River Cutters
Notes on Curriculum Analysis

The following preliminary analysis focuses on how well *River Cutters* addresses five benchmarks: 4C Processes that Shape the Earth (3-5)#1, 1B Scientific Inquiry (6-8)#2, 3B Design and Systems (6-8)#2, 4C Processes that Shape the Earth (6-8)#2, and 11B Models (6-8)#1.

The analysis was guided by two sets of questions, one related to content and the other to pedagogy. Reviewing curricula in light of the content questions helps you determine whether there is a content match to a particular benchmark. When there is a content match, the pedagogical questions are used to determine whether the instruction contributes to students' learning the benchmark. The pedagogical questions reflect the principles of effective learning and teaching in *Science for All Americans,* Chapter 13.

The analysis results for each benchmark are presented in two parts, Content Match and Pedagogical Match. Evidence cited reflects responses to the Content Match and Pedagogical Match Questions.

Benchmark 4C Processes that Shape the Earth (3-5)#1

> **Waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers.**

Summary: The activities in *River Cutters* address the content of the part of the benchmark in bold:

> Waves, **wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas**, sometimes in seasonal layers.

Students are likely to learn that the surface of the earth is shaped by the movement of water from the activities in *River Cutters* because this is a central focus of the activities and subsequent discussions.

Benchmark 4C Processes that Shape the Earth (3-5)#1 (continued)

Session	Pages	Content Match - Evidence
1	11-15	On p. 12, when explaining the river cutting system, students are told that the water that drips from the cup represents rain that falls on the earth. However, no mention is made of the fact that rains are seasonal.
2	17-22	Students make a model river cutter and observe how their model earth is shaped by the motion of water.
3	23-30	On p. 24-25, students are asked in discussion questions 3,4,5 to describe different formations or river features they have observed in their river-cutting tubs. The teacher is encouraged to build from their observations a list of geological features, which will be supplemented with observations from textbook photos or diagrams. In discussion question 8, students are asked to relate their observations of their river-cutter models to forces that carve and sculpt the surface of the earth. The teacher is encouraged to refer to such natural creations as the Grand Canyon and mention that ice and wind are also important forces shaping the earth's surface. The sidebar on p. 25 indicates that a river may cut valleys, or create canyons in connection with large scale movements of the earth. On p. 27, the teacher is directed to explain that materials from the sides and bottom of a stream bed are moved downhill as water and other materials scrape against the sides and bottom, sculpting the surface of the land through which the water flows.

Benchmark 4C Processes that Shape the Earth (3-5)#1 (continued)

Pedagogy Match - Evidence

Are students engaged in activities (including reading and listening to peers and the teacher) and provided with opportunities to reflect on their activities?

- Students encounter the idea that the earth's surface is shaped by the motion of water several times during the module's activities (see, for example, pages 24-25, 36). Students engage in hands-on activities that address this idea: They make a model river cutter and observe how their model earth is shaped by the motion of water. In addition, students engage in discussions that encourage them to reflect on these activities. For example, students are asked to relate their observations of their river-cutter models to forces that carve and sculpt the surface of the earth (p. 25).

Are opportunities provided for teachers to find out what students think about the ideas in a benchmark (or how the students perform the skill described in a benchmark) in the beginning and throughout the instruction? Is the information used?

- Teachers are encouraged to ask for students' ideas on how the surface of the earth gets its shape and changes during, but not before, instruction (see p. 25). Students are not provided with opportunities to express their ideas about whether the surface of the earth changes over time.

Are teachers alerted to prerequisite ideas? Does the resource provide activities that help students make connections between benchmarks and their prerequisites?

- If students do not have some understanding of benchmarks related to the role and utility of models (see for example, benchmarks 11B (K-2) #2, 11B (3-5) #1), they may have difficulty learning the ideas in this benchmark. Students are not provided with opportunities to make connections between their prior experiences that relate to these benchmarks and their current experiences with models in *River Cutters*, nor are teachers encouraged to make such connections explicit for their students.

Are teachers alerted to misconceptions such as those described in Benchmarks *Chapter 15: The Research Base? Do the materials provide the teacher with specific information about likely student responses to difficulties with questions, activities, and assignments?*

- Research indicates that some middle-school students may not consider that the surface of the earth has changed over time or believe that any changes that have occurred are the product of continuing processes rather than a single event (see *Benchmarks* Chapter 15: The Research Base). Students' recognition of long-term effects of erosion by wind and water may depend on an improving sense of long time periods and familiarity with the effect of multiplying tiny fractions by very large numbers (in this case, slow rates by long times). The module does not include such experiences for students.

Are assessment items aligned with Benchmarks *(or* National Science Education Standards*)?*

- Although no assessment tasks are specified in the unit, a task for *River Cutters* is included in *Insights and Outcomes: Authentic Assessment for Great Explorations in Math and Science* (Lawrence Hall of Science, 1995). Students are asked to design a travel brochure that includes “maps, drawings, or diagrams about the area’s physical features.” This assessment task is not aligned with the benchmark.

Benchmark 1B Scientific Inquiry (6-8)#2

If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.

Summary: The activities cited provide evidence for a content match between *River Cutters* and the part of the benchmark in bold:

> **If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables.** It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.

The experiments conducted *are* controlled, and in one case, students consider the effectiveness of their controls and how to improve them.

There is not sufficient evidence in the activities for a pedagogy match to this benchmark. Although students may be *running* controlled experiments, they are only asked once to reflect on *whether* or not the experiments are controlled and this discussion is listed as optional.

Benchmark 1B Scientific Inquiry (6-8)#2 (continued)

Session	Pages	Content Match - Evidence
2	20-21	Instructions to students and the teacher help ensure that variables will be controlled in the included experiments. On p. 20, the teacher is instructed to check to be sure that students are using the same drip rate for their rivers and to not disturb the set-up once river flow has begun. On p. 21 the students are told to stop their rivers after the same time has elapsed--5 minutes.
4	32-36	In session 4, p. 32, the teacher is told to remind students to re-slope their tubs before cutting their rivers. On p. 33 students are reminded not to interfere with the river flows and to keep the flow rates constant. On p. 34, students are reminded not to alter the results of the 5-minute run before the 10-minute run. On p. 36, if students report different results the teacher is encouraged to discuss what factors might have been different in their experimental technique and set-ups. However, no suggestion is made about discussing the *difficulty* of controlling variables.
5	42	In session 5, p. 40, students are reminded again to use the same flow rate as before. On p. 42, students explore the effect of one variable—slope—on the pattern a river takes during its formation. They are asked to consider other factors that might influence how a river cuts through earth—e.g., hardness of the earth, how wet it already is. The teacher is encouraged to have students discuss whether or not their test runs were well-controlled and how they could design a better-controlled experiment on the effect of slope.
Going Further	53	In a possible extension activity, p. 53, students could vary the flow rate in their rivers to compare dry seasons with wet.

Benchmark 1B Scientific Inquiry (6-8)#2 (continued)

Pedagogy Match - Evidence

Are opportunities provided for teachers to find out what students think about the ideas in a benchmark (or how the students perform the skill described in a benchmark) in the beginning and throughout the instruction? Is the information used?

- Teachers are not encouraged to find out what students know about controlling variables and not until session 5 are students provided with the opportunity to express their ideas about what is involved in controlling variables.

Are students engaged in activities (including reading and listening to peers and the teacher) and provided with opportunities to reflect on their activities?

- Students are engaged in several activities that require them to keep factors such as flow rate and time of run constant (unless they are exploring the effect of time on river formation). They are repeatedly reminded to keep particular factors constant but they are not asked to consider why this is important. For example, they are asked to re-slope their tubs but no mention is made that another variable could be introduced into the experiment if they don't return the tubs to the same starting conditions. An opportunity is provided on p. 42 for students to reflect on what other factors might have influenced their results and to consider how their experimental designs could be improved to better control variables.

Are technical terms introduced only as needed to clarify thinking and promote effective communication after students use their own language to understand?

- Students are given experiences running controlled experiments before the term is introduced. The teacher is told to pursue this topic if students are already familiar with the notion of controlled experiments.

Are teachers alerted to misconceptions such as those described in Benchmarks *Chapter 15: The Research Base? Do the materials provide the teacher with specific information about likely student responses to difficulties with questions, activities, and assignments?*

- No mention is made of the difficulties students may have in holding all but one variable constant. However, the experiments students are asked to do *are* controlled and students are repeatedly reminded not to vary certain factors.

Are teachers alerted to prerequisite ideas? Does the resource provide activities that help students make connections between benchmarks and their prerequisites?

- Research indicates that "students of all ages may overlook the need to hold all but one variable constant, although elementary students already understand the notion of fair comparisons, a precursor to the idea of "controlled experiments" (*Benchmarks*, Chapter 15:

The Research Base, p. 332). No attempt is made to connect the notion of controlling variables to something students are likely to understand—the notion of “fair tests.”

Are assessment items aligned with Benchmarks *(or* National Science Education Standards*)?*

- Although no assessment tasks are specified in the unit, a task for *River Cutters* is included in *Insights and Outcomes: Authentic Assessment for Great Explorations in Math and Science* (Lawrence Hall of Science, 1995). Students are asked to design a travel brochure that includes “maps, drawings, or diagrams about the area’s physical features.” This assessment task is not aligned with the benchmark.

Benchmark 3B Design and Systems (6-8)#2

All technologies have effects other than those intended by the design, some of which may have been predictable and some not. In either case, these side effects may turn out to be unacceptable to some of the population and therefore lead to conflict between groups.

Summary: Activities 6 and 7 in *River Cutters* address the content of the part of the benchmark in bold:

> **All technologies have effects other than those intended by the design, some of which may have been predictable and some not.** In either case, these side effects may turn out to be unacceptable to some of the population and therefore lead to conflict between groups.

The activities will contribute to students learning about intended and unintended effects of dams and toxic waste dumps since that is the central focus of the activities and students are asked to reflect on their activities. However, students are not asked to generalize that all technologies have intended and unintended effects.

Benchmark 3B Design and Systems (6-8)#2

Session	Pages	Content Match - Evidence
6 and 7	45-52	In session 6, students use their model river cutter systems to construct a dam in order to create a recreational reservoir. After constructing a dam and hollowing out a reservoir uphill from the dam, they observe what happens. In session 7, students determine the best location for a toxic waste dump. After positioning their dumps, represented by dye-soaked cotton swabs, they allow their rivers to flow. Unknown to them, the teacher has positioned additional dump sites in their river cutter systems. Students observe the consequences of the waste dumps on their rivers and surrounding land.

Benchmark 3B Design and Systems (6-8)#2 (continued)

Pedagogy Match - Evidence

Are students engaged in activities (including reading and listening to peers and the teacher) and provided with opportunities to reflect on their activities?

- Students are provided with opportunities to reflect on their activities. As soon as they have constructed their recreational reservoirs and restarted their rivers, students are asked to reflect on the intended and unintended effects: "Does a lake form? Are their problems with erosion? Is there a buildup of sediment behind the dam?" In the subsequent discussion, students are asked to consider the benefits and problems (e.g., sedimentation) of dams. Teachers are told to encourage discussion of students' unexpected discovery of toxic waste sites, but no specific questions are provided. Upon completion of the activity, teachers are encouraged to have students debate related issues such as hydroelectric vs. other power generation, flood hazards and control, and the pros and cons of various dump locations.

Are assessment items aligned with Benchmarks *(or* National Science Education Standards*)?*

- Although no assessment tasks are specified in the unit, a task for *River Cutters* is included in *Insights and Outcomes: Authentic Assessment for Great Explorations in Math and Science* (Lawrence Hall of Science, 1995). Students are asked to design a travel brochure that includes "maps, drawings, or diagrams about the area's physical features." This assessment task is not aligned with the benchmark.

Benchmark 4C(6-8)#2

Some changes in the earth's surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as uplift and wearing down of mountains). The earth's surface is shaped in part by the motion of water and wind over very long times, which act to level mountain ranges.

Summary: The activities in *River Cutters* address the content of the part of the benchmark in bold:

> Some changes in the earth's surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as uplift and wearing down of mountains). **The earth's surface is shaped in part by the motion of water and wind over very long times.**

Students are likely to learn that the surface of the earth is shaped by the movement of water from the activities in *River Cutters* because this is a central focus of the activities and subsequent discussions. Because students are not asked to reflect on the different time scales between the formation of their model rivers and real rivers, it is unlikely that they will appreciate the very long times scales needed for formation of real rivers. Student understanding long time scales is likely to be linked to their understanding of benchmark 11B(6-8)#1.

Benchmark 4C(6-8)#2 (continued)

Session	Pages	Content Match - Evidence
2	17-22	Students make a model river cutter and observe how their model earth is shaped by the motion of water.
3	23-30	On p. 24-25, students are asked in discussion questions 3, 4, and 5 to describe different formations or river features they have observed in their river-cutting tubs. The teacher is encouraged to build from their observations a list of geological features, which will be supplemented with observations from textbook photos or diagrams. In discussion question 8, students are asked to relate their observations of their river-cutter models to forces that carve and sculpt the surface of the earth. The teacher is encouraged to refer to such natural creations as the Grand Canyon and mention that ice and wind are also important forces shaping the earth's surface. The sidebar on p. 25 indicates that a river may cut valleys, or create canyons in connection with large-scale movements of the earth and <u>over time</u>.
4	31-38	Students observe differences between a young river, simulated by a 5-minute run, and an old river, simulated by a 10-minute run.

Benchmark 4C(6-8)#2 (continued)

Pedagogical Match - Evidence

Are students engaged in activities (including reading and listening to peers and the teacher) and provided with opportunities to reflect on their activities?

- Students encounter the idea that the earth's surface is shaped by the motion of water several times during the module's activities (see, for example, pages 24-25, 36). Students engage in hands-on activities that address this idea: They make a model river cutter and observe how their model earth is shaped by the motion of water. In addition, students engage in discussions that encourage them to reflect on these activities. For example, students are asked to relate their observations of their river-cutter models to forces that carve and sculpt the surface of the earth (p. 25).

Are sufficient examples (and when appropriate, non examples) included for students to make sense of concepts and generalizations?

- Students encounter the idea that the "earth's surface is shaped **over very long times**" only once in the module. Before students make their river cutter models, the teacher is encouraged to say that "in their models, time will be speeded up thousands of times, so geological events that would take many human lifetimes in a real river may only take seconds or minutes in their models." (p. 12)

Are opportunities provided for teachers to find out what students think about the ideas in a benchmark (or how the students perform the skill described in a benchmark) in the beginning and throughout the instruction? Is the information used?

- Teachers are encouraged to ask for students' ideas on how the surface of the earth gets its shape and changes during, but not before, instruction (see p. 25). Students are not provided with opportunities to express their ideas about whether the surface of the earth changes over time or over what time interval they think such changes occur.

Are teachers alerted to prerequisite ideas? Does the resource provide activities that help students make connections between benchmarks and their prerequisites?

- If students do not have some understanding of benchmarks related to the role and utility of models (see for example, benchmarks 11B (K-2) #2, 11B (3-5) #1, 11B(6-8)#1), they may have difficulties learning the ideas in this benchmark. Students are not provided with opportunities to make connections between their prior experiences that relate to these benchmarks and their current experiences with models in *River Cutters*, nor are teachers encouraged to make such connections explicit for their students.

Is an attempt made to address misconceptions? Do materials provide guidance concerning ways to address students' questions and difficulties?

- Research indicates that some middle-school students may not consider that the surface of the earth has changed over time, nor believe that any changes that have occurred are the product of continuing processes rather than a single event (see *Benchmarks* Chapter 15: The Research Base). Students' recognition of long-term effects of erosion by wind and water may depend on an improving sense of long time periods and familiarity with the effect of multiplying tiny fractions by very large numbers (in this case, slow rates by long times). The module does not include such experiences for students.

Are assessment items aligned with Benchmarks *(or* National Science Education Standards*)?*

- Although no assessment tasks are specified in the unit, a task for *River Cutters* is included in *Insights and Outcomes: Authentic Assessment for Great Explorations in Math and Science* (Lawrence Hall of Science, 1995). Students are asked to design a travel brochure that includes "maps, drawings, or diagrams about the area's physical features." This assessment task is not aligned with the benchmark.

Benchmark 11B Models (6-8)#1

Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.

Summary: The activities cited provide evidence for a content match between *River Cutters* and the part of the benchmark in bold:

> **Models are often used to think about processes that happen too slowly,** too quickly, or on too small a scale to observe directly, **or that are too vast to be changed deliberately**, or that are potentially dangerous.

Their river cutters model the formation of real rivers, which takes place over much longer time frames and are too vast to be changed deliberately.

There is insufficient evidence for a pedagogical match to this benchmark, mainly because students are not asked to reflect on the utility of their river cutter models in simulating real rivers and of this role of models in general. However, with specific questions to encourage such reflection about this particular model and of similar reflections following experiences with other models the activities could contribute to students learning the benchmark.

Benchmark 11B Models (6-8)#1

Session	**Pages**	**Evidence for Content Match**
1	11-16	On p. 12, students are told that they will be creating and observing the events in a simulated river model but that time is speeded up thousands of times in their models so geological events that would take many human lifetimes in a real river may only take seconds or minutes in their models. They are also told that the diatomaceous earth in the model represents the soil or dirt on the earth and that the water that drips from their dripper systems represents the rain that falls on the Earth. At the end of the session, p. 15, they are asked to make a "practice river."
2	17-22	Students make a model river cutter and observe features of the river and land forms created. On p. 18, they are asked to imagine that their model earth represents a real continent sloping to the seashore.
3	23-30	On p. 24-25, students are reminded that they have created models of a river system, and that models do not always work exactly like a particular river. On p. 27, the teacher is directed to explain that larger streams and rivers cut

		through the earth in much the same manner as the water in their tubs moved the diatomaceous earth. On p. 28, students are asked for their ideas on other experiments they could do with their river models.
4	31-38	Students model a new and an old river by allowing their river cutters to operate for 5 and 10 minutes, respectively. In the discussion, p. 36, students are asked to compare features of the “young” vs. “old” rivers (but they are not asked to consider whether or why 5 and 10 minute runs adequately model young and old rivers).
6 and 7	45-52	In sessions 6 and 7 students model constructing dams (in order to create a recreational reservoir) and finding locations for toxic waste dumps (in order to determine the best location to place a toxic dump waste site).

Benchmark 11B Models (6-8)#1 (continued)

Pedagogical Match - Evidence

Are opportunities provided for teachers to find out what students think about the ideas in a benchmark (or how the students perform the skill described in a benchmark) in the beginning and throughout the instruction? Is the information used?

- Teachers are not encouraged to find out what students know about models, and students are not provided with opportunities to express their ideas about what models are and what their utility is.

Are students engaged in activities (including reading and listening to peers and the teacher) and provided with opportunities to reflect on their activities?

- Students are engaged in making models of processes that happen too slowly or that are too vast to be changed deliberately. However, students are not encouraged explicitly to reflect on their activities with respect to the utility and role of models in science. (Even if students were encouraged to reflect on their activities, they would need experiences with other models in order to reach the generalization that "models are often used to think about processes that happen too slowly.")

Are teachers alerted to prerequisite ideas? Does the resource provide activities that help students make connections between benchmarks and their prerequisites?

- There are several precursors to this benchmark, such as:

    11B (K-2) #2
    A model of something is different from the real thing but can be used to learn something about the real thing.

    11B (3-5) #1
    Seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it.

  If students do not have some understanding of these precursors, they may have difficulties learning the ideas in this benchmark. Students are not provided with opportunities to make connections between their prior experiences that relate to these precursors and their current experiences with models in *River Cutters*, nor are teachers encouraged to make such connections explicit for their students.