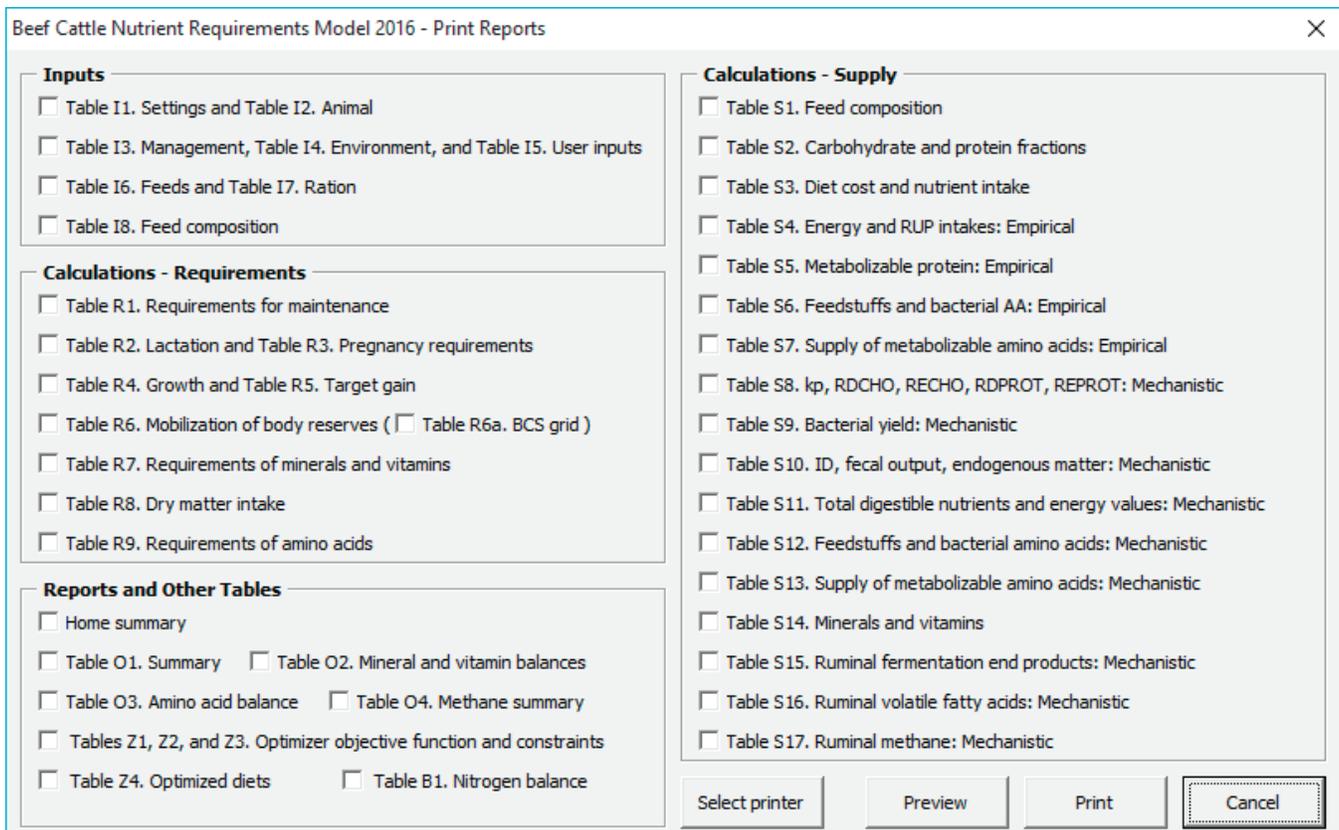


FIGURE 6 The Print Report options.

Saving and Loading Simulations

Clicking on the *Save* button will save current user inputs and settings into a BCNRM data file (*.bcNRF files). The bcNRF files can be shared, and they contain the data necessary to run the software in different computers. It saves current diet feed information but it does not save the feed library information per se (see Feed Library Options section).

Clicking on the *Load* button will retrieve the saved BCNRM data file (*.bcNRF files) into the software. Information about the creation of the saved .bcNRF simulation file will be shown to the user before effectively loading it, so the user can decide whether to continue or not with the loading process. This action cannot be undone and unsaved inputs will be lost.

Printing Tables and Reports

Clicking on the *Print* button will display the different reports that can be printed as depicted in FIGURE 6. The four buttons in this form are self-explanatory. It is recommended that the user select the printer and perform a preview before printing the reports. The printing date is added to the top, and the file name and version of the BCNRM are added to the bottom of each report. Reports are printed one by one; a combined printout will not be created.

Additional Reports

Clicking on the *Reports* button will display the Reports worksheet of the software. There are three tables in the Reports: Table O1 (summary), Table O2 (mineral and vitamin balances), and Table O3 (amino acid balance). Table O1 contains information similar to the Home worksheet. These tables can be printed using the *Print* option and selecting the appropriate tables in the Reports and Other Tables section (FIGURE 6).

Checking for Updates

Clicking on the *About* button will display a form similar to the welcome splash screen (FIGURE 2), except that the *Update* button is shown next to the *Website* button. This button will check for the availability of a newer version of the BCNRM software. If a newer version exists, the user will be prompted to download it.

Closing the Beef Cattle Nutrient Requirements Model

The *Exit* button will close the software, and unsaved inputs will be lost. This is the preferred method to close the software rather than closing Microsoft® Excel® because additional processes are performed before closing the software. The following will occur after the *Exit* button is clicked: (1) the updated UFL is saved; (2) a backup copy of the BCNRM spreadsheet is created; and (3) the user's preferences are

saved. The backup copy does not have all the functionality of the BCNRM spreadsheet, and the old backup is always replaced as the user exits the program. Some of the user's preferences are saved; they include type of solution (MLS or ELS), units, diet feed basis (dry matter or as-fed basis), and feed input method (amounts or percentage).

Inputs Options

The *Inputs* options are shown in FIGURE 3C. Clicking on the *Inputs* button of the *Inputs* group will display seven tables in the Inputs worksheet. The user may view one table at a time by clicking on the respective button of the *Inputs* group (Settings, Animal, Management, Environment, and Options). Clicking on the *Full Screen* button of the *Inputs* group will hide or display the Microsoft® Excel® ribbons. This option is used to increase the visible area of the spreadsheet. The *Inputs* tables are listed below and depicted in FIGURE 7 and FIGURE 8. Information in FIGURE 7 (cells D4 to D7, D55 to D59, D64 to D75, and D80 to D91) and in FIGURE 8 (D12 to D31, D36 to D44, and L48 to S48) may be changed by the user.

- (a) Table 1: Settings;
- (b) Table 2: Animal;
 - i. Table 2.1: Breeds, and
 - ii. Table 2.2: Prediction of empty body fat (EBF) and mature full body weight (MW) from carcass traits;
- (c) Table 3: Management and grazing;
- (d) Table 4: Environment; and
- (e) Table 5: Advanced options.

The Settings Options

The *Settings* options are in Table 1 of the Inputs worksheet (FIGURE 7). As discussed in Chapter 19, there are two levels of solution (1 = ELS and 2 = MLS). There are two unit systems (1 = metric and 2 = imperial) that can be interconverted. As soon as the user changes the units, a query message with three options similar to that depicted in FIGURE 5 will appear on the screen. Choosing *YES* will change the values and units of interchangeable variables, choosing *NO* will change the units but the values will remain the same, and choosing *CANCEL* will abort the unit change process. The *YES* option is likely the one to be used most frequently. The *NO* option is generally used when the user enters values in imperial units when metric units are selected, or vice versa, and needs to match them. Diet feeds can be entered either as dry matter or as as-fed basis. There are four animal classes (1 = growing/finishing, 2 = lactating cows, 3 = dry cows, and 4 = replacement heifers). These options can be changed in Table 1 of the *Inputs* (FIGURE 7) as well as in the *Home* screen (see the Summary Screen section).

	A	B	C	D	E	F	G	H	I
1									
2	Table 1. Settings								
3		Acronym	User	Unit	Metric	Unit	Description		
4	Solution type		2	MLS			1:=Empirical, 2:=Mechanistic		
5	Unit system		1	Metric			1:=Metric, 2:=Imperial (English)		
6	Feed basis		1	DM			1:=Dry Matter, 2:=As-Fed		
7	Animal class		1				1:=Grow/Finish, 2:=Lactating, 3:=Dry, 4:=Replacement		
8									
52									
53	Table 3. Management and Grazing								
54	Item	Acronym	User	Unit	Metric	Unit	Description		
55	Feed additive		2			2	1:=None, 2:=Monensin, 3:=Lasalocid		
56	Implant		2			2	1:=No, 2:=Yes		
57	Grazing unit size	GU	0	ha		0.00	ha	Grazing unit size per animal	
58	Days on pasture	DOP	0	days		0	days	Days of grazing	
59	Available forage mass	FM	1026	kg/ha		1026.0	kg/ha		
60									
61									
62	Table 4. Environment								
63	Item	Acronym	User	Unit	Metric	Unit	Description		
64	Wind speed	WS	1.61	km/h		1.6	Km/h		
65	Temperature, previous	Tp	20.00	oC		20.0	oC		
66	Temperature, current	Tc	20.00	oC		20.0	oC		
67	RH, previous	RHp	65.00			65.0	%		
68	RH, current	RHc	65.00			65.0	%		
69	Storm exposure		1			1		1:=No, 2:=Yes	
70	Lowest night temp.	LNT	20.00	oC		20.0	oC	with night cooling if LNT < 20 oC	
71	Hair depth		2.54	cm		2.54	cm		
72	Hide		2			2		1:=Thin, 2:=Average, 3:=Thick	
73	Hair coat		2			2		1:=No, 2:=Some, 3:=Mud lower body, 4:=Heavy	
74	Cattle panting		1			1		1:=No, 2:=Rapid shallow, 3:=Open mouth	
75	Mud depth		0.00	cm		0	cm		
76									
77									
78	Table 5. Advanced options								
79	Item	Acronym	User	Unit	Metric	Unit	Description		
80	Maintenance factor		0	%		0.00	%	Increases/decreases NE required for maintenance	
81	Adjustments for required NEm		0			FALSE		Apply environmental adjustment factors (0:=No, 1:=Yes)	
82	Adjustments for predicted DMI		0			FALSE		Apply environmental adjustment factors (0:=No, 1:=Yes)	
83	Monensin adjustment for DMI		-3.00	%		0.970		Monensin effect on DMI	
84	Implant adjustment for DMI		-6.00	%		0.940		Implant factor on DMI	
85	Ruminal pH		0			0.00		0:=Use default equation	
86	DE to ME efficiency		0	%		82.00	%	0:=Use default value (82%), 1:= Use Galyeen et al. (2016)	
87	Tabular ME and NE values for ELS		0			FALSE		0:=No (calculate from TDN), 1:=Yes (user input)	
88	MCP yield (MCP/TDN, %)		0	%		0.00	%	0:=Use default equation. NRC (2000) was 13%	
89	Desired animal ADG		1.5	kg/d		1.50	kg/d	Compare with least ME or MP allowable performance	
90	MP to NP efficiency		0	%		49.20	%	0:=Use default value. NRC (2000) was 49.2%	
91	Recycled ruminal N		0			0.00		0:=None, 1:=NRC (2000), 2:=R&K (2008), 3:=BCNRM (2016)	

FIGURE 7 The Settings (Table 1), Management and Grazing (Table 3), Environment (Table 4), and Advanced options (Table 5) of the Inputs worksheet of the Beef Cattle Nutrient Requirements Model.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	
10	Table 2. Animal																			
11	Item	Acronym	User	Unit	Metric	Unit	Description													
12	Age		10	mo			Used to calculate tissue insulation													
13	Age class (for DMI & WC)		1		1		1=Calves, 2=Yearlings													
14	Sex		2		2		1=Bull, 2=Steer, 3=Heifer, 4=Cow													
15	Body condition score	BCS	5		5		1=Emaciated, 2=Very thin, ..., 8=Fat, 9=Very fat													
16	Initial body weight	IBW	300	kg	300	kg	Live or full (unshrunk) initial BW of the feeding period													
17	Final body weight	FBW	500	kg	500	kg	Live or full (unshrunk) final BW of the feeding period													
18	Mature body weight	MBW	522	kg	522	kg	Current animal's full BW at reference animal's EBF													
19	Reference animal's EBF		3		3		EBF: 1=22%, 2=25% (Std), 3=27% (Sel), 4=28% (Ch-)													
20	Breed type		2		2		1=Dual-purpose, 2=Bos taurus, 3=Bos indicus, 4=Dairy													
21	Breeding system		3		3		1=Straightbred, 2=2-Way X, 3=3-Way X													
22	Sire's breed		1		1		Angus													
23	Maternal grandsire's breed		2		2		Braford													
24	Maternal granddam's breed		3		3		Brahman													
25	Days pregnant	DP	0		0	days														
26	Calving weight	CBW	30.8446	kg	30.8	kg	Recommended is 32.3 kg													
27	Days since calving		0		0	days														
28	Relative milk yield	RMV	5		5		1=Low, ..., 5=Average, ..., 9=High													
29	Milk production	MP	0	kg/d	0.0	kg/d	User-inputted milk yield (MY)													
30	Target calving age	TCA	30	mo	30	mo	Age at first calving													
31	Target calving interval	TCI	12	mo	12	mo	Herd calving interval													
32																				
33																				
34	Table 2.2. Prediction of empty body fat (EBF) and mature full (unshrunk) body weight (MW) from carcass traits																			
35	Item	Acronym	User	Unit	Metric	Unit	Description													
36	Hot carcass weight	HCW	0	kg	0.00	kg														
37	Fat thickness	FT	0	cm	0.00	cm	Backfat													
38	Ribeye area	REA	0	cm ²	0.00	cm ²	Longissimus dorsi muscle area													
39	Quality grade code	QG			0.00		4=Select, 5=Choice-, 6=Choice, 7=Choice+, 8=Prime													
40	% Prime	Pr					The sum of Pr, Ch+, Ch, Ch-, and Se has to be 100%													
41	% high Choice	Ch+					The sum of Pr, Ch+, Ch, Ch-, and Se has to be 100%													
42	% Choice	Ch					The sum of Pr, Ch+, Ch, Ch-, and Se has to be 100%													
43	% low Choice	Ch-					The sum of Pr, Ch+, Ch, Ch-, and Se has to be 100%													
44	% Select	Se					The sum of Pr, Ch+, Ch, Ch-, and Se has to be 100%													
45	Predicted empty body fat (EBF) from carcass traits				0.00	% EBW	Guirroy et al. (2001) and Tedeschi et al. (2004)													
46	Predicted empty body weight (EBW) from HCW				0.00	kg	Garrett and Hinman (1969) and Tedeschi et al. (2004)													
47	Predicted unshrunk MW at 27% EBF				0.00	kg	Guirroy et al. (2001)													
48																				
49																				
50																				
								Table 2.1. Breeds												
								Code	Breed	BE	L	CBW, kg	PKYD, kg	MkFat	MkProt	MkSNF	%FBW			
								1	Angus	1	1.2	31.0	8.0	4	3.8	8.3	8.3	0.6		
								2	Braford	0.95	1.2	36.0	7.0	4	3.8	8.3	8.3	0.55		
								3	Brahman	0.9	1.2	31.0	8.0	4	3.8	8.3	8.3	0.55		
								4	Brangus	0.95	1.2	33.0	8.0	4	3.8	8.3	8.3	0.62		
								5	Braunvieh	1.2	1	39.0	12.0	4	3.8	8.3	8.3	0.62		
								6	Canchim	0.9	1.2	32.0	6.0	4	3.8	8.3	8.3	0.62		
								7	Charolais	1	1.2	39.0	9.0	4	3.8	8.3	8.3	0.57		
								8	Chianina	1	1.2	41.0	6.0	4	3.8	8.3	8.3	0.65		
								9	Devon	1	1	32.0	8.0	3.5	3.3	8.3	8.3	0.6		
								10	Galloway	1	1.2	36.0	8.0	4	3.8	8.3	8.3	0.6		
								11	Gelbvieh	1	1	39.0	11.5	4	3.8	8.3	8.3	0.55		
								12	Gir	0.9	1.2	32.0	10.0	4	3.8	8.3	8.3	0.65		
								13	Guzerat	0.9	1.2	32.0	5.0	4	3.8	8.3	8.3	0.65		
								14	Hereford	1	1	36.0	7.0	4	3.8	8.3	8.3	0.6		
								15	Holstein	1.2	1	43.0	43.0	3.5	3.3	8.3	8.3	0.55		
								16	Jersey	1.2	1	32.0	34.0	5.2	3.9	8.3	8.3	0.55		
								17	Limousin	1	1.2	37.0	9.0	4	3.8	8.3	8.3	0.6		
								18	Longhorn	1	1.2	33.0	5.0	4	3.8	8.3	8.3	0.6		
								19	Maine Anjou	1	1.2	40.0	9.0	4	3.8	8.3	8.3	0.6		
								20	Nellore	1	1.2	32.0	7.0	4	3.8	8.3	8.3	0.65		
								21	Piedmontese	1	1.2	38.0	7.0	4	3.8	8.3	8.3	0.6		
								22	Pinzgauer	1	1.2	38.0	11.0	4	3.8	8.3	8.3	0.6		
								23	Polled Hereford	1	1.2	33.0	7.0	4	3.8	8.3	8.3	0.6		
								24	Red Poll	1	1.2	36.0	10.0	4	3.8	8.3	8.3	0.6		
								25	Sahiwal	0.9	1.2	38.0	8.0	4	3.8	8.3	8.3	0.65		
								26	Salers	1	1.2	35.0	9.0	4	3.8	8.3	8.3	0.6		
								27	Santa Gertrudis	0.95	1.2	33.0	8.0	4	3.8	8.3	8.3	0.62		
								28	Shorthorn	1	1.2	37.0	8.5	4	3.8	8.3	8.3	0.6		
								29	Simmental	1.2	1	39.0	12.0	4	3.8	8.3	8.3	0.57		
								30	South Devon	1	1.2	33.0	8.0	4	3.8	8.3	8.3	0.6		
								31	Tarentaise	1	1.2	33.0	9.0	4	3.8	8.3	8.3	0.6		
								Breeding System		3	4	5	6	7	8	9	10			
								Straightbred		1	1.2	31.0	8.0	4	3.8	8.3	8.3	0.6		
								2-Way		0.975	1.2	33.5	7.5	4	3.8	8.3	8.3	0.575		
								3-Way		0.9625	1.2	32.3	7.8	4	3.8	8.3	8.3	0.575		
								User input												
								Current		0.9625	1.2	32.3	7.8	4	3.8	8.3	8.3	0.575		
								Breed: 0.5Angus x 0.25Braford x 0.25Brahman												

FIGURE 8 The Animal (Table 2) and two auxiliary tables (Breeds and EBF/MW) of the Inputs worksheet.

The Animal Inputs

The *Animal* inputs are in Table 2 of the Inputs worksheet (FIGURE 8). Each main *Inputs* table has seven columns: item's name (column B); acronyms (column C); user-entered value (column D); current unit (column E); user-entered value in metric (column F); metric unit (column G); and additional description of the item (column H). Tables 2.1 and 2.2 are auxiliary tables.

Table 2.1 (Breeds; FIGURE 8) contains the default values for breed effect on NE required for maintenance (BE), lactating effect on NE required for maintenance (L), calf birth weight (CBW), peak milk yield (PKYD), milk fat (MkFat), protein (MkProt), and solids nonfat (MkSNF) contents, and expected target pregnant weight for 31 breeds. These factors are discussed in more detail in Chapter 19. The user may also override these default values by entering preferred values in cells L48 to S48. The peak milk yield is used to predict milk yield given days in milk as discussed in Chapter 19. The user may, however, override the predicted milk yield from peak milk by directly entering milk yield in cell D29. In this case, peak milk will be ignored and the user-inputted milk yield will be used to compute energy and protein requirements for lactation.

Table 2.2 (EBF and MW; FIGURE 8) computes the mature (unshrunk) body weight (MW) at a given empty body fat (EBF) based on carcass traits (hot carcass weight, fat thickness, longissimus dorsi muscle [ribeye] area, and USDA quality grade) as discussed in Chapter 19. The user can enter the average expected USDA quality grade for a pen in cell D39 or enter the percentage of USDA Prime, high Choice, Choice, low Choice, and Select in cells D40 to D44. The calculated MW at the selected EBF (cell D19) is shown in cell F47. The user can adjust the calculated MW and enter it in cell D18.

The Management and Grazing Inputs

The *Management and Grazing* inputs are shown in Table 3 of the Inputs worksheet (FIGURE 7). These options are discussed in detail in Chapter 19. In this case, the animals are in drylots so the grazing unit size and days on pasture are zero.

The Environment Inputs

The *Environment* inputs are in Table 4 of the Inputs worksheet (FIGURE 7). These options are discussed in detail in Chapter 19.

The Advanced Options

The *Advanced* options are in Table 5 of the Inputs worksheet (FIGURE 7).

Maintenance Factor. The maintenance factor (cell D80) is used to increase or decrease NE required for maintenance

(NEM). The user needs to pay careful attention to avoid double-adjusting NEM. Only choose one of the two ways to adjust NEM: cell L48 in Table 2 (see The Animal Inputs section) or cell D80 in Table 5.

Environmental Adjustments. Environmental adjustments for NE required for maintenance and DMI can be toggled on (1) or off (0) in cells D81 and D82, respectively.

Adjustments for DMI. The magnitude of DMI adjustments for monensin and implants can be changed in cells D83 and D84, respectively.

Ruminal pH. The user may enter the ruminal pH in cell D85; if zero is entered, the software will compute ruminal pH as discussed in Chapter 19.

The DE to ME Efficiency. The user may enter DE to ME efficiency in cell D86. The default is 82%.

Calculation of ME and NE for ELS. By default (cell D87 = 0), the ELS option of the software will compute ME, NEMA, and NE_g for each feed using the equations discussed in Chapter 19. The tabular values of ME, NEMA, and NE_g will be used if cell D87 is set to 1.

Microbial Crude Protein. When cell D88 is set to zero, the Equation 19-116 will be used to compute the MCP. The user may change the MCP calculation by entering the MCP/TDN coefficient in cell D88.

Desired Animal ADG. This option is used to compute the ration dry matter intake required (DMIR) for the average animal's daily gain (ADG) entered in this cell. The value of ADG entered in cell D89 is used by the *DMIR* option in the *Calculation* group (FIGURE 3F).

The MP to NP Efficiency. The calculation of MP to NP efficiency may be altered by the user in cell D90. If zero is entered, the software will compute the MP to NP efficiency as a function of shrunk body weight (SBW) as discussed in Chapter 19; if a negative number (e.g., -1) is entered, the software will compute the MP to NP efficiency based on NRC (1996, 2000). Otherwise, the software will use the value in cell D90 as the MP to NP efficiency.

Recycled Ruminal N. This option is used by the MLS calculation only; the ELS does not account for recycled ruminal N. There are four options for recycled ruminal N: option 0 uses no recycled ruminal N; option 1 uses the NRC (1985) equation adopted by NRC (1996, 2000); option 2 uses the urea N used for anabolism (UUA) that was developed by Reynolds and Kristensen (2008); and option 3 uses the UUA equation (Eq. 6-5) described in Chapter 6.

Diet Options

The *Diet* options are shown in FIGURE 3D. There are four components in the Diet group that are used to evaluate and formulate a diet: *Feeds* shows the feeds imported from the feed libraries (Table 6; FIGURE 9), *Diet* is used to enter amounts or percentage of diet feed ingredients (Table 7; FIGURE 9), *Feed Composition* is used to modify diet feed composition values (Table 8; FIGURE 10), and *Feed*

	AH	AI	AJ	AK	AL	AM	AN	AO	AP
1									
2	Table 8. Feed composition								
3	Locked	ID	Feed name	Cost, AF	Forage	DM	CP	SP	ADICP
4				\$/Tonne	%DM	%AF	%DM	%CP	%CP
5	<input checked="" type="checkbox"/>	5	Alfalfa hay	0	100	87.03	19.81	25.19	12.21
6	<input checked="" type="checkbox"/>	56	Corn grain steam flaked	0	0	80.70142	8.480428	8.200536	4.110104
7	<input type="checkbox"/>	155	Soybean meal high CP	0	0	89.23522	52.85348	44.10889	10.16993
8	<input type="checkbox"/>								
9	<input type="checkbox"/>								
10	<input type="checkbox"/>								
11	<input type="checkbox"/>								
12	<input type="checkbox"/>								
13	<input type="checkbox"/>								
14	<input type="checkbox"/>								
15	<input type="checkbox"/>								
16	<input type="checkbox"/>								
17	<input type="checkbox"/>								
18	<input type="checkbox"/>								
19	<input type="checkbox"/>								
20	<input type="checkbox"/>								
21	<input type="checkbox"/>								
22	<input type="checkbox"/>								
23	<input type="checkbox"/>								
24	<input type="checkbox"/>								
25	<input type="checkbox"/>								
26	<input type="checkbox"/>								
27	Diet (sum or average)			0.00	10.00	82.89	18.49	30.55	8.44
28									

FIGURE 10 The Feed composition (Table 8) of the Inputs worksheet of the Beef Cattle Nutrient Requirements Model, highlighting the row and column of the cell selected by the user. The arrow is pointing at the “locked” checkboxes used to prevent modification of feed composition by the software.

Library is used to view or select the feed library to be used and to import feeds into the user’s library. Setting up a diet begins with retrieving feeds from the software feed library that have the most similar and complete chemical, biological, and physical composition values to the feeds used in the diet. Then, the user can click on *Composition* and replace the values retrieved from the feed library with their own feed analysis values.

Feed Retrieval from Feed Library

There are two methods to retrieve feeds from the feed libraries. The *first method* involves the following: (1) viewing the feed library in the feed library subgroup; (2) finding the feeds to be used in the diet and their associated feed

IDs; (3) entering the feed IDs in cells W5 to W26 of Table 6 (FIGURE 9); and (4) clicking on the *Retrieve* button in the *Feeds* subgroup of the *Diet* group (FIGURE 3D). Diet feed numbers are shown in row W, and they are numbered from 1 to 22 in cells V5 to V26. If there are already feeds in the diet, the retrieval process will replace the feed composition in Table 8 (FIGURE 10) for all feeds that are not locked (cells AH5 to AH26; FIGURE 10).

During the retrieval process, the user is encouraged to lock the feeds (cells AH5 to AH26; FIGURE 10) after changing their composition values so that the feeds are protected and their composition values are not accidentally replaced by their original composition values in the feed library. For identification purposes only, locked feeds have a red background in Table 6 (FIGURE 9).

The *second method* involves using the *Select* button in the *Feeds* subgroup in the *Diet* group (FIGURE 3D). Clicking on this option will display the form in FIGURE 11.

The user may select feeds from the SFL and UFL using the dropdown boxes and lock/unlock feeds. *It is important to understand that the position of each feed is fixed, so feed #1 will always be retrieved and placed in the first feed position (row 5) and so forth.*

Diet Ingredients

After the feeds have been retrieved from the feed library, the user can click on *Diet* and enter the intake amount or percentage of each diet ingredient in Table 7 (cells AA5 to AA26; FIGURE 9). Whenever feeds are entered as percentage in Table 7 (cells AA5 to AA26; FIGURE 9), a ration intake amount must be entered in cell AA29 so that the intake amount of each diet ingredient can be calculated. Enter a value in cell AA29 to set the ration daily intake amount (kg/d or lb/d). To scale up or down the ration intake, change the value to the percentage desired in cell AA30. After the intake amount for each diet ingredient (kg/d or lb/d) has been scaled up or down, the scale value will revert to 100%. Amounts and percentages are calculated on dry-matter and as-fed bases and shown on the right side of the Table 7 (FIGURE 9).

Entering New Feeds and Changing Feed Composition

Users may enter their own feed composition values in Table 8 (FIGURE 10) or edit the composition values of a feed retrieved from a feed library as discussed in the Feed Retrieval from Feed Library section. During the retrieval process, the user is encouraged to lock the feeds (cells AH5 to AH26; FIGURE 10) after changing their composition so that feeds are protected and their composition is not replaced

by their original composition values in the feed library. The feed ID must be greater than 9000 for user-entered feeds so that the software can identify them correctly.

Erasing a Feed from the Diet

The user can erase (i.e., remove) a feed from the diet by erasing its ID, name, and composition values in Table 8 (FIGURE 10) or by selecting any cell in the row of the chosen feed within Table 8 and clicking on the *Delete* button in the *Composition* subgroup in the *Diet* group (FIGURE 3D). The erased feed is unlocked automatically.

Adding or Deleting Feeds from the User-Created Feed Library

The *Copy* and *Delete* buttons in the *Composition* subgroup in the *Diet* group (FIGURE 3D) can be used to copy a feed from Table 8 (FIGURE 10) to the UFL and to delete a feed from the UFL, as explained in the next section.

Feed Library Options

The values included in the BCNRM software feed composition library are based on previously published values (NRC, 1996, 2000) and values in Table 18-1 (Means and Standard Deviations for the Composition Data of Feeds Commonly Used in Beef Diets) of the 8th Revised Edition of the *Nutrient Requirements of Beef Cattle*. A compositional value in the software feed composition library that has a value of zero does not necessarily indicate lack of the nutrient, but that reliable composition data were not available for inclusion in the library. Although these tabular values can provide useful data on nutrient composition of common feeds, the user is ultimately responsible for ensuring the accuracy of

Feed #	Locked	Feeds	Feed #	Locked	Feeds
1	<input checked="" type="checkbox"/>	5 - Alfalfa hay	12	<input type="checkbox"/>	
2	<input checked="" type="checkbox"/>	56 - Corn stalks	13	<input type="checkbox"/>	
3	<input type="checkbox"/>	155 - Sunflower screenings	14	<input type="checkbox"/>	
4	<input type="checkbox"/>		15	<input type="checkbox"/>	
5	<input type="checkbox"/>		16	<input type="checkbox"/>	
6	<input type="checkbox"/>		17	<input type="checkbox"/>	
7	<input type="checkbox"/>		18	<input type="checkbox"/>	
8	<input type="checkbox"/>		19	<input type="checkbox"/>	
9	<input type="checkbox"/>		20	<input type="checkbox"/>	
10	<input type="checkbox"/>		21	<input type="checkbox"/>	
11	<input type="checkbox"/>		22	<input type="checkbox"/>	

NOTE: The composition of locked feeds will not be retrieved from the feed library.

Cancel Retrieve

FIGURE 11 The *Select* form to retrieve feeds from feed libraries. The arrow is pointing at the “locked” checkboxes used to prevent modification of feed composition values by the software.

feed composition data used in model simulations. Thus, when available, users should input their own measured feed composition data.

The *Feed Library* options are shown in FIGURE 3E. It is through this ribbon group that the user can interact with the standard (i.e., SFL) and user-created (i.e., UFL) feed libraries. Feed library files (*.FLF) are located in the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder. Feed libraries contain values that are averages obtained from commercial laboratories (i.e., DM, CP, protein solubility, NDF, ADF, lignin, fat, minerals, vitamins, amino acids) and published research (i.e., physically effective fiber, carbohydrate and protein digestion rates). The SFL (*Beef Std 2016.FLF*) is read only: it cannot be edited by the user; feeds cannot be added or deleted. Its only purpose is to allow the user to retrieve feed compositional information into the simulation file. The user may, however, load a different standard feed library by clicking on the *Load SFL* button of the *Feed Library* group. Note that the UFL cannot be opened as an SFL. A modified NRC (1996, 2000) feed library (*Beef Std 2000.FLF*) that can be used with the BCNRM is also available in the [C:]Users\[User Name]\Documents\National Academies\BCNRM2016 folder.

After clicking on the *View SFL* button of the *Feed Library* option (FIGURE 3E), the user will be able to browse the SFL (Table F1). Only the first 10 feeds are shown in FIGURE 12. The user can scroll vertically or horizontally using the scroll bars and can annotate the feed ID (first column; FIGURE 12) to be able to retrieve feeds into the simulation file, as explained below.

Adding Feeds to the User-Created Feed Library

There are two methods to add feeds to the UFL. The first method is the direct way and requires typing the values into

the UFL, whereas the second method is the indirect way and is done through Table 8 (Feed Composition).

Adding Feeds Directly. Clicking on the *View UFL* button in the *Feed Library* group (FIGURE 3E) will display Table F2 (FIGURE 13). To add one feed, click on the *Add* button in the *View UFL* subgroup (FIGURE 3E).

As an example, enter the information shown in FIGURE 13. The feed ID has to be greater than 9000, and the units of the feed components must be in metric, including the cost (\$/tonne as-fed), ME, NEm_a, and NE_g (Mcal/kg), and microminerals (mg/kg or ppm). To convert \$/ton to \$/tonne, multiply by 1.1023 and vice versa (e.g., \$200/ton = \$220.46/tonne), as 1 tonne = 1,000 kg and 1 ton = 2,000 lb. To convert Mcal/lb to Mcal/kg, multiply by 2.2046 and vice versa (e.g., 1.5 Mcal/lb = 3.3069 Mcal/kg).

Alternatively, the user may enter [sequentially] the feed ID numbers at the end of the UFL in the column BJ (e.g., cell BJ8 in FIGURE 13) to automatically add feed rows to the UFL.

Adding Feeds Indirectly. The user can add a feed and its complete compositional information to the UFL by clicking on *Composition*, then selecting a feed from Table 8 (i.e., select any cell in the row of the chosen feed within Table 8; FIGURE 10) and clicking on the *Copy* button of the *Composition* subgroup of the *Diet* group (FIGURE 3D). The new feed ID will be the current feed ID plus 9000. In case the new feed ID already exists in the UFL, the user would need to decide whether to replace it. To replace the existing feed in the UFL, the user should select *YES*. If the user does not want to replace the existing feed in the UFL, select *NO* and renumber the current feed ID (column AI) to a feed ID that does not exist in the UFL. Once the feed is copied into the UFL, the feed in the Diet (Table 8) will become locked (column AH) and the UFL will be shown. This option is very useful as the user can retrieve a feed from the SFL, replace

	A	B	C	D	E	F	G	H
1								
2		Table F1. Standard feed library						
3								
4		ID	Feed	IFN	Cost, \$/Ton	Forage, %D	DM, %AF	CP, %DM
5		1	Alfalfa cubes		0	100	91.0	18.1
6		2	Alfalfa dehy		0	100	93.8	18.5
7		3	Alfalfa fresh		0	100	30.7	23.1
8		4	Alfalfa greenchop		0	100	40.5	23.1
9		5	Alfalfa hay		0	100	87.0	19.8
10		6	Alfalfa haylage		0	100	41.0	20.1
11		7	Almond hulls		0	100	89.2	5.5
12		8	Apple pomace		0	100	18.5	6.4
13		9	Bakery products		0	0	88.9	13.1
14		10	Barley grain		0	0	89.7	12.8

FIGURE 12 The first 10 feeds of the standard feed library (Table F1) of the Beef Cattle Nutrient Requirements Model.

	A	BJ	BK	BL	BM	BN	BO	BP
1								
2		Table F2. User feed library						
3								
4		ID	Feed	IFN,	Cost, \$/Ton	Forage, %D	DM, %AF	CP, %DM
5		9001	Feed 1		100	35	90	15
6		9002	Feed 2		150	100	40	5
7		9003	Feed 3		50	100	10	10
8								
9								
10								

FIGURE 13 The first three feeds of the user-created feed library (Table F2) of the Beef Cattle Nutrient Requirements Model.

composition values with those available from their own analyses, and save it into the UFL for recurring use.

Deleting Feeds from the User-Created Feed Library

Similarly, there are two methods to delete feeds from the UFL. The first method is the direct way and requires selecting a feed in the UFL, and the second method is the indirect way and is done through Table 8 (Feed Composition).

Deleting Feeds Directly. Click on the *View UFL* button in the *Feed Library* option (FIGURE 3E) to display Table F2 (FIGURE 13). To delete a feed, select the feed you wish to delete permanently (remove from the UFL) by clicking on any column in the row of the feed ID. For instance, to delete Feed 2 shown in FIGURE 13, select the cell BK6 and click on the *Delete* button in the *View UFL* subgroup (FIGURE 3E). Select *YES* to delete the feed. This action cannot be undone.

Deleting Feeds Indirectly. The user can delete a feed from the UFL by clicking on *Composition* and selecting a feed in Table 8 (i.e., select any cell in the row of the chosen feed within Table 8; FIGURE 10) and then clicking on the *Delete* button of the *Composition* subgroup of the *Diet* group (FIGURE 3D). The feed will be deleted from the UFL, but it will remain in the diet (Table 8). To remove it from the diet, select a feed in Table 8 and click on the *Erase* button of the *Composition* subgroup of the *Diet* group (FIGURE 3D). These actions cannot be undone.

Deleting all Feeds from the User-Created Feed Library

Click on the *View UFL* button in the *Feed Library* option (FIGURE 3E) to display Table F2 (FIGURE 13). To delete all feeds permanently, click on the *Delete all* button in the *View UFL* subgroup (FIGURE 3E). Select *YES* to delete all feeds. This action cannot be undone.

Sorting Feeds in the User-Created Feed Library

Click on the *View UFL* button in the *Feed Library* option (FIGURE 3E) to display Table F2 (FIGURE 13). To sort

feeds, click on the *Sort* button in the *View UFL* subgroup (FIGURE 3E). Feeds will be sorted ascendingly by their ID. Alternatively, the user may sort feeds from the STL or UFL by clicking on the dropdown arrow button in the feed library's column name (heading row) and selecting *Sort A to Z* or *Sort Z to A*.

Exporting the User-Created Feed Library

Click on the *View UFL* button in the *Feed Library* option (FIGURE 3E) to display Table F2 (FIGURE 13). To export the UFL, click on the *Export* button in the *View UFL* subgroup (FIGURE 3E). The complete UFL will be saved into an FLF file that can be shared among users.

Importing a User-Created Feed Library

Click on the *View UFL* button in the *Feed Library* option (FIGURE 3E) to display Table F2 (FIGURE 13). The user has two importation options: append or replace the current UFL. The append option will add the feeds from the external UFL to the end of the current UFL. The user must ensure that there are no duplicate feed ID values, as this will cause incorrect identification of feeds in the UFL. Note that SFL cannot be imported to the UFL.

Calculations Options

The *Calculations* options are shown in FIGURE 3F. Clicking on the *All* button in the *Calculation* group will display the requirement calculations (cell B2) and the supply calculations (cell AG2). All calculations are performed using the metric system.

The Requirement Calculations

Clicking on the *Req's* button in the *Calculation* group (FIGURE 3F) will only display the requirement calculations. There are nine tables in the requirement calculations: maintenance (Table R1, cell B4); lactation (Table R2, cell

B44); pregnancy (Table R3, cell B69); growth (Table R4, cell B85); target gain for replacement heifers (Table R5, cell B102); body reserves for mature cows (Table R6, cell B124); minerals and vitamins (Table R7, cell B151); dry matter intake, water intake, and dry matter required (Table R8, cell B171); and amino acids requirement (Table R9, cell B194). Auxiliary tables are also available for these tables and they are located on the right side of these tables. Although not recommended, the user can change the target pregnant weight and target calving weight (cells I104 to K106), the method to compute body reserves (cell L142), and the change in SBW/BCS (cell Q142).

The Supply Calculations

Clicking on the *Supply* button in the *Calculation* group (FIGURE 3F) will only display the supply calculations. The supply section is extensive and contains 17 tables for the ELS and MLS calculations, as listed below.

- (a) Table S1: Feed composition (ELS and MLS, cell AG4);
- (b) Table S2: Carbohydrate and protein fractions (ELS and MLS, cell AG31), and methane (ELS, cell BJ31);
- (c) Table S3: Diet cost and nutrient intake (ELS and MLS, cell AG59);
- (d) Table S4: Energy and ruminally undegradable protein (RUP) (ELS, cell AG87);
- (e) Table S5: Metabolizable protein (ELS, cell 115);
- (f) Table S6: Feedstuffs and bacterial amino acid (ELS, cell AG143);
- (g) Table S7: Supply of metabolizable amino acids (ELS, cell AG171);
- (h) Table S8: Fractional passage rate, ruminally degraded carbohydrate and protein, and ruminally escaped carbohydrate and protein (MLS, cell AG199);

- (i) Table S9: Bacterial yield (MLS, cell AG227);
- (j) Table S10: Intestinal digestibility, fecal output, and endogenous matter (MLS, cell AG255);
- (k) Table S11: Total digestible nutrients and energy values (MLS, cell AG283);
- (l) Table S12: Feedstuff and bacterial amino acids (MLS, cell AG311);
- (m) Table S13: Supply of metabolizable amino acids (MLS, cell AG339);
- (n) Table S14: Minerals and vitamins (ELS and MLS, cell AG367);
- (o) Table S15: Ruminal fermentation end products (MLS, cell AG395);
- (p) Table S16: Ruminal volatile fatty acids (MLS, cell AG423); and
- (q) Table S17: Ruminal methane (MLS, cell AG451).

Although not recommended, the user may change the coefficients and factors that will modify the supply calculations such as microbial composition (cells BH89 to BH97), bacterial amino acid composition (cells AZ172 to BB183), bacterial yield factors (cells BC241 to BC247), and intestinal digestibility coefficients (cells BC256 to BC265). These coefficients and factors revert to their default values when a new simulation is initiated (see *Creating a New Simulation* section). In some tables, incorrect or infeasible calculations will be marked in red font.

Nitrogen Balance Calculation

Clicking on the *N Balance* button in the *Calculation* group (FIGURE 3F) will display the nitrogen balance calculations (Table B1, cell DA2), as discussed in Chapter 19, and depicted in FIGURE 14. Calculations are performed for ELS and MLS concurrently.

	A	DA	DB,DC	DD	DE	DF	DG	DH	DI	DJ	DK
1											
2		NUTRIENT BALANCE SECTION									
3											
4		Table B1. Nitrogen fluxes and balance									
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											

N Fluxes, g/d	ELS	MLS
Intake N	207.1	207.1
Metabolizable N	135.2	132.4
Net N required		
Growth	26.3	26.3
Pregnancy	0.0	0.0
Lactation (milk)	0.0	0.0
<i>Total</i>	26.3	26.3
Urinary N	111.8	123.9
Fecal N	68.9	56.8

N balance, g/d	ELS	MLS
Intake	207.1	207.1
Urinary	111.8	123.9
Milk	0.0	0.0
Fecal	68.9	56.8
Balance	26.3	26.3

Ammonia-N, g/d	ELS	MLS
Feedlot (1)	158.5	158.5
% of excreted N	87.7%	87.7%

(1) Only valid for feedlot animals with *ad libitum* access to feed (Todd et al., 2013).

FIGURE 14 Nitrogen balance calculations for the Empirical Level of Solution (ELS) and Mechanistic Level of Solution (MLS).

Methane Calculations

Clicking on the *Methane* button in the *Calculation* group (FIGURE 3F) will display the methane calculations (cell BD31), as discussed in Chapter 19, and depicted in FIGURE 15. Calculations for the MLS are shown in Table S17 (cell AG451), and those for the ELS are shown in cell BD31. For the ELS, the BCNRM reports the median of the prediction of methane production by different empirical equations (Chapter 19).

Although not recommended, the user can change the coefficients that will modify the calculations of methane in cells BO32 to BO35 (see top arrow on the right side of FIGURE 15). A comparative table for the MLS and ELS calculations is shown on the right side of FIGURE 15 (middle arrow). A table on the left side of FIGURE 15 (black arrow) has some descriptive statistics of the methane prediction by the ELS option. The graph on the right side of FIGURE 15 (bottom arrow) shows the relative position of methane prediction for high, medium, and low levels of forage in the diet.

Dry Matter Required Calculation

Clicking on the *DMIR* button in the *Calculation* group (FIGURE 3F) will display the dry matter required calculation (Table R8, cell H171). The user must enter the desired animal ADG in Table 5 (*Options* button in the *Inputs* group, FIGURE 3C). The DMIR uses the goal-seek tool of Microsoft® Excel® to change the actual DMI until the first-limiting ME- or MP-allowable gain matches the desired animal ADG. FIGURE 16 will be displayed at the end of the goal-seek process, and the user can then decide to keep the calculated DMIR or the actual (original) DMI. Subsequent calculations of DMIR may enhance the predicted DMIR.

Running Multiple Simulations as Batches

Clicking on the *Batch* button in the *Calculation* group (FIGURE 3F) will initiate the batch calculation mode. The batch calculation mode is used to perform multiple consecutive calculations by reading the input information from a

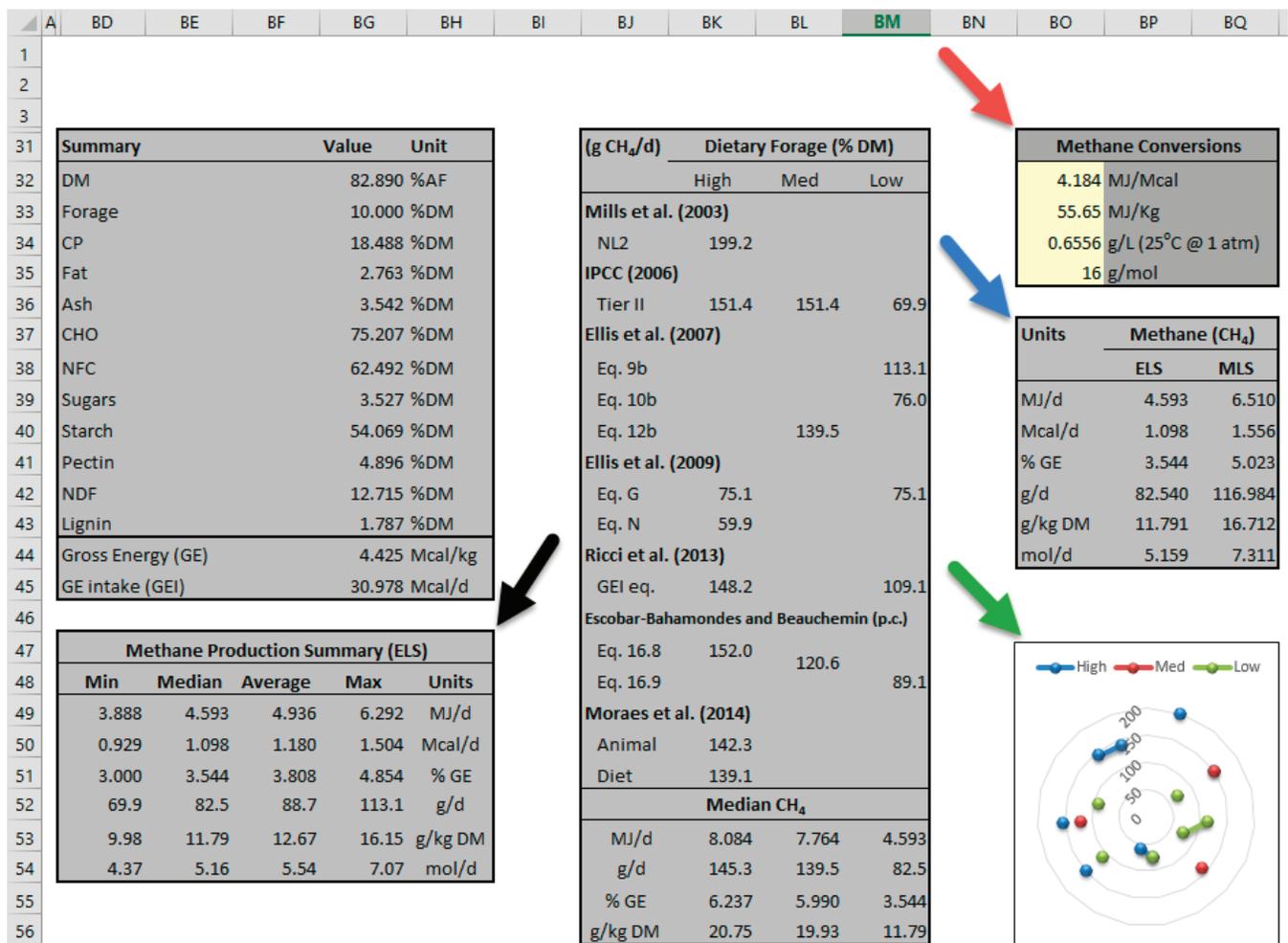


FIGURE 15 Methane calculations for the Empirical Level of Solution (ELS).

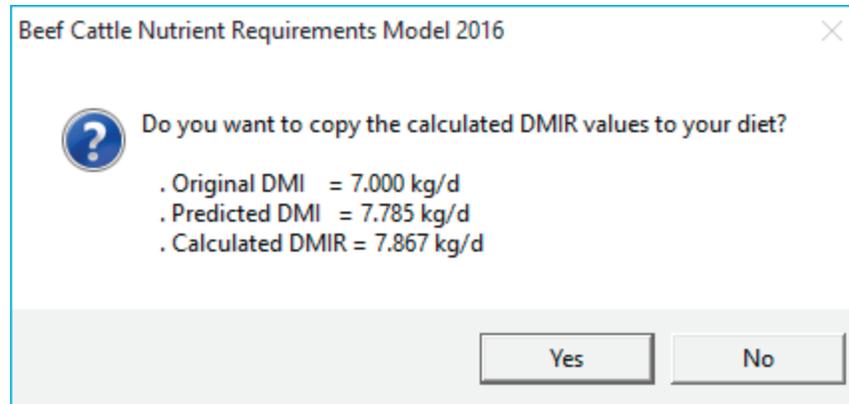


FIGURE 16 Dry matter intake required (DMIR) result.

batch file (Microsoft® Excel® file) and saving the calculations (i.e., outputs) in another Microsoft® Excel® file. A blank batch file is provided in the [C:\Users\[User Name]\Documents\National Academies\BCNRM2016] folder with an example. Each column (after the B column) in the batch file is a complete BCNRM simulation and the simulation ID (row 1) must be consecutive and unique.

Advanced Options

The *Advanced* options are shown in FIGURE 3G. The *Tables* and *Optimizer* options require the Microsoft® Excel® Solver Add-In to be installed and loaded.¹ The *Stochastic* option requires the Palisade @Risk 6.3 or later (Palisade Corp., Ithaca, NY) to be installed and loaded.

Table Generator

Clicking on the *Tables* button in the *Advanced* group (FIGURE 3G) will display the Table worksheet. The message “Solver was found and loaded” will appear on the lower left corner of Microsoft® Excel® if the Solver Add-in was loaded successfully. This advanced option was used to create the tables in Chapter 20 (Tables of Nutrient Requirements).

There are six main tables in the Table worksheet: requirements and diet evaluation for growing and finishing cattle (Tables T1.1 and T1.2); requirements and diet evaluation for replacement heifers and dry cows (Tables T2.1 and T2.2); and requirements and diet evaluation for lactating cows

(Tables T3.1 and T3.2). At the bottom of Tables T1, T2, and T3 are three buttons in row 36 that are used to solve or to copy these tables. The tables on the left side of the Table worksheet are auxiliary tables used during the optimization process. Information in the yellow-shaded cells may be changed by the user. The user can alter the objective function in cell D16, and the appropriate equation to predict DMI should be changed in cell A20, depending on which table is used (T1, T2, or T3) so that DMI is predicted for the correct physiological stage. The table optimization uses the ELS and, during the optimization process, only the first feed’s composition of the diet (Table 8) is changed. Although not recommended, the user may set the table optimization to use the current composition of feed #1 (set cell B18 to true).

Optimizing Diets

Clicking on the *Optimizer* button in the *Advanced* group (FIGURE 3G) will display the Optimizer worksheet. The message “Solver was found and loaded” will appear on the lower left corner of Microsoft® Excel® if the Solver Add-in was loaded successfully.

There are four tables in the Optimizer worksheet: objective function (Table Z1); constraints for diet ingredients (Table Z2); constraints for performance, required and supplied nutrients (Table Z3); and optimized diets (Table Z4). These tables can be printed by clicking on the *Print* button in the *File* group. Information in the yellow-shaded cells may be changed by the user. As a rule of thumb, the user should avoid restrictive constraints in the beginning, and start optimizations with relaxed constraints. Once the optimizer finds a feasible solution, and if needed, the user can set more restrictive constraints. The following steps should be followed for successful optimization:

- (a) Set the objective function in cell E4 in Table Z1. The default is 1.

¹Support to load the Solver Add-In for Microsoft® Excel® can be found in the following hyperlinks:

Excel® 2007: <http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP010021570.aspx?CTT=1>,

Excel® 2010: <http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP010342660.aspx?CTT=1>, and

Excel® 2013 and Excel® 2016: <https://support.office.com/en-US/Article/Load-the-Solver-Add-in-ec994cd0-a396-4bf3-a5dd-feda369cef37?ui=en-US&rs=en-US&ad=US>.

- (b) Set the minimum and maximum for each diet ingredient in Table Z2 (cells J5 to K26). The default is zero for minimum and 9999 for maximum.
- (c) Set the minimum and maximum for each constraint in Table Z3 (cells C16 to D34). Make sure the values match the units in column A.
- (d) Use the buttons in row 34, below Table Z2, to manage the optimization:
 - i. Click on the *Optimize* button to start the optimization.
 - ii. Click on the *Clear diet* button to erase one saved diet or all the saved, optimized diets listed in Table Z4.
 - iii. Click on the *Retrieve diet* button to copy a saved, optimized diet from Table Z4 to the solution range (cells H5 to H26) in Table Z2.
 - iv. Click on the *Save solution* button to save the current solution to Table Z4. The solution will be saved in the next available slot; if no empty slot is available in Table Z4, the user will be asked what Diet ID should be replaced. The user can save up to 10 optimized solutions.
 - v. Click on the *Accept solution* button to copy the current solution to the diet table (Table 7) in the Inputs worksheet.

Stochastic Simulation

Clicking on the *Stochastic* button in the *Advanced* group (FIGURE 3G) will display the Stochastic worksheet. The message “@Risk was found and loaded” will appear on the lower left corner if Palisade @Risk Add-in was successfully loaded. This advanced option was used to create the sensitivity analysis in Chapter 19. There are four tables in the Stochastic worksheet: mean, SD, and correlation matrix of animal weight and intake (Table K1); mean, SD, and correlation matrix of environment factors (Table K2); mean, SD, and correlation matrix of feed composition (Table K3); and stochastic results (Table K4). FIGURE 17 depicts Tables K1, K2, and K4. Information in the cells F and I (2 to 4), C to G (8 and 9), C to G (12 to 16), C to I (20 and 21), and C to G (24 to 30) may be changed by the user. All variables are assumed to follow the Gaussian (i.e., normal) distribution. Additional analysis can be performed with the Palisade @Risk Add-in. The Palisade @Risk Add-in is a third-party, commercial Add-in that is not included with the BCNRM.

FEEDLOT CASE STUDY

This feedlot case study is the same as the one presented in the *Nutrient Requirements of Beef Cattle*, 7th revised edition and update (NRC, 1996, 2000). The purpose of this study is to compare the predictions of the BCNRM and the NRC (1996, 2000) computer model.

Settings, Animal, Management and Grazing, Environment, and Advanced Inputs

Begin the tutorial by opening the BCNRM; agree with the *Terms of Use*; click on the *BCNRM 2016* tab (if not automatically selected); click on the *New* button of the *File* group (FIGURE 3B); and click on the *Inputs* button of the *Inputs* group (FIGURE 3C).

This case study is of a 20,000-head-capacity western Canada feedlot. Cattle are fed in open dirt lots surrounded by windbreaks. Typical pens contain 250 head. The basal diet is dry-rolled barley and barley silage. Data from closeouts will be used to adjust the model so it predicts accurately for that feedlot, and then inputs will be changed to answer the questions. The data set is from 1969 Hereford × Charolais crossbred steers fed in 8 pens in the fall, with an initial full weight of 872 lb and final weight of 1,337 lb, with an average grade of Canadian AA. The cattle received an estrogenic implant and were fed an ionophore. The average full weight during the feeding period was 1,104 lb, with an ADG of 3.48 and conversion of 6.98 lb DM/lb gain. The average daily dietary DMI was 5 lb coarsely chopped barley silage, 19 lb coarsely rolled barley grain, and 0.3 lb minerals. The available feed analysis indicated that the barley silage contains 48.7% NDF with 65% estimated to be peNDF, 10.4% CP, 3% fat, and 8% ash; and barley grain was 19% NDF with 34% estimated to be peNDF, 13% CP, 2.1% fat, and 3% ash. The average wind speed in the pens was 5 mph, the previous month’s average temperature was 40°F, and the average temperature during the feeding period was 30°F. Other inputs were average hide thickness, hair depth of 0.2 inch (typical of early summer-fall; 0.5 inch is typical of winter), and average hair coat condition is clean and dry.

Settings (Table 1). Confirm that solution type is 1 (ELS), unit system is 2 (Imperial), feed basis is 1 (DM), and animal class is 1 (growing/finishing cattle). It is often practical to adjust the diet until balanced with the ELS, and then evaluate it with the MLS to get the predicted feed net energy values and amino acid balances, based on actual feed analysis for carbohydrate and protein fractions.

Animal (Table 2). Enter the following information in this table:

- (a) Age (cell D12) = 14 mo; this value influences tissue insulation.
- (b) Age class (cell D13) = 2; this value influences expected DMI.
- (c) Sex (cell D14) = 2; this value influences maintenance requirement.
- (d) Body condition score (cell D15) = 5; see Chapters 3 (Energy Terms and Concepts) and 13 (Reproduction) for a detailed discussion of the 1 to 9 condition scoring system used and its biological basis. The choices are 1 through 9 (1 = emaciated, 5 = moderate, 9 = very fat). Body condition score (BCS) is used to

describe tissue insulation, the potential for compensatory growth in growing cattle, and energy reserves in cows.

- (e) Initial body weight (cell D16) = 872.
- (f) Final body weight (cell D17) = 1,337. This is the unshrunk final body weight that best represents the group being fed. The average between initial and final weights is a major determinant of DMI, maintenance, and growth requirements.
- (g) Mature body weight (cell D18) = 1337; this is the expected average unshrunk weight at the USDA grade selected in cell D19. For cows, replacement heifers, or breeding bulls, enter the expected mature weight at BCS 5. The weight that best corresponds to the cattle in question based on the user's experience for the type of growing animal, implant strategy, and ration should be entered. A general guide is that the finishing weight should be reduced by 50 to 75 lb if diets that contain more than 70% grain are fed continuously after weaning or if anabolic steroids are not used. Weight at the target grade should be increased by 50 to 75 lb if animals are grown at a slow rate for an extended period or if they are implanted with estrogen in combination with trenbolone acetate. More information in Chapters 12 (Growth) and 14 (Compounds That Modify Digestion and Metabolism).
- (h) Reference animal's EBF (cell D19) at slaughter = 3; choices are 1 (22% body fat), 2 (USDA Standard or Canadian A, which are related to 25% body fat), 3 (USDA Select or Canadian AA, which are related to 27% body fat), and 4 (USDA Choice or Canadian AAA, which are related to 28% body fat). The software uses this grading system to identify the standard reference weight. The standard reference weight is divided by the finished weight, and this result is multiplied by the actual weight. These calculations provide the weight used in the equations that compute net energy and protein in the gain.
- (i) Breed type (cell D20) = 2.
- (j) Breeding system (cell D21) = 2; choices are 1 (straightbred), 2 (two-way crossbred), and 3 (three-way crossbred). Cell D22 is used for animal breed if straightbred, cells D22 and D23 are used if describing two-way crossbred, and cells D22, D23, and D24 are used when describing three-way crossbred. Breeding system for growing cattle influences maintenance energy requirement and predicted DMI.
- (k) Breed cells (D22 and D23) = 14 (dam's breed is Hereford) and 7 (sire's breed is Charolais), respectively; valid breed codes are shown in Table 2.1. Stored breed values are used to determine maintenance energy requirements and defaults for calf birth weight and peak milk production. See Chapter 19 for the biological basis for these breed adjustments. Since this is a two-way crossbred (cell D21), the

software will ignore the values in cell D24, which is used only for three-way crossbreeding system.

- (l) Days pregnant (cell D25) = 0.
- (m) Calf birth weight (cell D26) = 0.
- (n) Days since calving (cell D27) = 0.
- (o) Relative milk yield (cell D28) = 5; although not used by software as this is a growing/finishing steer (cells D7 and D17), a number between 1 and 9 must be entered in this cell.
- (p) Milk production (cell D29) = 0.
- (q) Target calving age (cell D30) = 0.
- (r) Target calving interval (cell D31) = 0.

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Feedlot case study 1*. Once the *Home* screen is displayed, click on *Inputs* button of the *Inputs* group. FIGURE 18 shows the data entered so far.

Management and Grazing (Table 3). Enter the following information in this table:

- (a) Feed additive (cell D55) = 2; choices are 1 (none), 2 (monensin), or 3 (lasalocid). These affect the dietary ME values and predicted DMI.
- (b) Implant (cell D56) = 2; it affects the predicted DMI.
- (c) Grazing unit size (cell D57) = 0, because the cattle are fed in confinement. For animals that are on pasture, enter the number of hectares (metric) or acres (Imperial) per animal grazed in the pasture. If the distance traveled is minimal, enter zero. This input is used to adjust energy maintenance requirements for walking activity.
- (d) Days on pasture (cell D58) = 0. For grazing cattle, enter the number of days on the pasture.
- (e) Available forage mass (cell D59) = 0. For grazing cattle, enter the kg DM/hectare (metric) or lb DM/acre (Imperial) when the cattle are turned into the pasture. This can be estimated from hay harvesting experience, clippings, or calibrated measuring devices such as height and/or density estimates, Plexiglas weight plates, or electronic pasture probes. The available forage mass (cell D59), number of days on pasture (cell D58), and the grazing unit size (cell D57) are used to predict pasture DMI.

Environment (Table 4). Enter the following information in this table:

- (a) Wind speed (cell D64) = 5; this is the average wind speed the cattle are exposed to. Wind speed influences maintenance requirements by reducing the external insulation of the animal. Increasing wind speed decreases the external insulation value of the animal and thus results in increased energy maintenance requirements. The model is very sensitive to this input after the lower critical temperature is

	A	B	C	D	E	F	G
1							
2		Table 1. Settings					
3			Acronym	User	Unit	Metric	Unit
4		Solution type		1	ELS		
5		Unit system		2	Imperial		
6		Feed basis		1	DM		
7		Animal class		1			
8							
9							
10		Table 2. Animal					
11		Item	Acronym	User	Unit	Metric	Unit
12		Age		14		14	mo
13		Age class (for DMI & WC)		2		2	
14		Sex		2		2	
15		Body condition score	BCS	5		5	
16		Initial body weight	IBW	872	lb	396	kg
17		Final body weight	FBW	1337	lb	606	kg
18		Mature body weight	MW	1337	lb	606	kg
19		Reference animal's EBF		3		3	
20		Breed type		2		2	
21		Breeding system		2		2	
22		Dam's breed		14		14	
23		Sire's breed		7		7	
24		N/A		1		1	
25		Days pregnant	DP	0		0	days
26		Calf birth weight	CBW	0	lb	0.0	kg
27		Days since calving		0		0	days
28		Relative milk yield	RMY	5		5	
29		Milk production	MY	0	lb/d	0.0	kg/d
30		Target calving age	TCA	0		0	mo
31		Target calving interval	TCI	0		0	mo

FIGURE 18 Settings and Animal tables after data entry.

reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.

- (b) Temperature, previous (cell D65) = 40; this is the average temperature for the previous month. This value is used to increase NEm requirement, as it gets colder or to reduce it as it gets warmer. The model is extremely sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analyses were performed in Chapter 19.
- (c) Temperature, current (cell D66) = 30; this is the average temperature the cattle are exposed to. In most situations, the current average daily temperature is the most practical to use. This value is used to adjust predicted DMI for temperature effects and is used in the calculations for the effects of cold stress on energy maintenance requirements. The model is very

sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.

- (d) Relative humidity, previous (cell D67) = 65; this value can be used to compute the previous effective temperature index.
- (e) Relative humidity, current (cell D68) = 65; this value is used to compute the current effective temperature index to predict DMI, as discussed in Chapter 19.
- (f) Storm exposure (cell D69) = 1; this value is used to predict DMI, as discussed in Chapter 19.
- (g) Lowest night temperature (cell D70) = 30; if greater than 68°F (20°C) there is no night cooling and DMI is reduced with hot daytime temperatures; otherwise, it is assumed that cattle can dissipate heat at night and DMI is not affected.

- (h) Hair depth (cell D71) = 0.2; this is the average hair depth. This input is used to compute the external insulation of the animal. Enter the effective hair coat depth of the animal, in increments of 0.1. As hair length increases, so does the external insulation value provided by the animal’s hair coat. A general guide to use is an effective coat depth of 0.25 inches (0.6 cm) during the summer and 0.5 inches (1.3 cm) during the winter. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.
- (i) Hide (cell D72) = 2; enter either 1 (thin hide—i.e., dairy or Bos indicus types); 2 (average—i.e., most European breeds); or 3 (thick—i.e., Hereford or similar breeds). This value influences the external insulation value of the animal. Increased hide thickness implies increased external insulation. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.
- (j) Hair coat (cell D73) = 1; enter either 1 (clean and dry), 2 (some mud on lower body), 3 (some mud on lower body and sides), or 4 (heavily covered with mud). This value is used to adjust external insulation. The model

is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.

- (k) Cattle panting (cell D74) = 1; enter either 1 (no panting, not heat stressed), 2 (rapid shallow panting, or 3 (open-mouth panting). This value is used to adjust maintenance energy requirements for the energy cost of dissipating heat.
- (l) Mud depth (cell D75) = 0; this value affects predicted DMI. Because the animals in this study have clean and dry hair coat, there was no mud present in this situation.

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Feedlot case study 2*. Once *Home* screen is displayed, click on the *Inputs* button of the *Inputs* group. FIGURE 19 depicts the management and environment data entered so far.

Advanced options (Table 5). Let us use the following values in this table to make the BCNRM calculations of environment factors more compatible with the NRC (1996, 2000):

- (a) Maintenance factor (cell D80) = 0 (default).
- (b) Adjustments for required NEm (cell D81) = 1.
- (c) Adjustments for predicted DMI (cell D82) = 1.

	A	B	C	D	E	F	G
52							
53	Table 3. Management and Grazing						
54	Item	Acronym	User	Unit	Metric	Unit	
55	Feed additive			2		2	
56	Implant			2		2	
57	Grazing unit size	GU		0 acre		0.00 ha	
58	Days on pasture	DOP		0 days		0 days	
59	Available forage mass	FM		0 lb/acre		0.0 kg/ha	
60							
61							
62	Table 4. Environment						
63	Item	Acronym	User	Unit	Metric	Unit	
64	Wind speed	WS		5.00 miles/h		8.0 Km/h	
65	Temperature, previous	Tp		40.00 oF		4.4 oC	
66	Temperature, current	Tc		30.00 oF		-1.1 oC	
67	RH, previous	RHp		65.00		65.0 %	
68	RH, current	RHc		65.00		65.0 %	
69	Storm exposure			1		1	
70	Lowest night temp.	LNT		30.00 oF		-1.1 oC	
71	Hair depth			0.2 in		0.51 cm	
72	Hide			2		2	
73	Hair coat			1		1	
74	Cattle panting			1		1	
75	Mud depth			0.00 in		0 cm	

FIGURE 19 Management and Grazing and Environment tables after data entry.

- (d) Monensin adjustment for DMI (cell D83) = -3 (default).
- (e) Implant adjustment for DMI (cell D84) = -6 (default).
- (f) Ruminal pH (cell D85) = 0 (default).
- (g) DE to ME efficiency (cell D86) = 82 (default).
- (h) Tabular ME and NE values for ELS (cell D87) = 0 (default).
- (i) MCP yield (MCP/TDN, %) (cell D88) = 0 (default).
- (j) Desired animal ADG (cell D89) = 1.5 lb/d (default).
- (k) MP to NP efficiency (cell D90) = 0 (default).
- (l) Recycled ruminal N (cell D91) = 0 (default).

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Feedlot case study 3*.

Dietary Inputs

We will use the NRC (2000) feed library to retrieve the same feeds used in the original (NRC, 1996, 2000) case study. Click on the *Load SFL* (SFL = standard feed library) of the *Feed Library* group (FIGURE 3E). Locate the *Beef Std 2000.FLF* file in the [C:\Users\User Name\National Academies\BCNRM2016] folder. Select and open it. Click on *YES* to load it. Scroll down and confirm that feeds 301, 402, and 800 are barley silage, barley grain-heavy, and minerals, respectively. The following steps are used to retrieve these feeds into the diet of the current simulation:

- (a) Click on the *Feeds* button of the *Diet* group (FIGURE 3D).
- (b) Enter 301 in cell W5, 402 in cell W6, and 800 in cell W7. Confirm that the correct feed names are shown in column X, right next to the feed ID.
- (c) Click on the *Retrieve* button of the *Diet* group (FIGURE 3D). The feeds (barley silage, barley grain-heavy, and minerals) should appear in Table 8.
- (d) Check the checkboxes for these feeds in cells AH5, AH6, and AH7 (Table 8) to ensure their compositions are not changed by the software.
- (e) The user may click on the *Composition* button of the *Diet* group (FIGURE 3D) or simply scroll to the right to display Table 8. The first option will freeze the feed names, making it easier to browse the composition table. Click on the *Composition* button of the *Diet* group (FIGURE 3D) and modify their composition in Table 8 as per the following analytical values:

Feed	Cost, \$/Ton	NDF, % DM	peNDF, % NDF	CP, % DM	Fat, % DM	Ash, % DM
Barley silage	25	48.7	65	10.4	3	8
Barley grain	120	19	34	13	2.1	3
Minerals	200	0	0	0	0	100

- (f) To enter the feed amounts, click on the *Diet* button of the *Diet* group (FIGURE 3D) to display Table 7 (FIGURE 9). Make sure that the *Amount* option is selected in cell Z3 and then enter the following amounts: 5, 19, and 0.3 lb/d for barley silage, barley grain, and minerals, respectively.

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Feedlot case study 4*.

Performance Summary

After saving the simulation file, the *Home* screen will be displayed; it shows the animal performance given the current information entered. The actual DMI (24.3 lb/d) is nearly identical to the predicted DMI (24.2 lb/d). The predicted DMI using the NRC (1996, 2000) equations was 24.7 lb/d as shown in Table R8 (for quick view, click on the *DMIR* button of the *Calculation* group; FIGURE 3F) as shown in FIGURE 20 (11.208 kg/d × 2.2046 lb/kg = 24.7 lb/d).

The predicted DMI would be reduced even further if the environmental factors were not taken into account (Table 5; FIGURE 7). By disabling the adjustments for predicted DMI (cells D82 = 0), the predicted DMI would be 23.5 lb/d. As a rule of thumb, if actual and predicted DMI differ by more than 5 to 10%, the user should carefully check all inputs that influence DMI (breed, body weight, mature size, temperature, mud and storm exposure, diet energy density, ionophores, implant). However, the diet is evaluated with actual DMI.

FIGURE 21 has the BCNRM predictions as shown in the *Home* screen.

The predicted MP-allowable gain is greater than the ME-allowable gain; therefore, ME is likely the first limiting factor. The predicted ADG (3.59 lb/d; FIGURE 21) was slightly greater (+3.2%) than the observed ADG of 3.48 lb/d. The NRC (1996, 2000) predicted a greater ADG of 3.67 lb/d (+5.5%). The following table lists the selected differences between the predictions of the *previous* model (NRC, 1996, 2000) and the BCNRM.

Variables	Models		
	Previous ^a	BCNRM	Δ%
Predicted DMI, lb/d	24	24.2	0.8
ME-allowable gain, lb/d	3.67	3.59	-2.2
MP-allowable gain, lb/d	4.68	3.91	-16
Dietary ME, Mcal/lb	1.28	1.31	2.3
Dietary NEm, Mcal/lb	0.96	0.88	-8.3
Dietary NEg, Mcal/lb	0.57	0.59	3.5
MP feed, g/d	323	316	-2.2
MP bacteria, g/d	583	506	-13

^aAs reported by the NRC (1996, 2000). Change the units to metric to get the g/d values for MP.

	A	B	C	D	E	F
1						
2		REQUIREMENT SECTION				
3						
171		Table R8. Dry matter intake and water intake				
172		Item	Acronym	Value	Units	Description
173		Are adjustment factors being used?		TRUE		Except for ADTV that is always applied
174		Age effect		1.000	dmnl	Effect of age on intake
175		Empty body effect	BFAT	0.979	dmnl	Effect of body fat on intake
176		Breed type effect	BI	1.000	dmnl	Effect of breed type on intake
177		Effective temperature	CETI	4.742	°C	Current effective temperature index
178		Effect of night cooling	DMINC	1.150	dmnl	Effect of night cooling on intake
179		Temperature effect	TEMP1	1.048	dmnl	Effect of temperature on intake
180		Mud depth effect	MUD1	1.000	dmnl	Effect of mud depth on intake
181		Additive effect	ADTV _{DMI}	0.970	dmnl	Effect of monensin or anabolic implant on intake
182		Forage daily allowance	FA	0.000	g/kg SBW/d	
183		Grazing intake	GI	23.405	g/kg SBW	Unadjusted predicted DMI for grazing animals
184		Grazing effect	GRAZE	1.000	dmnl	Effect of grazing and forage allowance on intake
185		Initial SBW	ISBW	379.715	kg	Initial shrunk body weight
186		Beef calf or yearling		11.207	kg/d	NRC (1996, 2000), with adjustments
187		Growing-finishing cattle (NEm)		10.954	kg/d	Current Beef Committee, with adjustments
188		Growing-finishing cattle (ISBW)		9.219	kg/d	Current Beef Committee, with adjustments
189		Beef cow		12.325	kg/d	Lactating, pregnant, or non-pregnant beef cows
190		Beef cow (1.1 % of BW/dietary NDF)		21.267	kg/d	Uses cow SBW minus conceptus weight
191		Predicted DMI	DMI	10.954	kg/d	For growing-finishing, it uses the NEm equation
192		Predicted WI	WI	33.724	L/d	Water intake

FIGURE 20 Predicted dry matter intake and water intake (Table R8).

Predictions with the Mechanistic Level of Solution

Change the Solution Level from ELS to MLS by clicking on the *Settings* button of the *Inputs* group (FIGURE 3C) and enter 2 in cell D4. Go back to the *Home* screen (by clicking on the *Home* button of the *File* group; FIGURE 3B). Conversely, change from ELS to MLS in cell B37 in the *Home* screen. Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Feedlot case study 5*. FIGURE 22 has the MLS predictions. Compare the results.

The predictions of ME, NEm, NEg, ME-allowable ADG, and RUP using the Solution Level 2 of the *previous* model (NRC, 1996, 2000) and the MLS of the BCNRM were less than the Solution Level 1 and the ELS predictions, as shown below. However, the *current* model predicted identical ME-allowable gain and lower MP-allowable gain compared to the *previous* model (NRC, 1996, 2000). Although the dietary ME and NEg values predicted by the *current* model were nearly identical to the *previous* model's predictions, the NEm values were different likely because of the ionophore adjustment of the *previous* model. The MP values from feed and bacteria predicted by the BCNRM were less than the values predicted by *previous* model.

Variables	Models		
	Previous ^a	BCNRM	Δ%
Predicted DMI, lb/d	24.4	24.5	0.8
ME-allowable gain, lb/d	3.46	3.46	0
MP-allowable gain, lb/d	6.03	5.27	-14
Dietary ME, Mcal/lb	1.25	1.29	3.1
Dietary NEm, Mcal/lb	0.93	0.86	-8.1
Dietary NEg, Mcal/lb	0.54	0.57	5.3
MP feed, g/d	241	208	-14
MP bacteria, g/d	819	767	-6.4

^aAs reported by the NRC (1996, 2000). Change the units to metric to get the g/d values for MP.

For this scenario, the ME-allowable ADG predicted by the ELS and the MLS over- and underpredicted observed ADG (3.48 lb/d) by about 0.11 and 0.02 lb/d, respectively. Several factors can affect ME-allowable gain, and the actual characterization of the diet is needed to fully understand what factors are mostly affecting the predictive performance of these models.

ME & MP summary		Metabolizable Energy (ME)			Metabolizable Protein (MP)			Items				
	Available	Required	Balance	Available	Required	Balance	Supplied	Required	Balance			
	Mcal/d	Mcal/d	Mcal/d	lb/d	lb/d	lb/d						
Diet	31.81	31.81	0.00	1.8	1.7	0.1	Ca	g/d	16.10	42.53	-26.43	
Maintenance	31.81	13.46	18.35	1.8	0.9	1.0	P	g/d	36.74	22.51	14.23	
Pregnancy	18.35	0.00	18.35	1.0	0.0	1.0	Mg	g/d	14.65	11.02	3.63	
Lactation	18.35	0.00	18.35	1.0	0.0	1.0	Cl	g/d	28.03	0.00	28.03	
Growth	18.35	18.35	0.00	1.0	0.9	0.1	K	g/d	107.41	66.13	41.28	
Reserves	0.00	0.00	0.00	0.1	0.0	0.1	Na	g/d	3.58	7.72	-4.13	
							S	g/d	18.37	16.53	1.84	
							Co	mg/d	4.65	1.65	3.00	
							Cu	mg/d	63.14	110.22	-47.08	
							I	mg/d	0.43	5.51	-5.08	
							Fe	mg/d	1363.29	551.12	812.17	
							Mn	mg/d	259.32	220.45	38.87	
							Se	mg/d	1.89	1.10	0.79	
							Zn	mg/d	167.60	330.67	-163.07	
							Vit A	1000 IU/d	32.75	24.25	8.50	
							Vit D	1000 IU/d	0.00	3.03	-3.03	
							Vit E	IU/d	225.80	385.78	-159.98	
							ARG	g/d	34.51	25.97	8.54	
							HIS	g/d	14.44	19.67	-5.23	
							ILE	g/d	35.88	22.04	13.85	
							LEU	g/d	53.78	52.73	1.06	
							LYS	g/d	44.60	50.37	-5.77	
							MET	g/d	14.33	15.74	-1.41	
							CYS	g/d	0.00	—	—	
							PHE	g/d	36.49	27.54	8.95	
							TYR	g/d	20.69	—	—	
							THR	g/d	34.82	30.69	4.13	
							TRP	g/d	10.54	4.72	5.82	
							VAL	g/d	40.43	31.48	8.95	

ME allowable gain	3.59 lb/d		lb/d	%CP	%DM	
MP allowable gain	3.91 lb/d		RDP	2.10	70.25	8.64
			RUP	0.89	29.75	3.66
			RDP:RUP	2.36	0.00	0.00
			TDN and RDP allowable MCP			
			TDN allowable MCP	1.74 lb/d		
			RDP required	1.74 lb/d		
			RDP available	2.10 lb/d		
			RDP balance	0.36 lb/d		
			RDP allowable MCP	1.74 lb/d		
			Source of Metabolizable Protein			
			Bacteria	61.6%	1.1 lb/d	
			Feed	38.4%	0.7 lb/d	
			Total	1.8 lb/d		
			Ruminal Nitrogen Balance			
			Ruminal N balance	0.06 lb N/d		
			Ruminal N balance	20.45 % of req.		
			Diet Energy			
			Apparent TDN	78.0 % DM		
			Dietary DE	1.56 Mcal/lb		
			ME:DE	83.9 %		
			Dietary ME	1.31 Mcal/lb		
			Dietary NEm	0.88 Mcal/lb		
			Dietary NEg	0.59 Mcal/lb		

Nitrogen Balance		Methane (median)	
Intake	217.00 g/d		5.918 % GE
Retained	31.23 g/d		12.973 mol/d
Urinary	116.97 g/d		2.763 Mcal/d
Fecal	0.00 g/d		8.542 g/lb DM

FIGURE 21 Summary screen showing the Empirical Level of Solution (ELS) predictions.

COW-CALF CASE STUDY

Similar to the previous case study, this cow-calf case study is the same as the one presented in the *Nutrient Requirements of Beef Cattle*, 7th revised edition and update (NRC, 1996, 2000). The purpose of this study is to compare the prediction of both computer models.

Settings, Animal, Management and Grazing, Environment, and Advanced Inputs

Begin the tutorial by opening the BCNRM; agree with the *Terms of Use*; click on the *BCNRM 2016* tab (if not automatically selected); click on the *New* button of the *File* group (FIGURE 3B); and click on the *Inputs* button of the *Inputs* group (FIGURE 3C).

The ranch used in this case study is in the Northern Plains and carries approximately 600 beef cows and 100 replacement heifers. Cows are predominantly Simmental-sired females from Angus × Hereford cows with a mature size of approximately 1,300 lb at BCS 5. Calving season for mature cows is March and April, and calf birth weight averages 80 lb. The approximate weaning date for calves was October 15. Average steer calf weaning weight at 200 days is 575 lb, and average heifer calf weaning weight at 200 days is 525 lb. Replacement heifers wean at 45% of mature weight in the middle of October, conceive at 60% of mature weight during the first week of May, and are 85% of mature weight at calving. Body condition scores average 3 to 4 at weaning. The goal is to have them back to BCS 5 by December 1 to provide insulation for winter and maintain them at BCS 5 until calving. They will lose a score by pasture turnout

ME & MP summary	Metabolizable Energy (ME)			Metabolizable Protein (MP)			Items	Supplied	Required	Balance	
	Available Mcal/d	Required Mcal/d	Balance Mcal/d	Available lb/d	Required lb/d	Balance lb/d					
Diet	31.28	31.28	0.00	2.1	1.7	0.4	Ca	g/d	16.10	41.60	-25.49
Maintenance	31.28	13.51	17.77	2.1	0.9	1.3	P	g/d	36.74	22.13	14.61
Pregnancy	17.77	0.00	17.77	1.3	0.0	1.3	Mg	g/d	14.65	11.02	3.63
Lactation	17.77	0.00	17.77	1.3	0.0	1.3	Cl	g/d	28.26	0.00	28.26
Growth	17.77	17.77	0.00	1.3	0.8	0.4	K	g/d	107.41	66.13	41.28
Reserves	0.00	0.00	0.00	0.4	0.0	0.4	Na	g/d	3.58	7.72	-4.13
							S	g/d	18.37	16.53	1.84
							Co	mg/d	4.65	1.65	3.00
							Cu	mg/d	63.14	110.22	-47.08
							I	mg/d	0.43	5.51	-5.08
							Fe	mg/d	1363.29	551.12	812.17
							Mn	mg/d	259.32	220.45	38.87
							Se	mg/d	1.88	1.10	0.78
							Zn	mg/d	167.60	330.67	-163.07
							Vit A	1000 IU/d	32.75	24.25	8.50
							Vit D	1000 IU/d	0.00	3.03	-3.03
							Vit E	IU/d	225.80	385.78	-159.98
							ARG	g/d	60.10	25.53	34.58
							HIS	g/d	23.89	19.34	4.54
							ILE	g/d	50.69	21.66	29.03
							LEU	g/d	67.36	51.83	15.53
							LYS	g/d	67.31	49.51	17.80
							MET	g/d	21.77	15.47	6.29
							CYS	g/d	0.00	—	—
							PHE	g/d	47.50	27.08	20.43
							TYR	g/d	33.12	—	—
							THR	g/d	47.43	30.17	17.26
							TRP	g/d	14.31	4.64	9.67
							VAL	g/d	54.28	30.94	23.33

ME allowable gain	3.46 lb/d
MP allowable gain	5.27 lb/d
DMI predicted	24.48 lb/d
DMI actual	24.30 lb/d
NDF intake actual	0.57 % SBW
Water intake	8.91 gal/d
Diet Summary	
Cost per day	1.49 \$/d
Dry matter	70.00 %AF
Forage	20.58 %DM
Crude protein	12.30 %DM
Fat	2.26 %DM
Ash	5.23 %DM
NDF	24.88 %DM
Lignin	2.13 %DM
Carbohydrate (CHO)	80.21 %DM
Nonfiber CHO	55.33 %DM
Sugars	0.00 %DM
Starch	48.00 %DM
Pectin	7.33 %DM
RDP(N):S ratio	0.01
Ca:P ratio	0.44
peNDF	11.56 %DM
Ruminal pH (user)	5.90

	lb/d	%CP	%DM
RDP	2.25	75.11	9.24
RUP	0.74	24.89	3.06
RDP:RUP	3.02	0.00	0.00
TDN and RDP allowable MCP			
TDN allowable MCP	2.82 lb/d		
RDP required	2.82 lb/d		
RDP available	2.25 lb/d		
RDP balance	-0.57 lb/d		
RDP allowable MCP	2.25 lb/d		
Source of Metabolizable Protein			
Bacteria	78.6%	1.7 lb/d	
Feed	21.4%	0.5 lb/d	
Total	2.1 lb/d		
Ruminal Nitrogen Balance			
Ruminal N balance	-0.09 lb N/d		
Ruminal N balance	-20.27 % of req.		
Diet Energy			
Apparent TDN	76.7 % DM		
Dietary DE	1.53 Mcal/lb		
ME:DE	82.0 %		
Dietary ME	1.29 Mcal/lb		
Dietary NEm	0.86 Mcal/lb		
Dietary NEg	0.57 Mcal/lb		

Nitrogen Balance		Methane (median)
Intake	217.00 g/d	5.311 % GE
Retained	30.18 g/d	11.654 mol/d
Urinary	113.21 g/d	2.480 Mcal/d
Fecal	73.61 g/d	7.674 g/lb DM

FIGURE 22 Summary screen showing the Mechanistic Level of Solution (MLS) predictions.

(approximately May 1); but to meet the goal, they have to gain one score by the start of breeding on May 15. Over the 12-month reproductive cycle, the energy balance should average near zero. The winter-feed resources available include two qualities of hay. Corn and range cake are fed as needed to supplement the hay.

We will use this information to demonstrate how to use the ELS and MLS of the BCNRM to evaluate the feeding program for this herd, beginning with an evaluation of the winter feeding program.

Settings (Table 1). Confirm that solution type is 1 (ELS), unit system is 2 (Imperial), feed basis is 1 (DM), and animal class is 3 (dry cow). It is often practical to adjust the diet until balanced with the ELS, and then evaluate it with the MLS to get predicted feed net energy values and amino acid balances, based on actual feed analysis for carbohydrate and protein fractions.

Animal (Table 2). Enter the following information in this table:

- (a) Age (cell D12) = 60 mo; this value influences tissue insulation.
- (b) Age class (cell D13) = 2; this value influences expected DMI for growing/finishing cattle; it does not apply to this type of animals.
- (c) Sex (cell D14) = 4; this value influences maintenance requirement. A heifer is entered as a cow after calving the first time.
- (d) Body condition score (cell D15) = 5; see Chapters 3 and 13 for a detailed discussion of the 1 to 9 condition scoring system used and its biological basis. The choices are 1 through 9 (1 = emaciated, 5 = moderate, 9 = very fat). Body condition score is used to describe tissue insulation, the potential for compensatory

- growth in growing cattle, and energy reserves in cows.
- (e) Initial body weight (cell D16) = 1,354. For cows, the initial (D16) and final (D17) body weights are recommended to be the same.
 - (f) Final body weight (cell D17) = 1,354. This is the unshrunk final body weight that best represents the group being fed. The average between initial and final weights is a major determinant of DMI, maintenance, and growth requirements.
 - (g) Mature body weight (cell D18) = 1,354; this is the expected average unshrunk weight at the USDA grade selected in cell D19. For cows, replacement heifers, or breeding bulls, enter the expected mature weight at BCS 5. The weight that best corresponds to the cattle in question based on the user's experience for the type of growing animal, implant strategy, and ration should be entered.
 - (h) Breed type (cell D20) = 2.
 - (i) Breeding system (cell D21) = 3; choices are 1 (straightbred), 2 (two-way crossbred), and 3 (three-way crossbred). Cell D22 is used for animal breed if straightbred, cells D22 and D23 are used if describing two-way crossbred, and cells D22, D23, and D24 are used when describing three-way crossbred. The breeding system for growing cattle influences maintenance energy requirement and predicted DMI.
 - (j) Breed cells (D22, D23, and D24) = 29 (sire's breed is Simmental), 1 (maternal grandsire's breed is Angus), and 14 (maternal granddam's breed is Hereford), respectively; valid breed codes are shown in Table 2.1. Stored breed values are used to determine maintenance energy requirements and defaults for calf birth weight and peak milk production. See Chapter 19 for the biological basis for these breed adjustments. Since this is a three-way crossbred (cell D21), the software will use all cells (D22, D23, and D24) to calculate the defaults.
 - (k). Days pregnant (cell D25) = 190. This information is used along with expected birth weight (cell D26) to compute pregnancy requirements, conceptus weight, and ADG as described in Chapter 13.
 - (l) Calf birth weight (cell D26) = 80. This information is used along with days pregnant (cell D25) to compute pregnancy requirements, conceptus weight, and ADG as described in Chapter 13.
 - (m) Days since calving (cell D27) = 0 because the cows are dry. For lactating cows, this information is used along with peak milk and lactation number to predict milk production for the day entered. As this is a dry cow, there is no milk yield.
 - (n) Relative milk yield (cell D28) = 5; because the cows are dry, the default value of 5 (average) is left in this cell to avoid leaving it blank. For lactating cows, a number between 1 and 9 can be entered to adjust the peak milk up or down from the default value shown in the breed defaults table.
 - (o) Milk production (cell D29) = 0 because the cows are dry. For lactating cows in this case study, the default peak milk value of 21.5 lb/d (cell O49) for the breed type would be used along with the days in milk to compute requirements for lactation. Fox et al. (1988) calculated a male calf weaning weight of approximately 587 lb at 7 months for a 1,300-lb cow at 21.5-lb peak milk compared to the actual steer 200-d weaning weight of 575 lb. Thus, the default milk production is acceptable. The peak milk along with time of peak and duration of lactation is used to develop a lactation curve for predicting milk production for the day entered, as described in Chapter 13. If evaluating lactating cows, the default value of 21.5 would be used. However, the user may override this estimated peak milk yield by entering a value in cell O48 or D29.
 - (p) Target calving age (cell D30) = 24. Age at first calving (cell D30) and herd calving interval (cell D31) are used to compute growth requirements as described in Chapters 13 and 19.
 - (q) Target calving interval (cell D31) = 12. Herd Calving interval (cell D31) and age at first calving and (cell D30) are used to compute growth requirements as described in Chapters 13 and 19.
- Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Cow-calf case study 1*. Once the *Home* screen is displayed, click on the *Inputs* button of the *Inputs* group. FIGURE 23 depicts the data entered so far.
- Management and Grazing (Table 3).** Enter the following information in this table:
- (a) Feed additive (cell D55) = 1; choices are 1 (none), 2 (monensin), or 3 (lasalocid).
 - (b) Implant (cell D56) = 1; choices are 1 (no) or 2 (yes).
 - (c) Grazing unit size (cell D57) = 0 because this example is for a dry cow being wintered on harvested forage. When grazed forage is the primary feed used to meet requirements, the number of hectares (metric) or acres (Imperial) per head grazed in the pasture has to be entered. If the distance traveled is minimal, enter 0. This input is used to adjust energy maintenance requirements for walking activity.
 - (d). Days on pasture (cell D58) = 0 because the animals are being fed harvested feed in drylot. For grazing cattle, the number of days on the pasture would be entered.
 - (e) Available forage mass (cell D59) = 0. For grazing cattle, enter the kg DM/hectare (metric) or lb DM/acre (Imperial) when the cattle are turned into the pasture. This can be estimated from hay harvest-

	A	B	C	D	E	F	G
1							
2		Table 1. Settings					
3			Acronym	User	Unit	Metric	Unit
4		Solution type		1	ELS		
5		Unit system		2	Imperial		
6		Feed basis		1	DM		
7		Animal class		3			
8							
9							
10		Table 2. Animal					
11		Item	Acronym	User	Unit	Metric	Unit
12		Age		60		60 mo	
13		Age class (for DMI & WC)		2		2	
14		Sex		4		4	
15		Body condition score	BCS	5		5	
16		Initial body weight	IBW	1354	lb	614	kg
17		Final body weight	FBW	1354	lb	614	kg
18		Mature body weight	MW	1354	lb	614	kg
19		Reference animal's EBF		3		3	
20		Breed type		2		2	
21		Breeding system		3		3	
22		Sire's breed		29		29	
23		Maternal grandsire's breed		1		1	
24		Maternal granddam's breed		14		14	
25		Days pregnant	DP	190		190 days	
26		Calf birth weight	CBW	80	lb	36.3	kg
27		Days since calving		0		0 days	
28		Relative milk yield	RMY	5		5	
29		Milk production	MY	0	lb/d	0.0	kg/d
30		Target calving age	TCA	24		24 mo	
31		Target calving interval	TCI	12		12 mo	

FIGURE 23 Settings and Animal tables after data entry.

ing experience, clippings, or calibrated measuring devices such as height and/or density estimates, Plexiglas weight plates, or electronic pasture probes. The available forage mass (cell D59), number of days on pasture (cell D58), and the grazing unit size (cell D57) are used to predict pasture DMI.

Environment (Table 4). Enter the following information in this table:

- (a) Wind speed (cell D64) = 5; this is the average wind speed the cattle are exposed to. Wind speed influences maintenance requirements by reducing the external insulation of the animal. Increasing wind speed decreases the external insulation value of the animal and thus results in increased energy main-

tenance requirements. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.

- (b) Temperature, previous (cell D65) = 40; this is the average temperature for the previous month. This value is used to increase NEm requirement, as it gets colder or to reduce it as it gets warmer. The model is extremely sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analyses were performed in Chapter 19.
- (c) Temperature, current (cell D66) = 30; this is the average temperature the cattle are exposed to. In most situations, the current average daily temperature is the most practical to use. This value is used to adjust predicted DMI for temperature effects and is used

in the calculations for the effects of cold stress on energy maintenance requirements. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.

- (d) Relative humidity, previous (cell D67) = 65; this value can be used to compute the previous effective temperature index.
- (e) Relative humidity, current (cell D68) = 65; this value is used to compute the current effective temperature index to predict DMI, as discussed in Chapter 19.
- (f) Storm exposure (cell D69) = 1; this value is used to predict DMI, as discussed in Chapter 19.
- (g) Lowest night temperature (cell D70) = 30; if greater than 68°F (20°C) there is no night cooling and DMI is reduced with hot daytime temperatures; otherwise, it is assumed that cattle can dissipate heat at night and DMI is not affected.
- (h) Hair depth (cell D71) = 0.5; this is the average hair depth. This input is used to compute the external insulation of the animal. Enter the effective hair coat depth of the animal, in increments of 0.1. As hair length increases, so does the external insulation value provided by the animal. A general guide to use is an effective coat depth of 0.25 inches (0.6 cm) during the summer and 0.5 inches (1.3 cm) during the winter. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.
- (i) Hide (cell D72) = 2; enter either 1 (thin hide—i.e., dairy or Bos indicus types), 2 (average—i.e., most European breeds), or 3 (thick—i.e., Hereford or similar breeds). This value influences the external insulation value of the animal. Increased hide thickness implies increased external insulation. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.
- (j) Hair coat (cell D73) = 1; enter either 1 (clean and dry), 2 (some mud on lower body), 3 (some mud on lower body and sides), or 4 (heavily covered with mud). This value is used to adjust external insulation. The model is very sensitive to this input after the lower critical temperature is reached, so choose carefully. Sensitivity analysis was performed in Chapter 19.
- (k) Cattle panting (cell D74) = 1; enter either 1 (no panting, not heat stressed), 2 (rapid shallow panting), or 3 (open-mouth panting). This value is used to adjust maintenance energy requirements for the energy cost of dissipating heat.
- (l) Mud depth (cell D75) = 0; this value affects predicted DMI. Because the animals in this study have clean and dry hair coat, there was no mud present in this situation.

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Cow-calf case study 2*. Once the *Home* screen is displayed, click on the *Inputs* button of the *Inputs* group. FIGURE 24 shows the data entered for management and environment.

Advanced options (Table 5). Let us use the following values in this table to make the software calculations of environment factors more compatible with NRC (1996, 2000):

- (a) Maintenance factor (cell D80) = 0 (default).
- (b) Adjustments for required NEm (cell D81) = 1.
- (c) Adjustments for predicted DMI (cell D82) = 1.
- (d) Monensin adjustment for DMI (cell D83) = -3 (default).
- (e) Implant adjustment for DMI (cell D84) = -6 (default).
- (f) Ruminal pH (cell D85) = 0 (default).
- (g) DE to ME efficiency (cell D86) = 82 (default).
- (h) Tabular ME and NE values for ELS (cell D87) = 0 (default).
- (i) MCP yield (MCP/TDN, %) (cell D88) = 0 (default).
- (j) Desired animal ADG (cell D89) = 1.5 lb/d (default).
- (k) MP to NP efficiency (cell D90) = 0 (default).
- (l) Recycled ruminal N (cell D91) = 0 (default).

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Cow-calf case study 3*.

	A	B	C	D	E	F	G
52							
53		Table 3. Management and Grazing					
54		Item	Acronym	User	Unit	Metric	Unit
55		Feed additive		1		1	
56		Implant		1		1	
57		Grazing unit size	GU	0	acre	0.00	ha
58		Days on pasture	DOP	0	days	0	days
59		Available forage mass	FM	0	lb/acre	0.0	kg/ha
60							
61							
62		Table 4. Environment					
63		Item	Acronym	User	Unit	Metric	Unit
64		Wind speed	WS	5.00	miles/h	8.0	Km/h
65		Temperature, previous	Tp	40.00	oF	4.4	oC
66		Temperature, current	Tc	30.00	oF	-1.1	oC
67		RH, previous	RHp	65.00		65.0	%
68		RH, current	RHc	65.00		65.0	%
69		Storm exposure		1		1	
70		Lowest night temp.	LNT	30.00	oF	-1.1	oC
71		Hair depth		0.5	in	1.27	cm
72		Hide		2		2	
73		Hair coat		1		1	
74		Cattle panting		1		1	
75		Mud depth		0.00	in	0	cm
76							

FIGURE 24 Management and Grazing and Environment tables after data entry.

Dietary Inputs

We will use the NRC (2000) feed library to retrieve the same feeds used in the original (NRC, 1996, 2000) case study. Click on the *Load SFL* (SFL = standard feed library) of the *Feed Library* group (FIGURE 3E). Locate the *Beef Std 2000.FLF* file in the [C:\Users\[User Name]\Documents\National Academies\BCNRM2016] folder. Select and open it. Click on *YES* to load it. Scroll down and confirm that feeds 105, 107, and 800 are brome hay mid bloom, brome hay mature, and minerals, respectively. The following steps are used to retrieve these feeds and to enter them into the diet of the current simulation:

- Click on the *Select* button of the *Diet* group (FIGURE 3D).
- For feed #1, click on the list dropbox) and highlight feed 105; for feed #2, click on the list dropbox and highlight feed 107; and for feed #3, click on the list dropbox, scroll down, and highlight feed 800. Click on the *Retrieve* button of the *Feed Selection and Retrieval* form (FIGURE 11). The feeds (brome hay mid bloom, brome hay mature, and minerals) should show up in Table 8.
- Check the checkboxes for these feeds in cells AH5, AH6, and AH7 (Table 8) to ensure their composition are not changed by the software.
- The user may click on the *Composition* button of the *Diet* group (FIGURE 3D) or simply scroll to the right to display Table 8. The first option will freeze the feed names, making it easier to browse the composition table. Click on the *Composition* button of the *Diet* group (FIGURE 3D) and modify their composition in Table 8 as per the following analytical values:

Feed	Cost, \$/Ton	NDF, % DM	CP, % DM	RUP, % CP	TDN % DM
Brome hay, mid bloom	70	56	12	23	57
Brome hay, mature	50	65	7	25	50
Minerals	200	0	0	0	0

- To enter feed amounts, click on the *Diet* button of the *Diet* group (FIGURE 3D) to display Table 7 (FIGURE 9). Make sure that the *Amount* option is selected in cell Z3, and enter 26.4 lb/d for mature brome hay and 0.3 lb/d for minerals.

Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Cow-calf case study 4*.

Performance Summary

After saving the simulation file, the *Home* screen will be displayed; it shows the animal performance given the

current information entered. The actual DMI (26.7 lb/d) is the predicted DMI by the NRC (1996, 2000) equation. The DMI predicted by the BCNRM was 26.6 lb/d (12.041 kg/d \times 2.2046 lb/kg). Table R8 (for a quick view, click on the *DMIR* button of the *Calculation* group; FIGURE 3F) shows the predicted DMI assuming the 1.1% of BW/NDF was 21.6 lb/d as shown in FIGURE 25 (9.788 kg/d \times 2.2046 lb/kg = 21.6 lb/d).

The predicted DMI would be reduced even further if the environmental factors were not taken into account (Table 5; FIGURE 7). By disabling the adjustments for predicted DMI (cells D82 = 0 in Table 5), the predicted DMI would be 25.32 lb/d. As a rule of thumb, if actual and predicted DMI differ by more than 5 to 10%, the user should carefully check all inputs that influence DMI (breed, body weight, mature size, temperature, mud and storm exposure, dietary energy density, ionophores, implant). However, the diet is evaluated with actual DMI. FIGURE 26 shows the BCNRM predictions as shown in the *Home* screen.

The predicted ME balance is -1.63 Mcal/d and the predicted MP balance is zero (FIGURE 26). Given the small deficit of ME, these cows are expected to lose 1 BCS (from 5 to 4) in 120 days if the conditions remain the same. The current model's predicted TDN (49.4%) is nearly identical to that predicted by the *previous* model (NRC, 1996, 2000; 49%). The RDP (+0.14 lb/d) and ruminal N (+0.02 lb/d) balances indicate that this diet met the requirements of microbial protein (FIGURE 26). The following table lists the selected differences between the predictions of the *previous* model (NRC, 1996, 2000) and the BCNRM.

Variable	Model		
	Previous ^a	BCNRM	$\Delta\%$
Predicted DMI, lb/d	26.65	26.55	-0.56
Days to change BCS	3.199 (lose)	120 (lose)	-
RDP balance, g/d	30	70	57
Dietary ME, Mcal/lb	0.81	0.81	0
Dietary NEm, Mcal/lb	0.43	0.43	0
Dietary NEg, Mcal/lb	0.19	0.19	0
MP feed, g/d	168	126	-25
MP bacteria, g/d	383	361	-5.7

^aAs reported by the NRC (1996, 2000). Change the units to metric to get the g/d values for MP and RDP.

The *previous* model (NRC, 1996, 2000) predicted a negative RDP balance (-150 g/d) when the default coefficient of 13% was used to estimate MCP. The NRC (1996, 2000) recommended reducing this coefficient to 10% for cows or calves consuming low-quality diets. When that adjustment was made, the *previous* model predicted a positive RDP balance of 30 g/d as shown above. The BCNRM ELS predicted greater RDP balance without any adjustment. Furthermore, the BCNRM ELS predicted greater ME, NEm, and NEg and lesser MP from feed and ruminal bacteria than the *previous* model's Level 1.

	A	B	C	D	E	F
1						
2		REQUIREMENT SECTION				
3						
171		Table R8. Dry matter intake and water intake				
172		Item	Acronym	Value	Units	Description
173		Are adjustment factors being used?		TRUE		Except for ADTV that is always applied
174		Age effect		1.000	dmnl	Effect of age on intake
175		Empty body effect	BFAT	0.905	dmnl	Effect of body fat on intake
176		Breed type effect	BI	1.000	dmnl	Effect of breed type on intake
177		Effective temperature	CETI	2.655	°C	Current effective temperature index
178		Effect of night cooling	DMINC	1.170	dmnl	Effect of night cooling on intake
179		Temperature effect	TEMP1	1.048	dmnl	Effect of temperature on intake
180		Mud depth effect	MUD1	1.000	dmnl	Effect of mud depth on intake
181		Additive effect	ADTV _{DMI}	0.940	dmnl	Effect of monensin or anabolic implant on intake
182		Forage daily allowance	FA	0.000	g/kg SBW/d	
183		Grazing intake	GI	24.119	g/kg SBW	Unadjusted predicted DMI for grazing animals
184		Grazing effect	GRAZE	1.000	dmnl	Effect of grazing and forage allowance on intake
185		Initial SBW	ISBW	589.604	kg	Initial shrunk body weight
186		Beef calf or yearling		11.456	kg/d	NRC (1996, 2000), with adjustments
187		Growing-finishing cattle (NEm)		12.677	kg/d	Current Beef Committee, with adjustments
188		Growing-finishing cattle (ISBW)		10.912	kg/d	Current Beef Committee, with adjustments
189		Beef cow		12.041	kg/d	Lactating, pregnant, or non-pregnant beef cows
190		Beef cow (1.1 % of BW/dietary NDF)		9.788	kg/d	Uses cow SBW minus conceptus weight
191		Predicted DMI	DMI	12.041	kg/d	For growing-finishing, it uses the NEm equation
192		Predicted WI	WI	34.865	L/d	Water intake

FIGURE 25 Predicted dry matter intake using NEma (right arrow) or BW-to-NDF ratio (left arrow).

Predictions with the Mechanistic Level of Solution

Go back to the *Home* screen (by clicking on the *Home* button of the *File* group; FIGURE 3B). Change from ELS to MLS in cell B37 in the *Home*. Save the file by clicking on the *Save* button in the *File* group (FIGURE 3B) and name it as *Cow-calf case study 5*. FIGURE 27 has the MLS predictions and the following table lists the selected differences between the predictions of the *previous* model (NRC, 1996, 2000) and the BCNRM.

Variable	Model		
	Previous ^a	BCNRM	Δ%
Predicted DMI, lb/d	26.65	25.15	-5.63
Days to change BCS	170 (lose)	64 (lose)	-
Ruminal N balance, g/d	-24	-44.7	46.3
Dietary ME, Mcal/lb	0.77	0.79	2.5
Dietary NEm, Mcal/lb	0.39	0.41	4.88
Dietary NEg, Mcal/lb	0.15	0.16	6.25
MP feed, g/d	248	209	-15.7
MP bacteria, g/d	660	467	-29.2

^aAs reported by the NRC (1996, 2000). Change the units to metric to get the g/d values for MP and RDP.

Similar to the *previous* model’s Level 1 and the *current* model’s ELS, the *current* model’s MLS predicted nearly identical ME, NEm, and NEg, but lesser MP from feed and ruminal bacteria than the *previous* model’s Level 2 solution. Given this outcome, the *previous* model estimated that cows would lose one BCS (from 5 to 4) in 170 days whereas the *current* model estimated that cows would take 64 days to lose one BCS. In addition to the more negative ME balance predicted by the *current* model (-3.05 Mcal/d; FIGURE 27), as compared to the *previous* model’s prediction (-1.8 Mcal/d), the body reserves submodel differs between these models as discussed in Chapters 13 and 19.

For this scenario, both ruminal N balance (-44.7 g/d) and RDP balance (-0.280 g/d) were negative, suggesting that ruminal bacteria N requirement was not met. However, no recycled ruminal N was taken into account. In this scenario, the RDP-allowable MCP was only 1.10 lb/d.

Differences Between the ELS and MLS

The ME-allowable BCS change is computed in the MLS from energy availability based on simulations of ruminal fer-

ME & MP summary	Metabolizable Energy (ME)			Metabolizable Protein (MP)		
	Available Mcal/d	Required Mcal/d	Balance Mcal/d	Available lb/d	Required lb/d	Balance lb/d
Diet	21.65	23.27	-1.63	1.1	1.1	0.0
Maintenance	21.65	21.37	0.28	1.1	1.0	0.1
Pregnancy	0.28	1.91	-1.63	0.1	0.1	0.0
Lactation	-1.63	0.00	-1.63	0.0	0.0	0.0
Growth	-1.63	0.00	-1.63	0.0	0.0	0.0
Reserves	0.00	1.63	-1.63	0.0	0.0	0.0

		lb/d %CP %DM		
		lb/d	%CP	%DM
RDP	1.39	75.00	5.19	
RUP	0.46	25.00	1.73	
RDP:RUP	3.00	0.00	0.00	
TDN and RDP allowable MCP				
TDN allowable MCP	1.24 lb/d			
RDP required	1.24 lb/d			
RDP available	1.39 lb/d			
RDP balance	0.14 lb/d			
RDP allowable MCP	1.24 lb/d			
Source of Metabolizable Protein				
Bacteria	74.2%	0.8 lb/d		
Feed	25.8%	0.3 lb/d		
Total	1.1 lb/d			
Ruminal Nitrogen Balance				
Ruminal N balance	0.02 lb N/d			
Ruminal N balance	11.54 % of req.			
Diet Energy				
Apparent TDN	49.4 % DM			
Dietary DE	0.99 Mcal/lb			
ME:DE	82.0 %			
Dietary ME	0.81 Mcal/lb			
Dietary NEm	0.43 Mcal/lb			
Dietary NEg	0.19 Mcal/lb			

Items	Supplied	Required	Balance	
Ca	g/d	31.13	18.16	12.98
P	g/d	26.34	13.87	12.47
Mg	g/d	14.37	14.53	-0.16
Cl	g/d	0.00	0.00	0.00
K	g/d	221.54	72.67	148.87
Na	g/d	1.20	8.48	-7.28
S	g/d	0.00	18.17	-18.17
Co	mg/d	0.00	1.82	-1.82
Cu	mg/d	124.54	121.11	3.43
I	mg/d	0.00	6.06	-6.06
Fe	mg/d	958.00	605.55	352.44
Mn	mg/d	874.17	484.44	389.73
Se	mg/d	0.00	1.21	-1.21
Zn	mg/d	287.40	363.33	-75.93
Vit A	1000 IU/d	179.62	35.38	144.25
Vit D	1000 IU/d	11.97	3.36	8.61
Vit E	IU/d	0.00	430.41	-430.41
ARG	g/d	21.49	16.50	4.99
HIS	g/d	8.28	12.25	-3.96
ILE	g/d	23.49	14.00	9.49
LEU	g/d	35.81	33.51	2.30
LYS	g/d	30.83	31.36	-0.53
MET	g/d	9.75	9.80	-0.05
CYS	g/d	0.00	—	—
PHE	g/d	22.57	17.15	5.42
TYR	g/d	14.40	—	—
THR	g/d	23.83	19.11	4.72
TRP	g/d	12.62	2.94	9.68
VAL	g/d	26.78	20.00	6.77

Diet Summary	
Days to lose 1 BCS	120 d
DMI predicted	26.55 lb/d
DMI actual	26.70 lb/d
NDF intake actual	1.32 % SBW
Water intake	9.21 gal/d
Cost per day	0.75 \$/d
Dry matter	92.07 %AF
Forage	98.88 %DM
Crude protein	6.92 %DM
Fat	1.98 %DM
Ash	8.24 %DM
NDF	64.27 %DM
Lignin	7.85 %DM
Carbohydrate (CHO)	82.86 %DM
Nonfiber CHO	18.59 %DM
Sugars	0.00 %DM
Starch	5.94 %DM
Pectin	12.65 %DM
RDP(N):S ratio	0.00
Ca:P ratio	1.18
peNDF	62.98 %DM
Ruminal pH (calc.)	6.46

Nitrogen Balance		Methane (median)	
Intake	134.12 g/d	6.361 % GE	
Retained	4.80 g/d	14.522 mol/d	
Urinary	66.92 g/d	3.093 Mcal/d	
Fecal	0.00 g/d	8.702 g/lb DM	

FIGURE 26 Summary screen showing the Empirical Level of Solution predictions.

mentation and intestinal digestion. The simulations account for the effects of (1) individual feed content of carbohydrate and protein fractions, (2) ruminal rates of digestion and passage, (3) effect of rumen pH on fiber digestibility, and (4) intestinal starch, pectin, and fiber digestibility. The *previous* model (NRC, 1996, 2000) also included the urea cost.

The MP from bacteria in the MLS is computed from bacterial growth on fiber and nonfiber carbohydrates, which are sensitive to feed amounts of fiber and nonfiber carbohydrates and their digestion rates, and rumen pH. The MP from feeds is computed from feed protein escaping digestion in the rumen, which is sensitive to feed amounts of protein fractions with medium and slow digestion rates. In this example, the MP balance is greater in the MLS (FIGURE 27) than in the ELS (FIGURE 26) evaluations because both RUP and microbial protein production were greater (0.4 versus 0 lb/d, respectively).

Rumen N balances are given as total bacterial N balance. The total N balance was greater in the ELS than the MLS (0.02 vs. -0.1 g/d, respectively) because of a greater

predicted microbial yield in the MLS. The essential amino acid balances indicate that histidine was negative for the ELS simulation which is likely due to a lesser predicted microbial yield.

GENERAL RECOMMENDATIONS

The following recommendations are provided as troubleshooting guidelines in using the BCNRM in addition to the recommendations presented in the previous chapters.

Dry Matter Intake

Compare total feed dry matter entered vs. model-predicted DMI. If there is more than 5 to 10% difference, check input variables that influence predicted DMI (rations DM and quality control; accuracy of weights; body weight; current temperature; ionophore use; dietary energy density; feed processing). The actual DMI must be accurately determined,

ME & MP summary		Metabolizable Energy (ME)			Metabolizable Protein (MP)			Items						
		Available	Required	Balance	Available	Required	Balance	Supplied	Required	Balance				
		Mcal/d	Mcal/d	Mcal/d	lb/d	lb/d	lb/d							
Diet		21.01	24.05	-3.04	1.5	1.1	0.4	Ca	g/d	31.13	18.16	12.98		
Maintenance		21.01	22.14	-1.14	1.5	1.0	0.5	P	g/d	26.34	13.87	12.47		
Pregnancy		-1.14	1.91	-3.04	0.5	0.1	0.4	Mg	g/d	14.37	14.53	-0.16		
Lactation		-3.04	0.00	-3.04	0.4	0.0	0.4	Cl	g/d	12.50	0.00	12.50		
Growth		-3.04	0.00	-3.04	0.4	0.0	0.4	K	g/d	221.54	72.67	148.87		
Reserves		0.00	3.04	-3.04	0.4	0.0	0.4	Na	g/d	1.20	8.48	-7.28		
								S	g/d	0.00	18.17	-18.17		
								Co	mg/d	0.00	1.82	-1.82		
								Cu	mg/d	124.54	121.11	3.43		
								I	mg/d	0.00	6.06	-6.06		
								Fe	mg/d	958.00	605.55	352.44		
								Mn	mg/d	874.17	484.44	389.73		
								Se	mg/d	0.00	1.21	-1.21		
								Zn	mg/d	287.40	363.33	-75.93		
								Vit A	1000 IU/d	179.62	35.38	144.25		
								Vit D	1000 IU/d	11.97	3.36	8.61		
								Vit E	IU/d	0.00	430.41	-430.41		
								ARG	g/d	39.96	16.50	23.46		
								HIS	g/d	15.25	12.25	3.00		
								ILE	g/d	34.92	14.00	20.92		
								LEU	g/d	49.70	33.51	16.19		
								LYS	g/d	45.75	31.36	14.39		
								MET	g/d	14.30	9.80	4.50		
								CYS	g/d	0.00	—	—		
								PHE	g/d	33.35	17.15	16.20		
								TYR	g/d	20.17	—	—		
								THR	g/d	33.56	19.11	14.46		
								TRP	g/d	19.56	2.94	16.62		
								VAL	g/d	38.91	20.00	18.91		

		lb/d	%CP	%DM
RDP		1.10	59.46	4.12
RUP		0.75	40.54	2.81
RDP:RUP		1.47	0.00	0.00
TDN and RDP allowable MCP				
TDN allowable MCP		1.72 lb/d		
RDP required		1.72 lb/d		
RDP available		1.10 lb/d		
RDP balance		-0.62 lb/d		
RDP allowable MCP		1.10 lb/d		
Source of Metabolizable Protein				
Bacteria		69.1%	1.0 lb/d	
Feed		30.9%	0.5 lb/d	
Total		1.5 lb/d		
Ruminal Nitrogen Balance				
Ruminal N balance		-0.10 lb N/d		
Ruminal N balance		-35.94 % of req.		
Diet Energy				
Apparent TDN		48.0 % DM		
Dietary DE		0.96 Mcal/lb		
ME:DE		82.0 %		
Dietary ME		0.79 Mcal/lb		
Dietary NEm		0.41 Mcal/lb		
Dietary NEg		0.16 Mcal/lb		

		Nitrogen Balance	Methane (median)
Intake	134.12 g/d	2.917 % GE	
Retained	4.80 g/d	6.660 mol/d	
Urinary	50.28 g/d	1.419 Mcal/d	
Fecal	79.04 g/d	3.991 g/lb DM	

ME & MP summary		Metabolizable Energy (ME)			Metabolizable Protein (MP)		
		Available	Required	Balance	Available	Required	Balance
		Mcal/d	Mcal/d	Mcal/d	lb/d	lb/d	lb/d
Diet		21.01	24.05	-3.04	1.5	1.1	0.4
Maintenance		21.01	22.14	-1.14	1.5	1.0	0.5
Pregnancy		-1.14	1.91	-3.04	0.5	0.1	0.4
Lactation		-3.04	0.00	-3.04	0.4	0.0	0.4
Growth		-3.04	0.00	-3.04	0.4	0.0	0.4
Reserves		0.00	3.04	-3.04	0.4	0.0	0.4

		lb/d	%CP	%DM
RDP		1.10	59.46	4.12
RUP		0.75	40.54	2.81
RDP:RUP		1.47	0.00	0.00
TDN and RDP allowable MCP				
TDN allowable MCP		1.72 lb/d		
RDP required		1.72 lb/d		
RDP available		1.10 lb/d		
RDP balance		-0.62 lb/d		
RDP allowable MCP		1.10 lb/d		
Source of Metabolizable Protein				
Bacteria		69.1%	1.0 lb/d	
Feed		30.9%	0.5 lb/d	
Total		1.5 lb/d		
Ruminal Nitrogen Balance				
Ruminal N balance		-0.10 lb N/d		
Ruminal N balance		-35.94 % of req.		
Diet Energy				
Apparent TDN		48.0 % DM		
Dietary DE		0.96 Mcal/lb		
ME:DE		82.0 %		
Dietary ME		0.79 Mcal/lb		
Dietary NEm		0.41 Mcal/lb		
Dietary NEg		0.16 Mcal/lb		

		Nitrogen Balance	Methane (median)
Intake	134.12 g/d	2.917 % GE	
Retained	4.80 g/d	6.660 mol/d	
Urinary	50.28 g/d	1.419 Mcal/d	
Fecal	79.04 g/d	3.991 g/lb DM	

FIGURE 27 Summary screen showing the Mechanistic Level of Solution (MLS) predictions.

taking into account feed wasted, moisture content of feeds, and scale accuracy. The accuracy of any model prediction is highly dependent on the DMI used. Intake of each feed must be as uniform as possible over the day because to the committee’s knowledge, all field application models assume a total mixed ration with steady-state conditions.

ME-Allowable Performance

If predicted ADG or predicted days for BCS change are not as expected for the conditions described (cattle type, diet type, environment, and management conditions), carefully check all inputs for errors as they are the greatest source of prediction errors. Mistakes or incorrect judgments about inputs such as body size, milk production and its composition, environmental conditions, or feed additives are often made.

- Adjust feed carbohydrate fractions and their digestion rates as necessary. If inputs are correct and perfor-

mance is still not as expected, predicted dietary energy values are likely the cause. First, check if the predicted total dietary net energy values for each feed are near the expected values. The predicted energy values for individual feeds can be obtained by clicking on the *Supply* button in the *Calculation* subgroup (FIGURE 3F). Feed factors may be influencing energy derived from the diet as the result of feed compositional changes and, possibly, effects on digestion and passage rates. The net energy derived from forages is most sensitive to NDF amount and percentage of the NDF that is lignin, available NDF digestion rate (CHO B3), and peNDF value. For example, if the NDF of a feed is increased, the starch and sugar fractions in the feed will be decreased automatically by the software, more feed dry matter will escape digestion, and the feed will have a lower net energy value. Dry matter digestibility can be further decreased by lowering the NDF digestion rate. After making sure that the feed

composition values are appropriate, the digestion rate is considered. The major factors influencing energy derived from feeds high in nonfiber carbohydrates are ruminal and intestinal starch digestion rate (CHO B1). This is mainly a concern when feeding corn grain, corn silage, sorghum grain, or sorghum silage.

- Check postruminal starch digestibility (CB1ID) to make sure that it is appropriate for the starch source being fed. Intestinal digestibilities for starch, pectin, and protein B fraction can be modified in Table 8. The BCNRM assumes an average starch digestibility (CHO B1) of 75%; however, this may not be appropriate for all starch sources. Chapters 2 (Anatomy, Digestion, and Nutrient Utilization) and 19 provide additional values for the effects of processing on corn sources. For example, if cows were supplemented with whole corn, the intestinal starch digestibility should be lowered.

Physically Effective Fiber

This is generally not a problem with high-forage-based beef cow diets. Chapters 2 and 19 provide additional information on this topic.

Ruminally Degradable Protein Balance and Rumen N Balance

If the RDP and ruminal N balances are less than zero and MP balance is negative, feeds such as soybean meal that are high in degradable true protein can be added until these balances are positive. Adjustments can also be made with nonprotein nitrogen or soluble protein until total rumen N is balanced. Because of the number of assumptions required to adequately predict total N balance, including “recycled N” (i.e., urea N used for anabolism), it may be desirable under some conditions to have supply exceed requirements by about 5% (105% of requirement) to allow for prediction errors.

Metabolizable Protein

This component represents an aggregate of nonessential amino acids and essential amino acids. The MP requirement is determined in cows by the body weight and growth requirement, conceptus growth rate, and milk amounts and composition. The adequacy of the diet to meet these requirements will depend on the microbial protein produced from fiber and nonfiber carbohydrate fermentation and feed protein escaping fermentation. If MP balance appears to be unreasonable, check the starch (CHO B1) digestion rates first. Altering the amount of degradable starch will also alter the peptide and total rumen N balance because of altered microbial growth. Often, the most economical way to increase MP supply is to increase microbial protein production by adding highly degradable sources of starch, such as processed grains. Further adjustments are made with feeds

high in slowly degraded or rumen escape (bypass) protein (low protein fraction B digestion rate).

- Check total ration protein degradability and individual values for the feeds to compare with the tabular values. If considerably different, the user may have an entry error or need to adjust the protein fraction B digestion rate. First, check protein entered; then, check the protein fraction B digestion rate.

Essential Amino Acids

The amino acid with the least supply as a percentage of requirement is assumed the most limiting for the specified performance. Because of the number of assumptions required to predict amino acid adequacy, it may be desirable under some conditions to have first limiting amino acids exceed requirements by about 5% (105% of requirement) to allow for prediction errors. The adjustment for amino acids is done last because the amino acid balance is affected by the preceding steps. Essential amino acid balances can be estimated with both the ELS and MLS, but the MLS takes into account the effects of the interactions of intake, digestion, and passage rates on microbial yield and available undegraded feed protein, and estimates of their amino acid composition can be predicted along with microbial, body tissue, and milk amino acid composition. However, the development of more accurate feed composition and digestion rates, and more mechanistic approaches to predict utilization of absorbed amino acids will result in improved predictability of diet amino acid adequacy for cattle. To improve the amino acid profile of a ration, use feeds high in the first-limiting amino acids.

Dietary Crude Protein

After all of the above are correctly evaluated, the dietary CP content will be the CP requirement. The CP requirement represents the amount of RDP needed in the rumen and the amount of RUP needed to supplement the microbial protein to meet the MP requirement.

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